



Society for Risk Analysis



## 2011 Annual Meeting

December 4-7, 2011

Charleston Area Convention Center

Embassy Suites North Charleston-Airport Hotel

Charleston, South Carolina

# Final Program

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# Society For Risk Analysis Annual Meeting

## 2011 Final Program

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### Meeting Highlights

#### Poster Reception!

This year's meeting will feature a poster reception with food and drinks on Monday evening from 6:15 to 8:15 pm. Posters will be on display starting at noon and poster presenters will be at their posters for questions and discussion during the reception. Vote for the best poster awards. Don't miss it!

**Meeting Events!** - All events take place at the Charleston Convention Center, which is connected to the Embassy Suites Hotel by an indoor sky-bridge.

Start with the opening reception on Sunday (December 4, 6:00-7:30 PM), and continue to the closing (Wine and Cheese - Cash Bar) reception on Wednesday (December 7, 5:00-6:00 PM). The meeting includes three Plenary Sessions, three Presidential Roundtables on Monday, and lunch on all three days.

### Oral Presenter's Reminder

**If you are an Oral Presenter at the meeting, don't forget to upload your presentation in the Speaker Ready Room (Meeting Room 2) at least 24 hrs prior to your presentation.**

**If you have already uploaded your talk, come by the Ready Room to ensure it has been received and uploaded correctly.**

### Embassy Suites North Charleston

5055 International Boulevard

North Charleston, SC 29418

843-747-1882; Fax: 843-747-1895

### Charleston Area Convention Center

5001 Coliseum Drive

North Charleston, SC 29418

<b>Ballroom C1</b>	<b>Ballroom C2</b>	<b>Ballroom C3</b>	<b>Meeting Room 6</b>	<b>Meeting Room 7</b>
<p><b>Monday</b> <b>10:30 AM-Noon</b> M2-A Panel Discussion: Approaches to Animal Health Risk Assessment</p> <p><b>1:30-3:00 PM</b> M3-A Animal Epidemics, Terrorist Threats, and Siting Biological Research Facilities</p> <p><b>3:30-5:00 PM</b> M4-A Emerging Theories of Risk Communication</p>	<p><b>Monday</b> <b>10:30 AM-Noon</b> M2-B Poster Platform: Technical Topics in Decision Analysis and Risk</p> <p><b>1:30-3:00 PM</b> M3-B Exposure Assessment Tools</p> <p><b>3:30-5:10 PM</b> M4-B Panel Discussion: Synthetic Biology and Risk Governance</p>	<p><b>Monday</b> <b>10:30 AM-Noon</b> M2-C Symposium: Tox 21/NexGen Dose Response</p> <p><b>1:30-3:00 PM</b> M3-C Symposium: Dose Response for Biothreats</p> <p><b>3:30-5:00 PM</b> M4-C Biomonitoring Data for Risk Assessment</p>	<p><b>Monday</b> <b>10:30 AM-Noon</b> M2-D Symposium: Risks of Transportation Disruptions</p> <p><b>3:30-5:10 PM</b> M4-D Symposium: Risk Management Actions for Emerging Contaminants</p>	<p><b>Monday</b> <b>10:30 AM-Noon</b> M2-E Eco-Risk</p> <p><b>1:30-3:00 PM</b> M3-E Symp: Listeria Monocytogenes Dose-Response Data and Models: Current and Future Advancements</p> <p><b>3:30-5:10 PM</b> M4-E Symposium: Microbial Safety of Fresh Produce, Spices and Herbs: Mitigating Risk from Farm-to-Table</p>
<p><b>Tuesday</b> <b>10:30 AM-Noon</b> T2-A Climate Change Perceptions and their Consequences</p> <p><b>1:30-3:00 PM</b> T3-A Fukushima and Risk Communication</p> <p><b>3:30-5:00 PM</b> T4-A Risk Communication and Emerging Technologies</p>	<p><b>Tuesday</b> <b>10:30 AM-Noon</b> T2-B Symposium: Seafood Safety Following the Deepwater Horizon Oil Spill</p> <p><b>1:30-3:00 PM</b> T3-B Diverse Modeling Approaches for Exposure Assessment</p> <p><b>3:30-5:00 PM</b> T4-B Panel Discussion: Mercator-Symp: Public Preferences and Regulatory Decision-Making ...</p>	<p><b>Tuesday</b> <b>10:30 AM-Noon</b> T2-C Dose Response Modeling</p> <p><b>1:30-3:00 PM</b> T3-C Symp: Improving Problem Formulation and Dose-Response Beyond Science and Decision, Part 1</p> <p><b>3:30-5:00 PM</b> T4-C Symp: Improving Problem Formulation and Dose-Response Beyond Science and Decision, Part 2</p>	<p><b>Tuesday</b> <b>10:30 AM-Noon</b> T2-D Symposium: Climate Change Impacts and Adaptation Strategies: Evolving Roles of Risk Analysis</p> <p><b>1:30-3:00 PM</b> T3-D Disasters and Infrastructure Interdependencies</p> <p><b>3:30-5:10 PM</b> T4-D Aquatic Ecological Risk Analysis</p>	<p><b>Tuesday</b> <b>10:30 AM-Noon</b> T2-E Health, Safety and Society</p> <p><b>1:30-3:00 PM</b> T3-E Innovative Uses of QMRA to Support Risk Management</p> <p><b>3:30-5:10 PM</b> T4-E Symposium: Food Safety Risk Prioritization and Decision Analysis</p>
<p><b>Wednesday</b> <b>8:30-10:00 AM</b> W1-A Symp: How the Public Responds to Different Disasters over Time ...</p> <p><b>10:30 AM-Noon</b> W2-A Communicating Food Contamination</p> <p><b>1:30-3:00 PM</b> W3-A Communicating Risks in Times of Duress</p> <p><b>3:30-4:30 PM</b> W4-A Communicating Risks, Health and Well-Being</p>	<p><b>Wednesday</b> <b>8:30-10:00 AM</b> W1-B Symposium: Analytical Approaches to Food Safety Management</p> <p><b>10:30 AM-Noon</b> W2-B Symp: Poster Platform: The Development of High Throughput Exposure Techniques ...</p> <p><b>1:30-3:00 PM</b> W3-B Foodborne Exposures</p> <p><b>3:30-5:00 PM</b> W4-B Risk Assessment of Pharmaceuticals in the Environment</p>	<p><b>Wednesday</b> <b>8:30-10:00 AM</b> W1-C Risk Theory and Practice</p> <p><b>10:30 AM-Noon</b> W2-C Low-Dose Dose-Response</p> <p><b>1:30-3:00 PM</b> W3-C Symposium: Graphic Depictions of Toxicological Data</p> <p><b>3:30-5:10 PM</b> W4-C Symposium: Fulfilling the Potential of EPA's Integrated Risk Information System (IRIS) Program</p>	<p><b>Wednesday</b> <b>8:30-10:00 AM</b> W1-D Methods to Inform Environmental Management</p> <p><b>10:30 AM-Noon</b> W2-D Risk Analysis of Transportation Networks and Assets</p> <p><b>1:30-3:00 PM</b> W3-D Ecological Risk Assessment</p> <p><b>3:30-5:00 PM</b> W4-D Reliability Analysis and Modeling for Infrastructure Systems</p>	<p><b>10:30 AM-Noon</b> W2-E Symp: Rapid Risk Eval: Analytic Tools to Support Fed Response to Environ and Food Safety Incidents</p> <p><b>1:30-3:00 PM</b> W3-E Symposium: Innovative Means of Data Collection to Support a Quantitative Risk Assessment</p> <p><b>3:30-5:10 PM</b> W4-E Bio-Risk: Agriculture and Beyond</p>

Meeting Room 8/9	Meeting Room 10	Meeting Room 11	Meeting Rm 12/13	Meeting Room 14
<p align="center"><b>Monday</b> <b>10:30 AM-Noon</b></p> <p>M2-F Panel Discussion: Getting Beyond the Statistician's Bag of Marbles</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>M3-F Symp: Engaging Stakeholders in Risk-Informed Decision Making: Methodology and Case Studies</p> <p align="center"><b>3:30-5:00 PM</b></p> <p>M4-F Panel Discussion: Structuring Decision Processes to Manage Risks</p>	<p align="center"><b>Monday</b> <b>10:30 AM-Noon</b></p> <p>M2-G Vulnerability! Disaster! Oh My!</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>M3-G Symposium: Risk Communication and Trust in Canadian Aboriginal Communities</p> <p align="center"><b>3:30-5:10 PM</b></p> <p>M4-G Symp: Assessing and Managing Carbon Nanomaterials Risks: Current &amp; Future Approaches</p>	<p align="center"><b>Monday</b> <b>10:30 AM-Noon</b></p> <p>M2-H Symposium: Progress and Challenges in RA and RM at DHS: Culture and Methodology</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>M3-H Symp: Analyzing and Managing 21st Century Risks: Moving Beyond Newtonian Approaches</p> <p align="center"><b>3:30-5:10 PM</b></p> <p>M4-H Symposium: Adversary Modeling for Terrorism Risk Analysis Applications</p>	<p align="center"><b>Monday</b> <b>10:30 AM-Noon</b></p> <p>M2-I Symposium: Interagency Food Safety Analytics</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>M3-I Symp: Synthesizing Studies for Evidence-Based Decisionmaking: Part 1, Meta-Regression &amp; Related Methods</p> <p align="center"><b>3:30-5:10 PM</b></p> <p>M4-I Symp: Synthesizing Studies for Evidence-Based Decisionmaking: Part 2, Expert Elicitation</p>	<p align="center"><b>Monday</b> <b>10:30 AM-Noon</b></p> <p>M2-J Cumulative Exposures</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>M3-J Risk Assessment Methods Development</p> <p align="center"><b>3:30-5:10 PM</b></p> <p>M4-J Human Exposure to Contaminants in Food and Water</p>
<p align="center"><b>Tuesday</b> <b>10:30 AM-Noon</b></p> <p>T2-F Error in Risk Assessment</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>T3-F Applied Methodology for Transportation and Other Risk Management</p> <p align="center"><b>3:30-5:00 PM</b></p> <p>T4-F Organizational Processes for Risk-Oriented Decisions</p>	<p align="center"><b>Tuesday</b> <b>10:30 AM-Noon</b></p> <p>T2-G Games and Digital Platforms for Risk Communication</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>T3-G Nanomaterials: Environment, Dose-Response, and Expert Opinion</p> <p align="center"><b>3:30-5:00 PM</b></p> <p>T4-G Nanomaterials: Exposure, Hazard, Risk and Perception</p>	<p align="center"><b>Tuesday</b> <b>10:30 AM-Noon</b></p> <p>T2-H Bioterrorism: Analyzing Agents and Risks</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>T3-H Risk Analysis of Weapons of Mass Destruction in the Supply Chain</p> <p align="center"><b>3:30-5:10 PM</b></p> <p>T4-H Advanced Models and Decision Support for WMD Risk Management</p>	<p align="center"><b>Tuesday</b> <b>10:30 AM-Noon</b></p> <p>T2-I Symposium: Regulation and Risk</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>T3-I Symposium: Catastrophic Climate Change</p> <p align="center"><b>3:30-5:10 PM</b></p> <p>T4-I Symposium: Global Catastrophic Risk</p>	<p align="center"><b>Tuesday</b> <b>10:30 AM-Noon</b></p> <p>T2-J Risk Communication - Networks across Hazards and along Life Cycles</p> <p align="center"><b>3:30-5:00 PM</b></p> <p>T4-J Panel Discussion: Student and Young Professional Roundtable on Career Development</p>
<p align="center"><b>Wednesday</b> <b>8:30-10:00 AM</b></p> <p>W1-F Symposium: Risk Assessment for Acquisition and Assets Management</p> <p align="center"><b>10:30 AM-Noon</b></p> <p>W2-F Innovative Mathematical and Computational Methods for Risk Modeling</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>W3-F Symposium: Making the World Safer - Perspectives from Different Industries and Countries</p> <p align="center"><b>3:30-4:30 PM</b></p> <p>W4-F Environmental Risk Management Decisions</p>	<p align="center"><b>Wednesday</b> <b>8:30-10:00 AM</b></p> <p>W1-G Uncertainty, Bears, Dioxin and Well Water</p> <p align="center"><b>10:30 AM-Noon</b></p> <p>W2-G Epidemiological Dose Response Data</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>W3-G The Dose Response Wave</p> <p align="center"><b>3:30-5:00 PM</b></p> <p>W4-G Panel Discussion: SRA Specialty Groups: What's Missing</p>	<p align="center"><b>Wednesday</b> <b>8:30-10:00 AM</b></p> <p>W1-H Symposium: Managing Risks from Hurricanes in Coastal Areas</p> <p align="center"><b>10:30 AM-Noon</b></p> <p>W2-H Symposium: Risk Communication in the US Hurricane Forecast and Warning System</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>W3-H Symposium: Game Theory and Homeland Security</p> <p align="center"><b>3:30-5:00 PM</b></p> <p>W4-H Risk Analysis Approaches for Cybersecurity and Critical Infrastructure</p>	<p align="center"><b>Wednesday</b> <b>8:30-10:00 AM</b></p> <p>W1-I Preference Elicitation and Benefits Assessments, Part 1</p> <p align="center"><b>10:30 AM-Noon</b></p> <p>W2-I Preference Elicitation and Benefits Assessments, Part 2</p> <p align="center"><b>1:30-3:00 PM</b></p> <p>W3-I Symposium: Benefits, Co-Benefits and Uncertainties of Air Quality Improvements</p> <p align="center"><b>3:30-5:10 PM</b></p> <p>W4-I Symp: Quantifying and Communicating the US Domestic Benefits of GHG ...</p>	<p align="center"><b>T-Shirt Giveaway/ Wine &amp; Cheese Reception</b> <b>5:00-6:00 pm</b> <b>Charleston Convention Center Registration Foyer</b></p>

**SRA 2011 Specialty Group  
Award Winners**

**Decision Analysis & Risk**

Dan Skinner  
John Coles

**Ecological Risk Assessment**

Ryan Calder

**Economics and Benefits Analysis**

Austin Mitchell

**Exposure Assessment**

Tao Hong  
Wan Jiao

**Microbial Risk**

Tao Hong

**Risk Policy & Law**

Ahmad Safi

**Security & Defense**

Richard Hartz  
Susmit Panjwani

**SRA 2011 Student &  
International Award Winners**

Ackerlund, Steve	Liu, Yan
Agurenko, Alina	Lopez, Claudio
Andersson, Henrik	MacKenzie, Cameron
Barrios, Indira	Marlatt, Holly
Baum, Seth	Mauelshagen, Craig
Bouder, Frederic	Medrano, Diego
Bronfman, Nicolas	Mercer, Ashley
Cakmak, Sabit	Mitchell, Austin
Calder, Ryan	Mohapatra, Asish
Chu, Eric	Panjwani, Susmit
Cifuentes, Luis	Pant, Raghav
Coles, John	Resurreccion, Joanna
Connor, Melanie	Rivera Mancia, Maria Elena
Cornu, Marie	Rose, Stephen
Cummings, Christopher	Safi, Ahmad
Demichelis, Sandra	Shan, Xiaojun
de Oliveira Duarte, Heitor	Sides, Wena
Hamilton, Michelle	Skinner, Dan
Hartz, Richard	Stasiewicz, Matthew
Ho, Wen-Chao	Thekdi, Shital
Hong, Tao	Timofeev, Arsenii
Howe, Peter	Trump, Benjamin
Huang, Yin	Tsai, Meng-Shan
Jiao, Wan	Tsou, Ming-Chien
Jimenez, Raquel	Wang, Daisy
Kokotovich, Adam	Yu, Hwa-Lung
LaRocca, Sarah	Zhao, Yuchao
Lei, Hsiao Ling	Zwickle, Adam
Lemus-Martinez, Cecilia	
Lin, Meng-Hung	

# Meeting Events and Highlights

## Registration Hours

### Charleston Convention Center - Ballroom Foyer

Sunday, December 4	4:00 - 6:30 PM
Monday, December 5	7:00 AM - 5:30 PM
Tuesday, December 6	8:00 AM - 5:30 PM
Wednesday, December 7	8:00 AM - 5:30 PM

## Conference Events, Committee Meetings

(ES) = Embassy Suites Hotel, Lobby Level

### Sunday, December 4

#### **SRA Council Meeting**

Noon–5:00 PM - Meeting Room 3

#### **SRA Welcome Reception – (Cash Bar)**

6:00–7:30 PM - Ballroom A

#### **SRA World Congress Meeting**

9:00-10:30 PM - Wando (ES)

### Monday, December 5

#### **New Member and Fellows Networking & Coffee**

7:00-8:00 AM - Meeting Room 6 & 7

All SRA Fellows as well as 2011 and 2012 New Members (badges with a New Member ribbon) are welcome to attend.

#### **Publications Committee**

7:00-8:00 AM - Meeting Room 4

#### **Regions Committee (Chapters & Sections) Chairs Meeting**

7:30-8:30 AM - Meeting Room 5

#### **Finance Committee**

3:30-5:30 PM - Meeting Room 4

#### **Poster Reception**

6:15–8:15 PM - Ballroom A/B

### Tuesday, December 6

#### **Grad Student Breakfast**

7:00-8:00 AM - Meeting Room 4

#### **Specialty Group Chairs Breakfast**

7:00-8:00 AM - Meeting Room 3

#### **Communications Committee**

7:30-8:30 AM - Meeting Room 5

#### **Membership Committee**

7:30-8:30 AM - Executive Boardroom (ES)

#### **Career Fair**

5:00-6:30 PM - Ballroom Foyer

#### **Student & Young Professionals Mixer**

5:00-6:30 PM - Ballroom Foyer

#### **New England Chapter Mixer**

6:00-7:00 PM - Meeting Room 14

#### **SRA Council Meeting**

6:30-10:00 PM - Cooper (ES)

#### **World Congress Meeting**

7:00-10:00 PM - Wando (ES)

### Wednesday, December 7

#### **Education Committee Breakfast**

7:00-8:00 AM - Meeting Room 4

#### **Conferences and Workshops Committee**

7:30-8:30 AM - Meeting Room 5

#### **T-Shirt Giveaway/Wine & Cheese Reception - (Cash Bar)**

5:00–6:00 PM, Registration Area, Ballroom Foyer

Everyone who attends will receive a free T-shirt!



## Specialty Group Meetings

12:00-1:30 PM

All Specialty Group Meetings will take place during lunch time on Monday, December 5. Pick up your box lunch near the Registration desk and attend the meeting(s) of your choice.

### 12:05-12:30 pm

Dose Response, *Room 6*

Economics & Benefits Analysis, *Room 7*

Security & Defense, *Room 8/9*

Risk Communication, *Room 10*

### 12:35-1:00 pm

Ecological Risk Assessment, *Room 6*

Exposure Assessment, *Room 7*

Risk, Policy & Law, *Room 8/9*

Risk & Development, *Room 10*

### 1:05-1:30 pm

Decision Analysis & Risk, *Room 6*

Emerging Nanoscale Materials, *Room 7*

Engineering & Infrastructure, *Room 8/9*

Microbial Risk, *Room 10*

## Specialty Group Mixers

### Tuesday, December 6

6:00 - 7:30 PM - *Charleston Convention Center*

*DRSG, EASG - Meeting Room 4*

*EBASG, RPLSG, ENMSG, RDSG - Meeting Room 3*

*DARSG, EISG, SDSG - Meeting Room 5*

*MRSG, RCSG - Meeting Room 1*

### **Key to Specialty Group Designations**

DARSG = Decision Analysis and Risk	ERASG - Ecological Risk Assessment
DRSG = Dose-Response	MRSG = Microbial Risk
EASG = Exposure Assessment	RCSG = Risk Communication
EBASG = Economics & Benefits Analysis	RDSG = Risk & Development
EISG = Engineering and Infrastructure	RPLSG = Risk Policy and Law
ENMSG = Emerging Nanoscale Materials	SDSG = Security and Defense

## Exhibition - Ballroom Foyer

Monday, December 5.....Noon - 4:00 PM

Tuesday, December 6.....9:45 AM - 4:00 PM

Wednesday, December 7.....9:45 AM - Noon

### Exhibitors

#### Academia Book Exhibits

3512 Willow Green Court

Oakton, VA 22124

703-716-5537; Fax: 703-620-3676

Professional books and journals in a multi-publisher display.

#### H. Steven Logsdon/Wildlife Artist

PO Box 4070

Silver City, NM 88062

575-388-8101

Wildlife jewelry.

#### ICF International

9300 Lee Highway

Fairfax VA 22031

919-293-1621; Fax: 919-293-1645

www.icfi.com

ICF International (NASDAQ:ICFI), a global professional services firm, partners with government and commercial clients to deliver consulting services and technology solutions in the environment, energy, climate change, transportation, social programs, health, defense, and emergency management markets.

#### Toxicology Excellence for Risk Assessment (TERA)

2300 Montana Avenue, Suite 409

Cincinnati, OH 45211

513-542-7475; FAX: 513-542-8674

www.tera.org

TERA is a non-profit risk assessment organization dedicated to the best use of toxicity information for risk assessment. Information on key TERA projects and resources will be available, including risk databases (ITER, RiskIE) and training, the Alliance for Risk Assessment, assessments, and peer review.



**US Environmental Protection Agency (US EPA)**

1200 Pennsylvania Avenue NW

Maildrop 8601P

Washington, DC 20460

703-347-8545

[www.usepa.org](http://www.usepa.org)

EPA publications and information about EPA - Office of Research and Development.

**Wiley-Blackwell**

111 River Street 4-02

Hoboken, NJ 07030

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**Learn more about  
the Expert Panel Report  
on Animal Health  
Risk Assessment at  
[www.scienceadvice.ca](http://www.scienceadvice.ca)**

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*...Back by Popular Demand...Back by Popular Demand...Back by Popular Demand...*

## ***SRA Career Fair***

### **Career Fair, Tuesday, 5:00-6:30 pm - Ballroom Foyer**

Finding the right job. Continuing education. Work-force training. Career advancement. It's a giant puzzle, but the career fair at this year's SRA Annual Meeting can help you put all the pieces together. During this event, job seekers can network with employers looking to fill vacancies as well as participate in on-site interviews. This will be your opportunity to show off your first impressions, resumes and get one-on-one time with local recruiters and employment resources.

Come dressed professionally, and bring along plenty of résumés and a winning attitude. Remember, this is an employer's first impression of you, so treat this event like you would a job interview.

If you are a Student or Young Professional, join us for the Mixer while doing some networking at the Career Fair!

**Exponent<sup>®</sup>**



### **Sponsors:**

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US Army Engineer Research and Development Center

### **Participants:**

ARCADIS

RAND

Toxicology Excellence for Risk Assessment (TERA)

US EPA

US FDA, Office of Planning, Office of Commissioner

## Workshops - Sunday, December 4

### Full Day Workshops

8:30 am – 5:30 pm

(Lunch is on your own, 12:30-1:30 pm)

#### **WK1: Benchmark Dose Modeling (BMD) Analysis – An Introduction to BMD Methods and Application of EPA’s Benchmark Dose Software**

*Organizer: J. Allen Davis*

**\$350 onsite registration**

This workshop will provide participants with interactive training on the use of the U.S. EPA’s Benchmark Dose Software (BMDS) and its application to risk assessment. The course will provide an overview of the BMD process, including determination of data adequacy, model fitting and comparison, and selection of a benchmark response level. This workshop will cover all BMD models available in BMDS 2.2—including the new MS-COMBO model, which calculates multi-tumor composite risk values. Instruction will also be given in regard to new features that have been implemented in version 2.2. This interactive training workshop will consist of morning and afternoon sessions. The morning session will include instructor presentations covering the basic science and theory of BMD modeling, and is intended for those with no prior experience in BMD modeling. The afternoon session will expand upon the morning session and will consist of a demonstration of EPA’s BMDS 2.2 through individual and group class modeling exercises. Questions and critical discussions of presentation material and class activities are highly encouraged. Participants planning to attend the afternoon session need to bring their own laptops to the workshop with BMDS 2.2 installed (with necessary administrative rights). The latest version of the software can be found at: <http://epa.gov/ncea/bmds/>.

#### **WK2: Advancing Mechanisms of Gut Interactions Informing Microbial Risk Assessment**

*Organizer: Peg Coleman*

**\$350 onsite registration**

In the decade since the first SRA workshop on mechanistic modeling of host-pathogen interactions in the gastrointestinal tract, a paradigm shift arose that complicates microbial dose-response assessment for enteric patho-

gens: expansion of knowledge of the gut ecosystem to include not just human mucosal cells, but the indigenous microbiota and its collective genome, the microbiome. The goal of the workshop is to promote a paradigm shift to an ecosystem approach for microbial risk assessment that incorporates data on human microbiome interactions linked to stable pathways (health) or perturbed systems (disease). International experts will introduce new concepts and supporting evidence from metagenomic studies using high throughput sequencing methods rather than pure culture methods of past generations of medical microbiologists. Microbial risk analysts will be challenged to identify not just the two traditional metrics (pathogen dose and host response) as in simple empirical dose-response models of disease outcomes, but also the underlying interactions of the complex gut ecosystems that cause health and disease. Participants will consider how to scale data across spatial scales (genetic, molecular, tissue, organ, individual, subpopulation, population) for more coherent microbial dose-response assessment that incorporates innate and adaptive immune interactions of healthy ecosystems and immunomodulation by the microbiota in health and disease.

#### **WK3: Risk, Robustness and Info-Gaps**

*Organizer: Yakov Ben-Haim*

**\$375 onsite registration**

Risk analysts use measurements and science-based models to design systems, evaluate reliability, and make plans and policies. However, models may be simpler than reality, causal factors may be unknown, measurements may err or be incomplete, and systems may change over time in unknown ways. Probability is useful for modeling and managing some of these uncertainties. However some uncertainties are info-gaps: disparities between what is known and what needs to be known in order to make good decisions. For instance, we sometimes do not know the correct probability distribution or all of the relevant physical mechanisms such as non-linearities or time dependencies. This course studies info-gap theory for modeling and managing uncertainties in risk analysis and related decision problems. The course emphasizes the added value of an info-gap analysis as well as its limitations, and the integration of info-gap theory with probabilistic analysis. This course is built around lectures presenting a series of simple examples taken from a wide range of applications in the field of risk analysis, reliability assessment and policy selection. The examples illustrate the integration of info-gap robustness analysis in a variety of other decision strategies. The end of the workshop is devoted to

exercises which help the participants get a hands-on feel for info-gap analysis. Students, researchers, and analysts involved in risk analysis, reliability assessment and policy selection will find this workshop useful.

#### **WK4: Cumulative Risk Assessment: Grouping and Analyzing Combined Chemical, Biological, Physical and Socio-Economic Stressors**

*Organizer: Linda K. Teuschler*

##### **\$399 onsite registration**

Public interest has been growing regarding the health effects of environmental exposures and cumulative impacts from multiple chemical and non-chemical (e.g., microbes, noise) stressors on communities. Initiating factors for a cumulative risk assessment (CRA) could include: contaminants in environmental media from multiple pollutant sources; environmental quality metrics, e.g., pollution levels; exposure metrics, including biomonitoring; public health effect metrics; and ecosystem impacts. CRA can be defined as an analysis, characterization, and possible quantification of the combined risks to human health or the environment from multiple agents or stressors. In addition, population and individual vulnerability factors are being recognized as important to CRA, such as diet/nutritional status, behaviors, genetic traits, socio-economic status, sensitivities, and psychosocial stress. To meet this challenge, research efforts are ongoing to characterize exposure, health effects and risks from combinations of chemical, physical, biological and socio-economic stressors. This workshop highlights concepts, methods, and resources for scoping and conducting a population-based CRA. A central theme is integrating exposure information and population characteristics during CRA planning and scoping based on initiating factors. In the exercises, chemical, biological and physical stressor groups are formed using exposure and toxicity factors and are linked with vulnerability factors characteristic of the exposed population, including socio-economic stressors; these groups are used to develop risk characterization information. Methods for estimating human health risks are discussed and applied, including epidemiologic approaches and methods based on existing chemical mixtures risk assessment guidance and toxicological data. Teaching methods include lectures and hands-on exercises. Participants are asked to bring a calculator.

#### **WK6: Probabilistic Risk Analysis with Hardly Any Data**

*Organizer: Scott Ferson*

##### **\$300 onsite registration**

This full-day tutorial introduces and compares methods for developing

a probabilistic risk analysis when little or no empirical data are available to inform the risk model. The talks are organized around the basic problems that risk analysts face: not knowing the input distributions, not knowing their correlations, not being sure about the model itself, or even which variables should be considered. Possible strategies include traditional approximative methods and recent robust and bounding methods. Numerical examples are given that illustrate the use of various methods including traditional moment propagation, PERT, maximum entropy, uniformity principle, probability bounds analysis, Bayesian model averaging and the old work horse, sensitivity analysis. All of the approaches can be used to develop a fully probabilistic estimate useful for screening decisions and other planning. The advantages and drawbacks of the various approaches are examined. Essentially, the drawbacks are that bounding approaches may say too little about risks, and the rough and ready approximate methods may say too much. The discussion addresses how defensible decisions can be made even when little information is available, and when one should break down and collect some data and, in that case, what data to look for. The presentation style will be casual and interactive. Participants will receive a CD of the illustrations and numerical examples used during the tutorial.

#### **WK7: The Transformation of Energy Policies: Implications for Risk Governance, Communication and Stakeholder Participation**

*Organizer: Ortwin Renn*

##### **\$350 onsite registration**

The workshop will be focusing on risks from the generation and use of energy. This is a problem that has high popularity for risk professionals worldwide and includes typical risk components such as uncertainty, complexity and ambiguity. With the nuclear accident in Fukushima, the role of energy production is again in the forefront of public debate. The workshop will use this topic to explore the best means to communicate different types of risks and to involve stakeholders in the process of risk management and public communication. The basic core of this workshop is formed by a broad conceptual framework for risk governance developed by the International Risk Governance Council (IRGC), a private, non-profit foundation in Geneva, Switzerland. The workshop will be a combination of lecture and interactive case studies, including role-playing exercises and feedback discussions. It is designed to help workshop participants think through the issues involved in dealing with risk communication about energy risks.



## **WK9: Eliciting Judgments to Inform Decisionmaking**

*Organizer: Christina McLaughlin*

### **\$350 onsite registration**

Risk analysis often requires making inferences or estimating parameter values from studies that contain inconsistent or conflicting results or address dissimilar contexts. Such inferences or estimates should be consistent with the weight of evidence. Deciding whether and how to combine information from multiple studies requires thinking carefully about the nature of the problem to be addressed and the characteristics of the available evidence. In this workshop, we will investigate the advantages and limitations of alternative approaches to research synthesis from a cross-disciplinary perspective.

We will introduce the range of methods for evaluating and combining evidence and explore three prominent approaches in detail: systematic review, meta-analysis, and expert elicitation. These methods are used widely in the social sciences and medicine as well as in risk assessment. Each begins with a careful review of the research literature, but then the approaches diverge. Systematic review involves a largely qualitative evaluation of available studies against established criteria to identify those that are most appropriate for use in a particular context. Meta-analysis involves selecting studies from the available literature using formal criteria and then using statistical models to calculate summary estimates and explore sources of variation across studies. Expert elicitation uses a structured process to select experts who provide subjective probability distributions that characterize their knowledge about a quantity. The workshop will conclude with a panel discussion focused on questions raised by attendees, including the appropriate application of each method to the problems they face to support evidence-based decisionmaking.

## **Half Day AM Workshops**

**8:00 am - 12:00 pm**

### **WK1A: Benchmark Dose Modeling (BMD) Analysis – An Introduction to BMD Methods and Application of EPA’s Benchmark Dose Software**

*Organizer: J. Allen Davis*

#### **\$225 onsite registration**

This workshop will provide participants with interactive training on the use of the U.S. EPA’s Benchmark Dose Software (BMDS) and its application to risk assessment. The course will provide an overview of the BMD process, including determination of data adequacy, model fitting and comparison, and selection of a benchmark response level. This workshop will cover all BMD models available in BMDS 2.2—including the new MS-COMBO model, which calculates multi-tumor composite risk values. Instruction will also be given in regard to new features that have been implemented in version 2.2. This interactive training workshop will consist of morning and afternoon sessions. The morning session will include instructor presentations covering the basic science and theory of BMD modeling, and is intended for those with no prior experience in BMD modeling.

### **WK8A: ECETOC TRA, ESIG Consumer Generic Exposure Scenario and PetroRisk Exposure Tools**

*Organizer: Rosemary Zaleski*

#### **\$225 onsite registration**

A number of exposure and risk characterization tools have been developed to meet requirements of the European Union’s Registration Evaluation and Authorization of Chemicals (REACH) regulation; this workshop will focus on three tools developed and used by the petroleum and petrochemical sectors that have applicability to other sectors and chemicals. The morning session will include an overview of REACH exposure requirements and an overview and working session with two tools.

- The European Center for Ecotoxicology and Toxicology of Chemicals Targeted Risk Assessment (ECETOC TRA) is a preferred screening tool listed within European Chemical Agency guidance documents that provides occupational, environmental and consumer exposure estimates.

- The European Solvents Industry Group Consumer Generic Exposure Scenario Tool (ESIG Consumer GES) is based upon the consumer portion of the ECETOC TRA, but implements refinements described within the TRA annex and autopopulates output in REACH format.

## **WK12: Synthesizing Evidence: An Introduction to Systematic Reviews, Meta-Analysis, and Expert Elicitation**

*Organizer: Lisa Robinson*

### **\$275 onsite registration**

Risk analysis often requires making inferences or estimating parameter values from studies that contain inconsistent or conflicting results or address dissimilar contexts. Such inferences or estimates should be consistent with the weight of evidence. Deciding whether and how to combine information from multiple studies requires thinking carefully about the nature of the problem to be addressed and the characteristics of the available evidence. In this workshop, we will investigate the advantages and limitations of alternative approaches to research synthesis from a cross-disciplinary perspective. We will introduce the range of methods for evaluating and combining evidence and explore three prominent approaches in detail: systematic review, meta-analysis, and expert elicitation. These methods are used widely in the social sciences and medicine as well as in risk assessment. Each begins with a careful review of the research literature, but then the approaches diverge. Systematic review involves a largely qualitative evaluation of available studies against established criteria to identify those that are most appropriate for use in a particular context. Meta-analysis involves selecting studies from the available literature using formal criteria and then using statistical models to calculate summary estimates and explore sources of variation across studies. Expert elicitation uses a structured process to select experts who provide subjective probability distributions that characterize their knowledge about a quantity. The workshop will conclude with a panel discussion focused on questions raised by attendees, including the appropriate application of each method to the problems they face to support evidence-based decisionmaking.

## **Half Day PM Workshops**

**1:00 - 5:00 pm**

### **WK1B: Benchmark Dose Modeling (BMD) Analysis – An Introduction to BMD Methods and Application of EPA’s Benchmark Dose Software**

*Organizer: J. Allen Davis*

#### **\$225 onsite registration**

This workshop will provide participants with interactive training on the use of the U.S. EPA’s Benchmark Dose Software (BMDS) and its application to risk assessment. The course will provide an overview of the BMD process, including determination of data adequacy, model fitting and comparison, and selection of a benchmark response level. This workshop will cover all BMD models available in BMDS 2.2—including the new MS-COMBO model, which calculates multi-tumor composite risk values. Instruction will also be given in regard to new features that have been implemented in version 2.2. This interactive training workshop will consist of morning and afternoon sessions. The afternoon session will expand upon the morning session and will consist of a demonstration of EPA’s BMDS 2.2 through individual and group class modeling exercises. Questions and critical discussions of presentation material and class activities are highly encouraged. Participants planning to attend the afternoon session need to bring their own laptops to the workshop with BMDS 2.2 installed (with necessary administrative rights). The latest version of the software can be found at: <http://epa.gov/ncea/bmds/>.

### **WK8B: ECETOC TRA, ESIG Consumer Generic Exposure Scenario and PetroRisk Exposure Tools**

*Organizer: Rosemary Zaleski*

#### **\$225 onsite registration**

A number of exposure and risk characterization tools have been developed to meet requirements of the European Union’s Registration Evaluation and Authorization of Chemicals (REACH) regulation; this workshop will focus on three tools developed and used by the petroleum and petrochemical sectors that have applicability to other sectors and chemicals. The afternoon session will focus on:

- PETRORISK estimates exposures arising from environmental release of complex substances and can be used to quantify risks to human and wildlife receptors.

These freely available tools apply REACH exposure assessment guidance and demonstrate approaches developed to enable efficient and consistent implementation for meeting REACH requirements. Their design reflects parameters and defaults appropriate for hydrocarbon substances. Participants are encouraged to bring laptops for the working sessions. Participants will gain a general understanding of REACH exposure requirements, as well as the scientific basis of the tools being discussed. They will learn how to use these three tools and develop an understanding of their strengths, limitations, and application boundaries.

### **WK16: Chemical-Specific Adjustment Factors: Application of Data to Reduce Uncertainty in Inter- and Intraspecies Extrapolation for Chemical Risk Assessment**

*Organizer: John Lipscomb*

#### **\$300 onsite registration**

The World Health Organization, through the International Programme on Chemical Safety (IPCS), has established guidance on the use of mechanistic data to replace default uncertainty factors for interspecies extrapolation and intraspecies variability in deriving risk values such as Reference Doses (RfDs) and Tolerable Concentrations (TCs). This guidance informs the choice and application of data that can be used to replace defaults with chemical specific adjustment factors (CSAFs), resulting in values that better reflect the data for the chemical of interest. Under this approach, the uncertainty factors for interspecies differences (UFA) and human variability (UFH) are first subdivided into toxicokinetic (TK) and toxicodynamic (TD) components. The data relevant for each subcomponent is then evaluated to determine whether chemical-specific data can be used in place of the default. Use of the CSAF framework allows the improved use of available data in deriving risk values, and can assist in targeting new studies to address uncertainties and lead to more accurate risk values, including kinetic and dynamic data in in vitro systems. CSAFs have been used by the U.S. EPA in deriving an RfD for boron and by Health Canada in deriving a TC for 2-butoxyethanol. This half-day workshop will provide a brief review of the use of uncertainty factors and historical perspective on the reliance on quantitative data to develop values for inter- and intraspecies extrapolation. The course will focus on the IPCS methodology for CSAF development, including the thinking process and steps used for evaluating data. Examples and classroom activities will be used as instructional aides.

### **WK17: Risk Analysis: Fundamental Concepts, Applications and Controversies**

*Organizer: Branden B. Johnson*

#### **\$300 onsite registration**

Meetings and publications of the Society for Risk Analysis can be daunting to newcomers. More generally, risk analysis incorporates and spans many disciplines. It is often difficult for people, even those who work on some topic within risk analysis—be it toxicology, terrorist threat assessment or human behavior—to understand how their work fits into the risk analysis big picture. Likewise, disciplinary training does not prepare people to understand, much less converse with, fellow practitioners. This workshop, taught by two experts with extensive histories in practice, government and academia, is designed to fill that gap. We introduce fundamental risk analysis concepts, terminology, applications and calculations. The workshop is suitable for first time Society for Risk Analysis Annual Meeting attendees, as well as all individuals new to risk analysis and those who have been involved in only a limited aspect of risk analysis. Participants should have an undergraduate degree in an area relevant to risk analysis, and / or relevant work experience. Upon completion of this course, students will understand the origins, applications and controversies surrounding risk analysis. They will be prepared to evaluate risk analysis reports and presentations. Most importantly, they will be prepared to engage comfortably in the range of conversations that distinguish Society for Risk Analysis Annual Conferences.



## Workshop - Thursday, December 8

### Full Day Workshop – 8:30 am – 5:30 pm

#### WK18: Probabilistic Risk Analysis with Hardly Any Data

*Organizer: Scott Ferson*

#### **\$300 onsite registration**

This full-day tutorial introduces and compares methods for developing a probabilistic risk analysis when little or no empirical data are available to inform the risk model. The talks are organized around the basic problems that risk analysts face: not knowing the input distributions, not knowing their correlations, not being sure about the model itself, or even which variables should be considered. Possible strategies include traditional approximative methods and recent robust and bounding methods. Numerical examples are given that illustrate the use of various methods including traditional moment propagation, PERT, maximum entropy, uniformity principle, probability bounds analysis, Bayesian model averaging and the old work horse, sensitivity analysis. All of the approaches can be used to develop a fully probabilistic estimate useful for screening decisions and other planning. The advantages and drawbacks of the various approaches are examined. Essentially, the drawbacks are that bounding approaches may say too little about risks, and the rough and ready approximate methods may say too much. The discussion addresses how defensible decisions can be made even when little information is available, and when one should break down and collect some data and, in that case, what data to look for. The presentation style will be casual and interactive. Participants will receive a CD of the illustrations and numerical examples used during the tutorial.

**SRA 2012**

9-12 December

Hyatt Regency, San Francisco

Check the website for details

[www.sra.org](http://www.sra.org)

## PLENARY SESSIONS

All Plenary Sessions will be held in the Charleston Area Convention Center

### Opening Plenary Session

**Monday, December 5, 8:30 – 10:00 AM, Ballroom A/B**

“Extremes: in Weather and Risk”

*Speakers:* Margaret Davidson, *Director, National Oceanic and Atmospheric Administration Coastal Services Center*

**Tuesday, December 6, Plenary Session, 8:30 – 10:00 AM, Ballroom A/B**

“Reducing risks of oil spills from the Exxon Valdez to Deepwater Horizon”

*Speakers:* Admiral Thad Allen, former National Incident Commander of the BP oil spill and Senior Analyst at Rand

Admiral Allen will discuss national attempts to reduce risks of future events following the Exxon Valdez spill and how these actually played out in the Deepwater Horizon Spill.

*Discussant:* P. Lynn Scarlett, *Visiting Scholar and Co-Director, Center for the Management of Ecological Wealth, Resources for the Future, and former Deputy Secretary and Chief Operating Officer of the US Department of the Interior (2005-2009);*

*Discussant:* Anne Hayward Walker, *President, Scientific Environmental Associates*

**Wednesday, December 7, Plenary Luncheon, Noon – 1:30 PM, Ballroom A/B**

“A Tribute to Lester Lave”

Through his research and education contributions, as well as his service to SRA, as a member and chair of many NRC committees, and in many other ways, Lester Lave was a leader building the field of risk analysis.

During this session, three of Lester Lave’s long-time colleagues and research collaborators will reflect on his many contributions to risk and policy analysis, highlighting the promise and future trajectory stemming from their collaborative research with Lester.

*Speakers:* M. Granger Morgan, *Lord Chair Professor in Engineering, Professor and Department Head, Engineering and Public Policy, Professor, Electrical and Computer Engineering and Heinz College, Carnegie Mellon University;* Gil Omenn, *Director of Center for Computational Medicine and Bioinformatics, Professor of Internal Medicine, Human Genetics, and Public Health, University of Michigan;* Jay Apt, *Professor of Technology, Tepper School of Business and Engineering and Public Policy, Carnegie Mellon University, Executive Director, Carnegie Mellon Electricity Industry Center*

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## PRESIDENTIAL ROUNDTABLES

The Presidential Roundtables will be held in the Charleston Area Convention Center

**Monday 5:15-6:15pm, Ballroom C1**

Presidential Roundtable on  
OECD and Critical Issues in Risk Analysis  
of Nanomaterials

*Organizer:* JoAnne Shatkin

**Monday 5:15-6:15pm, Ballroom C2**

Presidential Roundtable on Sustainability and the  
U.S. EPA, the “Green book” Report from the  
National Academies

*Organizers:* Bernie Goldstein and Lauren Zeise

**Monday 5:15-6:15pm, Ballroom C3**

Presidential Roundtable on The Prospects  
for a Congressional Office of  
Regulatory Analysis

*Organizer:* Rick Belzer

Monday

10:30 AM-Noon Ballroom C1	10:30 AM-Noon Ballroom C2	10:30 AM-Noon Ballroom C3	10:30 AM-Noon Room 6	10:30 AM-Noon Room 7
<p><b>M2-A Panel Discussion: Approaches to Animal Health Risk Assessment</b> Co-Chairs: <i>Tim Krywulak, Darrell Donahue</i></p>	<p><b>M2-B Poster Platform: Technical Topics in Decision Analysis and Risk</b> Sponsored by <i>DARSG</i> Chair: <i>Patricia Gillespie</i></p>	<p><b>M2-C Symposium: Tox 21/ NexGen Dose Response</b> Sponsored by: <i>DRSG</i> Chair: <i>George Woodall</i></p>	<p><b>M2-D Symposium: Risks of Transportation Disruptions</b> Sponsored by: <i>EISG, S&amp;D</i> Chair: <i>Cameron MacKenzie</i></p>	<p><b>M2-E Eco-Risk</b> Chair: <i>Sally Kane</i></p>
<p><b>10:30 am M2-A.1</b> The Report of the Expert Panel on Approaches to Animal Health Risk Assessment <i>Krywulak T</i> <i>Council of Canadian Academies</i></p>	<p><b>M2-B.1</b> Delphi analysis of issues after the 2011 Pacific Coast of Tōhoku earthquake <i>Maeda Y, Seo K</i> <i>Shizuoka University, Aoyama Gakuin University</i></p>	<p><b>10:30 am M2-C.1</b> Summary of the 2011 DRSG Teleseminar Presentations and Discussions <i>Abraham IM, Henry S</i> <i>TERA</i></p>	<p><b>10:30 am M2-D.1</b> Risk management: the heart of the transport dangerous goods program <i>Oliver G, Tardif C*, Provencher M</i> <i>Transport Canada</i></p>	<p><b>10:30 am M2-E.1</b> Exploring public participation decision-making at superfund sites: a mental models approach <i>Ackerlund WS</i> <i>Ackerlund, Inc.</i></p>
<p><b>10:50 am M2-A.2</b> Enhancing the Frameworks for Assessing Risks Relating to Animal Health <i>Donahue D</i> <i>University of Maine</i></p>	<p><b>M2-B.2</b> Synthetic biology: evaluation using integrated risk assessment, life cycle assessment and multi-criteria decision analysis <i>Chu E, Bockelie A, Linkov I</i> <i>Carnegie Mellon University</i></p>	<p><b>10:50 am M2-C.2</b> Tox21: Activities of the U.S. National Toxicology Program (NTP) <i>DeVito MJ, Tice R</i> <i>National Institute of Environmental Health Sciences</i></p>	<p><b>10:50 am M2-D.2</b> A port security risk analysis and resource allocation system - from tactical to strategic <i>Orosz MD, Southwell C, Chen J, Maya I, Chatterjee S, Salazar D, Soutbers E</i> <i>University of Southern California</i></p>	<p><b>10:50 am M2-E.2</b> Enabling eco-friendly choices by using human psychological biases <i>Dutt V, Gonzalez C</i> <i>Carnegie Mellon University</i></p>
<p><b>11:10 am M2-A.3</b> Leveraging the Strategic Role of Risk Managers, Risk Assessors, and Other Stakeholders <i>Hurd HS</i> <i>Iowa State University</i></p>	<p><b>M2-B.3</b> Vapor intrusion: risks and benefits of an alternative approach <i>Schuer HJ</i> <i>US Environmental Protection Agency</i></p>	<p><b>11:10 am M2-C.3</b> An update on advancing the next generation of risk assessment (NexGen) <i>Burgoon LD</i> <i>US Environmental Protection Agency</i></p>	<p><b>11:10 am M2-D.3</b> Post-disaster resilience for interdependent systems: application to inland port disasters <i>Pant R, Barker K, Landers TL</i> <i>University of Oklahoma</i></p>	<p><b>11:10 am M2-E.3</b> Environmental risk management and economic performance of policy instruments: a strategic analysis of UK experience since 1997 <i>Taylor CM, Pollard SJT, Rocks SA, Smith MC</i> <i>Cranfield University</i></p>
<p><b>11:30 am M2-A.4</b> Integrating Interdisciplinary Expertise and Research in Animal Health Risk Assessments <i>Hall DC</i></p>	<p><b>M2-B.4</b> Use of quantitative microbial risk assessment and projective transport models to inform beach closures <i>Panzl BM, Weir MH, Pope JM, Rose JB</i> <i>Michigan State University</i></p>		<p><b>11:30 am M2-D.4</b> Optimal resource allocation for recovery from multimodal transportation disruptions <i>MacKenzie CA, Barker K</i> <i>University of Oklahoma</i></p>	<p><b>11:30 am M2-E.4</b> Linking theories of attribution, risk perception, and communication to investigate risk management and safety in an applied context <i>Rickard LN</i> <i>Cornell University</i></p>

Monday

**10:30 AM-Noon**  
*Room 8/9*  
**M2-F Panel Discussion:**  
**Getting Beyond the Statistician's Bag of Marbles**  
*Chair: Scott Ferson*  
**Panelists:**  
*Huber W, Sentz Z, Balch M, Ferson S*  
*Quantitative Decisions, LANL, Ramas,*  
*Applied Biomathematics*

**10:30 AM-Noon**  
*Room 10*  
**M2-G Vulnerability!**  
**Disaster! Oh My!**  
*Chair: Rachel Davidson*  
**10:30 am M2-G.1**  
 Evolving regional natural disaster risk in the international development context  
*Brink SA, Davidson RA\**  
*University of Delaware*

**10:50 am M2-G.2**  
 Dynamic risk analysis in the life cycle of complex infrastructure systems  
*Huang T*  
*University of California, Berkeley*

**11:10 am M2-G.3**  
 Analysis of inland crude oil spill threats, vulnerabilities, and emergency response in the midwest United States  
*Brody TM, Di Bianca P, Krzysa J*  
*United States Environmental Protection Agency*

**11:30 am M2-G.4**  
 Risk culture: local responses to global threats. Transforming vulnerabilities into capabilities  
*Restrepo R*  
*Universidad del Norte*

**10:30 AM-Noon**  
*Room 11*  
**M2-H Symposium: Progress and Challenges in RA and RM at DHS: Culture and Methodology**  
*Sponsored by: SDSG*  
*Chair: Steve Bennett*

**10:30 am M2-H.1**  
 Tomorrow's government: building a risk management culture at the Department of Homeland Security  
*Gilmour L, Rath C, Kolasky RP*  
*US Department of Homeland Security, Office of Risk Management and Analysis*

**10:50 am M2-H.2**  
 From calculations to results to decisions: how a risk architecture approach supports decision making at the Domestic Nuclear Detection Office (DNDO)  
*Streetman SS*  
*Data Architecture Solutions Inc*

**11:10 am M2-H.3**  
 Using expert judgment to understand the rare event threat space of Homeland Security: practices, challenges, and opportunities  
*Hawkins NL, Kirson A, Levine ES, Susel I, Szved P, Waters J*  
*US Department of Homeland Security, Office of Risk Management and Analysis, United States Coast Guard*

**11:30 am M2-H.4**  
 "Intelligent" integration of intelligent adversary modeling into Homeland Security risk analyses: theory and practice  
*Bennett SP, Cheesebrough AJ, Waters J*  
*US Department of Homeland Security, Office of Risk Management and Analysis*

**10:30 AM-Noon**  
*Room 12/13*  
**M2-I Symposium:**  
**Interagency Food Safety Analytics**  
*Sponsored by: MRASG*  
*Chair: Kara Morgan*

**10:30 am M2-I.1**  
 Use of consumption data to inform human illness surveillance data  
*Cole D, Hoekstra M*  
*Centers for Disease Control and Prevention*

**10:50 am M2-I.2**  
 Evaluation of outbreak data as representative of foodborne sporadic illness data for the purpose of estimating attribution  
*Golden NJ, Zablotsky-Kufel J, Cole DJ, Hoekstra M, Spires C, Morgan K*  
*Government*

**11:10 am M2-I.3**  
 Meeting near-term needs for the estimated attribution of foodborne illness to food commodities  
*Hoekstra RM*  
*Centers for Disease Control and Prevention*

**11:30 am M2-I.4**  
 Introduction to the interagency Food Safety Analytics Collaboration  
*Morgan KM, Spires C, Golden N, Zablotsky-Kufel J, Cole D, Hoekstra M*  
*US Food and Drug Administration*

**10:30 AM-Noon**  
*Room 14*  
**M2-J Cumulative Exposures**  
*Chair: Amanda M Evans*  
**10:30 am M2-J.2**  
 Cumulative risk assessment and multidimensional indicators  
*Schultz BD*  
*US Environmental Protection Agency*

**10:50 am M2-J.3**  
 A cumulative exposure assessment of noise and volatile organic compounds  
*Evans AM, Rice G, Teuschler LK, Wright JM*  
*Association of Schools of Public Health, National Center for Environmental Assessment, Office of Research and Development, US Environmental Protection Agency*

**11:10 am M2-J.4**  
 Cumulative risk assessment to evaluate cognitive deficits consistent with IQ reduction in children  
*Liu CL, Luke NL*  
*CDM*

**1:30-3:00 PM***Ballroom C1***M3-A Animal Epidemics, Terrorist Threats, and Siting Biological Research Facilities***Chair: Jeryl Mumpower*

**1:30 pm M3-A.1**  
Perceived riskiness and WTP of four terrorist threats  
*Mumpower JL, Shi L, Vedlitz A*  
*Texas A&M University*

**1:50 pm M3-A.2**  
Risk perceptions and actions of World Trade Center attack survivors compared inside and outside the WTC towers  
*Zimmerman R, Sherman MF, Gershon R*  
*New York University, Loyola University Maryland, Columbia University*

**2:10 pm M3-A.3**  
Gender differences in lay people and experts concerning their decisions about different strategies to fight epidemics  
*Zingg A, Siegrist M*  
*ETH Zurich*

**2:30 pm M3-A.4**  
Risk publics: understanding the unifying ties of personal beliefs vs. community of residence in the site-selection for a biological research facility  
*Binder AR, Scheufele DA, Brossard D*  
*North Carolina State University, University of Wisconsin-Madison*

**1:30-3:00 PM***Ballroom C2***M3-B: Exposure Assessment Tools***Chair: Michael Breen*

**1:30 pm M3-B.1**  
Up in the air: comparison of exposure tools from across the globe that can predict worker inhalation exposures  
*Gaborek BJ*  
*DuPont Haskell Global Centers for Health & Environmental Sciences*

**1:50 pm M3-B.2**  
Microenvironment tracker (MicroTrac) for individuals in health studies: estimation of time-microenvironment profiles from GPS data loggers  
*Breen M, Crooks J, Long T, Isaacs K, Schultz B, Mukerjee S, Devlin R*  
*US Environmental Protection Agency*

**2:10 pm M3-B.3**  
Integrating cumulative risk and environmental justice assessments to guide decision-making, promote stakeholder involvement and assess cumulative impacts: the CRA-EJ Wizard  
*Barzyk TM, Perlmutter L, Dana G, Martin L, Foster S, Bollweg G*  
*US Environmental Protection Agency*

**2:30 pm M3-B.4**  
A probabilistic depleted uranium performance assessment: methodology and results  
*Perona R, Lee R, Black P, Tauxe J, Stockton T, Fitzgerald M, Balsli M, Catlett K*  
*Neptune and Company, Inc.*

**1:30-3:00 PM***Ballroom C3***M3-C Symposium: Dose Response for Biothreats***Sponsored by: DRSG**Chair: Peg Coleman*

**1:30 pm M3-C.1**  
Need drives development - Army Biological Military Exposure Guidelines (BMEGs)  
*Thran BH, Intano GI, McAtee MJ*  
*Army Institute of Public Health*

**1:50 pm M3-C.2**  
Let the data speak: extrapolating information for biothreats  
*Donadue D*  
*University of Maine*

**2:10 pm M3-C.3**  
Modeling respiratory mechanics in animals: tularemia in the rhesus monkey  
*McClellan G, Weber P, Asgharian B, Price O*  
*Applied Research Associates, Inc.*

**2:30 pm M3-C.4**  
Aerosol disease models: limitations of current data and promise of model-directed research  
*Roy CJ*  
*Tulane University School of Medicine*

**1:30-3:00 PM***Room 7***M3-E Symposium: Listeria Monocytogenes Dose-Response Data and Models: Current and Future Advancements***Sponsored by: MRASG**Chair: Sherri Dennis, Dan Gallagher*

**1:30 pm M3-E.1**  
Lots of bacteria - few cases: reopening the listeria dose-response model black-box  
*Pouillot R*  
*Food and Drug Administration*

**1:50 pm M3-E.2**  
From experimental infections in animals to quantifying subtypes in foods: advancements and challenges of data collection for listeria dose-response  
*Chen Y*  
*Food and Drug Administration - CFSAN*

**2:10 pm M3-E.3**  
Future advancements: recommendations from the IRAC-JIFSAN listeria dose-response workshop  
*Walls I*  
*US Department of Agriculture National Institute of Food and Agriculture*



1:30-3:00 PM	1:30-3:00 PM	1:30-3:00 PM	1:30-3:00 PM	1:30-3:00 PM
Room 8/9	Room 10	Room 11	Room 12/13	Room 14
<p><b>M3-F Symposium: Engaging Stakeholders in Risk-Informed Decision Making: Methodology and Case Studies</b></p>	<p><b>M3-G Symposium: Risk Communication and Trust in Canadian Aboriginal Communities</b></p>	<p><b>M3-H Symposium: Analyzing and Managing 21st Century Risks: Moving Beyond Newtonian Approaches</b></p>	<p><b>M3-I Symposium: Synthesizing Studies for Evidence-Based Decisionmaking: Part 1, Meta-Regression and Related Methods</b></p>	<p><b>M3-J Risk Assessment Methods Development</b></p>
<p>Chair: Igor Linkov and Jose Palma Oliveira</p>	<p>Sponsored by: Risk Communication Chair: Michelle Driedger</p>	<p>Sponsored by: DAR, SDSG Chair: Bob Ross</p>	<p>Sponsored by: EBASG Chair: Lisa Robinson</p>	<p>Chair: Patricia Gillespie</p>
<p><b>1:30 pm M3-F.1</b> Industry and stakeholder engagement: the case of co-incineration of hazardous waste by cement industry Palma Oliveira J University of Lisbon, Portugal</p>	<p><b>1:30 pm M3-G.1</b> Risk communication and trust in decision-maker action: lessons from first nations, Inuit and Metis case studies in Canada - the theoretical and methodological framework Cooper EJ, Jardine C, Furgal C, Driedger SM University of Manitoba</p>	<p><b>1:30 pm M3-H.1</b> The importance of risk type in selecting appropriate analytic approaches and management strategies Ross RG Department of Homeland Security, Science and Technology Directorate</p>	<p><b>1:30 pm M3-I.1</b> Why meta-analyses and systematic reviews come to different conclusions about formaldehyde and leukemia Goodman JE Gradient</p>	<p><b>1:30 pm M3-J.1</b> US Environmental Protection Agency Risk Assessment Forum action plan for advancing human health risk assessment Fitzpatrick JW, Obanian EV US Environmental Protection Agency</p>
<p><b>1:50 pm M3-F.2</b> Getting consensus across interagency stakeholders: application of multi-criteria decision analysis to prioritize skills required for future diplomatic missions Linkov I, Rosoff H, Valverde LJ, Bates M, Trump B, Friedman D, Evans J, Keisler J US Army Engineer Research and Development Center, US Department of State, University of Massachusetts</p>	<p><b>1:50 pm M3-G.2</b> Evaluating Trust of Contaminants and Food Messaging in Inuit Communities Furgal C, Driedger SM, Jardine CG Trent University chrisfurgal@trentu.ca</p>	<p><b>1:50 pm M3-H.2</b> Assessment of complex adaptive system theory for homeland security risk management Langbehn W Homeland Security Institute/ANSER</p>	<p><b>1:50 pm M3-I.2</b> Robust meta-analysis using median-quantile and nonparametric regression procedures: investigating the validity of benefit transfers Kaul S, Boyle K, Pope J, Parmeter C, Kuminoff N, Moeltner K* Virginia Tech</p>	<p><b>1:50 pm M3-J.2</b> Chemical infrastructure risk assessment Hawkins B, Shroy B, Montello B, Gooding R, Kolakowski J, Whitmire M, McGarvey D Battelle Memorial Institute, DHS Chemical Security Analysis Center</p>
<p><b>2:10 pm M3-F.3</b> Stakeholder engagement in the dredged material management plan for Long Island Sound Collier ZA, Bates ME, Chu EJ, Fredette TJ, Keegan MF, Habel ML, Wolf S, Linkov I US Army Corps of Engineers</p>	<p><b>2:10 pm M3-G.3</b> Evolution of trust in risk communication: the development of the giant mine remediation plan and the Yellowknives Dene First Nation Jardine CG, Driedger SM, Furgal CM University of Alberta</p>	<p><b>2:10 pm M3-H.3</b> The modeler meets the expert on terrorist decision making: risk management based on two cultures Lathrop JF, Post JM Innovative Decisions, Inc. and Political Psychology Program, Elliot School of International Affairs, George Washington University</p>	<p><b>2:10 pm M3-I.3</b> Bayesian data combination for benefit transfer Moeltner K Virginia Tech</p>	<p><b>2:10 pm M3-J.3</b> A Mathematical Compartment Model for estimating donor loss due to changes in the inter-donation interval Forshee RA, Simonetti A, Fernando AM US Food and Drug Administration</p>
<p><b>2:30 pm M3-F.4</b> Chemical Hazards Emergency Medical Management (CHEMM): mental models approach to improving provision of emergency preparedness and response information Kovacs D, Thorne S, Butte G, Chang F, Pakiam J, Hakkinen B, Linkov I Decision Partners, LLC, National Institutes of Health, National Library of Medicine, US Army Corps of Engineers</p>	<p><b>2:30 pm M3-G.4</b> Finding a voice for the Metis: risk communication and trust during the management of pandemic H1N1 Driedger SM, Cooper EJ, Jardine CJ, Furgal C University of Manitoba</p>	<p><b>2:30 pm M3-H.4</b> Aviation risk management: the importance of government/industry collaboration Hart CA National Transportation Safety Board</p>	<p><b>2:30 pm M3-I.4</b> Comparison of strategies to structure weight-of-evidence evaluations Rbomberg LR Gradient</p>	

3:30-5:00 PM	3:30-5:10 PM	3:30-5:00 PM	3:30-5:10 PM	3:30-5:10 PM
<i>Ballroom C1</i>	<i>Ballroom C2</i>	<i>Ballroom C3</i>	<i>Room 6</i>	<i>Room 7</i>
<b>M4-A Emerging Theories of Risk Communication</b>	<b>M4-B Panel Discussion: Synthetic Biology and Risk Governance</b>	<b>M4-C Biomonitoring Data for Risk Assessment</b>	<b>M4-D Symposium: Risk Management Actions for Emerging Contaminants</b>	<b>M4-E Symposium: Microbial Safety of Fresh Produce, Spices and Herbs: Mitigating Risk from Farm-to-Table</b>
<i>Chair: David Berube</i>	<i>Chair: Dana Genya</i>	<i>Co-Chairs: Lesa Aylward and Scott Arnold</i>	<i>Sponsored by: SDSG, ERSG</i>	<i>Sponsored by: MRASG</i>
<b>3:30 pm M4-A.1</b> DART: Digital Amplification/attenuation of Risk Theory <i>Berube DM</i> <i>North Carolina State University</i>	<b>3:30 pm M4-B.1</b> Synthetic Biology Applications: Health and the Environment <i>Carr PA</i> <i>Massachusetts Institute of Technology</i>	<b>3:30 pm M4-C.1</b> Development and use of toxicity based Human Biomonitoring (HBM) values by the German Human Biomonitoring Commission <i>Koch HM, Angerer J</i> <i>Institute for Prevention and Occupational Medicine (IPA), Ruhr-University Bochum</i>	<b>3:30 pm M4-D.1</b> The changing landscape of chemical toxicity values and possible impacts to DoD Legacy Site Cleanup <i>Meyer AK</i> <i>Army Corps of Engineers</i>	<b>3:30 pm M4-E.1</b> Lessons learned from a preliminary quantitative microbial risk assessment for leafy greens <i>Schaffner DW, Danyluk MD</i> <i>Rutgers University</i>
<b>3:50 pm M4-A.2</b> Probability paradoxes explained by the second uncertainty processor <i>Siegrist J, Ferson S, Lubmann C, Ginzburg L</i> <i>Rutgers University</i>	<b>3:50 pm M4-B.2</b> DIYBIOSAFETY: Responsible Science for Do-It-Yourself Biologists <i>Kuiken T</i> <i>Woodrow Wilson International Center for Scholars</i>	<b>3:50 pm M4-C.2</b> Challenges in interpreting and communicating human biomonitoring results <i>Haines DA, Murray JL, Donaldson SG</i> <i>Health Canada</i>	<b>3:50 pm M4-D.2</b> After the analysis: risk management actions for emerging contaminants <i>Yaroschak PJ</i> <i>Office of the Secretary of Defense</i>	<b>3:50 pm M4-E.2</b> Produce consumption patterns in the US: importance for produce risk assessments <i>Hoelzer K, Ponillot R, Egan K, Dennis S</i> <i>Food and Drug Administration, Center for Food Safety and Applied Nutrition</i>
<b>4:10 pm M4-A.3</b> Strategic frame alignment and the communication of risk <i>Cummings CL</i> <i>North Carolina State University</i>	<b>4:10 pm M4-B.3</b> NGO Community Perspectives on Synthetic Biology <i>Hoffman EM</i> <i>Friends of the Earth</i>	<b>4:10 pm M4-C.3</b> Interpreting NHANES data on arsenic levels in urine using biomonitoring equivalents <i>Kirman CR, Hays SM, Aylward LL*, Ramasamy S, Schoeny R</i> <i>Summit Toxicology, US Environmental Protection Agency</i>	<b>4:10 pm M4-D.3</b> Closing the loop: an assessment of the life cycle of beryllium-containing materials in the Department of Defense <i>Scanlon KA, McDonald SM</i> <i>Concurrent Technologies Corporation</i>	<b>4:10 pm M4-E.3</b> Identification, monitoring and management of risks in the spice industry <i>Lawrence R, Brown SM</i> <i>McCormick &amp; Company Inc</i>
<b>4:30 pm M4-A.4</b> The role of construal level theory in risk communication <i>Zwicker AK, Wilson RS</i> <i>Ohio State University</i>	<b>4:30 pm M4-B.4</b> Comprehensive Environmental Assessment of Synthetic Biology Applications <i>Dana GV</i> <i>Dana &amp; Sharpe Risk Associates</i>	<b>4:30 pm M4-C.4</b> Enhancing the Agency for Toxic Substances and Disease Registry's (ATSDR) site assessments with pharmacokinetic models and biomonitoring data <i>Wheeler JS, Worley RR, Ruiz P, Satarug S, Fowler DA</i> <i>Agency for Toxic Substances and Disease Registry, Atlanta, University of Queensland School of Medicine, Australia</i>	<b>4:30 pm M4-D.4</b> Naphthalene dosimeter for assessment of exposure for fuel handlers: a case study <i>Rak A</i> <i>Noblis</i>	<b>4:30 pm M4-E.4</b> Surveillance sampling at import: characterizing risk <i>Van Doren JM, Kleinmeier D, Ma Y, Blodgett R, Westerman A, Ziobro GC, Muckenfuss M, Gill V, Hammack T, Parish M, Neil KP, Mettee S, Nsofor O, Gieraltowski L</i> <i>Food and Drug Administration and Centers for Disease Control and Prevention</i>
<b>4:50 pm M4-A.5</b> European synthetic biology: present and future regulatory trends <i>Lofstedt R</i> <i>Kings College London</i>	<b>4:50 pm M4-B.5</b> European synthetic biology: present and future regulatory trends <i>Lofstedt R</i> <i>Kings College London</i>	<b>4:50 pm M4-C.5</b> European synthetic biology: present and future regulatory trends <i>Lofstedt R</i> <i>Kings College London</i>	<b>4:50 pm M4-D.5</b> Methodology for using life cycle assessment to minimize environment, energy, water, and chemical liabilities <i>Cammarata C</i> <i>Concurrent Technologies Corporation</i>	<b>4:50 pm M4-E.5</b> Methodology for using life cycle assessment to minimize environment, energy, water, and chemical liabilities <i>Cammarata C</i> <i>Concurrent Technologies Corporation</i>



Monday

**4:50 pm** **M4-E.5**  
 Modeling of landscape and meteorological factors influencing the probability of pathogen isolation from an environmental location: *Listeria* spp. in the natural environment as a model system  
*Ivanek R, Grohn YT, Wells MT, Lembo Jr AJ, Sanders BD, Wiedmann M, Park S-S*  
*Texas A&M University, Cornell University, Salisbury University, NYS Dept of Agriculture & Markets*

**3:30-5:00 PM**  
**Room 8/9**  
**M4-F Panel Discussion:**  
**Structuring Decision Processes to Manage Risks**  
*Sponsored by DARSG*  
*Chair: Jeffrey Keisler*  
*Bier VM, Cox LA, Guikema SD, Lambert JH, Merrick JR*  
*University of Wisconsin-Madison, Cox Associates and University of Colorado, Innovative Decisions, Inc., University of Virginia, Virginia Commonwealth University*

**3:30-5:10 PM**  
**Room 10**  
**M4-G Symposium:**  
**Assessing and Managing Carbon Nanomaterial Risks: Current and Future Approaches**  
*Chair: Ron White*  
**3:30 pm** **M4-G.1**  
 An overview of carbon nanomaterial toxicity research  
*White RH*  
*Johns Hopkins University*

**3:50 pm** **M4-G.2**  
 Methods and uncertainties in carbon nanotube risk assessment  
*Kuempel ED*  
*National Institute for Occupational Safety and Health*

**4:10 pm** **M4-G.3**  
 State of the science and information gaps regarding a comprehensive environmental assessment of an application of a carbon-based nanomaterial  
*Marenberg AA, Burch DF, Shatkin JA, Davis JM*  
*ICF International, CLF Ventures, US Environmental Protection Agency*

**4:30 pm** **M4-G.4**  
 Life-cycle based approaches for evaluating carbon nanomaterials  
*Powers C, Gillespie P, Davis JM*  
*National Center for Environmental Assessment, US Environmental Protection Agency*

**4:50 pm** **M4-G.5**  
 Managing risks of CNTs in a large company  
*David RM*  
*BASF Corporation*

**3:30-5:10 PM**  
**Room 11**  
**M4-H Symposium:**  
**Adversary Modeling for Terrorism Risk Analysis Applications**  
*Sponsored by: SDSG, DAR*  
*Chair: Sara Klucking*  
**3:30 pm** **M4-H.1**  
 Value focused modeling of adaptive adversaries for informing countermeasure decisions  
*John RS, Rosoff H*  
*University of Southern California*

**3:50 pm** **M4-H.2**  
 Modeling and risk assessment of terrorist-counterterrorist interactions with Multi-Agent Influence Diagrams  
*Sentz K, Powell D, Ambrosiano J, Graves T*  
*Los Alamos National Laboratory*

**4:10 pm** **M4-H.3**  
 Adaptive adversary risk analysis: linking models to primary data on terrorist behavior  
*Jackson BA, Frelinger DR, Hart J, Kavanagh J, Loidolt B, Wallace BA*  
*RAND Corporation*

**4:30 pm** **M4-H.4**  
 Adaptive adversary agent-based modeling for CBRN terrorism risk analysis  
*Austin T, Sageman M, Luckey T, Cameron J*  
*The Boeing Company*

**4:50 pm** **M4-H.5**  
 Plural models for adaptive adversary modeling  
*Buede DM, Ezell BC, Guikema SD, Lathrop JF, Mahoney SM, McLay LA, Post JM, Rothschild C*  
*Innovative Decisions, Inc.*

**3:30-5:10 PM**  
**Room 12/13**  
**M4-I Symposium:**  
**Synthesizing Studies for Evidence-Based Decisionmaking: Part 2, Expert Elicitation**  
*Sponsored by: EBASG*  
*Chair: Lisa Robinson*  
**3:30 pm** **M4-I.1**  
 Alternative methods for aggregation of expert judgments  
*Gwenc U, Small MJ, Morgan MG*  
*Carnegie Mellon University*

**3:50 pm** **M4-I.2**  
 Combining experts' judgments: comparison of algorithmic methods  
*Hammitt JK, Zhang Y*  
*Harvard University*

**4:10 pm** **M4-I.3**  
 Encoding the meanings of probability terms  
*Wallsten TS*  
*University of Maryland*

**4:30 pm** **M4-I.4**  
 Expert elicitation of adversary preferences using ordinal judgments: methodology and applications  
*Wang C, Jamshidi T, Bier VM*  
*University of Wisconsin-Madison*

**4:50 pm** **M4-I.5**  
 Expert judgment and stakeholder preference modeling with probabilistic inversion  
*Cooke RM*  
*Resources for the Future, TU Delft*

**3:30-5:10 PM**  
**Room 14**  
**M4-J Human Exposure to Contaminants in Food & Water**  
*Chair: Anthony Fristachi*  
**3:30 pm** **M4-J.1**  
 Updated estimates of human organotin exposures due to leaching from PVC pipe into drinking water  
*Fristachi A, Rice G, Little J, Xu Y, Adams W, Impellitteri C*  
*Environmental Risk Resources, Virginia Tech, The University of Texas at Austin, US Environmental Protection Agency*

**3:50 pm** **M4-J.2**  
 Comparison of chemical composition of complex Disinfection By-product (DBP) mixtures produced by different treatment methods  
*Parvez S, McCurry D, Rice GE, Tenschler LK, Speth TF, Miltner RJ, Pressman JG*  
*Oak Ridge Institute for Science and Education*

**4:10 pm** **M4-J.3**  
 Prevalence of variant Creutzfeldt-Jakob disease in the UK: estimation from dietary exposure to bovine spongiform encephalopathy during the period 1980 to 1996  
*Chen CC, Wang YH, Wu KY, Chang HY*  
*National Health Research Institutes, Taiwan*

**4:30 pm** **M4-J.5**  
 Quantitative risk assessment of listeriosis due to consumption of raw milk  
*Pradban AK, Latorre AA, Van Kessel JS, Karns JS, Schukken YH*  
*University of Maryland, University of Concepcion-Chile, USDA/ARS-Beltsville, Cornell University*

6:15 - 8:15 PM

**P Poster Session  
Ballroom AB**

**EBASG**

**P.1** Seeing the forest through the trees: NRD and dynamic ecosystems  
*Cantor RA, Menzie CA, Deardorff TL, Hulme-Lowe CK, Wickwire WT*  
*Exponent*

**Decision Analysis & Risk**

**P.2** Quantitative risk model for foodborne pathogens in herbs and spices  
*Fedoruk A, Davidson VJ, Fazil A*  
*University of Guelph, Public Health Agency of Canada*

**Risk, Policy and Law**

**P.3** China's newly promulgated regulation on the environmental management of new chemical substances  
*Cragin DW, Silverman KC*  
*Merck & Co.*

**Biological Stressors**

**P.4** Comparing and prioritizing pathogen risks  
*Joe AL, Gurian PL, Olson MS, Teng J, Marquez EB, Kumar A, Pepper I, Gerba CP, Galada HC*  
*Drexel University*

**P.5** Increasing the temperature of high temperature, short time pasteurization may increase the risk of listeriosis from consumption of pasteurized fluid milk.  
*Stasiewicz M, Martin N, Lane S, Wiedmann M*  
*Cornell University*

**P.6** Identifiability of bioaerosol size fraction from environmental sampling  
*Hong T, Gurian PL*  
*Drexel University*

**Nanomaterials: Occupational****Exposure Limits**

**P.7** Proposal for an occupational exposure limit of carbon nanotubes based on their risk evaluation  
*Nakanishi J, Gamo M, Ema M, Ogura I, Kobayashi N*  
*Advanced Industrial Science and Technology (AIST)*

**P.8** Risk assessment of nanomaterials - fullerene C60  
*Shinohara N, Gamo M, Nakanishi J*  
*National Institute of Advanced Industrial Science and Technology*

**P.9** Risk assessment of nanomaterials - titanium dioxide (TiO<sub>2</sub>)  
*Gamo M, Ogura I, Kobayashi N, Ema M, Nakanishi J*  
*National Institute of Advanced Industrial Science and Technology (AIST)*

**P.11** Quantifying the interdependent effects of supply chain disruptions and mitigation strategies  
*MacKenzie CA, Barker K*  
*University of Oklahoma*

**P.12** International symposium on cultural property risk analysis: report on an SRA sponsored event  
*Waller RR, Dinis MF*  
*Protect Heritage Corp., Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa*

**Security & Defense**

**P.13** Extending methods of vulnerability analysis to address resilience and robustness  
*Tas S, Bier VM*  
*University of Wisconsin at Madison*

**P.14** Subsidizing to disrupt a terrorism supply chain - a four-player game  
*Shan X, Zhuang J*  
*University at Buffalo, The State University of New York*

**P.15** The chemical terrorism risk assessment  
*Cox J, McGarvey D, Whitmire M, Hawkins B, Montello B, Sbroj B*  
*DHS Chemical Security Analysis Center (CSAC), Battelle Memorial Institute*

**P.16** Risk screening assessments at Los Alamos National Laboratory (Part 1. Human Health)  
*Frstachi A, Mirenda R*  
*Environmental Risk Resources, Los Alamos National Laboratory*

**P.17** Ensuring consistency in risk analysis event trees and consequences  
*Streetman SS*  
*Data Architecture Solutions, Inc., DHS*

**P.18** ITRA sensitivity study: subway event response analysis  
*McMillan NJ, Tollar E, Wightman J, Huckett J*  
*Battelle*

**Ecological Risk**

**P.19** Analysis of coastal pollution: looking for water quality index which correlates physicochemical parameters and biomarkers in native aquatic plants used as sentinels.  
*Dopchiz LP, Martin P, Michieli JL, Demichelis SO*  
*University John F. Kennedy of Argentina, National University of La Plata*

**P.20** Integral plan of management for chemical emergencies in Lanús-Argentina  
*Lopez CR, Demichelis SO*  
*National University of Lanus*

**P.21** Population risks in a small coastal town of the Rio de la Plata river: a case of study  
*Medrano D, Demichelis SO*  
*National University of Lanus*

**P.22** Landslide risk assessment in fundamental roads of Bolivia using multi-criteria and Geographic Information Systems analysis  
*Ledezma FFL*  
*Water and Sanitation Centre*

**P.23** Analysis of changes in density of distribution of air temperature over last decades using quantile regression method and radiosonde measurements  
*Timofeev AA, Sterin AM*  
*RIHMI-WDC*

**P.24** Preliminary assessment of the carbon footprint in the chemical industry in the field of basic chemistry  
*Villarraga Farfán EJ*  
*Universidad de los Andes*

**P.25** Meteorological risks reduction in forecasting convective events from satellite data  
*Agurenko AO, Korshunov AA*  
*RIHMI-WDC*

**P.27** Evaluation of formaldehyde air emissions from a washing machine and potential human exposure  
*McCready D, Arnold S, Fontaine D*  
*The Dow Chemical Company*

**P.28** Update to the U.S. EPA's guidelines for (human) exposure assessment and monitoring  
*Tulve NS, Olsen M, Broder M*  
*US Environmental Protection Agency*

**P.29** An in vitro to in vivo extrapolation approach for conducting a cumulative risk assessment for phthalate esters  
*Choi K, Campbell J, Clewell H*  
*The Hamner Institutes for Health Sciences*

**P.30** Exposure assessment for ambient hexavalent chromium (Cr(VI)) in Japanese industrial area  
*Ono K, Toyoda T, Shimada S, Nezu T*  
*National Institute of Advanced Industrial Science and Technology*

**P.31** Blood mercury concentration and fish consumption: risk and perceptions of risk among urban and coastal mother in Taiwan  
*Jiang CB, Chien LC, Han BC, Hsu CS*  
*TMU*

**P.32** Mouthing frequency of children under 2 years old in Taiwan  
*Tsou MC, Chien LC, Özkaynak H, Beamer P, Dang W*  
*TMU*

**P.33** Exposure assessment of metal concentration and relevant factors on women reproductivity ability  
*Lei HL, Chien LC, Liao KW, Yeh CY*  
*Taipei Medical University*

**P.34** A study on alternative risk assessment scheme of flame retardants  
*Kotani K, Managaki S, Masunaga S*  
*Yokohama National University*

- P.35** Health risk assessment of metal toxicity from the consumption of fish from different water layers: application of mixture risk assessment method  
*Hsu HT, Ling MP, Wu CC, Yang KR*  
*China Medical University*
- P.36** Substance flow-based exposure assessment for HBCD from a life-cycle perspective in Japan  
*Managaki S, Kotani K, Hondo H, Kobayashi T, Miyake A, Masunaga S*  
*Yokohama National University*
- P.37** Conducting uncertainty and sensitivity analyses in radiological risk assessment with the probabilistic database of SYMBIOSE  
*Simon-Cornu M, Beaugelin-Seiller K, Calmon P, Moulon C, Nicoulaud V, Garcia-Sanchez L, Gonze MA*  
*Institut de Radioprotection et de Surete Nucleaire (IRSN), DEI, Cadarache, France*
- P.38** Young kids potentially at greatest risk due to exposures to perfluorinated compounds through water consumption  
*Dalajants C, Wu KY*  
*Institute of Occupational Medicine and Industrial Hygiene, College of Public Health, National Taiwan University*
- P.39** Identifying and evaluating drinking water contaminants of emerging concern: a state perspective  
*Greene CW, Goeden HM, Dady JM, Ross M, Shubat PJ*  
*Minnesota Department of Health*
- P.40** European solvents industry group consumer generic exposure scenario tool  
*Zaleski R, Qian H, Zelenka M, George-Ares A, Money C*  
*ExxonMobil Biomedical Sciences, Inc; ExxonMobil Petroleum and Chemical*
- P.41** Quantitative model evaluation: lessons learned from symposia on getting the numbers right  
*von Stackelberg KE, Williams PRD*  
*E Risk Sciences, LLP*
- P.42** Gene-environment interactions in exposure-response between organophosphate pesticide exposures and the phenotypic anchor of acetylcholinesterase inhibition in farmworkers  
*Griffith WC, Guerrette ZN, Moreira EG, Thompson B, Coronado GD, Vigoren EM, Faustman EM*  
*University of Washington, Fred Hutchinson Cancer Research Center, State University of Londrina*
- P.43** Proposition 65 dermal exposure assessment for DEHP in clothing with plasticized images  
*Williams E, Keenan J, Le M, Gaffney S*  
*ChemRisk LLC*
- P.44** Understanding the temporal patterns of aerosols at Hsin-Chuang in Taipei by dynamic factor analysis  
*Yu HL, Lin YC*  
*National Taiwan University*
- P.45** Too big or not too big? That is the systemic risk question!  
*Pai PK*  
*The University Texas of the Permian Basin*
- P.46** Contaminant dispersion modeling in complex urban landscapes using hybrid computational fluid dynamics techniques  
*Mazumdar S, Isukapalli S*  
*UMDNJ-RW Johnson Medical School and Rutgers University*
- P.47** Ultrafine particles in combustion source emissions: the role of waste-to-energy facilities  
*Foster SA, Chrostowski PC, Porter TJ*  
*CPF Associates, Inc. and Wheelabrator Environmental Technologies, Inc.*
- P.48** CAREX Canada: Using risk-based indicators in support of prioritizing actions to reduce or eliminate exposures to known and suspected carcinogens in the environment  
*Setton E, Hystad P, Poplawski K, Cheasley R, Cervantes A, Nicol AM, Demers P*  
*University of Victoria, University of British Columbia, Cancer Care Ontario*
- P.49** Para-occupational exposure to pesticides in agricultural families: amiss opportunity for Risk Assessment  
*Blewett C, McKenzie A, Nicol A-M*  
*University of British Columbia*
- P.50** Use of random forest for estimation of significant exposures in case control studies of foodborne diseases  
*Gu W, Cole D, Hoekstra M*  
*Federal Government*
- P.51** An Exposure Index estimation framework for the National Children's Study (NCS)  
*Georgopoulos PG, Brinkerhoff CJ, Isukapalli SS, Liou P, Dellarco M, Landrigan P*  
*Environmental & Occupational Health Sciences Institute*
- DRSG**
- P.52** A unified system biology data integration by using a modified JDL framework  
*Mohapatra AK*  
*Health Canada Alberta Region*
- P.53** Development of a human PBPK model for carbaryl using an in vitro to in vivo extrapolation approach and its application in reverse dosimetry  
*Yoon M, Yang Y, Tan Y-M, Clewell HJ*  
*The Hamner Institutes for Health Sciences*
- P.54** An analysis of the growth curves of control Sprague-Dawley rats fed ad-libitum from weaning to 90 days of age  
*Walker JT, Walker TD, Walker OA*  
*US Environmental Protection Agency*
- P.55** A mathematical description of National Toxicology Program (NTP) 2-year growth curves of male and female F344/N rats  
*Walker JT, Walker TD, Walker OA*  
*US Environmental Protection Agency*
- P.56** Air pollution, abnormal birth weight and obesity may increase the risk of developing asthma during adolescence  
*Tsai MS, Pan SC, Lin MH, Ho WC, Chen PC, Lin RS*  
*China Medical University*
- P.58** A proposed framework for evaluating alternative temporal patterns of exposure for risk characterization  
*Parker AL, Maier A, Haber LT, Sweeney LM*  
*Toxicology Excellence for Risk Assessment (TERA)*
- P.59** Shipwrecked: finding the life raft of knowledge for risk assessment  
*Nance P, Haber L, Maier A, Patterson J*  
*Toxicology Excellence for Risk Assessment*
- P.60** Use of physiologically-based pharmacokinetic models to assess whether epidemiologic associations are due to reverse causality  
*Locisano AE, Longnecker MP, Campbell JL, Andersen ME, Clewell HJ*  
*The Hamner Institutes for Health Sciences*
- P.61** Effects of early life exposure to air pollution on childhood ADHD among newborn infants in Taiwan  
*Lin MH, Ho WC, Chen PC, Cheng TJ, Wu TN*  
*China Medical University*
- P.62** Ozone exposure is associated with cardiovascular diseases mortality based on both acute and longer term analyses  
*Ho WC, Lin MH, Lin YS, Chen PC, Cheng TJ, Wu TN*  
*China Medical University*
- P.63** Review of issues relevant to ambient air quality criteria  
*Haber LT, Kaden DA, Meek ME, Schroeder J*  
*TERA, ENVIRON, University of Ottawa, Ontario Ministry of the Environment*
- P.64** Using information from alternative models to guide research in mixtures: a case study on interactions between Polycyclic Aromatic Hydrocarbons (PAHs) with different mechanisms of action in zebrafish  
*Fleming CR, Di Giulio RT, Lambert JC*  
*Oak Ridge Institute for Science and Education, Duke University, US Environmental Protection Agency, Cincinnati, OH*



**P.65** Use of genomics data and other early effect biomarkers in risk assessment: opportunities and challenges

*Dourson ML, Haber LT, Maier A, Reichard J, Abraham IM*

*TERA*

**P.66** PBPK modeling with atrazine: simulation of the dynamic changes in an in vitro system to support in vitro to in vivo extrapolation across species

*Campbell, Jr. JL, Andersen ME, Kim D, Yi KD, Pastoor T, Breckinridge CB, Clewell, III HJ*

*The Hammer Institutes, Syngenta, LLC*

**P.67** The influence of air pollution on cardiovascular and pulmonary function and exercise capacity: Canadian Health Measures Survey (CHMS)

*Cakmak S, Dales R, Leech J, Liu L*

*Health Canada*

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**P.68** Extending your community-based research to other communities: US EPA's C-FERST (Community-Focused Exposure and Risk Screening Tool)

*Schultz BD, Zartarian VG, Geller A, Barzyk T, O'Shea S*

*US Environmental Protection Agency*

**P.69** Varieties of emotional judgment and its determinants in case of the nuclear power

*Jung J, Song Y, Kim S*

*Chungju National University*

**P.70** Trust in organizations relevant to the Tohoku Earthquake and to the crisis at the Fukushima Daiichi nuclear power plant

*Nakayachi K*

*Doshisha University*

**P.71** Risk communication in multi-organizational complex crisis: experiences from key decision makers

*Lemus-Martinez C, Lemyre L, Pinsent C, Boutette P, Johnson C, Blust S, Corneil W*

*University of Ottawa*

**P.72** Experimental investigation into public response to food terrorism vs. accidental contamination

*Cuite CL, Johnson BB, McWilliams RM, Hallman WK*

*Rutgers, The State University of New Jersey*

**P.73** Impacts of science and technology citizens' schools on expert presenters

*Foster CB*

*University of South Carolina*

**P.74** Front page or 'buried' beneath the fold? Media coverage of carbon capture and storage

*Boyd AB, Pavaglio TB, Emsiedel EF*

*University of Calgary*

**P.75** The empirical test of several vulnerability hypotheses in terms of risk perception and experience

*Jung S, Kim S, Wang J*

*Korea University*

**P.76** Perception of causes of deaths from diseases, accidents and suicide in persons of young and seniors

*Kugihara NK*

*Osaka University*

**P.77** Government's persuasion strategies and acceptance/reactance effect in risk conflicts

*Wang J, Kim S, Jung S*

*Ajou University*

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*Severtson DJ, Myers J*

*UW-Madison*

**P.79** A New York (or Pennsylvania) state of mind: cross-state differences in print media coverage of drilling for natural gas in the Marcellus Shale region

*Evensen DT*

*Cornell University*

**P.82** A proposed model to analyze audiences' behavioral barriers to adopting climate change mitigation strategies

*Marlatt HL*

*Colorado State University*

**P.83** Detection of local climate change through individual experience

*Howe PD*

*Pennsylvania State University*

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*Aoyagi M, Tasaki T, Yoshida A, Kanamori Y*

*National Institute for Environmental Studies*

**P.85** The role of risk perception in potential vaccination uptake for West Nile Virus

*Trumbo CW, Zielinski-Gutiérrez E, Kronauge C, Evans S*

*Colorado State University, Centers for Disease Control, Weld County (CO) Department of Health*

**P.86** Scary news: how journalists view media framing of public response to terrorist attacks

*Swain KA*

*University of Mississippi*

**P.87** BP's use of twitter as a crisis communication tool during the Gulf of Mexico oil spill response phase

*Jordan LA, Swain KA*

*University of Mississippi*

**P.88** Trust and responsibility attributions: variations across hazard managers in accidental and intentional food contamination incidents

*Johnson BB, Cuite C, Hallman W*

*Decision Research; Rutgers University*

**P.89** In Google We Trust: presentation and information seeking of uncertain information about the 2011 Japan nuclear crisis

*Steinhardt JS, Scherer CW, Buckingham JL, Kermis AD, Klopp AL, Kubli KA, Ross E*

*Cornell University*

**P.90** Investigating the role of identities and opinion leadership on risk information seeking and sharing about proposed natural gas drilling in New York's Marcellus Shale

*Clarke CE*

*Cornell University*

**P.91** Weighing the risks of immunization: a review of public and stakeholder perceptions of vaccine risk to inform policies and programs

*Brewer J, Sperber B, Raquet J, Briley C*

*The Keystone Center*

### **Risk and Development**

**P.92** Spatio-temporal analysis of black spots of traffic accidents in Santiago, Chile

*Bronfman NC, Jiménez RB, Blázquez C, Guerra K*

*Universidad Andres Bello*

**P.93** Modeling and optimization of risk in fuel transportation networks for urban areas

*Barrios I, Velasco N, Gutierrez E, Munoz F*

*Universidad de los Andes*

**P.94** The influence of integrity-based and competence-based trust on public acceptability of electricity generation sources: the case of Chile

*Bronfman NC, Jiménez RB, Arévalo P*

*Universidad Andres Bello*

**P.95** Experimental design for the assessment of the animal welfare during cattle slaughtering with and without previous stunning

*Tarres JT, Ribo OR, Serratos JA*

*European Food Safety Authority*

**P.96** Multi-attribute assessment method for pharmacy compounding

*Murphy MM, Rahaman F, Claycamp HG*

*Food and Drug Administration (FDA)*

**P.97** Communicating about One Health: examining the risks of a "shared risk" paradigm

*McComas K, Decker D, Rickard L, Wild M, Higgins C, Wong D, Castle K*

*Cornell University, National Park Service*

**P.98** Target excess lifetime cancer risks commonly used in practice

*Amaral ME, Baker K, Magee B\**

*ARCADIS*

**Works-In-Progress**

**P.99** Assessing the noncancer chemical risk of 1,3-dibromobenzene: Preliminary surrogate approaches and QSAR models employing long-term LOAELs and chemical structures of halogenated benzenes

*Collar CJ, Wang NCY*

*ORISE/US Environmental Protection Agency*

**P.100** Risk perception, public opinion and the acceptability of public decisions in Quebec (Canada)

*de Marcellis-Warin N, Peignier I  
CIRANO - Ecole Polytechnique*

**P.101** Media coverage, “false balance,” and the autism-vaccine controversy: a preliminary experiment

*Dixon G, Clarke C*

*Cornell University*

**P.102** A tale of two systems: synergy in managing risks to people and to museum collections

*Hawks C, Waller R\**

*Protect Heritage Corp.*

**P.103** Carcinogenic risk assessment for the use of methylene blue in dairy cows

*Zhou T, Gaido K, Qiu JS, Oriani J, Ekelman K*

*US Food and Drug Administration, Center for Veterinary Medicine*

**P.104** Breastfeeding and number of children are relevant risk factors in breast cancer patients from an Argentine coastal midclass population

*Demichelis SO, Cermignani L, Segal-Eiras A, Giacomi N, Croce MV*

*National University of La Plata, University J.F. Kennedy of Argentina, Buenos Aires*

**P.105** Safety data sheet alteration during alignment with the Globally Harmonized System of Classification (GHS) and implications for chemical manufacturers, suppliers, and distributors

*Grespin ME, Le MH, Panko JM*

*ChemRisk*

**P.106** Explaining risk information seeking: food risk versus industrial risk

*Kuttschreuter M, Misana-ter Huurne EFJ  
University of Twente*

**P.107** Towards an integrated approach for monitoring environment, health and safety aspects within an organization

*Mazri C, Jovanovic A, Balos D*

*INERIS*

**P.108** Objective-based risk assessment methods for advanced nuclear power plant deployment

*Talabi S*

*Carnegie Mellon University*

**P.109** Rat thermoregulation: exploration of its value in risk assessment of mixtures of Type I and Type II pyrethroid insecticides

*Pato A, Sosa Holt C, Wolansky MJ*

*University of Buenos Aires/Argentine National Research Council*

**P.110** The southern states outbreak sequence: surveying survivors and informing risk management

*Youngblood SA, Chaney PL, Weaver GS*

*Auburn University*

**P.111** A statistical approach for judging stability of whole mixture chemical composition over time for highly complex disinfection by-product mixtures from EPA's four lab study

*Teuschler LK, Aume LS, Rice GE, Simmons JE, Pressman JG, Narotsky MG, Speth TF, Milner RJ, Hunter ES, Richardson SD*

*US Environmental Protection Agency, Battelle*

**P.112** An updated inhalation unit risk factor for arsenic and inorganic arsenic compounds based on a meta-analysis of epidemiology studies

*Erraguntla NK, Sielken RL, Valdez-Flores C, Grant RL*

*Texas Commission on Environmental Quality*

**P.113** Assessing the risk of Asian gypsy moth, *Lymantria dispar* (Linnaeus), introduction into the United States on maritime shipments

*Fowler G, Takeuchi Y, Sequeira R, Fussell W, Simon M, Lougee G, Sato A, Xu Y*

*USDA-APHIS*

**P.114** Risk analysis based on coastal biomonitoring: synergic effect of global change on stress generated by xenobiotics in Antarctic key species of trophic webs

*Demichelis SO, Di Fonzo CI, Dopchiz LP, Zappala CM, Rosa GA, Genovese G,*

*Lo Nostro F, Lavarias SML, Guiralde MC, Ansaldo M*

*Argentine Antarctic Institute, UAJFK, UBA, UNLP*

**P.115** You don't test for nothing: beliefs about exposure from living on dioxin-contaminated soil

*Zikmund-Fisher BJ, Diebol JK, Turkelson AE, Franzblau A, Allerton L, Parker EA*

*University of Michigan*

**P.116** Aggregate risk assessment of inhalable particle matter

*Xu LY, Shu X*

*State Key Joint Laboratory of Environmental Simulation and Pollution Control, School of Environment, China*

**P.117** The probability statistics analysis of food intake input distribution by sensitivity groups (YOPI) of food-borne disease for quantitative microbial risk assessment

*Choi EJ, Kim HT, Song BR, Babk GJ\**

*Department of Food and Nutrition, Kumisan National University*

**P.118** Risk and crisis communication requirements following an acute chemical incident

*Pearce JM, Rogers MB*

*King's College London*

**P.119** Japanese consumers' risk perception of beef: the effect of nuclear explosion

*Hosono H, Kumagai Y, Sekizaki T*

*The University of Tokyo*

**P.120** Radon in the public eye: a review of the evidence for radon risk perception, risk communication and mitigation potential

*McKenzie A, Sloan B, Blewett C, Nicol AM*

*Carex Canada, University of British Columbia*

**P.121** Quantifying an example systems approach used to mitigate the risk of establishment of fruit flies

*Caton BP, Miller CE, Jang EB  
USDA-APHIS, Consultant, USDA-ARS*

**P.122** The influence of social media on risk perception and reputation risk

*Hosseinali Mirza V, de Marcellis-Warin N, Warin T*

*Ecole Polytechnique de Montreal*

**P.123** Arsenic in apple juice: myth versus reality

*Charnley G, Melnikov F, Beck B  
HealthRisk Strategies, Gradient*

**P.124** Genomic changes in primary human uroepithelial cells following 24 hour exposure to mixtures of arsenite and its trivalent methylated metabolites

*Clewell HJ, Efremenko A, Black M, Thomas RS, McKim J, Wilga PC, Arnold LL, Gentry PR, Yager JW*

*The Hamner Institutes for Health Sciences, CeeTax, Inc., University of Nebraska Medical Center, Environ International, University of New Mexico, Albuquerque*

**P.125** A critical analysis of ecological risk assessment endpoints for biofuel feedstocks

*Ridley CE, Frederick RJ\**

*US Environmental Protection Agency*

**P.126** Variability in air quality models influences social cost estimates for air emissions

*Gilmore EA, Moore A, Murphy BN, Adams PJ*

*University of Maryland, Carnegie Mellon University*

10:30 AM-Noon <i>Ballroom C1</i>	10:30 AM-Noon <i>Ballroom C2</i>	10:30 AM-Noon <i>Ballroom C3</i>	10:30 AM-Noon <i>Room 6</i>	10:30 AM-Noon <i>Room 7</i>
<b>T2-A Climate Change Perceptions and Their Consequences</b> <i>Chair: Chris Clark</i>	<b>T2-B Symposium: Seafood Safety Following the Deepwater Horizon Oil Spill</b> <i>Chair: Mike Bolger</i>	<b>T2-C Dose Response Modeling</b> <i>Chair: Juleen L. Lam</i>	<b>T2-D Symposium: Climate Change Impacts and Adaptation Strategies: Evolving Roles of Risk Analysis</b> <i>Sponsored by: EISG</i> <i>Chair: Arthur Rypinski</i>	<b>T2-E Health, Safety and Society</b> <i>Co-Chairs: Tee Guidotti, Margaret MacDonell</i>
<b>10:30 am</b> <b>T2-A.1</b> What, me worry? The role of affect in information seeking <i>Yang JZ, Kablor L</i> <i>SUNY-Buffalo</i>	<b>10:30 am</b> <b>T2-B.1</b> A review of seafood safety after the Deepwater Horizon blowout <i>Goblke JM, Doke D, Tipre M, Leader M, Fitzgerald T</i> <i>University of Alabama at Birmingham, School of Public Health</i>	<b>10:30 am</b> <b>T2-C.1</b> Bayesian Model averaging for benchmark dose estimation from continuous data <i>Shao K</i> <i>Carnegie Mellon University</i>	<b>10:30 am</b> <b>T2-D.1</b> Anticipating and adapting to climate change in coastal deltas <i>Burkett VR</i> <i>United States Geological Survey, Department of the Interior</i>	<b>10:30 am</b> <b>T2-E.1</b> UK health and safety and the “Lofstedt review” <i>Lofstedt R</i> <i>Kings College London</i>
<b>10:50 am</b> <b>T2-A.2</b> Climate change in the Indian Country: culture, beliefs, risk perception and behavior <i>Safi AS, Smith WJ, Chief K, Liu Z</i> <i>University of Michigan</i>	<b>10:50 am</b> <b>T2-B.2</b> A retrospective on the multiagency response to seafood safety following the 2010 Deepwater Horizon Oil Spill <i>Dickey R</i> <i>FDA, Gulf Coast Seafood Laboratory</i>	<b>10:50 am</b> <b>T2-C.2</b> Developing a Bayesian approach to dose response assessment: an application to trihalomethanes in drinking water <i>Lam JL, Fox MA, Burke TA</i> <i>Johns Hopkins University, Bloomberg School of Public Health</i>	<b>10:50 am</b> <b>T2-D.2</b> Using Bayesian Networks to evaluate sea-level rise <i>Plant NG</i> <i>United States Geological Survey, Department of the Interior</i>	<b>10:50 am</b> <b>T2-E.2</b> Public safety and risk assessment <i>Ball DJ, Ball-King LN</i> <i>Middlesex University, London</i>
<b>11:10 am</b> <b>T2-A.3</b> Energy systems and climate change: Canadian perspectives and evaluations of trade-offs and values <i>Boyd AD, Einsiedel EF</i> <i>University of Calgary</i>	<b>11:10 am</b> <b>T2-B.3</b> Assessing seafood safety during the Deepwater Horizon oil spill MC252 <i>Dickhoff WW, Walker C, Ylitalo G, Wilson S, Stein J</i> <i>NOAA Fisheries</i>	<b>11:10 am</b> <b>T2-C.3</b> Estimating noncancer human health risks associated with acrolein inhalation using the Straw Man Model <i>Lynch MT, Hattis D, Greco S, Belova A</i> <i>ABT Associates Inc.</i>	<b>11:10 am</b> <b>T2-D.3</b> National Climate Assessment & US adaptation strategies <i>Rypinski AD, Cantral R</i> <i>US Department of Transportation</i>	<b>11:10 am</b> <b>T2-E.3</b> Using the concept of systemic risks to approach social unrest <i>Renn O, Jovanovic A, Schroeter R</i> <i>Stuttgart University</i>
<b>11:30 am</b> <b>T2-A.4</b> The potentially alarming effect of communicating CCS monitoring <i>L'Orange Seigo S, Wallquist L, Doble S, Siegrist M</i> <i>ETH Zurich</i>	<b>11:30 am</b> <b>T2-B.4</b> The state of Mississippi's response to the Gulf Oil Spill <i>Brown A, Rodriguez J, Hagood G, Kang X, Armbrust K, Jewell J, Diaz D, Gatian N, Folmer H</i> <i>Mississippi State University, Office of the State Chemist-MS, Mississippi Department of Marine Resources, Mississippi Department of Environmental Quality</i>	<b>11:30 am</b> <b>T2-C.4</b> Application of a data fusion framework to integrate toxicity data for a petroleum hydrocarbon mixture <i>Dyck R, Sadiq R, Zargar A, Islam S, Mohapatra A</i> <i>Health Canada Alberta Region</i>	<b>11:30 am</b> <b>T2-D.4</b> Risk assessment strategies for adaptation and sea-level rise <i>MacDonell MM, Rypinski AD</i> <i>Argonne National Lab</i>	<b>11:30 am</b> <b>T2-E.4</b> Enterprise- and workplace-level risk management and the Deming Cycle <i>Guidotti TL</i> <i>Medical Advisory Services</i>

<p><b>10:30 AM-Noon</b> <i>Room 8/9</i></p>	<p><b>10:30 AM-Noon</b> <i>Room 10</i></p>	<p><b>10:30 AM-Noon</b> <i>Room 11</i></p>	<p><b>10:30 AM-Noon</b> <i>Room 12/13</i></p>	<p><b>10:30 AM-Noon</b> <i>Room 14</i></p>
<p><b>T2-F Error in Risk Assessment</b> <i>Chair: Robin Keller</i></p>	<p><b>T2-G Games and Digital Platforms for Risk Communication</b> <i>Chair: Janet Yang</i></p>	<p><b>T2-H Bioterrorism: Analyzing Agents and Risks</b> <i>Sponsored by: SDSG</i> <i>Chair: Patricia Underwood</i></p>	<p><b>T2-I Symposium: Regulation and Risk</b> <i>Chair: Rick Belzer</i></p>	<p><b>T2-J Risk Communication - Networks across Hazards and along Life Cycles</b> <i>Chair: Christy Powers</i></p>
<p><b>10:30 am T2-F.1</b> Time inconsistency of risk perception <i>Feng TJ, Keller LR, Wang YT</i> <i>Fudan University, University of California, Irvine</i></p>	<p><b>10:30 am T2-G.1</b> Informed public choices for low-carbon electricity portfolios using a portfolio-building computer decision tool <i>Fleishman LA, Bruine de Bruin W, Morgan MG</i> <i>Carnegie Mellon University, RAND Corporation</i></p>	<p><b>10:30 am T2-H.1</b> Dose-response research to support risk-based site-specific decisions following an anthrax attack <i>Taft SC, Comer JE, Hines SA, Barnewall RE, Nichols TL</i> <i>US Environmental Protection Agency, Battelle Memorial Institute</i></p>	<p><b>10:30 am T2-I.1</b> Regulatory science and policy - a case study of the National Ambient Air Quality Standards <i>Dudley SE</i> <i>The George Washington University</i></p>	<p><b>10:30 am T2-J.1</b> The value of knowledge-based decisions: improving terrorism defense by integrating multi-criteria decision analysis, game theory, and the value of information <i>Hartz RT, Coles JB, Keisler JM, Zhuang J, Linkov I</i> <i>University of Pittsburgh, University at Buffalo, University of Massachusetts, US Army Engineer Research and Development Center</i></p>
<p><b>10:50 am T2-F.2</b> Factoring out bias and overconfidence: advanced bias correction in risk analysis <i>Ferson S, Siegrist J, Balch M, Finkel A</i> <i>Applied Biomathematics, Rutgers University, University of Pennsylvania Law School</i></p>	<p><b>10:50 am T2-G.2</b> LinkIT - a gaming approach for eliciting mental models about risk <i>Cao Y, McGill WL</i> <i>The Pennsylvania State University</i></p>	<p><b>10:50 am T2-H.2</b> Dose-response study for mice exposed to single and multiple doses of Francisella tularensis type A strains <i>Huang Y, Haas CN, Rose JB, Bolin CA</i> <i>Michigan State University</i></p>	<p><b>10:50 am T2-I.2</b> The extent of uncertainty analysis for major proposed regulations <i>Ellig JR</i> <i>Mercatus Center</i></p>	<p><b>10:50 am T2-J.2</b> Modeling the safety and efficacy of vaccines through the life cycle <i>King DB</i> <i>US Food and Drug Administration</i> <i>CBER</i></p>
<p><b>11:10 am T2-F.3</b> Accounting for professional judgment in risk maturity: a case study from the power utility sector <i>Mauehsbagen CW, Denyer D, Pollard SJ</i> <i>Cranfield University, UK</i></p>	<p><b>11:10 am T2-G.3</b> SortIT - an online multiplayer adventure game for pairwise ranking of risks <i>Calle JJ, McGill WL</i> <i>The Pennsylvania State University</i></p>	<p><b>11:10 am T2-H.3</b> Updating data for the Department of Homeland Security's Bioterrorism Risk Assessment <i>Hawks ES, Burns JM, Bowdle DA, Middleton JK</i> <i>Battelle</i></p>	<p><b>11:10 am T2-I.3</b> Uncertainty and estimates of the benefits of reducing fine particle pollution <i>Fraas A, Lutter R</i> <i>Resources for the Future</i></p>	<p><b>11:10 am T2-J.3</b> A framework for regional all-hazards risk assessment and mitigation <i>Chatterjee S, Abkowitz MD</i> <i>CREATE- University of Southern California, Vanderbilt University</i></p>
<p><b>11:30 am T2-F.4</b> Assessing climate as a factor in crop yield in SubSaharan Africa <i>Cullen A, Smoliak B, Po-Chedley S, Anderson CL</i> <i>Evans School of Public Affairs, Department of Atmospheric Sciences, Program on Climate Change, University of Washington</i></p>	<p><b>11:30 am T2-G.4</b> Visualizing risk and uncertainty: an experimental study <i>Eosco GM, Scherer CW</i> <i>Cornell University</i></p>	<p><b>11:30 am T2-H.4</b> Gap Analysis Methodology for the Department of Homeland Security's Bioterrorism Risk Assessment <i>Middleton JK, Hale TL, Lordo RA, Hockett JC</i> <i>Battelle</i></p>	<p><b>11:30 am T2-I.4</b> Utility of regulations and inspection: food safety example <i>Williams RA</i> <i>Mercatus Center at George Mason University</i></p>	<p><b>11:30 am T2-J.4</b> What affects the sharing of risk knowledge in government networks - a social network analysis <i>Shaw H, Rocks SA, Denyer D</i> <i>Cranfield University</i></p>



1:30-3:00 PM Ballroom C1	1:30-3:00 PM Ballroom C2	1:30-3:00 PM Ballroom C3	1:30-3:00 PM Room 6	1:30-3:00 PM Room 7
<b>T3-A Fukushima and Risk Communication</b> <i>Chair: Gina Eosco</i>	<b>T3-B Diverse Modeling Approaches for Exposure Assessment</b> <i>Chair: Mark Weir</i>	<b>T3-C Symposium: Improving Problem Formulation and Dose-Response Beyond Science and Decision, Part 1</b> <i>Sponsored by: DRSG</i> <i>Co-Chairs: Julie Fitzpatrick, Rick Becker</i>	<b>T3-D Disasters and Infrastructure Interdependencies</b> <i>Chair: Joost Santos</i>	<b>T3-E Innovative Uses of QMRA to Support Risk Management</b> <i>Chair: Hong Yang</i>
<p><b>1:30 pm</b> <b>T3-A.1</b> Explaining radiation risks: a comparison of media coverage of Fukushima, Chernobyl and TMI <i>Friedman SM</i> <i>Lehigh University</i></p> <p><b>1:50 pm</b> <b>T3-A.2</b> How the accident at Fukushima affected the public's perception of nuclear power: results of a longitudinal survey <i>Siegrist M, Visschers VHM</i> <i>ETH Zurich, Switzerland</i></p> <p><b>2:10 pm</b> <b>T3-A.3</b> Calm panic of the Japanese against the complex disaster 3-11 <i>Tsuchida S</i> <i>Kansai University</i></p> <p><b>2:30 pm</b> <b>T3-A.4</b> Nuclear energy and the contingent impact of media attention <i>Besley JC</i> <i>University of South Carolina</i></p>	<p><b>1:30 pm</b> <b>T3-B.1</b> A novel modeling system for studying the effects of climate change on exposures to aeroallergens and co-occurring gas pollutants <i>Isukapalli SS, Zhang Y, Bielory L, Roubek A, Georgopoulos PG</i> <i>Environmental and Occupational Health Sciences Institute, Rutgers University</i></p> <p><b>1:50 pm</b> <b>T3-B.2</b> A tiered approach to dermal exposure assessment for antimicrobial pesticides <i>McDougal JN, Guy RH*, Leighton T, Bronaugh RL, Shah PV, Olin SS, O'Brien TM, Canady RA</i> <i>Wright State University, University of Bath, UK, US Environmental Protection Agency, US Food and Drug Administration, ILSI Research Foundation, Ecolab</i></p> <p><b>2:10 pm</b> <b>T3-B.3</b> Uncertainty in multimedia mass-balance models: an evaluation by fuzzy arithmetic and probability bounds analysis <i>Oberg T, Iqbal MS</i> <i>Linnaeus University</i></p> <p><b>2:30 pm</b> <b>T3-B.4</b> Stochastic modeling of water reclamation treatment redesign suggestions addressing cryptosporidiosis risk at a recreational spray park <i>Weir MH, Razzolini MTP, Rose JB, Masago Y</i> <i>Michigan State University</i></p>	<p><b>1:30 pm</b> <b>T3-C.1</b> The collaborative ARA adventure: extending and expanding discussions of problem formulation and dose-response <i>Pottenger LH</i> <i>The Dow Chemical Company</i></p> <p><b>1:50 pm</b> <b>T3-C.2</b> Linking problem formulation to dose-response assessment <i>Paoli G</i> <i>Risk Sciences International</i></p> <p><b>2:10 pm</b> <b>T3-C.3</b> The importance of mode of action <i>Meek ME</i> <i>University</i></p> <p><b>2:30 pm</b> <b>T3-C.4</b> Where the rubber meets the road: a practical methods compendium for risk assessors <i>Haber LH, Kroner OL</i> <i>TERA</i></p>	<p><b>1:30 pm</b> <b>T3-D.1</b> Effects of network topology on vulnerability during targeted attacks <i>Guikema SD, LaRocca S</i> <i>Johns Hopkins University</i></p> <p><b>1:50 pm</b> <b>T3-D.2</b> Developing an inventory-based prioritization methodology for assessing inoperability and economic loss in interdependent sectors <i>Resurreccion JZ, Santos JR</i> <i>George Washington University</i></p> <p><b>2:10 pm</b> <b>T3-D.3</b> Water system reliability under hurricane impact considering electrical grid interdependency <i>Christian J, Rokneddin K, Onyang M, Duenas-Osorio L</i> <i>Rice University</i></p> <p><b>2:30 pm</b> <b>T3-D.4</b> Broadening the discourse on infrastructure interdependence by modeling the 'ecology' of infrastructure systems <i>LaRocca S, Guikema SD, Cole J, Sanderson E</i> <i>Johns Hopkins University</i></p>	<p><b>1:30 pm</b> <b>T3-E.1</b> Risk Assessment of potential transmission of variant Creutzfeldt-Jakob Disease (vCJD) via transfusion in the United States <i>Yang H, Anderson SA</i> <i>Center for Biologics Evaluation and Research, Food and Drug Administration</i></p> <p><b>1:50 pm</b> <b>T3-E.2</b> Risk based microbiological criteria for Shiga toxin-producing E. coli (STEC) in ground beef <i>Sanaa M, Poisson S, Lailler R</i> <i>ANSES</i></p> <p><b>2:10 pm</b> <b>T3-E.3</b> A Campylobacter QMRA (Quantitative Microbiological Risk Assessment) for petting zoos <i>Evers EG, Horneman ML, Berk PA, Van Leusden FM, De Jonge R</i> <i>Natl Inst for Pub Hlth, Bilthoven, The Netherlands</i></p> <p><b>2:30 pm</b> <b>T3-E.4</b> Quantitative Microbial Risk Assessment of Fomites Accounting for Surface Sampling Efficiency for Viruses and Non-Spore Forming Bacteria <i>Weir MH, Shibata T, Masago Y, Cologgi DL, Rose JB</i> <i>Michigan State University</i></p>

**1:30-3:00 PM**  
*Room 8/9*  
**T3-F Applied**  
**Methodology for Transportation and Other Risk Management**  
*Sponsored by: DARSG, EISG*  
*Chair: Mark Abkowitz*

**1:30 pm T3-F.1**  
 An application of enterprise risk management in the marine transportation industry  
*Abkowitz MD, Camp JS*  
*Vanderbilt University*

**1:50 pm T3-F.2**  
 Quantifying factors & trends in casualties due to hazardous materials transportation  
*Locke MS*  
*Pipeline & Hazardous Materials Safety Administration (PHMSA)*

**2:10 pm T3-F.3**  
 Risks related to the transportation of hazardous materials: a decision-making tool for selecting a carrier  
*Peignier I, De Marcellis-Warin N*  
*CIRANO (Center for Interuniversity research and Analysis of Organizations)*

**2:30 pm T3-F.4**  
 Computer based classification of performance shaping factors for safety analysis  
*Yemehyanov AM, Yemehyanov AA*  
*Georgia Southwestern State University*

**1:30-3:00 PM**  
*Room 10*  
**T3-G Nanomaterials: Environment, Dose-Response, and Expert Opinion**  
*Chair: Margaret MacDonell*

**1:30 pm T3-G.1**  
 Nanomaterial release from products is not related to hazard data: methods and data lacking  
*Froggett S, Canady RA*  
*Center for Risk Science Innovation and Application, ILSI Research Foundation*

**1:50 pm T3-G.2**  
 A modeling framework for assessing risk from engineered nanoparticles in the environment  
*Isukapalli SS, Mukherjee D, Royce SG, Georgopoulos PG*  
*Environmental & Occupational Health Sciences Institute, New Jersey*

**2:10 pm T3-G.3**  
 Evaluating biphasic dose-responses in nanotoxicology assays  
*Nascarella MA*  
*Gradient*

**2:30 pm T3-G.4**  
 Expert opinion and lifecycle regulation for emerging nanomaterials  
*Beaudrie CEH, Kandlikar M, Satterfield T, Herr Harthorn B*  
*Institute for Resources, Environment and Sustainability, University of British Columbia, Center for Nanotechnology in Society, University of California Santa Barbara*

**1:30-3:00 PM**  
*Room 11*  
**T3-H Risk Analysis of Weapons of Mass Destruction in the Supply Chain**  
*Sponsored by: SDSG*  
*Chair: Nancy McMullan*

**1:30 pm T3-H.1**  
 Screening cargo containers for nuclear material using a layered, risk-based screening system  
*Dreiding RA, McLay LA*  
*Virginia Commonwealth University*

**1:50 pm T3-H.2**  
 Chemical supply chain incident model for human health consequence estimates  
*Montello BM, Shroy BC, Buchta DA, Hawkins BE, Gooding R, Kolakowski J, McGarvey D*  
*Battelle Memorial Institute, DHS CSAC*

**2:10 pm T3-H.3**  
 Food supply chain safety and security risk management: an innovative information integration approach  
*Krishen L*  
*Futron Corporation*

**2:30 pm T3-H.4**  
 Modeling health care surge capacity requirements during an attack on the food supply  
*Hartnett E, Schaffner D, Lysak K, Hedberg C, Paoli G*  
*Risk Sciences International, Rutgers, Clarity Healthcare, University of Minnesota*

**1:30-3:00 PM**  
*Room 12/13*  
**T3-I Symposium: Catastrophic Climate Change**  
*Sponsored by: EBASG*  
*Chair: Seth Baum*

**1:30 pm T3-I.1**  
 International differences in risk tolerance and implications for global climate policy  
*Borsuk ME, Ding P, Gerst MD, Bernstein A, Howarth RB*  
*Dartmouth College*

**1:50 pm T3-I.2**  
 Risk governance of nano-geoengineering  
*Hollenkamp L, Kuzma J*  
*Humphrey School of Public Affairs, University of Minnesota*

**2:10 pm T3-I.3**  
 Public understanding of Solar Radiation Management and its implications on future research  
*Mercer AM, Keith DW, Sharp JD*  
*University of Calgary, Simon Fraser University*

**2:30 pm T3-I.4**  
 Risk-risk tradeoffs in climate engineering  
*Wiener JB*  
*Duke University*

3:30-5:00 PM Ballroom C1	3:30-5:00 PM Ballroom C2	3:30-5:00 PM Ballroom C3	3:30-5:10 PM Room 6	3:30-5:10 PM Room 7
<p><b>T4-A Risk Communication and Emerging Technologies</b> <i>Chair: Christy Powers</i></p>	<p><b>T4-B Panel Discussion: Symposium: Public Preferences and Regulatory Decision-Making: Smart Imputs for Smart Decisions?</b> <i>Sponsored by: Stiftung Mercator</i> <i>Chair: Sharon Dunwoody, Dirk Scheer</i></p>	<p><b>T4-C Symposium: Improving Problem Formulation and Dose-Response Beyond Science and Decision, Part 2</b> <i>Sponsored by: DRSG</i> <i>Co-Chairs: Rick Becker, Julie Fitzpatrick</i></p>	<p><b>T4-D Aquatic Ecological Risk Analysis</b> <i>Sponsored by: ERASG</i> <i>Chair: Jerry Cura</i></p>	<p><b>T4-E Symposium: Food Safety Risk Prioritization and Decision Analysis</b> <i>Sponsored by: MRASG</i> <i>Chair: David Oryang</i></p>
<p><b>3:30 pm T4-A.1</b> Searching for determinant and change in attitude toward nanotechnology <i>Wang JS, Jung SC, Kim SY, Jung JY</i> <i>Ajou University</i></p>	<p><b>3:30 pm T4-A.1</b> Eliciting informed, policy-relevant public preferences of low-carbon electricity technologies <i>Fleishmann LA</i> <i>RAND Corporation</i></p>	<p><b>3:30 pm T4-C.1</b> The “straw man” system for replacing uncertainty factors with empirical distributions for traditional systemic toxicants - examples and use for value of information analysis of in vitro measurements <i>Hattis D, Lynch M, Greco S, Goble R</i> <i>Clark University</i></p>	<p><b>3:30 pm T4-D.1</b> The use of a Bayesian Network for the calculation of ecological risk for Hg Contamination in the South River, VA <i>Ayre KK, Summers HM, Landis WJ</i> <i>Western Washington University</i></p>	<p><b>3:30 pm T4-E.1</b> Practical tools for prioritizing food safety projects and research <i>Oryang D</i> <i>US Food and Drug Administration</i></p>
<p><b>3:50 pm T4-A.2</b> Do they practice what they preach? Using publication records as a predictor of scientists’ attitudes toward the regulation and communication of nanoscience <i>Cacciatore MA, Schenfele DA, Corley EA, Shapira P, Youtie J</i> <i>University of Wisconsin-Madison, Arizona State University, Georgia Institute of Technology</i></p>	<p><b>3:50 pm T4-A.2</b> Public evaluation of energy technologies and the energy mix 2035: preferences, reasoning, and decisions <i>Scheer, D</i> <i>Stuttgart University</i></p>	<p><b>3:50 pm T4-C.2</b> Application of a source-to-outcome model to quantitatively assess variability in dose and sensitivity in humans <i>Price PS, Juberg DR</i> <i>The Dow Chemical Company</i></p>	<p><b>3:50 pm T4-D.2</b> Exposure and risk relationship between selenium and mercury in fish: variations among and with species <i>Burger J, Gochfeld M</i> <i>Rutgers State University</i></p>	<p><b>3:50 pm T4-E.2</b> A multifactorial risk prioritization framework for foodborne pathogens <i>Fazil A, Ruzante J, Davidson V, Caswell J, Nguyen T, Cranfield J, Henson J, Anders S, Schmidt C, Farber J</i> <i>Public Health Agency of Canada</i></p>
<p><b>4:10 pm T4-A.3</b> The stability of risk and benefit perceptions: a longitudinal study assessing the perception of technological risk <i>Connor M, Siegrist M</i> <i>USI</i></p>	<p><b>4:15 pm T4-A.3</b> Panel Discussion on: Public preferences and regulatory decision-making: smart inputs for smart decisions? <i>Moderator: Sharon Dunwoody</i> <i>University of Wisconsin-Madison</i></p>	<p><b>4:10 pm T4-C.3</b> Risk assessment of exposure to trihalomethane drinking water disinfection by-products. Use of biomonitoring equivalents and biomonitoring data from NHANES <i>Aylward LL, Hays SM, Kirman CR, Becker RA</i> <i>Summit Toxicology, LLP</i></p>	<p><b>4:10 pm T4-D.3</b> Integrated modeling for risk and decision analysis of shoreline-dependent species threatened by sea-level rise <i>Kiker GA, Munoz-Carpena R, Conventino M, Chu-Agor M, Aiello-Lammens M, Akçakaya HR, Fischer R, Linkov I</i> <i>University of Florida</i></p>	<p><b>4:10 pm T4-E.3</b> Overview of a food safety risk information management system <i>Anderson M, Beaulieu S, Jaykus L, Oryang D</i> <i>RTI, International, North Carolina State University, US Food and Drug Administration</i></p>
<p><b>4:30 pm T4-A.4</b> Perceived and managed risks of biotechnologies in the medical field: a study of French experts’ views <i>Chawet S, Boudier FE, Le Louet H</i> <i>Maastricht University</i></p>	<p><b>4:15 pm T4-A.4</b> Panelists: Löfstedt R, Morgan MG, Renn O <i>King’s College London, Carnegie Mellon University, Stuttgart University</i></p>	<p><b>4:30 pm T4-D.4</b> A methodology to quantify ecological risks originating from industrial accidents: application in a refinery near an aquatic ecosystem in Brazil <i>Duarte HO, Droguett EL, Araújo M, Teixeira SF, Silva RA</i> <i>Federal University of Pernambuco (UFPE)</i></p>	<p><b>4:30 pm T4-D.4</b> A methodology to quantify ecological risks originating from industrial accidents: application in a refinery near an aquatic ecosystem in Brazil <i>Duarte HO, Droguett EL, Araújo M, Teixeira SF, Silva RA</i> <i>Federal University of Pernambuco (UFPE)</i></p>	<p><b>4:30 pm T4-E.4</b> An integrated decision support system for food safety risk management <i>Mokhtari A, Beaulieu S, Jaykus LA, Oryang D</i> <i>RTI International</i></p>
			<p><b>4:50 pm T4-D.5</b> Decision model for management of sewage plumes in a tidal environment <i>Calder RSD, Schmitt KA, Salazar-Garcia OE</i> <i>Concordia University</i></p>	<p><b>4:50 pm T4-E.5</b> Ranking the US public health impact of 14 major foodborne pathogens by pathogen and by foods <i>Hoffmann S, Batz M, Morris JG</i> <i>USDA ERS, University of Florida</i></p>

3:30-5:00 PM Room 8/9	3:30-5:00 PM Room 10	3:30-5:10 PM Room 11	3:30-5:10 PM Room 12/13	3:30-5:00 PM Room 14
<p><b>T4-F Organizational Processes for Risk-Oriented Decisions</b> Sponsored by: DARSG Chair: Myriam Merad</p>	<p><b>T4-G Nanomaterials: Exposure, Hazard, Risk and Perception</b> Chair: Margaret MacDonell, J. Michael Davis</p>	<p><b>T4-H Advanced Models and Decision Support for WMD Risk Management</b> Sponsored by: SDSG Chair: Eric Tollar</p>	<p><b>T4-I Symposium: Global Catastrophic Risk</b> Chair: Anthony Barrett</p>	<p><b>T4-J Panel Discussion: Student and Young Professional Roundtable on Career Development</b> Co-Chairs: Franziska Boerner and Amanda Boyd</p>
<p><b>3:30 pm</b> <b>T4-F.1</b> Inter-organizational problem solving in emergency management: coordination and collaboration <i>Blust S, Lemyre L, Pinsent C, Boutette P, Corneil W, Johnson C, Lemus C</i> University of Ottawa</p>	<p><b>3:30 pm</b> <b>T4-G.1</b> The curiously understudied toxicity of “nanofibers”: a risk-benefit approach <i>Philbrick M, Taylor MR</i> University of California, Berkeley</p>	<p><b>3:30 pm</b> <b>T4-H.1</b> Modeling retailer and consumer behavior in a food contamination event <i>Buchta DA, Luedeke JD, Hawkins BE, Cox J, McGarvey D, Whitmire M</i> Battelle Memorial Institute, DHS CSAC</p>	<p><b>3: 30 pm</b> <b>T4-I.1</b> Towards consensus on global catastrophic risk reduction objectives <i>Barrett AM, Baum SD</i> ABS Consulting</p>	
<p><b>3:50 pm</b> <b>T4-F.2</b> Local risks, strategic consequences; improving risk management in UK local government <i>Smith MC, Rocks SA, Pollard SJT</i> Cranfield University</p>	<p><b>3:50 pm</b> <b>T4-G.3</b> Identifying uncertainties within environmental risk assessments <i>Skinner DJC, Rocks SA, Drew GH, Pollard SJT</i> Cranfield University</p>	<p><b>3:50 pm</b> <b>T4-H.2</b> Assessing the benefits of the public health response in the event of a chemical terrorism attack <i>Winkel D, Good K, VonNiederhausern M, Hawkins B, Cox J, McGarvey D, Whitmire M</i> Battelle Memorial Institute, DHS CSAC</p>	<p><b>3: 50 pm</b> <b>T4-I.2</b> Assessment of methods for estimating existential risks: part I <i>Tonn B, Stiefel D</i> University of Tennessee, Knoxville</p>	
<p><b>4:10 pm</b> <b>T4-F.3</b> Value orientatins, risk perception, and institutional trust-driven policy dilemmas in the nuclear waste arena: toward a process for forecasting and avoiding policy gridlock <i>Whitfield S, Anthony R, Lambrum G</i> National Security Programs InScope International, Institute for Defense Analysis, RAMTASC</p>	<p><b>4:10 pm</b> <b>T4-G.4</b> Prioritizing nanomaterials research through value of information analysis <i>Bates ME, Chappell MA, Stevens JS, Linkov I</i> US Army Corps of Engineers</p>	<p><b>4:10 pm</b> <b>T4-H.3</b> Utility-based adversary models in risk analysis for terrorist decision making <i>Tollar E, McMillan N, Simkins J</i> Battelle Memorial Institute</p>	<p><b>4:10 pm</b> <b>T4-I.3</b> Assessment of methods for estimating existential risks: part II <i>Stiefel D, Tonn B</i> University of Tennessee, Knoxville</p>	
<p><b>4:30 pm</b> <b>T4-F.4</b> Decision aid process in risk management - from the conduct of the expertise process to its governance <i>Merad M, Marcel F</i> INERIS</p>	<p><b>4:30 pm</b> <b>T4-G.5</b> A new nanocrystalline cellulose pilot plant in Alberta: environmental health and safety considerations <i>Sheremeta L</i> National Institute for Nanotechnology</p>	<p><b>4:30 pm</b> <b>T4-H.4</b> Public Health Response Sensitivity Study Tool (PHRSSST): a risk-based decision support tool for assessing public health response strategies <i>Dingus CA, McMillan NJ, Born A</i> Battelle Memorial Institute</p>	<p><b>4:30 pm</b> <b>T4-I.4</b> Partnership optimization decision support system (PODSS): improving partnership development and resource allocation in disaster recovery operations using game theory <i>Coles JB, Zhuang J</i> State University at Buffalo</p>	
		<p><b>4:50 pm</b> <b>T4-H.5</b> Developing planning scenarios and resource requirements based on quantitative risk assessment <i>Carnell R, McMillan N</i> Battelle</p>	<p><b>4:50 pm</b> <b>T4-I.5</b> Communicating the importance of global catastrophic risk <i>Baum SB</i> Pennsylvania State University</p>	



**8:30-10:00 AM**

*Ballroom C1*

**W1-A Symposium: How the Public Responds to Different Disasters over Time: The Role of Perceived Risk, Emotion and Risk Communication**

*Sponsored by: RCSG, SDSG  
Chair: William Burns*

**8:30 am W1-A.1**  
Incorporating a value-focused decision model of public response into setting recovery policy following a large-scale biological disaster  
*Rosoff H, John R, Burns W  
University of Southern California, CRE-ATE*

**8:50 am W1-A.2**  
Avoidance and adaptive behaviors following the Fukushima nuclear disaster: lessons in preparing for radiological terrorism  
*Sheppard B  
University of Maryland*

**9:10 am W1-A.3**  
The instructional dynamic in risk messages: a comparative analysis of messages intended to enhance perceptions of self-protection  
*Sellnow TL, Veil SR, Wickline M, Roberts H  
University of Kentucky*

**9:30 am W1-A.4**  
Public response in the U.S. to the Japanese crisis: reactions to the earthquake and tsunami versus the nuclear accident  
*Burns WJ  
Decision Research*

**8:30-10:00 AM**

*Ballroom C2*

**W1-B Symposium: Analytical Approaches to Food Safety Management**

*Sponsored by: MRASG  
Chair: Neal Golden*

**8:30 am W1-B.1**  
Incorporating uncertainty when evaluating risk assessment metrics: modeling *Listeria monocytogenes* contamination in ready-to-eat deli meats  
*Gallagher DL, Ebel E, Gallagher OD, LaBarre D, Williams M, Golden N, Kause J, Deerfield K  
Virginia Tech*

**8:50 am W1-B.2**  
Use of risk assessment with risk management metrics to link public health estimates to food safety performance  
*Kause J, Dearfield K, Ebel ED, Golden NJ, LaBarre D, Disney T  
Government*

**9:10 am W1-B.3**  
Risk management metrics in domestic food safety and international trade contexts: the changing role of quantified variability and uncertainty in different contexts  
*Paoli G, Ryan C, Hartnett E, Golden NJ, Dearfield K, Kause J, LaBarre D, Disney T  
Risk Sciences International*

**9:30 am W1-B.4**  
Techniques for linking public health goals and microbiological criteria across multiple hazards: application to poultry, salmonella and campylobacter  
*Ryan C, Paoli G, Hartnett E\*, Golden NJ, Dearfield K, Kause J, LaBarre D, Disney T  
Risk Sciences International*

**8:30-10:00 AM**

*Ballroom C3*

**W1-C Risk Theory and Practice**

*Chair: Steve Lewis*

**8:30 am W1-C.1**  
The Pantoxin Project: a value of information framework for combining information of different types in chemical risk dose-response assessments.  
*Goble R, Hattis D  
Clark University*

**8:50 am W1-C.2**  
Critical analysis of radiation protection regulations  
*Tikhomirov NP, Tikhomirova TM  
Plekhanov Russia University of Economics*

**9:10 am W1-C.3**  
Finally, a SCIENTIFIC definition of adverse effect  
*Belzer RB  
Regulatory Checkbook*

**9:30 am W1-C.4**  
None of the occupational exposure limits reveal risk information: a quantitative ‘nudge’ could save lives  
*Finkel AM, Altemose B, Hattis D  
University of Pennsylvania Law School*

**8:30-10:00 AM**

*Room 6*

**W1-D Methods to Inform Environmental Management**

*Sponsored by: ERASG  
Chair: Branden Johnson*

**8:30 am W1-D.1**  
Assessing risk of invasive species under severe uncertainty: a dominance-based approach  
*Yemshanov D, Koch F, Lyons B, Ducey M, Koehler K*

*Natural Resources Canada, Canadian Forest Service, North Carolina State University, University of New Hampshire, Canadian Food Inspection Agency*

**8:50 am W1-D.2**  
Advancements in integrated wildfire risk assessment  
*Thompson MP, Calkin DE  
US Forest Service*

**9:10 am W1-D.3**  
Challenges of managing small suburban natural areas: Public beliefs, attitudes and behaviors regarding ecological effects  
*Johnson BB, Horowitz L, Ehbrenfeld J  
Decision Research*

**9:30 am W1-D.4**  
An ecological, multidisciplinary approach to nuclear facilities: protecting society, human health and the environment.  
*Burger J, Gochfeld M, Clarke J, Powers C, Kosson D  
Rutgers State University, CRESP, Vanderbilt*

**8:30-10:00 AM**  
*Room 8/9*  
**W1-F Symposium: Risk Assessment for Acquisition and Assets Management**  
*Sponsored by: DARSG*  
*Chair: Igor Linkov*  
**8:30 am** **W1-F.1**  
 Identification, prioritization, and management of risks for energy systems acquisition and portfolio of assets  
*Hamilton M, Lambert J, Linkov I*  
*University of Virginia*  
**8:50 am** **W1-F.2**  
 Best practices for risk and trade space analysis for acquisition management: overview of the military operations research society workshop  
*Scriven J, Linkov I*  
*US Army TRADOC, Engineer Research and Development Center*  
**9:10 am** **W1-F.3**  
 Review of risk analysis use in Department of Defense (DoD) acquisition  
*Pabon NA, Collier Z, Linkov I*  
*US Army Corps Engineer Research and Development Center*  
**9:30 am** **W1-F.4**  
 Portfolio optimization for asset management: a USACE case study  
*Valverde LJ, Convertino M, Dokukin D, Keisler J, Linkov I*  
*US Army Engineer Research and Development Center and University of Massachusetts*

**8:30-10:00 AM**  
*Room 10*  
**W1-G Uncertainty, Bears, Dioxin and Well Water**  
*Chair: Lori Severtson*  
**8:30 am** **W1-G.1**  
 Carnivores as a hazard: the role of risk perception in predicting public acceptance  
*Zajac RM, Bruskotter JT, Wilson RS, Prange S*  
*The Ohio State University, Ohio Division of Wildlife*  
**8:50 am** **W1-G.2**  
 Exploring the use of evaluative labels to increase the saliency of uncertainty information  
*Dieckmann NF, Gregory R, Peters E, Tusler M*  
*Decision Research, Ohio State University*  
**9:10 am** **W1-G.3**  
 Do maps promote water testing among residents with private wells? The influence of map features and perceived proximity to mapped hazards on risk beliefs, uncertainty, and testing intentions.  
*Severtson DJ*  
*UW-Madison*  
**9:30 am** **W1-G.4**  
 Misconceptions in community members' mental models of dioxin-like compounds following an exposure assessment study  
*Zikmund-Fisher BJ, Diebol JK, Ross PT, Turkelson AE, Weber I, Franzblau AD, Parker EA*  
*University of Michigan, University of Iowa*

**8:30-10:00 AM**  
*Room 11*  
**W1-H Symposium: Managing Risks from Hurricanes in Coastal Areas**  
*Sponsored by: SDSG*  
*Chair: Henry Willis*  
**8:30 am** **W1-H.1**  
 Risk-based regional hurricane evacuation planning  
*Apivotanagul P, Davidson RA, Nozick LK, Wachtendorf T*  
*University of Delaware, Cornell University*  
**8:50 am** **W1-H.2**  
 Expert perspectives for improving USACE flood risk management and stakeholder engagement  
*Wood MD, Linkov I, Bridges T*  
*Carnegie Mellon University, US Army Corps of Engineers, Engineer Research and Development Center - Environmental Laboratory*  
**9:10 am** **W1-H.3**  
 Assessing long-term flood risks to coastal Louisiana under deep uncertainty  
*Fischbach JR, Ortiz DS, Johnson DR, Burger NE*  
*RAND Corporation*  
**9:30 am** **W1-H.4**  
 Adapting to future hurricane risk in New Orleans under climate change uncertainty  
*Willis HH, Groves D, Fischbach J, Johnson DJ, Andrews L*  
*RAND Corporation*

**8:30-10:00 AM**  
*Room 12/13*  
**W1-I Preference Elicitation and Benefits Assessments, Part 1**  
*Chair: Sandra Hoffman*  
**8:30 am** **W1-I.1**  
 Preferences related to urban sustainability under risk, uncertainty, and dynamics: a combined elicitation and modeling approach  
*Gray GM, Francis RA, Carruthers JJ, Malczynski LA, Lee RC*  
*George Washington University, Sandia National Laboratories, Neptune and Company, Inc.*  
**8:50 am** **W1-I.2**  
 Intrahousehold bargaining and stated-choice experiments: mothers' fathers', and couples' willingness-to-pay to protect their children from environmental neurotoxins  
*Hoffmann S, Krupnick A, Adamowicz V, Boström A*  
*USDA Economic Research Service, Resources for the Future, University of Alberta, University of Washington*  
**9:10 am** **W1-I.3**  
 Preferences for and perception of road safety  
*Andersson H*  
*Toulouse School of Economics*  
**9:30 am** **W1-I.4**  
 Quantifying health impacts in life-years: a bridge between two methods  
*Brand KB, Stieb D*  
*University of Ottawa, Health-Canada*

**10:30 AM-Noon**  
*Ballroom C1*  
**W2-A Communicating Food Contamination**  
*Chair: Ashley Mercer*  
**10:30 am** **W2-A.1**  
 Egg recall of 2010: high awareness did not match behavioral impact  
*Hallman WK, Cuite CL*  
*Rutgers, The State University of New Jersey*  
**10:50 am** **W2-A.2**  
 Aflatoxin and population attributable liver cancer risk in high exposure prevalent areas- a systematic review  
*Liu Y, Wu F*  
*University of Pittsburgh*  
**11:10 am** **W2-A.4**  
 Reassuring the public after a contamination incident: public perceptions of microbiological testing and reconditioned food products  
*Cuite CL, McWilliams RM, Hallman WK*  
*Rutgers, The State University of New Jersey*

**10:30 AM-Noon**  
*Ballroom C2*  
**W2-B Symposium: Poster Platform: The Development of High Throughput Exposure Techniques for Prioritizing Chemical Risks**  
*Chair: Jade Mitchell-Blackwood*  
**W2-B.1** Characterization of uncertainties associated with screening level exposure-based prioritization of toxic chemicals using PRoTEGE  
*Isukapalli SS, Brinkerhoff CJ, Georgopoulos PG*  
*Environmental & Occupational Health Sciences Institute*  
**W2-B.2** Challenging exposure prioritization approaches  
*Mitchell-Blackwood J, Vallero DA, Eggeby P*  
*US Environmental Protection Agency*  
**W2-B.3** From SHEDS to SHEDS-lite: development of an efficient human exposure model  
*Ozkaynak H, Eggeby P, Mitchell-Blackwood J*  
*US Environmental Protection Agency*  
**W2-B.4** Introduction to chemical safety for sustainability: exposure-based prioritization  
*Vallero DA, Eggeby P*  
*US Environmental Protection Agency*

**W2-B.5** High-throughput exposure potential prioritization for Toxic Cast chemicals  
*Wambaugh JF*  
*US Environmental Protection Agency*  
**W2-B.6** Using Multicriteria Decision Analysis (MCDA) to prioritize the exposure potential of existing and emerging chemicals  
*Wang D, Collier Z, Mitchell-Blackwood J, Keisler J, Linkov I*  
*DW-Carnegie Mellon University, ZC-US Army Engineer Research and Development Center, JMB-USEPA, JK-University of Massachusetts, IL-US Army Engineer Research and Development Center*

**10:30 AM-Noon**  
*Ballroom C3*  
**W2-C Low-Dose Dose-Response**  
*Chair: Rick Reiss*  
**10:30 am** **W2-C.1**  
 Pesticide residues on food: a mountain or a mole hill  
*Reiss R, Johnston J, DeSesso J, Tucker K*  
*Exponent*  
**10:50 am** **W2-C.2**  
 EPA's endocrine disruptor screening program: lessons from an inert substance consortium  
*Gulledge B*  
*American Chemistry Council*  
**11:10 am** **W2-C.3**  
 Application of systems biology approach to identify the controlling mechanisms for J-shaped dose response curve  
*Zhao Y, Wu Y*  
*University*  
**11:30 am** **W2-C.4**  
 Using dose-response curves to create win-win environmental legal policies  
*Rowell KA*  
*University of Illinois College of Law*

**10:30 AM-Noon**  
*Room 6*  
**W2-D Risk Analysis of Transportation Networks and Assets**  
*Chair: Shital Thekdi*  
**10:30 am** **W2-D.1**  
 Risk models and negotiation analysis for land development adjacent to infrastructure systems  
*Thekdi SA, Lambert JH*  
*University of Virginia*  
**10:50 am** **W2-D.2**  
 Climate change impacts on freight transportation infrastructure - adaptation strategies and challenges  
*Camp JS, Abkowitz MD, Hornberger GM*  
*Vanderbilt University*  
**11:10 am** **W2-D.3**  
 Modeling the socio-economic risks of bridge failures  
*Andrijić E, Haines YY*  
*University of Virginia*  
**11:30 am** **W2-D.4**  
 A systemic approach to bridge sensing and monitoring systems  
*Guo Z, Haines YY*  
*University of Virginia*



10:30 AM-Noon Room 7	10:30 AM-Noon Room 8/9	10:30 AM-Noon Room 10	10:30 AM-Noon Room 11	10:30 AM-Noon Room 12/13
<p><b>W2-E Symposium: Rapid Risk Evaluation: Analytic Tools to Support Federal Response to Environmental and Food Safety Incidents</b> Sponsored by: MRASG Chair: Janell Kause</p>	<p><b>W2-F Innovative Mathematical and Computational Methods for Risk Modeling</b> Sponsored by: DARSG Chair: Mark Borsuk</p>	<p><b>W2-G Epidemiological Dose Response Data</b> Chair: Bob Park</p>	<p><b>W2-H Symposium: Risk Communication in the US Hurricane Forecast and Warning System</b> Sponsored by: RCSG Chair: Bob O'Connor</p>	<p><b>W2-I Preference Elicitation and Benefits Assessments, Part 2</b> Chair: David Calkin</p>
<p><b>10:30 am W2-E.1</b> Risk analysis during food safety emergencies Callaban J, Dennis S Food and Drug Administration, Center for Food Safety and Applied Nutrition</p>	<p><b>10:30 am W2-F.1</b> Optimizing and satisficing in the management of risk Ben-Haim Y Technion - Israel Institute of Technology</p>	<p><b>10:30 am W2-G.1</b> Health risk assessment of exposures associated with Nigerian oil fields Vorbees D, Strauss H, Heiger-Bernays W, Gopinathan B, Oruchin E, Stirrett-Wood G, Ighara J, Covell W, Chien J, Dong Z Boston University School of Public Health</p>	<p><b>10:30 am W2-H.1</b> Inundation or ignorance? Perception and communication of storm surge risk Lazo JK, Morrow BH, Rhome JR, Feyen JC National Center for Atmospheric Research</p>	<p><b>10:30 am W2-I.1</b> Modeling skip-row corn risk using experimental trial data: production, insurance, and economic implications Woodard JD, Pavlista AD, Schmitkey GD, Burgener PA, Ward KA Cornell University, Texas A&amp;M University, University of Nebraska, University of Illinois, Windsor Strategy Partners</p>
<p><b>10:50 am W2-E.2</b> Rapid risk evaluation: an important tool for addressing food contamination incidents and emerging food safety concerns Domesle ARM, Bennett P, Dearfield K, Kause J Food Safety and Inspection Service, US Department of Agriculture</p>	<p><b>10:50 am W2-F.2</b> Facilitating pareto-optimal coordination by subsidies in deterministic and stochastic payoff settings Gong M, Heal G, Krantz D, Kunreuther H, Weber E Columbia University</p>	<p><b>10:50 am W2-G.2</b> Sources of variability in biomonitoring data: temporal variation in spot sample concentrations Hays S, Kirman C, Aylward L Summit Toxicology</p>	<p><b>10:50 am W2-H.2</b> Communication successes and challenges of the hurricane warning system: a case study Demuth JL, Morss RE, Morrow BH, Lazo JL National Center for Atmospheric Research</p>	<p><b>10:50 am W2-I.2</b> Risk preferences and probability weighting in strategic wildfire decision-making: a choice experiment of US wildfire managers Calkin DE, Wibbenmeyer MJ, Hand MS, Thompson MP, Venn TJ US Forest Service Rocky Mountain Research Station, The University of Montana</p>
<p><b>11:10 am W2-E.3</b> Rapid risk evaluations: applications, challenges and limitations Kadry AM, Woodall GM, Reid J US Environmental Protection Agency</p>	<p><b>11:10 am W2-F.3</b> Modeling operational risk using a Bayesian approach to EVT Rivera Mancina ME McGill University</p>	<p><b>11:10 am W2-G.3</b> Microwave popcorn workers: pulmonary impairment and preliminary risk assessment Park RM, Gilbert SJ, Sofge CW National Institute for Occupational Safety and Health</p>	<p><b>11:10 am W2-H.3</b> Studying and improving response to tropical cyclone threats: lessons from the virtual hurricane lab Meyer RJ University of Pennsylvania</p>	<p><b>11:10 am W2-I.3</b> The economics of environmental reclamation for shale gas development in Pennsylvania Mitchell A, Casman E Carnegie Mellon University</p>
<p><b>11:30 am W2-E.4</b> Agent-based modelling of the linked energy, economic, and climate system for scenario generation and robust decision-making Gerst MD, Wang P, Roventini A, Dosi G, Howarth RB, Borsuk ME Dartmouth College</p>	<p><b>11:30 am W2-F.4</b> Agent-based modelling of the linked energy, economic, and climate system for scenario generation and robust decision-making Gerst MD, Wang P, Roventini A, Dosi G, Howarth RB, Borsuk ME Dartmouth College</p>	<p><b>11:30 am W2-G.4</b> Use of worker epidemiological data to assess inhalation risk from 2-Mercaptobenzothiazole Weinrich AJ, Jinot J US Environmental Protection Agency National Center for Environmental Assessment</p>	<p><b>11:30 am W2-H.4</b> Warning decisions in extreme weather events: forecasters' perceptions and perspectives on hurricane forecasts, warnings, decisions and risks Bostrom A, Hudson R, Lazo J, Morss R, DeMuth J University of Washington</p>	<p><b>11:30 am W2-I.4</b> Stakeholder engagement in practice - the experience of the National Tree Safety Group in the development of a nationally recognised approach to tree safety management in the UK Watt JM, Fay N Middlesex University, UK, Treework Environmental Practice, UK</p>

**1:30-3:00 PM**  
*Ballroom C1*  
**W3-A Communicating Risks in Times of Duress**  
*Chair: Andrew Binder*  
**1:30 pm W3-A.1**  
 Relationship between judgments of health risk and satisfaction with hazard and exposure communications  
*Diebol JK, Zikmund-Fisher BJ, Ross PT, Turkelson A, Weber I, Franzblau A, Parker E*  
*University of Michigan, The University of Iowa*  
**1:50 pm W3-A.2**  
 A strategic risk communication process for biosolids professionals: advancing the field  
*Eggers SL, Thorne SL, Sousa KAT, Butte G, Ackerlund S\**  
 DECISION PARTNERS  
**2:10 pm W3-A.3**  
 Social and psychological elements of hurricane risk perception  
*Trumbo CW, Peek L, Lueck M, Marlatt HM, McNoldy B, Grunfest E*  
*Colorado State University*  
**2:30 pm W3-A.4**  
 Same test, same result - same information? A study of physician and lay understanding of medical tests and risk  
*Austin LC*  
*Copenhagen Business School*

**1:30-3:00 PM**  
*Ballroom C2*  
**W3-B Foodborne Exposures**  
*Sponsored by: MRASG*  
*Chair: Anthony Fristachi*  
**1:30 pm W3-B.1**  
 Exposure assessment for caffeine in the United States  
*DiNovi M, Srinivasan J, Srinivasan US Food and Drug Administration*  
**1:50 pm W3-B.2**  
 Foodborne contamination consequence modeling  
*Luedeke JD, Buchta DB, Truong C, Hawkins BE, Cox J, McGarvey D, Whitmire M*  
*Battelle Memorial Institute, DHS CSAC*  
**2:10 pm W3-B.4**  
 Estimation of human infection risks for foodborne viruses due to consumption of fresh produce, pork and mussels in Europe  
*Bouwknegt M, Verbaelen K, Rutjes SA, De Roda Husman AM*  
*National Institute for Public Health and The Environment*

**1:30-3:00 PM**  
*Ballroom C3*  
**W3-C Symposium: Graphic Depictions of Toxicological Data**  
*Sponsored by: DRSG*  
*Co-Chairs: George Woodall, A Boyle*  
**1:30 pm W3-C.1**  
 Exposure response array project and summary of an October workshop  
*Woodall GM*  
*US Environmental Protection Agency, NCEA*  
**1:50 pm W3-C.2**  
 Software for displaying toxicological data at NTP: the Exposure Response Array and Forest Plot Viewer programs  
*Rooney AA, Boyles AL, Harris SF, Thayer KA*  
*Office of Health Assessment and Translation, SRA International, Inc.*  
**2:10 pm W3-C.3**  
 Development of ATSDR's levels of significant exposure tables and figures  
*Abadin HG*  
*ATSDR*  
**2:30 pm W3-C.4**  
 Weight of evidence evaluation for adverse health effects of several pesticides at environmentally-relevant concentrations  
*von Stackelberg KE*  
*E Risk Sciences, LLP*

**1:30-3:00 PM**  
*Room 6*  
**W3-D Ecological Risk Assessment**  
*Sponsored by: ERASG*  
*Chair: Greg McDermott*  
**1:30 pm W3-D.1**  
 Risk screening assessments at Los Alamos National Laboratory (Part 2. Ecological)  
*Fristachi A, Miranda R*  
*Environmental Risk Resources, Los Alamos National Laboratory*  
**1:50 pm W3-D.2**  
 Can soil bioassays be used to establish or modify site-specific cleanup goals?  
*Swanson WL, Rytty RT*  
*Neptune and Company, Inc.*  
**2:10 pm W3-D.3**  
 Water pollution risk associated with natural gas extraction from the Marcellus shale  
*Rozell DJ, Reaven S*  
*Stony Brook University*  
**2:30 pm W3-D.4**  
 Differential body burdens of various compounds in co-occurring bivalves  
*Cura J, Occhialini J, Vorhees D*  
*Woods Hole Group, Alpha Analytical, The Science Collaborative, North Shore*

**1:30-3:00 PM**  
*Room 7*  
**W3-E Symposium: Innovative Means of Data Collection to Support a Quantitative Risk Assessment**  
*Chair: Marie Cornu*  
**1:30 pm W3-E.1**  
 Site visits: a novel means of filling-in the data gaps  
*Fanaselle WL, Dennis S, Oryang D, Pouillot R, Van Doren J*  
*Food and Drug Administration, Center for Food Safety and Nutrition*  
**1:50 pm W3-E.2**  
 Geospatial risk assessment of contamination of agricultural produce by enteric pathogens  
*Anyamba A, Smith M, Oryang D, Fanaselle W*  
*NASA Goddard Space Flight Center*  
**2:10 pm W3-E.3**  
 Collecting data to assess food exposure: comparison of a 4-year project (L. monocytogenes in smoked salmon) versus a real-time assessment after Fukushima Accident (radiological hazards)  
*Simon-Cornu M, Beaufort A, Gonze MA, Metivier JM, Mourlon C, Parache V*  
*ANSES, France, Institut de Radioprotection et de Surete Nucleaire (IRSN), France*  
**2:30 pm W3-E.4**  
 Global burden of disease caused by foodborne toxins: use of biomarkers vs. dietary recall and market samples  
*Wu F, Liu Y, Khlanguiset P*  
*University of Pittsburgh*

**1:30-3:00 PM**  
*Room 8/9*  
**W3-F Symposium: Making the World Safer - Perspectives from Different Industries and Countries**  
*Sponsored by DARSG*  
*Chair: Ian Hall*

**1:30 pm** **W3-F.1**  
 Securing improved risk governance for water utilities  
*Gormley AM, Pollard SJT, Mauelshagen C*  
*Cranfield University*

**1:50 pm** **W3-F.2**  
 Changing perceptions of risk appetite through the use of simulations and scenarios  
*Hall IS*  
*Open University*

**2:10 pm** **W3-F.3**  
 Using the portfolio decision quality framework to guide risk assessment  
*Keisler JM, Linkov I*  
*University of Massachusetts Boston*

**2:30 pm** **W3-F.4**  
 Aligning risk with reality - a case study from the UK Financial Services Industry  
*Sides W, Hall IS*  
*LTSB Asset Finance*

**1:30-3:00 PM**  
*Room 10*  
**W3-G The Dose Response Wave**  
*Chair: Dwaipayan Mukherjee*

**1:30 pm** **W3-G.1**  
 Updated safety assessment of aluminum exposures from vaccination in infants using pharmacokinetic modeling  
*Walderhaug MO, Mitkus R, Hess M, King D*  
*FDA CBER*

**1:50 pm** **W3-G.2**  
 Effects of atrazine dose distribution on pharmacokinetics and pharmacodynamics in the rat  
*Kim D, Pastoor T, Yi KD, Campbell JL, Anersen ME, Clewell HJ, Handa RH, Breckenridge CB*  
*Syngenta Crop Protection, LLC, The Hamner Institutes, University of Arizona*

**2:10 pm** **W3-G.3**  
 Physiologically based toxicokinetic modeling of zearalenone and zearanol: estimating dietary exposure and toxicity for individuals at risk  
*Mukherjee D, Bandera E, Buckley B, Isukapalli SS*  
*Environmental & Occupational Health Sciences Institute*

**2:30 pm** **W3-G.4**  
 Polycyclic aromatic hydrocarbons analysis using chemical mass balance model  
*Julias C, Liu C, Luke N*  
*CDM*

**1:30-3:00 PM**  
*Room 11*  
**W3-H Symposium: Game Theory and Homeland Security**  
*Chair: Jun Zhuang, Vicki M Bier*

**1:30 pm** **W3-H.1**  
 Defender-attacker model for computer network security  
*Ertem M, Bier VM*  
*University of Wisconsin-Madison*

**1:50 pm** **W3-H.2**  
 Adversary modeling and defensive decision analysis for robust terrorism risk management  
*Barrett AM*  
*ABS Consulting*

**2:10 pm** **W3-H.3**  
 Attacker-defender games in cyber-physical networks  
*He F, Zhuang J, Rao NSV*  
*University at Buffalo, SUNY, Oak Ridge National Laboratory*

**2:30 pm** **W3-H.4**  
 Cost of equity in defensive resource allocations in the face of a possibly non-strategic attacker  
*Shan X, Zhuang J*  
*University at Buffalo, The State University of New York*

**1:30-3:00 PM**  
*Room 12/13*  
**W3-I Symposium: Benefits, Co-Benefits and Uncertainties of Air Quality Improvements**  
*Sponsored by: EBASG*  
*Chair: Elizabeth Gilmore*

**1:30 pm** **W3-I.1**  
 Reassessing the evidence on health benefits of cleaning air  
*Cox LA*  
*Cox Associates and University of Colorado*

**1:50 pm** **W3-I.2**  
 Health and climate benefits of cook-stove replacement options  
*Grieshop AP, Marshall JD, Kandlikar M*  
*North Carolina State University, University of Minnesota, University of British Columbia*

**2:10 pm** **W3-I.3**  
 Public health co-benefits from GHG mitigation options at a developing country  
*Pica APT, Cifuentes LAC, Borchers NBA, Cabrera CCC, Rodriguez MRB*  
*Pontificia Universidad Catolica de Chile*

**2:30 pm** **W3-I.4**  
 Assessment of inter-individual, geographic, and seasonal variability in estimated human exposure to PM2.5  
*Jiao W, Frey HC*  
*North Carolina State University*

3:30-4:30 PM	3:30-5:00 PM	3:30-5:10 PM	3:30-5:00 PM	3:30-5:10 PM
Ballroom C1	Ballroom C2	Ballroom C3	Room 6	Room 7
<p><b>W4-A Communicating Risks, Health and Well-Being</b>  <i>Chair: Amanda Boyd</i></p>	<p><b>W4-B Risk Assessment of Pharmaceuticals in the Environment</b>  <i>Chair: Matteo Conventino</i></p>	<p><b>W4-C Symposium: Fulfilling the Potential of EPA's Integrated Risk Information System (IRIS) Program</b>  <i>Chair: Becki Clark</i></p>	<p><b>W4-D Reliability Analysis and Modeling for Infrastructure Systems</b>  <i>Chair: Margaret MacDonell</i></p>	<p><b>W4-E Bio-Risk: Agriculture and Beyond</b>  <i>Chair: Mark Powell</i></p>
<p><b>3:30 pm W4-A.1</b>  H1N1 - Credibility of traditional health information sources and Web 2.0 information in Alberta  <i>Boerner FU, Jardine C, Driedger M University of Alberta, University of Manitoba</i></p>	<p><b>3:30 pm W4-B.1</b>  Pharmaceuticals in the environments: water occurrence assessment  <i>Conerly O, Hallberg G, Tomasik T US Environmental Protection Agency, The Cadmus Group</i></p>	<p><b>3:30 pm W4-C.1</b>  New initiatives for EPA's Integrated Risk Information System (IRIS) program  <i>Clark B, Kadry AM, Flowers L, Cogliano V US Environmental Protection Agency</i></p>	<p><b>3:30 pm W4-D.1</b>  Quantifying the hurricane risk to off-shore wind turbines  <i>Rose S, Jaramillo P, Small M, Grossmann I, Apt J Carnegie Mellon University</i></p>	<p><b>3:30 pm W4-E.1</b>  A systems approach to retrospective regulatory review: a case study of agricultural regulation in Washington  <i>Abbott LC, Schaub JD US Department of Agriculture</i></p>
<p><b>3:50 pm W4-A.2</b>  The influence of risk communication formats on benefit perception of medical treatments  <i>Keller C, Siegrist M ETH Zurich</i></p>	<p><b>3:50 pm W4-B.2</b>  Pharmaceuticals in the environment: health effects screening  <i>Conerly O, Gebhart AM, Fitzpatrick S, Bloom R US Environmental Protection Agency, Toxservices, US Food and Drug Administration</i></p>	<p><b>3:50 pm W4-C.2</b>  ATSDR approaches for increasing transparency, speed and stake-holder involvement in chemical risk assessments  <i>Fowler BA, Abadin H, Chou S, Demchuk E, Tie Y, Ruiz P, Mumtaz M, Wheeler J Agency for Toxic Substances and Disease Registry (ATSDR)</i></p>	<p><b>3:50 pm W4-D.2</b>  Recent advances in probability-bounds theory applied to aerospace  <i>Balch MS Applied Biomathematics</i></p>	<p><b>3:50 pm W4-E.2</b>  Examining the potential futures of plant targeted genetic modification  <i>Kokotovich AE, Kuzma J University of Minnesota</i></p>
<p><b>4:10 pm W4-A.4</b>  Which pictorial warning labels on cigarette packaging work best? Experimental evidence from smokers and youth in Mexico and the US  <i>Thrasher JF, Hammond D, Reid J, Driezen P, Boudreau C University of South Carolina</i></p>	<p><b>4:10 pm W4-B.3</b>  Decision-driven risk assessment of the pharmaceutical supply chain  <i>Conventino M, Collier ZA, Valverde JL, Tourki Y, Barber M, Keisler JM, Linkov I University of Florida, USACE ERDC, Ecole des Mines Nancy, MIT, University of Massachusetts Boston</i></p>	<p><b>4:10 pm W4-C.3</b>  Corrective lenses for IRIS  <i>Steinzor R, Shudtz M University of Maryland School of Law and the Center for Progressive Reform</i></p>	<p><b>4:10 pm W4-D.3</b>  Advancing probabilistic risk analysis by enhanced treatment of common cause failures: a mechanistic perspective  <i>Mohaghegh ZM, Modarres MM University of Maryland</i></p>	<p><b>4:10 pm W4-E.3</b>  Risk assessment on animal welfare performed at the European Food Safety Authority in the EU  <i>Serratos JS, Ribo OR European Food Safety Authority</i></p>
<p><b>4:30 pm W4-B.4</b>  Comparability of toxicological evaluation frameworks for veterinary and human pharmaceuticals and environmental chemicals for four federal programs  <i>Nachman K, Fain K, Shah S, Fox M Johns Hopkins University</i></p>	<p><b>4:30 pm W4-C.4</b>  Recommendations for Retooling IRIS  <i>Becker RA, Moran E, Fensterbeim R, Pottinger LH American Chemistry Council</i></p>	<p><b>4:50 pm W4-C.5</b>  Natural Resources Defense Council (NRDC) perspective on transparency, speed and stakeholders' involvement in EPA's chemical risk assessment  <i>Sass J Natural Resources Defense Council (NRDC)</i></p>	<p><b>4:30 pm W4-D.4</b>  Quantifying the interdependence between bridge capacity and load  <i>Hwang S, Haines YY University of Virginia</i></p>	<p><b>4:30 pm W4-E.4</b>  How do you model a "negligible" probability under the WTO Sanitary and Phytosanitary Agreement?  <i>Powell M US Department of Agriculture</i></p>
				<p><b>4:50 pm W4-E.5</b>  How to deal with gene-biohazard interaction?  <i>Eisinger F IPC</i></p>



**3:30-4:30 PM**

*Room 8/9*

**W4-F Environmental Risk Management Decisions**

*Sponsored by: DARSG*

*Chair: Robert Lee*

**3:30 pm**

**W4-F.1**

Natural resource damage assessment, risk assessment, and decision analysis:

Why can't we all be friends?

*Lee RC, Rytz R, Fitzgerald M, Black P*

*Neptune and Company, Inc.*

**3:50 pm**

**W4-F.2**

Evaluation of different data sources used to populate environmental strategic risk appraisal framework

*Dagonneau JM, Prpich G, Rocks SA, Polard SJT*

*Cranfield University*

**4:10 pm**

**W4-F.3**

Reducing the uncertainty in water quality assessment of corn verses switchgrass ethanol production

*Biksey T, Wu F, Kaltenbach M*

*EHS Support, Inc., University of Pittsburgh, University of Notre Dame*

**3:30-5:00 PM**

*Room 10*

**W4-G Panel Discussion: SRA Specialty Groups: What's Missing**

*Chair: Benjamin Trump*

Panelists:

*Trump BD, Linkov I, Palma OJ, Tokai A, Bostrom A*

*Carnegie Mellon University, US Army Engineer Research and Development Center, University of Lisbon, Portugal, University of Osaka, Japan, University of Washington*

**3:30-5:00 PM**

*Room 11*

**W4-H Risk Analysis Approaches for Cybersecurity and Critical Infrastructure**

*Sponsored by: SDSG*

*Chair: Thad Odderston*

**3:30 pm**

**W4-H.1**

Identifying and managing national-level cybersecurity risk

*Odderston TW*

*Department of Homeland Security, National Cyber Security Division*

**3:50 pm**

**W4-H.2**

Cyber-security risk assessment: challenges and solutions

*Panjwani S, Baecher G*

*University of Maryland*

**4:10 pm**

**W4-H.3**

Towards more risk- and performance-based US government standards for protecting buildings from vehicle bomb attacks

*Heatwole NT, Florig HK*

*University of Southern California, University of Florida, Carnegie Mellon University*

**4:30 pm**

**W4-H.4**

Game theoretical risk management

*Sneekenes E*

*Gjovik University College, Norway*

**3:30-5:10 PM**

*Room 12/13*

**W4-I Symposium: Quantifying and Communicating the US Domestic Benefits of GHG Emissions Reductions**

*Chair: Marus Sarofim*

**3:30 pm**

**W4-I.1**

Modeling US agricultural response under climate change

*Beach RH, McCarl BA, Ohrel SB,*

*DeAngelo BJ, Ross MT*

*RTI International*

**3:50 pm**

**W4-I.2**

Quantifying and communicating benefits and risks of GHG emission scenarios

*DeAngelo BJ, Gilmore EA, Sarofim MC,*

*Waldhoff ST, Martinich J, Cardamone K,*

*Ohrel S, Ragnauth S, Birnbaum R*

*US Environmental Protection Agency*

**4:10 pm**

**W4-I.3**

Quantifying and valuing climate change impacts on coral reefs in the US

*Martinich J, Lane D, Buddemeier R, Ready*

*R, Cardamone K, Carney K*

*US Environmental Protection Agency*

**4:30 pm**

**W4-I.4**

The impact of climate change on mortality risk and impacts attributable to extreme heat and cold in major U.S. metropolitan areas

*Mills D, Deck L*

*Stratus Consulting Inc.*

**4:50 pm**

**W4-I.5**

Assessing the economic impact of climate change induced sea level rise and storm surge in the US

*Neumann JE, Martinich J, Hudgens D, Emanuel K, Ravela S, Kirsben P, Bosma K, Ludwig L, Herter J*

*Industrial Economics, Incorporated; Climate Change Division, USEPA, WindRisk-*

*Tech, Battelle Memorial Institute, Woods Hole Group, Independent Consultant*



# SYMPOSIA DESCRIPTIONS

**Disclaimer:** All presentations represent the views of the authors, and not the organizations that support their research. Please apply the standard disclaimer that any opinions, findings, and conclusions or recommendations in abstracts, posters, and presentations at the meeting are those of the authors and do not necessarily reflect the views of any other organization or agency. Meeting attendees and authors should be aware that this disclaimer is intended to apply to all abstracts contained in this document. Authors who wish to emphasize this disclaimer should do so in their presentation or poster. In an effort to make the abstracts as concise as possible and easy for meeting participants to read, the abstracts have been formatted such that they exclude references to papers, affiliations, and/or funding sources. Authors who wish to provide attendees with this information should do so in their presentation or poster.

## MONDAY

### **M2-C Symposium: Tox 21/NexGen Dose Response**

The National Research Council (NRC) report, “Toxicity Testing in the 21st Century: A Vision and a Strategy,” provides a step-wise process that includes chemical characterization, toxicity testing, and dose-response and extrapolation modeling, with consideration of population-based and human exposure data at each step, along with consideration of what data are needed for decision-making. Another NRC report, “Science and Decisions: Advancing Risk Assessment,” cited a need for “a better match of the level of detail needed in a risk assessment to the questions that should be addressed.” The Tox21 program is a collaborative effort between the Environmental Protection Agency (EPA), National Institutes of Environmental Health Sciences (NIEHS)/National Toxicology Program (NTP), National Human Genome Research Institute (NHGRI)/NIH Chemical Genomics Center (NCGC), and the Food and Drug Administration. Tox21 is designed to develop, validate and translate innovative chemical testing methods that characterize toxicity pathways. In a parallel effort to leverage the availability of these new technologies and to implement the second NRC report, the EPA embarked on a program entitled “Advancing the Next Generation of Risk Assessment (NexGen),” which is a collaborative effort with the NIEHS/NTP, the Centers for Disease Control and the Agency for Toxic Substances and Disease Registry, NHGRI, the Department of Defense, and the State of California’s Environmental Protection Agency. The Dose Response Specialty Group teleseminars for 2011 covered topics on a central theme in talks by Weihsueh Chiu (EPA), Barbara Wetmore (Hamner Institutes for Health Sciences), Richard Judson (EPA). In this symposium, the teleseminars are summarized by rapporteurs on those talks, along with additional overview presentations on the two major projects (Tox21 and NexGen), and concluding with a panel discussion.

### **M2-D Symposium: Risks of Transportation Disruptions**

This symposium focuses on the risks of transportation disruptions. Disruptions in the transportation network may cause significant delays in transporting commodities, lead to lost business, and possibly endanger lives. This symposium includes talks examining several aspects of the risks of transportation disruptions. One presentation examines the risks of transporting dangerous goods, including the difficulties of transporting hazardous materials and some of the safety risks if a disruption causes hazardous materials to be released. Another presentation focuses on port security and examines methods to evaluate and improve port security. A third presentation explores the interdependent consequences of a multimodal transportation handling facility such as an inland waterway port, and how the resiliency of the facility impacts those consequences. The final presentation also analyzes the impact of transportation disruptions on companies and how companies can mitigate the risks of these disruptions. These presentations will include discussions of the importance of transportation infrastructure, economic analysis of disruptions, decision making to mitigate risks, and security and safety risks. Presenters are affiliated with the University of Southern California, Transport Canada, and the University of Oklahoma.

### **M2-H Symposium: Progress and Challenges in RA and RM at DHS: Culture and Methodology**

In the “Implementing Recommendations of the 9/11 Commission Act of 2007,” Congress required the Department of Homeland Security (DHS) to conduct a Quadrennial Homeland Security Review (QHSR) with the objective of outlining the strategic framework for Homeland Security. The first QHSR, published in 2010, states that “homeland security is about effectively managing risks to the Nation’s security.” DHS has made steady progress in risk management since it was formed in 2003, and this symposium will highlight

both recent advances, and ongoing challenges in risk practice. Specifically, this symposium will focus on advances and remaining challenges in two important areas: 1) building a culture of risk management in a young and maturing security organization, and 2) tackling some of the most difficult and important methodological challenges relevant to Homeland Security risk analysis. In the first area, organizational processes are just as important as sound analysis in terms of achieving risk-informed decisions. Different from approaches for improving methodological aspects of risk analysis, the difficulties in establishing lasting processes in a security organization are about changing the decision making culture, and can take a significant amount of time. This symposium will feature a presentation on progress in establishing risk-informed processes and culture within DHS. In the second area, the Department faces a number of methodological challenges including difficulties in estimating event likelihoods for “intelligent adversary” driven events such as terrorism, difficulties in quantitatively capturing the effect of deterrence, and the need for improved expert elicitation methods for security risk analyses. This symposium will discuss methodological improvements and remaining challenges in these and other areas, and in addition, will allow the broader risk community at SRA to offer feedback and suggestions to DHS for further improvement.

### **M2-I Symposium: Interagency Food Safety Analytics**

To meet shared analytical needs related to food safety, CDC, FSIS and FDA have joined together to form the Interagency Food Safety Analytics Collaboration (IFSAC). As its first priority, the IFSAC is focusing on improving estimates of foodborne disease attribution fractions. Attribution fractions indicate the percent of total foodborne illnesses due to a specific pathogen that is associated with contaminated food from a particular commodity; for example, the proportion of foodborne Salmonella illnesses that are due to contaminated eggs. Attribution fractions allow the regulatory agencies to estimate the number of illnesses linked to each food commodity, which helps with prioritization, economic analyses, and evaluation of the effectiveness of interventions. Collecting and analyzing the epidemiological data used to estimate the total number of foodborne illnesses is the responsibility of CDC. There are many different methodologies for estimating attribution fractions, and all have their strengths and weaknesses. The goal of IFSAC is to align the three agencies so they are working collaboratively to improve the estimation of these attribution fractions - to increase consistency in interpretation and application of attribution fractions, and to clarify the uncertainty associated

with these estimates. This symposium will present four sessions describing the framework and current work of IFSAC. First, an overview will be provided, describing the IFSAC Strategic Plan and the process that was undertaken to develop and get stakeholder input on the plan. Next, the approach to meet the short term needs for attribution will be discussed. Also, projects developed to expand or validate existing methodologies and estimates will be presented. The final presentation will discuss approaches that estimate attribution fractions as functions of consumption.

### **M3-C Symposium: Dose Response for Biothreats**

DRSG Symposium: The paucity of our knowledge of mechanisms controlling human resistance and susceptibility to doses of pathogens including biothreat agents currently limits options for risk managers to make science-based decisions about levels of concern for public health outcomes. US Army Public Health Command (USAPHC) recognizes a critical procedural gap: limited ability to integrate mechanistic knowledge of dose-response relationships into the military risk assessment matrix used to categorize population-level health and operational risks. USAPHC is utilizing available data from published dose-response studies to derive Biological Military Exposure Guidelines (BMEGs) for pathogens in air or water. This symposium focuses on the need for robust dose-response assessment (DRA) for pneumonic tularemia in primates, with extensive but fragmentary evidence of dose-dependency not only for likelihood of disease, but also for disease severity, duration, and incubation period. Extrapolations are needed between hosts, strains, and endpoints for robust, biologically-based modeling to support BMEGs derivation. Tularemia detection in urban aerosols with no corresponding human illness is inconsistent with the widely held assumption that as few as 10 bacterial cells are sufficient to cause human tularemia. The speakers address this and other inconsistencies from diverse perspectives including medical microbiology, microbial risk assessment, statistics and engineering, and aerosol research. The approaches presented for tularemia are relevant to multiple agencies seeking to transition into more biologically-based processes and procedures that integrate and expand knowledge of dose dependencies essential for establishing valid exposure guidelines for pathogens in air, food, and water.

### **M3-E Symposium: Listeria Monocytogenes Dose-Response Data and Models: Current and Future Advancements**

Invasive listeriosis is associated with a hospitalization rate of around 90% of those infected, and a high case fatality rate (among the highest of any food-borne pathogen, the third highest cause of death), leading to overall high public health burden and high health-related costs. Listeriosis is nevertheless a relatively rare disease in the general population, with regard to its relatively high frequency of isolation in food. The two major dose-response models scaled on epidemiological data for *Listeria monocytogenes* were developed by FDA/FSIS/CDC in 2003 and by FAO/WHO in 2004. Since then, knowledge on the bacteria, the host and their interaction has increased, notably concerning the physiopathology of the infection, the virulence of the strains and/or the susceptibility of individuals. New data from experimental infections on animal models as well as the distribution of different *L. monocytogenes* subtypes in ready-to-eat foods are available. A workshop on *Listeria* Dose-Response Models, co-sponsored by the Interagency Risk Assessment Consortium (IRAC) and the Joint Institute for Food Safety and Applied Nutrition (JIFSAN) was held in Washington DC in March 2011. This symposium will provide an overview of data and models for understanding the relationship between dose and adverse health effects for *L. monocytogenes* and a summary of the recommendations for future advancements in this area from the IRAC/JIFSAN workshop.

### **M3-F Symposium: Engaging Stakeholders in Risk-Informed Decision Making: Methodology and Case Studies**

There are many situations involving risk where stakeholders could have a major role in decision making. Traditionally, stakeholder values and opinions have been integrated qualitatively. This is a deficient method of operation, due to the large degree of information lost and the tendency of the loudest or most insistent opinion to be the only one heard. Further, a qualitative approach to stakeholder engagement does not allow for the expression of value judgements or for dealing with tradeoffs. Lastly, stakeholders can have a great variety of differing viewpoints. Thus, a method that integrates multiple lines of evidence is needed to account for the scope of information that must go into a comprehensive decision-making process. Quantitative methods, including Multi-criteria decision analysis (MCDA), offer a means to integrate value judgments into complex decision-making processes. They can also serve as tools to resolve conflicts which would normally prevent action in an important yet contested area. By quantitatively accounting for stakeholder opinions and

concerns, their ideas can be integrated into decision-making in a real and transparent way so that their views are accounted for. This session will present four examples in which stakeholders' opinions have been integrated into complex decision-making processes. Examples will be presented which show the integration of stakeholders from local communities and federal agencies, as well as domestic and international case studies. The symposium will give useful examples of how integrated risk management and decision analysis tools can be used to resolve stakeholder conflicts. Session topics include: • Stakeholder involvement in development of a dredged materials management plan for Long Island Sound • Integration of opinions of multiple government agencies for Department of State's Civilian Response Corps • Mental modeling approaches to cognitive decision-making • International example from Portugal showing informal examples of integrating stakeholder opinions

### **M3-G Symposium: Risk Communication and Trust in Canadian Aboriginal Communities**

In recent years, communication about risks to human health has commanded increasing public attention and reaction. As various agencies and organizations struggle to deal with an increasingly apprehensive and distrustful public about a bewildering variety of natural, man-made, voluntary and involuntary risks, it has become evident that social and individual trust in risk managers plays a profound role in the acceptability of decisions for risk actions. This is particularly pronounced in risk communication with Canadian Aboriginal populations. We examine this through three unique risk issues in a First Nations, Inuit and Metis community context in distinct geographic areas of Canada. In this session, the first presentation will outline the mixed methods research design for this project as well as highlight challenges in using a common evaluative framework to measure trust in these different cultural contexts. The second presentation will highlight the challenges of engaging effective risk communication processes in a community context that has been plagued by poor risk management processes in the remediation of a former gold mining operation. The third presentation will explore the complicated nature of communicating food risk messaging in a context where early attempts resulted in significant secondary risk exposures and an agency's efforts to address these in subsequent messaging through more community engagement. The last presentation will explore how one Aboriginal group has felt marginalized in most risk communication engagements as they are frequently considered an 'add on' if they are even considered at all. This will be explored looking at how risk communication efforts during pandemic H1N1 sought to redress this.

### **M3-H Symposium: Analyzing and Managing 21st Century Risks: Moving Beyond Newtonian Approaches**

At the dawn of the 20th Century, Newtonian physics proved inadequate in explaining newly recognized characteristics of energy, light, and other electromagnetic radiation and had to make way for the new theory of quantum mechanics. This did not mean that Newtonian approaches had no value. To the contrary, Newtonian physics still serves quite well for many purposes; for example, to describe the performance of the ballistic delivery systems developed to deliver weapons based on new physics theory. What it really meant was that that Newtonian physics was recognized as being both useful for many purposes and inadequate for many others. Similarly, it appears increasingly likely that traditional approaches to risk analysis and risk management, while perfectly suited to risks exhibiting certain fundamental characteristics, may be poorly suited, or even entirely unsuited, for use with risks exhibiting very different fundamental characteristics. This panel will explore this possibility through structured presentations that set forth the underlying proposition – that traditional risk analytic methods and management approaches are at best insufficient or at worst misleading when applied to certain categories of emerging 21st Century risks. First, a descriptive risk typology based on fundamental characteristics relevant to the appropriateness of various analytic and/or management approaches will be proposed. The remaining three presentations will provide more practically focused discussions on Complex Adaptive System theory and its potential utility for 21st Century risks, assessing the risks posed by adaptive terrorist adversaries, and a case study on a successful new paradigm for collaborative complex system risk management in civil aviation.

### **M3-I Symposium: Synthesizing Studies for Evidence-Based Decision-making: Part 1, Meta-Regression and Related Methods**

Risk analysts working in diverse areas are often faced with inconsistent or conflicting results from different studies of the same outcome or phenomenon, or with the need to assess policy outcomes that differ in some respects from those that have been studied. Deciding whether to rely on an individual study or whether (and how) to combine information across studies requires careful thinking about the nature of the problem to be addressed and the characteristics of the available research. Analysts interested in processing existing information quantitatively also must choose among various statistical methods, each of which will have advantages and limitations that depend in part on the nature of the research and the decisionmaking context. In Part 1

of this symposium, we consider some alternative approaches for addressing these quantitative issues. We show how strategies such as meta-regression and Bayesian data combination can be used to efficiently exploit existing information to inform proposed policies. We illustrate the use of these methods in different disciplines, including toxicology, epidemiology, and economics.

### **M4-D Symposium: Risk Management Actions for Emerging Contaminants**

This symposium will comprise five briefings that, when taken together, provide a holistic overview of how the Department of Defense's (DoD) Chemical and Material Risk Management Directorate (CMRMD) identifies, evaluates, and proactively manages the risks presented by emerging contaminants (ECs). ECs are those chemicals and materials with no existing peer-reviewed toxicity values or health standards or the existing standards are being re-evaluated due to new scientific findings. The presentations in this symposium will address the outcomes from DoD's three-tiered scan-watch-action process to identify ECs, methods to increase participation in interagency review of toxicity assessments, novel means of detecting and analyzing specific ECs, and initiatives to expand life cycle thinking as a means of minimizing potential impacts. The first briefing of the symposium will discuss the insights gathered from several interagency reviews of EPA IRIS toxicity assessments and will use a case study to demonstrate how changes in polycyclic aromatic hydrocarbons relative potency factors could impact certain DoD cleanup projects. The purpose of this presentation is to demonstrate how interagency participation strengthens the overall assessment and provides a head start for CMRMD's management of ECs. The second presentation will provide an update on the status of several risk management actions (RMAs) that have been initiated to proactively address potential impacts to the DoD from ECs. Two subsequent presentations will highlight RMAs for naphthalene and beryllium. Specifically, the two briefings will address the development of a personal dosimeter and its potential use to advance exposure assessment and new approaches to managing beryllium, a strategic, critical material, at end-of-life. The symposium will close with a discussion of a proposed life cycle assessment method that can better address environment, energy, water, and chemical liabilities.

### **M4-E Symposium: Microbial Safety of Fresh Produce, Spices and Herbs: Mitigating Risk from Farm-to-Table**

In the United States, outbreaks of foodborne illness have increasingly been associated with the consumption of fresh produce and spices in recent



years. Some of the most prominent examples include the Salmonella Montevideo outbreak with black and red pepper in 2009, the Salmonella Saintpaul outbreak associated with jalapeno and serrano peppers in 2008, and the E. coli O157:H7 outbreak associated with spinach in 2006. The reasons for the increase in apparent prevalence have so far remained unclear, and may reflect changes in consumption habits, alterations in production systems including increased imports to meet growing demands year-round, or other factors such as improved surveillance. Agricultural production systems are subject to numerous, highly diverse contamination sources along the farm-to-table continuum. In the absence of effective bacterial inactivation steps prior to consumption, contamination at any production stage may pose a direct risk to consumers. Due to the complex and highly diverse nature of current production systems, effective risk mitigation requires multi-disciplinary collaboration between regulatory agencies, relevant industries, academic partners and consumers. The session will begin with a discussion of risk assessments that evaluate the microbial risks associated with fresh produce consumption. The session will then address meteorological and landscape factors that could predict microbial contamination on farm. This discussion will be followed by review of surveillance sampling by the Food and Drug Administration and its use to characterize and prevent import of contaminated spices. Next, current risk analysis, mitigation, and control strategies employed by the spice industry to minimize the microbial risk will be presented. The session will conclude with an in-depth discussion of produce consumption patterns in the United States.

#### **M4-F Panel Discussion: Structuring Decision Processes to Manage Risks**

Risk analysis provides structure for understanding risks and their relation to an array of regulations and outcomes. Actions that are taken to affect risks are the result not just of analysis but of a decision process. Practical decision analytic methods can be combined with risk analysis. When risks are ambiguous, a decision focus may help to identify opportunities to manage or even exploit the nature of the problem. Technical aspects of risks form a basis for alternative generation. In some cases, axioms of rationality are appropriate and useful guidance. Yet risk-oriented decision processes must account for a range of stakeholder concerns. Many of these process considerations depend on the type of risk involved. This panel of practitioner-scholars experienced in both risk and decision analysis will discuss these and other issues.

#### **M4-G Symposium: Assessing and Managing Carbon Nanomaterials Risks: Current and Future Approaches**

With the continuing expansion of production and use of carbon nanomaterials, concerns regarding the potential health and environmental risks from these materials is also increasing. As with many of the nanomaterials currently in use and in development, there are significant challenges to assessing and managing the health and environmental risks that may be associated with these materials. This session will: 1) provide an overview of current research on the toxicity of carbon nanomaterials; 2) discuss key issues in assessing the risk of carbon nanomaterials; and 3) present recent efforts and proposed approaches by governmental agencies and industry to assess and manage these risks.

#### **M4-H Symposium: Adversary Modeling for Terrorism Risk Analysis Applications**

Homeland Security Presidential Directives (HSPD) -10, -18, and -22, recognize the need for systematic, science-based, terrorism risk assessments that inform strategic planning and resource prioritization. To address this need, the Department of Homeland Security (DHS) Science and Technology (S&T) Terrorism Risk Assessments (Bioterrorism Risk Assessment [BTRA]; Chemical Terrorism Risk Assessment [CTRA]; Integrated Chemical, Biological, Radiological and Nuclear Terrorism Risk Assessment [ITRA]) were developed. The TRAs are comprehensive, probabilistic risk assessments that integrate the expert judgments of the intelligence and law enforcement communities with those from the scientific, medical, and public health communities. S&T is committed to continual improvement of the TRAs in support of decision makers. This panel showcases some of S&T's recent investments in modeling the dynamic nature of an intelligent, adaptive adversary for risk analysis applications. The value of these and other approaches as a supplement or alternative to elicited static probabilities are being evaluated. The range of showcased approaches represents improvements to traditional probabilistic risk assessment as well as application of novel and existing methodologies to the problem.

#### **M4-I Symposium: Synthesizing Studies for Evidence-Based Decision-making: Part 2, Expert Elicitation**

Risk analysts often require estimates of quantities that cannot be easily derived from the available research, due to data gaps, conflicting or inconsistent results, or other sources of uncertainty. In Part 1 of this symposium, we considered cross-disciplinary methodological advances in the use of meta-regression and other statistical methods to combine data across studies. In



Part 2, we consider the use of expert elicitation, which is a rigorous, structured process for characterizing what is known about a quantity by eliciting experts' subjective probability distributions for the quantity. This symposium considers methodological innovations for addressing several related challenges, including how to most appropriately combine results across experts, how to use ordinal data, how to encode varying terminology used to describe probabilities, and how to address probabilistic inversion.

## **TUESDAY**

### **T2-B Symposium: Seafood Safety Following the Deepwater Horizon Oil Spill**

Since the Deepwater Horizon accident and oil spill in the Gulf of Mexico of April of 2010, a number of ambitious post-spill scientific studies have been undertaken, including large-scale studies of seafood wholesomeness and safety for human consumption. The most-widely recognized of those studies have been conducted by the U.S. Food and Drug Administration (FDA), the National Oceanic and Atmospheric Administration (NOAA), and government agencies from the states that border the Gulf of Mexico. To assure scientific integrity of the overall assessment of seafood safety and to meet public demand, those sampling and testing programs will continue for the foreseeable future. In addition, substantial research has been undertaken by academic and other independent investigators, private parties, and public/environmental groups. This symposium will include presentations by senior researchers from the University of Alabama (Birmingham), an international environmental advocacy group, U.S. FDA, NOAA, and state governments from the Gulf of Mexico region. Time permitting, the symposium will be concluded with an open panel discussion. T2-D Symposium: Climate Change Impacts and Adaptation Strategies: Evolving Roles of Risk Analysis

### **T2-D Symposium: Climate Change Impacts and Adaptation Strategies: Evolving Roles of Risk Analysis**

Climate adaptation is emerging as a critical mechanism by current policy can help human and natural systems can better adjust to a changing climate. Adaptation efforts in the United States are being conducted at multiple Governmental levels and by both public and private organizations. Because of the inherent uncertainty in both long-range societal projections and regional-scale climate projections, risk analysis will play an important and growing role in developing climate adaptation strategies at all levels. This symposium will bring together leading scientists from the US Geological Survey with

expertise on climate change impacts, who will describe cutting edge research on regional climate impacts with special reference to effects on the coastal margin. US Government officials will describe current Federal adaptation policies, and a risk assessment professional will consider how risk analysis can contribute to better decision making in the light of this information. Dr. Virginia Burkett, Chief Scientist for Global Change Research at the USGS, will describe regional climate change impacts using the latest available regional modeling data. Dr. Nathaniel Plant, Oceanographer with USGS, will discuss the use of Bayesian methods to derive estimate of coastal erosion as a function of sea level rise, local geology, and wave action that generates improved estimates of coastal erosion and hence climate impacts. Arthur Rypinski, US DOT economist, and Ralph Cantral, geographer and Senior Coordinator for the National Climate Assessment, will discuss the current climate adaptation and assessment efforts, in the light of the information presented by the scientists. Dr. Margaret MacDonell, Cumulative Risk Program Manager at Argonne National Laboratory, will survey current risk assessment practices in US adaptation efforts, and discuss potential improvements in the current state of practice.

### **T2-I Symposium: Regulation and Risk**

The four papers in this session illustrate a variety of issues involved in the regulation of risk and the treatment of risk in regulatory analysis. Presenters will discuss the role of science in regulatory decisionmaking, the efficacy of regulation when the nature of the regulated risks change, incorporation of uncertainty analysis into environmental benefit estimation, and recent trends in the assessment of uncertainty in regulatory impact analysis.

### **T3-C Symposium: Improving Problem Formulation and Dose-Response Beyond Science and Decision, Part 1**

Under the Alliance for Risk Assessment (ARA), a series of public workshops led by an Expert Panel of toxicologists and risk assessors were held in 2010 and 2011 to continue the discussion on elements of risk assessment set forth by the 2009 NRC report "Science and Decisions: Advancement of Risk Assessment." This ARA activity was supported by 45 entities, including government agencies, industry groups, scientific societies, non-profit organizations/consortia, and consulting groups. The first ARA workshop explored a variety of perspectives on issues raised by the NAS 2009 report and discussed possible case studies to address these. Representative case studies were then developed and evaluated during the second ARA workshop. In the third ARA

workshop, held in May 2011, additional case studies illustrating advanced risk assessment methodologies were presented and the Expert Panel discussed overarching considerations for problem formulation, use of mode of action, and addressing background and endogenous exposures. Recognizing that there is wide variety of risk assessment applications, depending upon problem formulation, the Expert Panel adopted a framework to organize examples of methodology applicable to different risk assessment needs, including qualitative, screening, and in-depth assessments. The case studies were linked to these different risk assessment objectives to provide examples of the range of available methods; this is envisioned to be expanded to provide a compendium of methods to illustrate specific dose-response techniques for different risk assessment settings. This symposium will present the results and recommendations of this ARA project with specific focus on the Expert Panel's discussions for improving problem formulation and use of mode of action, the framework and compendium of dose-response methods, and specific case studies centered on conveying the application of the framework for informing method selection.

### **T3-I Symposium: Catastrophic Climate Change**

Climate change is among the most significant catastrophic risks that global society faces. This session features a range of perspectives on catastrophic climate change and responses to it. Scholarship a diverse range of fields including economics, engineering, geography, and psychology bring insight to how severe the threat of climate change is and how the threat can be addressed through measures including incentives, institutions, and geoengineering.

### **T4-B Panel Discussion: Symposium: Public Preferences and Regulatory Decision-Making - Smart Inputs for Smart Decisions?**

As climate change becoming one of the most important issues facing human development, countries are trying to find suitable solutions to this non-reversible procedure. All over the world, low-carbon development options are widely discussed and have started being adopted both at national and local level. As the basic unit of public service providing economic development as well as ecological sustainability, various actors in society including governments, industry and civil society, take on responsibility for balancing environmental protection and economic development. In this process, the essential question lies in how to make smart decisions on the basis of expertise, public values and citizen preferences. The key research question in the research presented here is to explore how these essential groups form their own opinion on low-

carbon technologies selection for power supply, communicate these opinions to others and how this selection may influence regulatory decision making. The symposium will be divided into two parts. First, three short presentations will provide data and results from the US and Germany within a total of 45 minutes. Second, a set of panelists (including Ortwin Renn, Ragnar Löfstedt) will discuss within a total of 45 minutes the issue of public preferences as a policy factor. We would like to thank the Stiftung Mercator for financial support for doing this research.

### **T4-C Symposium: Improving Problem Formulation and Dose-Response Beyond Science and Decision, Part 2**

Under the Alliance for Risk Assessment (ARA), a series of public workshops led by an Expert Panel of toxicologists and risk assessors were held in 2010 and 2011 to continue the discussion on elements of risk assessment set forth by the 2009 NRC report "Science and Decisions: Advancement of Risk Assessment." This ARA activity was supported by 45 entities, including government agencies, industry groups, scientific societies, non-profit organizations/consortia, and consulting groups. The first ARA workshop explored a variety of perspectives on issues raised by the NAS 2009 report and discussed possible case studies to address these. Representative case studies were then developed and evaluated during the second ARA workshop. In the third ARA workshop, held in May 2011, additional case studies illustrating advanced risk assessment methodologies were presented and the Expert Panel discussed overarching considerations for problem formulation, use of mode of action, and addressing background and endogenous exposures. Recognizing that there is wide variety of risk assessment applications, depending upon problem formulation, the Expert Panel adopted a framework to organize examples of methodology applicable to different risk assessment needs, including qualitative, screening, and in-depth assessments. The case studies were linked to these different risk assessment objectives to provide examples of the range of available methods; this is envisioned to be expanded to provide a compendium of methods to illustrate specific dose-response techniques for different risk assessment settings. This symposium will present the results and recommendations of this ARA project with specific focus on the Expert Panel's discussions for improving problem formulation and use of mode of action, the framework and compendium of dose-response methods, and specific case studies centered on conveying the application of the framework for informing method selection.

#### **T4-E Symposium: Food Safety Risk Prioritization and Decision Analysis**

Increasing concerns regarding food safety in the U.S. has led to new legislation that affects producers and suppliers at all levels of the supply chain and helps increase protection for consumers. The Food Safety Modernization Act, signed into law on January 4, 2011, includes provisions to prevent, detect, and respond to food safety problems. The law calls for a risk-based approach that establishes priorities, targets significant food safety risks, and minimizes foodborne illness, a strategy that was advocated in the 2010 report released by the Institute of Medicine and National Research Council, *Enhancing Food Safety: The Role of the Food and Drug Administration*. Consequently, there is an urgent need for decision frameworks and associated methods/tools/data that can be used to (1) rank risks for food commodities and hazards; (2) establish priorities based on public health impacts and other non-health related consequences; (3) compare the feasibility, efficacy, and cost effectiveness of various mitigation options; and (4) develop an optimal strategy to allocate resources to reduce the burden of foodborne disease. This symposium will focus on ongoing and recent research into methods, models, and data that can be used to support science-based decision making, prioritizing hazard-commodity risks using decision attributes relevant to public health outcomes and policy objectives. The symposium will provide an overview of a prototype decision support system recently completed by the U.S. Food and Drug Administration, and highlight recent research in the risk ranking/prioritization methods that is critical in the decision-making process. Key issues that will be addressed include the importance of developing quality data, the advantages and disadvantages of “top down” versus “bottom up” approaches, and the integration of risk-based metrics with non-risk metrics within a decision-making context.

#### **T4-I Symposium: Global Catastrophic Risk**

Global catastrophic risks (GCRs) are risks of events that could significantly harm or even destroy civilization at the global scale. GCRs are thus risks of the highest magnitude, regardless of probability. Major GCRs include climate change, pandemics, nuclear warfare, and potential new technologies. This symposium features diverse perspectives on how to effectively assess and respond to GCRs through research, policy, and other means.

#### **WEDNESDAY**

#### **W1-A Symposium: How the Public Responds to Different Disasters over Time: The Role of Perceived Risk, Emotion and Risk Communication**

To understand the underlying dynamics of public response amidst a crisis we need to observe how perceived risk, emotion, and risk-related behaviors emerge and co-vary over time. Specifically, we must examine their trajectories, that is, how these factors escalate, peak and then decline. We also need to consider their potential consequences, and the mitigating role of risk communication. This session will discuss findings from studies that include terrorism, technological accidents and natural disasters. Reports are drawn from case studies, simulated scenarios and longitudinal surveys following actual events. Methodological challenges will be discussed. Recommendations for risk and crisis communication will be offered.

#### **W1-B Symposium: Analytical Approaches to Food Safety Management**

The USDA Food Safety and Inspection Service is exploring quantitative risk assessment methodologies to incorporate the use of Codex Alimentarius' newly adopted risk management metrics. Traditionally, regulated food processing systems have relied on process control and performance standards to achieve a safe and wholesome product. In the past, such measures have not been associated with public health outcomes and therefore the impact not easily measured. However, the use of quantitative microbiological risk assessment has allowed linking of public health outcomes due to consumption with the product's microbiological status at the processing establishment. To improve public health and the sanitary situation in member countries, the World Trade Organization agreed to sanitary and phytosanitary measures including the Appropriate Level of Protection (ALOP, risk of illness per serving), and the recently adopted risk management metrics Food Safety Objective (FSO, cfu/g at consumption) and Performance Objectives (PO, cfu/g at designated control points in the food process). By hypothesizing various levels of acceptable risk, risk assessment can be used to link these public health outcomes with bacterial levels in food at the point of processing and ultimately establish the stringency of a food safety process. However, the practical application of using risk assessment for this purpose and the development of the methodological tools has only recently garnered attention. To meet the need to develop tools to establish these new food safety metrics, two examples were developed: *Listeria monocytogenes* in ready-to-eat (RTE) deli meats and *Salmonella* and *Campylobacter* in chicken. By modifying these risk assessments, we demonstrate



how risk assessment can be used to set regulatory ALOP, FSO and POs for not only these examples, but other pathogen-commodity pairs. In addition, this symposium will review the background, current state of knowledge, and policy and trade implications.

### **W1-F Symposium: Risk Assessment for Acquisition and Assets Management**

In the context of federal acquisition and asset management systems, risk analysis could have valuable application in forecasting the life cycles and associated resource requirements of newly proposed programs. Currently, both systems experience frequent cost and schedule overruns. This year, DoD and MORS took a closer look into how risk analysis and decision analysis is conducted. To improve the process and address increased fiscal constraints, federal agencies require more fidelity in risk analysis prior to approving acquisition and management programs. These more stringent requirements have forced the investigation of improved risk analysis and trace space decision methods and tools. This session will start with an evaluation of risk analysis in Department of Defense acquisition programs and a discussion of current shortcomings. It will continue with an overview of September's Military Operations Research Society (MORS) Workshop on Risk, Trade Space and Analytics for Acquisition, including a review of the newly defined best practices for risk and trade space analytics. Following this will be an examination of risk analysis in federal asset management programs, incorporating an application of risk portfolio and decision analysis methodologies for the US Army Corps of Engineers. The session will conclude with presentation on the identification, ranking, and management of risks in a major system acquisition.

### **W1-H Symposium: Managing Risks from Hurricanes in Coastal Areas**

Protecting communities from hurricane risks presents a myriad of homeland security challenges. Risks can be reduced through coastal restoration, structural mitigation (e.g. levees), building codes, evacuation planning, insurance, or incentives for construction in less threatened areas. The effectiveness of any of these measures is highly uncertain and depends on both technical and societal factors. Risk management choices are further complicated by potential and observed trends in hurricane frequency or severity, coastal elevation, and sea-level rise. Risk analysis is being used to help government organizations and communities address the complexity of this risk management problem. This symposium describes four studies that are applying interdisciplinary risk analysis methods to help communities in Louisiana, Texas, and North Carolina

better understand the risks that hurricanes represent. The studies draw on a broad set of methods including hurricane modeling, risk perception studies, mental models analysis, and multicriteria decision analysis under uncertainty. Together these studies demonstrate how risk analysis can contribute to improving decisions about how best to manage hurricane risks.

### **W2-B Symposium: Poster Platform: The Development of High Throughput Exposure Techniques for Prioritizing Chemical Risks**

A set of diverse factors drives the need to develop high throughput risk characterization techniques for managing chemical risk. While only limited data are available to characterize the potential toxicity of over 8 million commercially available chemical substances, there is even less information available on the exposure and use-scenarios that are required to link potential toxicity to human and ecological health outcomes. Recent improvements and advances such as high throughput toxicological testing, genomics and metabonomics, high performance computational capabilities, and predictive chemical inherentcy methodology demand comparable rapid exposure assessment approaches to establish a risk based prioritization of chemicals. The findings of a 2009 USEPA workshop on chemical prioritization suggested that current approaches have significant limitations in their applicability to EPA's need to prioritize thousands of chemicals on the basis of human exposure necessitating the development, refinement and evaluation of new methods. In response to the EPA's need for development of novel approaches and tools for rapidly prioritizing chemicals, a "Challenge" was issued to several exposure model developers to aid understanding of current systems in a broader sense and to assist EPA's effort to develop a new approach comparable to other international efforts. Topics presented in this symposium include: (1) an overview of EPA's new multi-tiered testing framework under the research plan, Chemical Safety for Sustainability; (2) the results and gap analysis of the model "Challenge"; (3) development of two novel models for rapid exposure; (4) development of a decision analytic model to synthesize disparate metrics of exposure and rank chemicals; and (5) application of this knowledge to risk characterization through integration with data from high throughput toxicity assays.

### **W2-E Symposium: Rapid Risk Evaluation: Analytic Tools to Support Federal Response to Environmental and Food Safety Incidents**

Over the past decade, U.S. federal agencies have focused on the development of robust quantitative risk assessments to guide regulatory decisions to improve food safety and mitigate environmental exposures to contaminants.

While integral to guiding the development of sound science-based policies to protect public health, these probabilistic risk assessments are data intensive and take several months up to a few years to develop. In the event of incidents such as fires, chemical or oil spills, or other accidental or intentional releases of chemical contaminants, there is a need to rapidly evaluate environmental and public health risks. This symposium will explore the development of rapid risk evaluation approaches and modeling tools developed by the U.S. Department of Agriculture and Food and Drug Administration to rapidly respond to food safety incidents, and by the Environmental Protection Agency to address accidental environmental releases. Panelists will discuss a wide array of issues in developing rapid risk evaluation systems, including the development of novel modeling methods to guide public health-based laboratory detection methods for emerging hazards, use of graphical tools to array the available dose-response data and/or health effect reference values available for the agent being considered, and the role of toxicity values using structural-surrogates for chemicals that lack adequate human or animal studies. Case studies will be presented along with information on the utility of these models and lessons learned.

### **W2-H Symposium: Risk Communication in the US Hurricane Forecast and Warning System**

From the National Climatic Data Center list of billion dollar U.S. weather events from 1980 to 2009, 25 out of the 96 were hurricanes (Lott, Ross, Smith, Houston, & Shein, 2010). Despite significant and ongoing improvements in hurricane forecast accuracy, economic and social risks from hurricanes continue to grow, and may be exacerbated by increasing frequency or intensity of extreme weather events due to climate change. Forecasts and warnings can contribute to the protective action decisions that individuals make during hurricanes, but research suggests room for improvement. Just communicating the probabilities required to demonstrate the uncertainty implicit in weather forecasting has proven particularly difficult for the meteorological community (Joslyn, Nadav-Greenberg, Taing, & Nichols, 2009; Morss, Demuth, & Lazo 2008). This session reports on research to assess the status of and specific potentials for improvements in the U.S. hurricane forecast and warning system. The first paper in the session explores people's awareness and understanding of storm surge risks and preferences for surge warning information messages (Lazo, NCAR). The second paper examines the social and cultural communication context of the hurricane

warning system with an emphasis on inter-organizational successes and challenges (Demuth, NCAR and Colorado State). The third paper reports new findings about the effectiveness of alternative communication approaches derived by observing behavior in realistic hurricane simulations (Meyer, U. Penn). The final paper in the session reports on forecasters' understanding and perceptions of the hurricane forecast and warning system, based on individual mental models interviews and a group decision modeling session with forecasters from the National Hurricane Center and the Miami-Dade Weather Forecast Office (Bostrom, U. Washington).

### **W3-C Symposium: Graphic Depictions of Toxicological Data**

Graphical depictions of toxicological and epidemiological data (e.g., exposure-response arrays and forest plots) are increasingly being incorporated into risk assessment documents. Exposure-response arrays have recently been added to documents developed by the EPA for the IRIS program, and they have been proposed for inclusion into the Integrated Science Assessment (ISA) documents for the National Ambient Air Quality Standards. There are similar data presentations in the Technical Support Documents developed for the Acute Exposure Guideline Levels (AEGs) and have long been a part of the Toxicological Profiles developed by ATSDR. Similarly, forest plots have been used to depict epidemiological data and have become integral components of the ISA documents, as well as in NIEHS National Toxicology Program documents. The goals of this symposium are to highlight recent activities within Federal Agencies in developing the most effective and consistent approaches to relaying complex toxicological and epidemiological information into more easily understood graphic displays.

### **W3-E Symposium: Innovative Means of Data Collection to Support a Quantitative Risk Assessment**

Quantitative risk assessments depend on availability of data from multiple sources. Although classic approaches such as market basket surveys, laboratory studies and regulatory sampling continue to be the main data sources for exposure assessment of food hazards (including microbial pathogens and pollutants), recently innovative means have been used to expand data acquisition capacity. For example, site visits to manufacturing plants, produce growing fields and cruise ships have been conducted to help risk assessment teams better understand the industry and potential routes of contamination. Seeing first-hand industry control measures and differences among establishments can facilitate the development of more realistic product-pathway models. An-



other novel approach is the use of geographic information system to incorporate real-time field environmental and climatic geospatial data from NASA satellites into risk assessment of *E. coli* O157:H7 and other enteric pathogens in produce. Attention will be paid to the importance of the time schedule through comparison between assessing a routine situation versus an accidental crisis for radiological hazards in foods (e.g. Fukushima accident). This symposium aims to bring together speakers from different organizations to share their experiences, as well as sharing lessons learned from these and other innovative means so as to facilitate expanding data collection efforts to support risk assessments.

### **W3-F Symposium: Making the World Safer - Perspectives from Different Industries and Countries**

This symposium seeks to provide perspectives from different industries and countries to the question; How does how the Corporate World makes practical use of Risk Assessment theories, bodies of knowledge, and deal with the challenges presented by information time & monetary constraints? Each participant considers this question from a different perspective, with studies focusing on the use of scenarios, decision making constrained by time and information and the ways in which the value of analytic efforts may be quantified and compared against their cost, resulting in an explicit theoretical framework for how to deal with the challenges. Presenters are from the UK, USA and Canada providing an international flavour to this session

### **W3-H Symposium: Game Theory and Homeland Security**

This symposium will consist of four or five presentations on game theory modeling in attacker-defender models in homeland security. Confirmed presenters include: (1) Dr. Vicki Bier (University of Wisconsin-Madison) who will talk about “Attacker-Defender Model for Computer-Network Security”; (2) Dr. Anthony M. Barrett (ABS Consulting) who will talk about “the integrated analysis of attack risks and defensive resource allocation decisions for a set of illustrative examples, using Monte Carlo modeling to propagate and analyze uncertainties and to help identify robust strategies”; (3) Dr. Jun Zhuang (University at Buffalo) who will talk about “Game-Theoretic Analysis of Attack and Defense of Cyber Infrastructures”; (4) Mr. Xiaojun Shan (University at Buffalo) who will talk about “Cost of Equity in Defensive Resource Allocations in the Face of a Possibly Nonstrategic Attacker”. One more presenter from the University of Stavanger, Norway, is

still deciding whether to join or not. W3-I Symposium: Benefits, Co-Benefits and Uncertainties of Air Quality Improvements

The estimated public health benefits from controlling air pollution have generally exceeded the estimated mitigation costs. For example, the US Environmental Protection Agency calculated that thousands of premature deaths and numerous cases of illness could be prevented by reducing exposure. These estimates, however, can still be controversial and hide some important sources of uncertainty. Understanding this uncertainty is critical, especially as climate change mitigation strategies are increasingly being justified by the large air quality co-benefits. In this symposium, we review the air quality and human health relationships and the estimation of air quality benefits. We follow with analyses that evaluate uncertainties in air quality exposure and co-benefits. We also discuss the implications for air quality improvements and climate change mitigation strategies.

### **W4-C Symposium: Fulfilling the Potential of EPA’s Integrated Risk Information System (IRIS) Program**

EPA’s Integrated Risk Information System (IRIS) provides health risk information on over 500 chemical contaminants found in air, water, or soil. Each assessment identifies adverse health effects associated with the chemical and provides toxicity values used to set health-based regulatory standards or to evaluate health risks from chemical exposure. Originally an internal tool for EPA risk assessors, in 15 years IRIS has become a resource used by scientists and nonscientists the world over. Increasing utility has brought greater scrutiny to IRIS. The process for developing IRIS assessments includes review by scientists across EPA, external review by other federal agencies, external peer review by independent scientists, and final review by EPA and other federal agencies. EPA also solicits comments from stakeholders and the general public, and these opportunities have sometimes created pressure on EPA to delay assessments, to wait for studies in progress, and then to loop back for further review. As a result of these pressures, an average of only two new assessments per year had been completed for the several years through 2008. The IRIS process was streamlined in 2009, subsequently, the pace has accelerated. The year 2011 is a pivotal one: major IRIS assessments with important public health implications – some under development for more than 10 years – are scheduled to be completed, a National Research Council report recommended major changes in the development and presentation of IRIS first drafts, and the Government Accountability Office will release an analysis of factors that

have contributed to past difficulties. This workshop will examine challenges facing IRIS and compare them with those faced by other public health assessment programs. The discussion will include perspectives from risk assessors who worked at different public agencies, regulated stakeholders, and public-advocacy organizations.

#### **W4-I Symposium: Quantifying and Communicating the US Domestic Benefits of GHG Emissions Reductions**

A strong motivation for climate policy in the US is avoiding economic and environmental damages and preventing adverse human health effects. Developing consistent estimates of these benefits for specific emission pathways, however, is challenging. Existing literature estimates may have been generated using different and possibly inconsistent scenarios which cannot be easily adapted for policy analysis. In addition, these estimates may not have sufficient spatial or sectoral resolution for assessing the benefits of GHG reductions for the US. To address this gap, the Climate Change Division (CCD) within the US Environmental Protection Agency (EPA) is developing a framework for the quantification and communication of US domestic damages and benefits under multiple GHG emissions pathways. The methodology consists of four main components: 1) Establishing a consistent set of socio-economic and climate scenarios that can be applied across models of differing temporal and spatial resolution; 2) Coordinating and integrating general and partial equilibrium and sectoral models; 3) Describing and quantifying uncertainty; and, 4) Presenting and communicating the results through metrics and indicators, both physical and monetized, that span a range of impacts and risks. In the first presentation, EPA presents the framework and a preliminary description of the benefits and risks of climate scenarios. Next, four interdisciplinary groups present their modeling efforts to quantify the benefits of emission reduction in terms of impacts on coastal areas from sea level rise, human health from changes in extreme heat and cold temperatures, coral damage from bleaching events, and land use change and its impacts for agriculture, forestry and bioenergy. Each presentation covers how the EPA framework was applied to the specific model. The views expressed in this symposium are those of the authors and do not necessarily reflect the views of the Environmental Protection Agency.

# ABSTRACTS

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*ATSDR*

## **DEVELOPMENT OF ATSDR'S LEVELS OF SIGNIFICANT EXPOSURE TABLES AND FIGURES**

ATSDR's toxicological profiles are developed in response to the Superfund Amendments and Reauthorization Act of 1986 which amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). This public law directed ATSDR to prepare profiles for hazardous substances most commonly found at facilities on the National Priorities List and that pose the most significant potential threat to human health. While the profiles contain a wide variety of information about the substance being profiled, one of the ultimate goals is to provide a summary of available health effect data. Key to this effort is the extraction of data into a central database, compiling significant exposure level information. The Levels of Significant (LSE) tables and figures found in the profiles represent a subset of what is determined to be the most reliable data from what has been collected in the central database. LSE tables and figures are used collectively and individually to provide a visual representation of the data.

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## **A SYSTEMS APPROACH TO RETROSPECTIVE REGULATORY REVIEW: A CASE STUDY OF AGRICULTURAL REGULATION IN WASHINGTON**

Regulation is frequently used as a risk management tool to reduce human health, safety or environmental risks. Regulatory analysis evaluates the projected costs and benefits of such regulations designed to reduce risk, but may not evaluate the impact of a regulation on risks not targeted by that regulation. Choosing a regulatory tool to reduce one type of risk may have unintended consequences on management of other risks. Retrospective analysis of the series of regulations addressing agricultural pesticide use could yield information about actual costs and benefits of concurrently applied actions. We evaluate the cumulative impact of a series of pesticide and endangered species risk management decisions - some by federal agencies, some judicially mediated - on agriculture and salmon populations in an agricultural watershed. The use of pesticides is a risk management decision by growers to mitigate crop damage from pests or diseases arising in the agroecosystem. Assessing changes in pesticide use alone only examines one aspect of the agroecosystem - we examine the regulatory impact of pesticide restrictions on several aspects of the Yakima County agroecosystem. We examine temporal dynamics of agroecosystem components, including changes in land use, crops, pest pressure, production, market value, and pesticide use

on major crops grown in the watershed as well as changes in salmon populations and pesticide concentrations in environmental media. Risk reduction due to new pesticide use patterns is estimated for human health and non-target species through application of the methodology used by the Environmental Protection Agency to register pesticides. Impacts to agriculture are assessed by examining changes in agricultural land use, production, marketing adjustments and farm revenues. We compare our findings to the cost and benefit analyses supporting changes to pesticide registrations and the designation of critical habitat for the salmon in Yakima County.

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## **AN APPLICATION OF ENTERPRISE RISK MANAGEMENT IN THE MARINE TRANSPORTATION INDUSTRY**

Establishing the current status and future direction of an organization's enterprise risk management (ERM) practice demands an ability to benchmark the existing level of performance and prioritize where risk mitigation actions are warranted. This requires a systematic and holistic approach that can identify and assess all foreseeable risk scenarios, compare them on a common basis for prioritization purposes, and evaluate the effectiveness of candidate risk mitigation strategies. Designing and implementing a management tool that organizations can utilize for this purpose is challenging, given that it must be comprehensive in nature, yet easy to apply without requiring considerable investment of both staff time and financial resources. This paper describes the development of such a tool and its subsequent application to a large marine transportation carrier. In this application, two separate ERM activities were undertaken; one focusing on a functional line of operations throughout the entire organization (information technology and cyber security), and the other involving all activities associated with a specific geographical region that serves as an operations hub. The resulting scenario development, risk assessments and candidate mitigation strategies are described and discussed. The paper also shares several lessons learned that are important for organizations interested in developing and applying ERM tools. These include how to overcome the challenges of: (1) structuring a framework for identifying enterprise risks and creating corresponding scenarios that are all inclusive, (2) involving employees at multiple levels of the organization in the risk assessment process, (3) creating an appropriate method for estimating the likelihood and consequences of various risk scenarios, and (4) developing a protocol to enable evaluation of the benefits and costs of potential risk mitigation strategies directed at those risks that warrant priority attention.

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## **SUMMARY OF THE 2011 DRSG TELESEMINAR PRESENTATIONS AND DISCUSSIONS**

The DRSG sponsored teleseminar series for 2011 had the theme “Tox21/NexGen: Dose-Response and In vitro to In vivo Extrapolation.” The series consisted of three teleseminar presentations, with the anticipation of a continued discussion in a symposium format at the 2011 SRA Annual Meeting. In the first talk in the series, Weihseh Chiu (EPA NCEA) spoke on the topic “NexGen Risk Assessments: Challenges and Opportunities for Dose-Response Assessment.” The second talk, given by Barbara Wetmore (Hamner Institutes for Health Sciences), covered the topic “Integration of Dosimetry, Human Exposure and High-Throughput Screening Data in the Toxicity Assessment of Environmental Chemicals,” and the final talk in the series was presented by Richard Judson (EPA NCCIT), who covered a paper on the topic “Estimating Toxicity-Related Biological Pathway Altering Doses for High-Throughput Chemical Risk Assessment.” This presentation by the teleseminar rapporteurs will share the general themes covered in each talk and incorporate the information exchanged during the question and answer period following each presentation. This report of the teleseminar series will also identify some of the broader aspects that should be considered in the panel discussion that will conclude the symposium session.

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## **EXPLORING PUBLIC PARTICIPATION DECISION-MAKING AT SUPERFUND SITES: A MENTAL MODELS APPROACH**

While public policies and programs in the United States encourage public participation in agency decisions on environmental issues, how best to engage the public remains controversial and challenging, particularly when complex and uncertain technical issues are involved. This research applies a mental model methodology to explore what people engaged in Superfund site cleanup decisions think about when making public participation decisions. Mental models of public participation decision-making are developed based on a literature review, expert interviews, professional workshop discussions, and semi-structured interviews of participants engaged in public participation at two Superfund sites. The models provide an illustrative framework of interconnected variables that are coherent to public participation professionals and consistent with current public participation theory. Analysis of the interview are used to distinguish three characteristic ways of thinking - experiential, analytical, and strategic - which are associated with ad hoc, informing, and intentional types of public participation decision-making, respectively. Also, differences in expert and participant models indicate that experts are generally more attentive to broad-reaching, long-term societal objectives than participants. While established in risk communication

research, this is the first known application of the Mental Models methodology for public participation research. The mental models that emerge from this research identify the diverse range of variables and the relationships among variables that should be considered during public participation planning and decision-making. The identified different ways of thinking about public participation reveal communication barriers that can lead to different decisions about how best to conduct public participation and frustrate efforts to work together. Implications to public participation theory, research, policy, and practice are discussed.

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## **METEOROLOGICAL RISKS REDUCTION IN FORECASTING CONVECTIVE EVENTS FROM SATELLITE DATA**

There exists a problem of forecasting convective weather hazards (showers, hail, thunderstorm, strong wind, etc.) that present a high risk to all spheres of social and economic activity. These events are generally hard to predict, so it is highly probable that they affect the economy and society and cause substantial economic losses that represent one of the components of meteorological risks. Observations at meteorological stations and measurement data are used to produce forecasts of hazardous events, with satellite data being of particular interest here. The aim of this work is to give an estimate of the contribution of satellite data to the production of reliable and accurate forecasts of hazardous convective events. These estimates are based on the data obtained from the experiments conducted in July-August 2010 and February-March 2011 at two divisions of the Russian Hydrometeorological Service that are located in different regions. In the course of these experiments, two forecasters concurrently prepared two forecasts, with and without using satellite data. Data from Meteosat-8 geostationary satellite and NOAA polar orbiting satellites were used to produce the forecast. The results of the two forecasts were compared with the actual weather. Based on the comparison results, matrices of the coincidence of the forecast with the actual weather were constructed. Numerical calculations and comparative analysis were conducted by using criteria of Russian and foreign authors. The calculation from each of the above criteria shows that the forecasts produced by using satellite data are more successful and accurate than those produced without using satellite data. Owing to these forecasts, users of hydrometeorological data make better decisions that make it possible to reduce the risks related to hazardous hard predictable convective events.

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## **QUANTIFYING RISK USING ERROR TOLERANCE**

Quantitative risk analysis typically involves a probabilistic approach in which uncertain parameters contributing to risk are quantified as continuous or discrete distri-



bution of values with associated probabilities. When there are insufficient data, these distributions must be elicited from experts. Assessing ranges and probabilities from expert interview is a significant challenge, and in our experience can be a roadblock to implementing risk analysis in decision making. When the objective of risk quantification is risk mitigation, the probabilistic approach is not always necessary. What is necessary is that the risk factors are identified and prioritized in the order of their impact on the business objective. For this purpose, we propose the use of error tolerance as a measure of risk. The essential idea of this approach is to analyze a system using current assumptions and then to quantify the extent to which the error in those assumptions can be tolerated before the assessment of the system performance has to change significantly. It is different from a straight forward uncertainty analysis in that the error tolerance provides a more explicit measure of the risk of being wrong. This approach is useful when the decision makers have very limited access to information. The idea will be illustrated through examples, including one in which the risk of throughput shortfalls is estimated for a new plant design, for which the process technology is provided entirely by a third party.

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### **TARGET EXCESS LIFETIME CANCER RISKS COMMONLY USED IN PRACTICE**

The stated goal of environmental management programs is almost uniformly to protect human health and the environment. There is no real disagreement on this fact. However the ultimate target for reaching this goal is not as clearly defined. Common misconceptions are that it is routine regulatory practice to make risk-based management decisions for carcinogens solely on a total site excess lifetime cancer risk (ELCR) equal to one additional cancer case in an exposed population of one million ( $1 \times 10^{-6}$ ) estimated by conservative risk assessments and that deviations from this target are unusual. Although this may be true in some cases, in practice government agencies more typically establish a target ELCR exceeding  $1 \times 10^{-6}$  to protect human health and the environment and to take remedial actions, both on a per chemical basis and a total site risk basis. The United States Environmental Protection Agency (USEPA) has set a total site target ELCR risk range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  for decision making purposes. The purpose of this paper is to review target ELCRs set by state, national and international agencies and to describe the policies of some agencies that are utilizing risk-based approaches that incorporate socio-economic, geographic and political factors to promote cost-effective remediation. Included is a discussion of target ELCRs used by USEPA and described in Records of Decision (RODs) for sites under the Superfund program and the potential benefits of settling on ELCRs exceeding  $1 \times 10^{-6}$  for decision making purposes.

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### **OVERVIEW OF A FOOD SAFETY RISK INFORMATION MANAGEMENT SYSTEM**

The development of reliable methods with which to prioritize hazard-commodity risks and evaluate mitigation options relies on access to a wide range of data that relate to hazards, commodities, and consumers. For example, data on preventative measures that can be undertaken during the processing stage (e.g., washing techniques) relate to both the commodity and hazard (e.g., certain techniques may have higher kill rates than others). Further, the integration of this information in a data management system that supports direct queries as well as different types of modeling approaches (e.g., top down or bottom up) promotes both consistency and efficiency in risk management. Therefore, we developed the Food Safety Risk Information Management System (FS-RIMS) as the “core” for the Integrated Decision Support System as well as other modeling applications such as iRisk and the Quantitative Predictive Risk Assessment Model (QPRAM) developed as a farm-to-fork virtual laboratory. The FS-RIMS includes data on the number of outbreaks and total cases of foodborne illness associated with FDA-regulated commodities, susceptible populations, hospitalization and death rates, disease multiplier data, prevalence of pathogen contamination and growth potential for hazard-commodity combinations, and consumption data. In addition, the database includes information on specific pathways and modes of contamination; growth, spread, and survival of hazards on food during lifecycle stages of the food commodities; research on the effectiveness of preventive measures; and information on consumer populations and associated exposure likelihood. The FS-RIMS serves as a repository for food safety information as well as the inputs/outputs associated with each module in iDeSS, provides a set of “canned” queries that produce specific types of reports for risk managers, and facilitates customizable queries that respond to a wide variety of risk management questions.

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### **PREFERENCES FOR AND PERCEPTION OF ROAD SAFETY**

The monetary value of reducing road mortality risk is one of the dominating components of the benefit side in a benefit cost analysis of transport investments and policies. The dominant approach to derive the value of safety is the willingness to pay (WTP) approach, where the tradeoff between risks and wealth is estimated. For mortality risks, this value is usually referred to as the value of a statistical life (VSL). To estimate VSL analysts have to rely on non-market evaluation techniques which can, broadly speaking, be classified as revealed- (RP) or stated-preference (SP) techniques. Both approaches have their strengths and weaknesses; the RP approach is based on

actual decisions but cannot always be used and confounding factors may bias results and the SP approach offers flexibility and a possibility for the analyst to control the survey/experiment but in the end answers are hypothetical. In this study we combine the two approaches. The aim is to examine the correlation between stated WTP and precautionary behavior (which reveals actual WTP), i.e. the usage of seat-belts and bicycle helmets, and traveling behavior, i.e. distance and mode of transport. An additional aim of the study is to examine how stated and revealed WTP is related to individual risk perception. The objective is to examine the consistency of individuals' stated and revealed WTP and to examine what characteristics, e.g. socio-economics and traffic behavior, explain consistency or deviation from consistency. The aims and the objective stated above require a within-sample analysis which is made possible by data from a Swedish SP study with ca. 1,000 usable answers. In addition respondents are asked about their perception of their own mortality risk. We, therefore, have access to a very rich data set to examine the question about consistency in respondents stated and revealed preferences for road safety.

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### **MODELING THE SOCIO-ECONOMIC RISKS OF BRIDGE FAILURES**

This article on the U.S. bridge infrastructure system focuses on the interplay and interdependencies among its network of physical and engineering assets, human, and economic elements, and the impacts of a failing public policy for the allocation of adequate resources for its proper maintenance and sustainability. One premise is that existing bridge management practices are inadequate because they fail to fully identify the complex interdependencies among the various components of the system, and as a result they often neglect potentially significant and unanticipated emergent socio-economic risks associated with complete or partial bridge failures. This article presents a modeling theory and framework that enable, through a combination of existing and newly developed analytical and simulation models, the identification of sub-system interdependencies and the quantification of the socio-economic impacts associated with bridge failure resulting from improper bridge maintenance. Furthermore, the bridge system is modeled as a system of systems, by extending and building on the intrinsic relationships among the multiple perspective-models and on the Phantom System Models (PSM). The results generated by this modeling effort are expected to guide and improve existing bridge management decisions. The developed modeling theory and framework, while applied in this article to the U.S. bridge infrastructure, is expected to be applicable to other complex systems of systems.

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### **GEOSPATIAL RISK ASSESSMENT OF CONTAMINATION OF AGRICULTURAL PRODUCE BY ENTERIC PATHOGENS**

Over the past decade, increased numbers of food borne outbreaks have been associated with fresh produce. The increase in the proportion of food borne outbreaks linked to fresh produce from the 1970s (<1%) to the 1990s (6%) provides a vivid description of the increase. The increase is largely due to a combination of an increase in the consumption of fresh produce, along with improved outbreak surveillance techniques. Biological hazards, such as enteric pathogens like Salmonella, E. coli 0157 and norovirus are the most common cause of foodborne illness linked to fresh produce. However, our understanding of the microbial ecology of pathogens on farms is extremely limited, and more research is needed on survival, growth, and transport of pathogens. Suspected risk factors include contamination of surface water and irrigation water with cattle and wild animal feces, direct contamination of growing fields with insects, bird, or wild animal fecal droppings; and improperly composted animal manure used on growing fields. In an effort to address a number of these problems, we are examining the role of precipitation as a leading indicator and driver of potential contamination. An index of cumulative precipitation is shown to provide an early warning retrospectively. In combination with other environmental data sets a risk ranking of potential outbreak areas can be derived. This method is currently being adapted to real-time monitoring and risk assessment for Salinas Valley, California.

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### **RISK PERCEPTION OF CLIMATE CHANGE AND NUCLEAR POWER GENERATION: FROM RECENT JAPANESE SURVEY RESULTS**

We investigate about the risk perception of two huge, long-term incidents of climate change and nuclear accidents in Japan, using two waves of public opinion surveys both carried out by National Institute for Environmental Studies. Japanese government announced to re-consider Japan's long-term national plan of energy and also the plan for the policies for tackling climate change which heavily depend on nuclear power generation for reducing carbon dioxide in May. We are now facing risk-risk trade offs, current and future possible accidents of nuclear power generation and climate change. Our surveys are about climate change risk and power generation in January 2007 and July 2011. We compare a) the relationships between energy-saving actions taken by respondents and risk perception of the perception of different sources of electric power generation from nuclear, fossil oil, wind, solar, hydro and biomass. b) people's risk perception of nuclear power generation before and after the

serious accident of the Tokyo Electric Power Company's Fukushima Plant. Some opinion polls carried out by Newspaper companies in April and May showed that the percentage of support for Japan's nuclear power generation become lower than before, but still higher than those of European survey results, such as a result from the Cardiff University. (We are going to submit on-going survey, but we thought it is important for us and other members of SRA to know and consider about Japan's current crisis as early as possible).

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### **RISK-BASED REGIONAL HURRICANE EVACUATION PLANNING**

Regional hurricane evacuation involves moving thousands of people with different needs from a wide geographic area in only a few days under uncertain, dangerous conditions, getting them to safe locations, and keeping them safe until they return. It is an extraordinarily complicated process and the stakes are high. Despite great progress, recent events and unchecked population growth in hurricane-prone regions make it clear that challenges remain. The traditional, appropriately conservative approach of evacuating everyone thought to be at risk is no longer feasible in many areas where there are just too many people and too little transportation capacity. In the past, math modeling in this application has been limited to estimating the time required to clear a region. In this paper we introduce a new approach that reframes the problem more broadly. By refocusing on the true objectives of minimizing risk and cost, this new decision frame allows direct integration and comparison of new alternatives like sheltering-in-place and phased evacuation. It considers the uncertainty in hurricane track and intensity explicitly so we can pursue a strategy that is good on average but also robust so that the impact is not terrible no matter how the hurricane evolves. Specifically, we present a new bi-level optimization model developed to help guide: (1) who should evacuate and (2) when. The upper-level develops the evacuation plan and the lower-level is a dynamic traffic assignment model that evaluates the proposed plan in terms of the resulting expected risk and travel times across all possible hurricane scenarios. The model iterates between the levels until they converge. To demonstrate the model, we present a regional case study for North Carolina that includes the recommended plans under different assumptions about which scenarios are possible. We compare the resulting performance for each plan in terms of risk and travel times for different actual hurricane scenarios.

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### **SAME TEST, SAME RESULT - SAME INFORMATION? A STUDY OF PHYSICIAN AND LAY UNDERSTANDING OF MEDICAL TESTS AND RISK**

Increasingly, technology offers ways to screen asymptomatic people for undetected conditions or risks of future conditions, imposing new demands on doctors and patients in terms of understanding risk and risk management. An important but sometimes underappreciated difference between diagnosis of symptomatic people and screening of asymptomatic people is the fact that different prevalence rates (i.e., prior risk) in two groups can lead to dramatically different positive predictive values (PPV = probability a positive result is a true positive) given the same test and a positive result. This arises because the prevalence of a condition in a symptomatic population is generally higher than in the overall population. Intuitively, it can be difficult to comprehend that the same test, with the same positive result, can have very different meanings for different people. This work examines 59 Scandinavian general practitioners' and 44 international MBA students' understanding of this for mammography, which is routinely used for screening and diagnosis. In written surveys, two women who had positive mammogram test results were described. They were essentially identical (in age, work environment, family history), but one had a mammogram as part of a mass screening program, and the other because of a lump in her breast. GPs estimated breast cancer prevalence in the general screening population and among symptomatic women, and the probability each result was a true or false positive. MBAs estimated the probability each woman truly had cancer given a positive test. Half of the MBAs wrongly believed the two women were equally likely to actually have cancer, suggesting many intuitively do not understand the difference between screening and diagnosis. Only 10% of GPs responded that the PPVs are the same, but they underestimated the magnitude of the difference. These and other results are discussed.

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### **ADAPTIVE ADVERSARY AGENT-BASED MODELING FOR CBRN TERRORISM RISK ANALYSIS**

An agent-based methodology framework has been developed to model the behavior, decision making, and asymmetric tactics, techniques and procedures of an intelligent, adaptive and reactive adversary planning, preparing to execute an attack using chemical, biological, radiological or nuclear weapons of mass destruction (WMD). WMD terrorist attack likelihoods and risk assessments will be modeled by adaptive learning computer software agents who operate in a virtual world and follow planned and contingency-based rule sets that adapt to the defender's world. The



model framework is built on the cornerstone of the Observe, Orient, Decide and Act Loop process. This methodology was developed for the Department of Homeland Security Science & Technology Directorate requirement to build new terrorism risk analysis applications that provide the estimation of attack likelihoods and attack modes of potential terrorist WMD attacks against the U.S.

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#### **RISK ASSESSMENT OF EXPOSURE TO TRIHALOMETHANE DRINKING WATER DISINFECTION BY-PRODUCTS. USE OF BIOMONITORING EQUIVALENTS AND BIOMONITORING DATA FROM NHANES**

This case study explores the application of the Biomonitoring Equivalents (BE) paradigm and population-representative biomonitoring data for THMs in blood from the National Health and Nutrition Examination Survey (NHANES) to risk assessment of non-cancer endpoints for THMs. BEs provide a translation of existing risk assessment exposure guidance values such as reference doses (RfDs) or risk-specific doses into estimates of equivalent biomarker concentrations using available pharmacokinetic data or models. BE values can be used to provide a screening level assessment of chemical biomonitoring data such as that generated by NHANES in the context of the current risk assessments. Biomonitoring data provide an integrated reflection of exposure from all routes and pathways of exposure. Because THMs are rapidly absorbed and eliminated, issues in interpretation of biomonitoring data associated with the transience of the biomarker are discussed. This case study explores alternative approaches for low-exposure extrapolation of risk of non-cancer hepatic outcomes from THM exposure in the general US population based on the NHANES biomonitoring data and the BE approach. The approaches used here conform to the IPCS framework for risk assessment of combined exposures to multiple chemicals (Meek et al. 2011). Specifically, this case study examines combined exposures (as reflected in population-representative biomonitoring data) to a group of chemicals that share common structural elements, common exposure sources, pathways, and characteristics, common target organ and toxic response, and probably, a shared mode of action. For this case study, dose addition is assumed, and a hazard quotient and index approach is applied. Alternative methods of low-dose extrapolation are also examined.

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#### **THE USE OF A BAYESIAN NETWORK FOR THE CALCULATION OF ECOLOGICAL RISK FOR HG CONTAMINATION IN THE SOUTH RIVER, VA**

Historic industrial activities in Waynesboro, Virginia from 1929 to 1950 resulted in mercury contamination of the South River. Despite the time that has elapsed from the mercury release, mercury concentrations in the river, fish and wildlife remain. The role of this landscape-scale ecological risk assessment was to assess the potential impacts of mercury and other stressors to fish and wildlife, and provide a modeling framework to evaluate the effects of different environmental management scenarios to support restoration of the watershed. The results presented in this talk will focus on risk evaluation for smallmouth bass populations in the South River extending from the watershed upstream of Waynesboro to the confluence of the South River with the North River and Shenandoah. Sources of stressors in the watershed include: mercury contaminated sites, stream modification, discharges, effluents, run-off, recreational activities and land uses such as agriculture and residential development. The structure of the risk assessment is based on that of the relative risk model but with a Bayesian network being used to calculate risk and uncertainty. The Bayesian network reflects causal pathways, incorporates a broad array of data available for the site, and includes the results of opinions solicited from experts. The results suggest that mercury contamination is not the only factor that is impacting the populations of smallmouth bass in the South River, and restoration of the watershed will require more than removal of mercury from the system.

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#### **RECENT ADVANCES IN PROBABILITY-BOUNDS THEORY APPLIED TO AEROSPACE**

The practice of segregating aleatory and epistemic uncertainty has gained recent traction in the aerospace engineering community. Under this approach, aleatory uncertainty is still represented probabilistically, but epistemic uncertainty sometimes is represented using intervals. When propagating mixed forms of uncertainty, it is necessary to express answers in terms of probability bounds statements. The statements can be represented using p-boxes, credal sets, or Dempster-Shafer structures. A number of recent discoveries concerning probability-bounds methods have been made. The first concerns application of these methods to the problem of quantifying uncertainty in the Mars atmosphere density profiles due to uncertainty in dust levels. It was found that probability-bounds methods not only yield more defensible results, but results that supported confidence intervals that were twice as wide as would be obtained using a purely probabilistic maximum entropy approach. Secondly, it has



been found that independence assumptions (which may or may not be valid) still lurk within certain sampling-based p-box construction methods. An alternative sampling-based approach utilizing the theory of random-sets is proposed. This approach was successfully applied to the aforementioned Mars atmosphere uncertainty project. Finally, on a more positive note, a p-box to random-set transformation has been recently validated as yielding conservative results. Although of a fairly detailed nature, these discoveries should prove to be of practical interest to engineers analyzing risk in the face of epistemic uncertainty.

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### **PUBLIC SAFETY AND RISK ASSESSMENT**

In the UK a major issue has developed during the last decade over the impact of an emergent health and safety culture upon business and public life. In 2010 Lord Young, at the request of the new coalition government, delivered a report (Common Sense - Common Safety) describing the problem and making recommendations. The report was accepted fully by government and is now being taken forward by Professor Ragnar L&ouml;fstedt. This paper will describe from a multidisciplinary perspective the nature, causes and implications of these problems from the perspective of public life. The heart of the matter is that safety from injury requirements have had a serious impact upon many things and activities which were previously enjoyed by the public. The impacts affect numerous aspects of public life, from children's play provision to the conservation of trees, the enjoyment of natural or historic landscapes, and the pursuance of adventure activities. The struggle between competing worldviews, which is what this is about, can be witnessed in the behaviours of safety professionals, regulators, advisory bodies, insurance companies and last but by no means least, the courts. The contest raises fundamental issues about the appropriate way to manage public safety, on who should decide on how safe things should be, and even about the conduct of risk assessment itself.

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### **TOWARDS CONSENSUS ON GLOBAL CATASTROPHIC RISK REDUCTION OBJECTIVES**

The reduction of global catastrophic risk (GCR) has emerged as a clear priority from certain risk analytic perspectives. However, GCR reduction raises several contentious issues, on which conflicting views can often be found among communities currently active in GCR assessment and reduction. In this presentation, we review these contentious issues with an eye towards what consensus might exist for specific GCR reduction objectives. The contentious issues include: discounting and time scales of analysis; trade-offs between objectives; and values regarding the fate of humanity in the contexts of technological change and diverse eschatological beliefs.

We review issues in assessing trade-offs of GCR reduction options, analyze areas of agreement and disagreement in views, and discuss implications for GCR research and policy.

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### **ADVERSARY MODELING AND DEFENSIVE DECISION ANALYSIS FOR ROBUST TERRORISM RISK MANAGEMENT**

We develop and illustrate an integrated approach to homeland security risk analysis and defensive resource allocation decision analysis under a variety of uncertainties. The process includes modeling attack processes and attacker decisions; modeling effects of countermeasures on probabilities and consequences of successful attacks; and conducting risk and decision analyses to find optimal or robust defensive countermeasure investment strategies. We illustrate this approach to analyze risks posed by particular attack scenarios, and the trade-offs and robustness of particular attack risk management strategies. Our approach has value in addressing the variety of factors and scenarios that may need to be included for realistic adversary modeling and risk management, as well as in incorporating and analyzing important modeling uncertainties.

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### **MODELING AND OPTIMIZATION OF RISK IN FUEL TRANSPORTATION NETWORKS FOR URBAN AREAS**

The industry is rapidly developing according to the society's needs. For this reason, the use of hazardous materials (HazMat) is required for the development of the majority of the production processes. The inherent risks in this activity are very high due to the potential damages to the receptors. In this study, a specific transportation problem has been considered in an urban area in which the vulnerability increases due to the high population density and the volume of the infrastructure. The purpose of this work is to provide a multiobjective formulation integrating both the minimization of total risk and the reduction of distance cost of transport. This model considers the risk equity law as a restriction to avoid the exposure to an unacceptable risk in a punctual region in comparison to the rest of the transport area. The accidental risk included in this model is defined in a more strict procedure. Approved empirics approximations such as probit equations (Crowl & Louvar, 2002) have been used to determine the consequences of the release. The risk was assessed by taking into account fires and explosions as objective events for the study. The estimation based in the dynamics event-receptor provides the model of an accurate approximation of risk necessary to validate, the efficiency of the model in the description of operations of urban transport and optimization to a minimal risk. A distribution network with an acceptable risk was implemented in GAMS (General Algebraic Modeling System)

with a combination of arcs (section of roads) and nodes (intersection points). The optimized network generates the minimum risk difference among the arcs in order to accomplish an equity distribution. Finally, a specific risk assessment was performed to determine the possible consequences and mitigation plans if regular distribution routes are affected. The results are applied to the scenario of Bogota D.C (Colombia).

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### **INTEGRATING CUMULATIVE RISK AND ENVIRONMENTAL JUSTICE ASSESSMENTS TO GUIDE DECISION-MAKING, PROMOTE STAKEHOLDER INVOLVEMENT AND ASSESS CUMULATIVE IMPACTS: THE CRA-EJ WIZARD**

Population-based exposure and risk assessments typically identify a local-scale area on the order of a few square kilometers or less, characterize its population and ecosystem, and identify and prioritize all the environmental stressors that may affect the health of the community and ecosystem. These cumulative risk assessments (CRA) often include vulnerability factors, such as income or ethnicity, and susceptibility factors, such as age or genetic predisposition, as contributing factors to adverse health effects. Ecosystems directly impacted by anthropogenic stressors, such as contaminated watersheds, could affect local flora and fauna, but could also present an additional stressor to a downstream community or area. A typical CRA involves many steps, which include defining purpose and objectives, partnership roles and responsibilities, and geographic and temporal scope; developing a conceptual model that identifies hazards and assessment endpoints; assessing cumulative exposures and potential risks; ranking actionable priorities; developing sustainable risk management and mitigation options; and measuring success. Many of these steps are common, though often underutilized themes of Environmental Justice (EJ) assessments, which have recently adopted a broader consideration of various stressor types. Though many definitions of EJ exist, two topics often overlap: meaningful involvement of participants and stakeholders, and assessment of disproportionate impacts. The CRA-EJ Wizard is a methodology that integrates common themes between CRA and EJ and provides a simple user interface to work through the process, from beginning to end. The depth of the assessment depends on user requirements and familiarity with either process, but can be tailored towards screening or quantitative-level assessments. The Wizard is being developed with constant feedback from CRA and EJ stakeholders. This presentation includes integration methods and case study results for the CRA-EJ Wizard.

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### **PRIORITIZING NANOMATERIALS RESEARCH THROUGH VALUE OF INFORMATION ANALYSIS**

Despite their rapid commercialization and increasing use in consumer, military, and industrial applications, much remains to be understood about nanomaterial properties and effects. Both our current lack of knowledge and the results of future research are and will shape the use and acceptance of nanomaterials over time. Current uncertainties in human and ecological health risks are particularly relevant for regulatory decisions and increased certainty in material properties and performance may improve future product-development decisions. Not all uncertainties, however, warrant equal consideration or research investment. In each specific decision context, available knowledge in one or more topic areas may be more likely to shift the chosen alternative than in others. Knowledge of these relationships might be valuable, for instance, to product designers seeking to select the best materials to use in product development or for governmental researchers seeking to best ensure long-term environmental health through regulatory restrictions. Using Multi-Criteria Decision Analysis (MCDA) to frame the specific decision context and quantify uncertainties in nanomaterial properties and effects, Value of Information (VoI) analysis is used to stochastically simulate research within the estimated bounds of uncertainty to identify topical areas most likely to initiate a shift in the rank order of preferred alternatives. This approach can help scientists and decision-makers focus research efforts and funding by prioritizing sources of uncertainty according to their impact on the ultimate decision.

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### **COMMUNICATING THE IMPORTANCE OF GLOBAL CATASTROPHIC RISK**

The reduction of global catastrophic risk (GCR) has been identified by a growing group of researchers as a top societal priority. However, many of these researchers also express concern that GCR is not receiving enough attention, either from the research community or from the general public. In response to this concern, this presentation presents approaches to communicating the importance of GCR to broad audiences. The presentation draws on insights from research on risk and science communication, professional practice in popular media and the arts, and firsthand experience in GCR communication. Emphasis is on how GCR researchers from all disciplines can more effectively communicate the importance of GCR in a broad range of settings.

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*RTI International*

## **MODELING U.S. AGRICULTURAL RESPONSE UNDER CLIMATE CHANGE**

Climate change will affect future agricultural production through changes in atmospheric carbon dioxide levels, average and extreme temperatures, precipitation patterns and intensity, and the frequency and severity of extreme events such as flooding, drought, hail, and hurricanes. Assessing the impact of the climatic changes on crop yield, output levels and commodity prices, however, also depends on behavioral and adaptive responses in the agricultural sector. In this study, we estimate potential long-term implications of climate change on U.S. landowner decisions regarding land use, crop mix, and production practices, combining a crop process model (EPIC) to capture the changes in the physical system with a forward-looking dynamic economic model of the U.S. forestry and agricultural sector (FASOM). Climate-induced changes in crop yields simulated with EPIC were used as inputs into the stochastic version of FASOM. We observe both substantial increases and decreases in crop yields. In general, yields increase in northern areas relative to southern areas. The patterns of simulated yield changes for a given climate scenario, however, show significant intraregional variation depending on the type of crop, irrigation status, and changes in water availability, nutrient availability, as well as many other factors. We model crop allocation decisions based on the relative returns and risk associated with alternative cropping patterns under future climate scenarios. Our results show substantial changes in regional crop acreage allocation and production patterns as producers switch crops and practices in response to changes in expected profitability and risk under climate change, which in turn may inform agricultural adaptation measures. Finally, impacts estimated using FASOM are incorporated within the Applied Dynamic Analysis of the Global Economy (ADAGE) dynamic computable general equilibrium model to assess interactions with other sectors and macroeconomic impacts.

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## **EXPERT OPINION AND LIFECYCLE REGULATION FOR EMERGING NANOMATERIALS**

Engineered nanoscale materials (ENMs) present a difficult challenge for risk assessors and regulators. Assessment of risks along the life cycle of nanomaterials is limited both by a lack of inventory data (since production information is scarce) and by the paucity of impact data (since exposure and toxicity data is lacking). Continuing uncertainty about potential exposure and toxicity of ENMs implies that expert opin-

ion will play an important role in assessing and regulating risk. This paper employs data from a recent survey of nanotechnology experts (n=430 nano-scientists and engineers, toxicologists and regulators) alongside a comprehensive review of existing regulatory options across the lifecycle of nanomaterials. We find, overall, differences in opinions among classes of experts about the lifecycle risk of nanomaterials; different expert views of responsibility and preparedness for managing any risks posed by nanomaterials; and differing perspectives on barriers to implementing a life cycle approach to the regulation of nanomaterials and nano-based products.

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## **RECOMMENDATIONS FOR RETOOLING IRIS**

We now know more than ever about biological systems, modes by which chemicals interact with these and dose-dependency of effects which transition from nil (homeostasis) to adaptation to adverse. Yet in IRIS assessments such knowledge seems never enough to supersede defaults. Criticisms of IRIS include overreliance on assumptions instead of data, inconsistent data evaluation/study integration methods and opaque justifications for conclusions. Our retooling recommendations involve improvements in data acquisition, data evaluation, risk determination, and transparency. Problem formulation is key for data acquisition; if critical data needs are identified, a process and schedule can be agreed. Meaningful dialogue with stakeholders during problem formulation should focus assessments on key issues and enable development of relevant peer-review charge questions to evaluate these. Retooling data evaluation requires consistent application of uniform criteria for determining method validity, study reliability, data quality, and criteria for establishing cause and effect, coupled with a hypothesis-based weight of evidence framework for mode of action evaluation, including evaluation of default(s). In risk determination, modernization means selecting appropriate dose-response methods and conducting quantitative estimates of central tendency for population probability risk distributions, not just upper bounds. Restructuring and enhancing public comments and peer-review processes are also needed to improve transparency and scientific integrity. Enhanced consideration of scientifically relevant public comments by the independent scientific peer reviewers, and documentation that an assessment was revised to adequately address peer-review findings and recommendations, should be considered. Given the importance of IRIS assessments to EPA program offices, other federal agencies, states, and private & public sector impacts, retooling along the lines of our recommendations is warranted.



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### **FINALLY, A SCIENTIFIC DEFINITION OF ADVERSE EFFECT**

The scientific assessment of human health risk has been predicated on the existence of a scientific definition for adverse effects. Yet, ever since Arnold Lehman introduced the dawn of health risk assessment in 1949, and proceeding through thousands of scholarly articles, hundreds of scholarly books, scores of National Research Council reports, dozens of Federal and State agency guidance documents, myriad laws and regulations, and the creation in 1980 of the Society for Risk Analysis, adverse effect still lacks a scientific definition. Channeling their inner Justice Potter Stewart, theoreticians and practitioners alike profess to know an adverse effect when they see one. This is surely true, at least for effects so bad that even an economist could recognize them. But it is not true at the margin, where fine distinctions separate adverse from nonadverse effects and the risk management consequence of assignment are most meaningful. This paper reviews the domain of conventional definitions of adverse effect, adding to them several refinements that have been recently proposed by various individuals and groups. It is shown that none are genuinely scientific. Some are measurable but not refutable, and all are dependent on the policy judgment of the risk assessor. Most conventional methods are further compromised because they impose the strong assumption of monotonicity in dose-response, and thus they cannot reconcile the possibility that an effect may be adverse at some doses but beneficial at others. Finally, none can address the case where, at any given dose, effects may be adverse for some persons but beneficial for others, or even adverse or beneficial for the same person at the same time. An alternative definition is proposed that is measurable and refutable, and unlike every competing definition, it is independent of the discretion and policy judgment of the risk assessor. Thus, unlike conventional definitions and their progeny it is scientific in every respect.

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### **OPTIMIZING AND SATISFICING IN THE MANAGEMENT OF RISK**

We admire excellence in all areas of endeavor: art, sport, science, business, and risk management. The fastest runner wins the race and our admiration. The lowest-risk design - all else being equal - is preferred. `Better`, almost by definition, is `more desirable` and - by the logic of preference - the best is most preferred. The logic of preference is so compelling that there is a moral imperative to do our best. Optimization also has deep roots in the physical and natural realms. The laws of physics can be derived from optimization principles. Biological evolution is a process of selection of the better over the less good leading - all else being stable - to optimal morphologies. Mathematical economics was quick to adopt the imperative of optimization, which underlies modern theories of economic dynamics. Decision makers often

face severe uncertainties. Is optimization a good strategy under uncertainty? Uncertainty has profound implications for any attempt to optimize the outcome of decisions. We first discuss the equity premium paradox from financial economics which belies the cardinality of performance-optimization by economic agents. We contrast performance-optimization with a strategy of robustly achieving critical goals. We then apply this concept to technological risk analysis, and consider a schematic design of a critical but risky infra-structure. Finally, we discuss the importance of disaster recovery as an integral part of risk management.

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### **“INTELLIGENT” INTEGRATION OF INTELLIGENT ADVERSARY MODELING INTO HOMELAND SECURITY RISK ANALYSES: THEORY AND PRACTICE**

As a risk management organization, the U.S. Department of Homeland Security (DHS) is charged with producing relevant and technically defensible risk assessments of a wide range of potential adverse events within its mission domain in order to inform and support decision making. Many of these potential adverse events, such as pandemics and many forms of natural disasters (as well as drug smuggling and illegal immigration to a degree) are 1) stochastic in nature, and 2) replete with historical frequency and consequence data making analysis of event risks relatively straightforward. However, many events that are intentionally initiated, such as terrorism, are neither stochastic in nature, nor frequent enough (thankfully) to yield statistically useful frequency data. Currently referred to as the “intelligent adversary” problem, the ability to estimate reasonable and defensible frequencies (or at least relative probabilities) for terrorism events is an important research focus of the Department’s risk analysis community. Current DHS “solutions” to this problem have tended to assume that probability elicitation of relevant experts capture the equilibrium position of event probabilities, incorporating the adaptation, deterrence, and threat-shifting tendencies of different adversary groups. However, there has been no lack of proposed alternative solutions from as evidenced from the pages of Risk Analysis and other top journals over the past two years. These alternatives have ranged from game theoretic and agent-based methods to recommendations that DHS not attempt to characterize these likelihoods at all. This presentation will discuss a number of these proposed alternatives from both theoretical and practical perspectives and present a framework for evaluating and incorporating intelligent adversary models for estimating terrorism frequencies/probabilities into existing Department risk analysis frameworks.



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### **DART: DIGITAL AMPLIFICATION/ATTENUATION OF RISK THEORY**

DART is a response to SARF (Social Amplification/Attenuation of Risk Framework). Risk events interact with individual psychological, social and other cultural factors in ways that either increase or decrease public perceptions of risk. SARF's strength is drawn from its power as a metaphor to help organize a large number of social science research in multiple disciplines. Amplifiers/attenuators can be friends and family, government officials, but more often than not they are media. SARF influenced risk theory for a quarter century. It has been the subject of over 180 scholarly articles and the authors have been cited hundreds of times in book chapters. The concept of amplification stations animated discussions over the effect of individuals and organizations on the amplification/attenuation of risk messages. The bulk of work incorporated under this banner has involved studies of mass media, especially television and newspapers, however, the ascension of digital media as both a supplementary and, in some cases, alternative media, calls for a reexamination because much of what we know about SARF is being challenged. For example, the speed at which risk messages can be exchanged has increased sharply. While a decade ago a risk event and its communication were asynchronous, today photos, videos, and discussions in micro-blogs and on social media occur instantaneously. In addition, the roles of authority and expertise in digital media have altered how risks are amplified and attenuated. Traditional media involved editors and producers as well as seasoned journalists, today any amateur can be a journalist and friends on Facebook may have replaced experts as purveyors of risk events. DART posits some principles, ask questions, and anticipates new research activities over the next few years.

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### **NUCLEAR ENERGY AND THE CONTINGENT IMPACT OF MEDIA ATTENTION**

The proposed presentation will draw on survey data (expected n=800) currently being collected on nuclear energy risk perceptions in the context of the Fukushima-Daiichi accident in Japan. The data will include interviews with members of a panel that previously responded to two surveys about nuclear energy during the spring and late summer of 2010. The second, late-summer survey was fielded just after the Deepwater Horizon oil spill. The underlying survey instrument includes a range of questions assessing risk perceptions and views about risk decision-makers in both the private and public sector. The analysis will focus on the interaction between attention to news about the spill and both environmental attitudes and views about risk decision-makers. Exploring these interactions will enable a discussion of the degree

to which the impact of attention to news about accidents such as occurred at the Fukushima-Daiichi plant are contingent on pre-existing attitudes. Analyses of wave 1 and 2 data suggested that those with relatively strong environmental attitudes who paid greater attention to the Deepwater spill became less supportive of nuclear energy. In contrast, those with relatively weak environmental attitudes who paid high levels of attention to the Deepwater spill became more supportive of nuclear energy. The addition of a third, post-Fukushima-Daiichi wave will enable a broader assessment of the contingent nature of media effects. The analyses will also enable a discussion of how the accident in Japan affected additional factors associated with nuclear energy development. Public surveys conducted after the accident emphasized direct impacts on overall views about nuclear energy but the panel data here includes questions about decision-makers and specific risks/benefits of nuclear energy production (e.g., concern about waste or safety). The data is also unique because it involves panel data and therefore enables a greater emphasis on potential causal relationships.

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### **REDUCING THE UNCERTAINTY IN WATER QUALITY ASSESSMENT OF CORN VERSUS SWITCHGRASS ETHANOL PRODUCTION**

It has becoming increasingly recognized that policy decisions regarding the optimal pathway for ethanol production via corn or switchgrass feedstock in the United States must include studies that examine potential environmental, public health, and economic impacts. One specific environmental indicator, water quality, may have a potential negative impact resulting in effects on groundwater, surface water, and drinking water resources, and the loss of aquatic habitat and ecological natural resources. As part of an overall assessment of environmental and public health impacts from corn versus switchgrass ethanol production, an expert elicitation was conducted to determine the importance of various environmental stressors related to feedstock and ethanol production on overall water quality within the receiving watershed. The expert elicitation required a ranking of the stressors, including nutrient, sediment, and pesticide loading to the receiving watershed, relative to their potential impact on water quality. The expert elicitation approach reduced uncertainty in the overall assessment process that was due to insufficient data availability on water quality, especially with regards to switchgrass feedstock and ethanol production. The results of the expert elicitation parameterized the focus of the water quality assessment, and provided a tool to reduce the uncertainty of the analysis.

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### **RISK PUBLICS: UNDERSTANDING THE UNIFYING TIES OF PERSONAL BELIEFS VS. COMMUNITY OF RESIDENCE IN THE SITE-SELECTION FOR A BIOLOGICAL RESEARCH FACILITY**

In the past few decades, a systematic understanding of how audiences perceive risks has begun to take shape. Individual reactions, of course, can result from communication behaviors (e.g., watching news media, talking with others) as well as from cognitive mechanisms of information processing (e.g., relying on heuristics). This study builds on insights from both perspectives by systematically comparing and contrasting perceptions of individuals residing in communities considered for a high-risk research facility. The overall goal is to delineate how similar and different these individuals are (1) when grouped in terms of geographical boundaries and (2) when grouped in terms of perceptual boundaries. The data for this study come from public opinion surveys carried out in five locations under consideration for a new biological research facility in the U.S. Segmenting the survey sample in terms of geography reveals some differences in terms of risk and benefit perceptions of the research facility. Cluster analysis designed to achieve a replication of geographic (community) clusters were compared with analyses identifying distinct groupings of individuals based upon risk vs. benefit perceptions. Results indicate that these individuals are more similar in terms of beliefs or attitudes than they are in terms of where they live. In particular, four distinct “latent risk publics” emerged and were distributed equally across the different communities: the concerned public (high risk/low benefit), the optimistic public (low benefit/high risk), the conflicted public (high risk/high benefit), and the disengaged public (low risk/low benefit). Group comparisons revealed significant differences in terms of demographic characteristics, media use patterns, levels of knowledge about the facility, and trust in key stakeholders. Implications for the study of public perceptions of risk are discussed.

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### **PARA-OCCUPATIONAL EXPOSURE TO PESTICIDES IN AGRICULTURAL FAMILIES: A MISSED OPPORTUNITY FOR RISK ASSESSMENT**

Pesticide exposure has been correlated with adverse maternal and child health outcomes. This review examines the state of the literature on para-occupational exposure and its implications for Quantitative Risk Assessment. Relevant papers in the literature discussing para-occupational exposure to spouses and children of farmers and farmworkers in North America, including exposure assessments and epidemiologic studies were identified (n=42). Environmental and biological sampling and epidemiological data from these studies were critically examined and catalogued.

Though para-occupational exposure has been characterized as restricted to developing countries, it has been clearly documented in North America. The studies examined showed increased exposure in farm children compared to non-farm children. A smaller increase was seen in some studies of farm spouses. Major sources of exposure included workers’ boots, clothes and vehicles. Children who were present during spraying showed even higher levels of exposure. Proximity of the home to spraying locations explained some, but not all, of the home exposure reported, indicating para-occupational exposure was still present. Epidemiologic studies showed higher rates and risks of cancer and decreased neurobehavioral performance in children whose parents had occupational exposure to pesticides. We propose a stratified para-occupational risk assessment model, with low (typically spouses), medium (children not present for spraying) and high (children present for spraying) exposure categories to capture this currently neglected area of risk in Quantitative Risk Assessment. The para-occupational pathway is a significant route of exposure, particularly for children. This has implications for whole exposure Risk Assessment methodology. Additionally, it poses an opportunity for interventions in hygiene practices among agricultural families and a general improvement in child health.

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### **INTER-ORGANIZATIONAL PROBLEM SOLVING IN EMERGENCY MANAGEMENT: COORDINATION AND COLLABORATION**

Effective emergency management often requires inter-organizational problem solving. Unfortunately, despite managers and planners’ best efforts, optimal problem solving is not always achieved within multi-organizational environments. What hinders and facilitates optimal inter-organizational problem solving? Based on a complex emergency event scenario requiring responses from multiple organizations, an experiment with a sample of 33 junior-level emergency response professionals was performed to determine the potential impact of problem-solving approach on various decision processes and outcomes. Differences in participants’ satisfaction in the quality of the outcome were analyzed by inter-organizational problem solving approach (coordination vs. collaboration) and by level of self-reported frustration working with other groups. Based on analysis of variance, findings demonstrated that both problem solving approach and level of frustration had an impact on satisfaction with problem solving outcome. Collaboration and frustration levels both had a negative impact on the satisfaction with the quality of the decision outcome. Main effects were further explored with respect to interactions and other variables such as leadership. These findings suggest implications for inter-organizational decision making in risk management. With the financial support of DRDC, SSHRC, NSERC and the McLaughlin Research Chair on Psychosocial Risk.

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### **H1N1 - CREDIBILITY OF TRADITIONAL HEALTH INFORMATION SOURCES AND WEB 2.0 INFORMATION IN ALBERTA**

The H1N1 pandemic in 2009 provides a unique opportunity to study traditional health information sources vs. the upcoming Web 2.0 as an avenue to communicate health risks to the general public. The objective of this study was to determine the sources of information used by the Alberta public during the H1N1 outbreak and vaccination program, and how useful and credible they found these various information sources. A random digit dialled telephone survey was conducted of 1,203 Albertans in May to July 2010. Respondents were asked to rate their use of various information sources, including newspapers, television, radio, Internet, social networking sites, HealthLinks, doctors, other health professionals (both known and unknown) and friends and relatives. They were further asked to rate these sources on their usefulness and credibility. Degree of worry during the event and at the time of the survey was also assessed. The most widely used information source was television, followed by the Internet, newspapers, radio, known health professionals and friends or relatives. The most useful and credible sources were doctors, known health professionals, HealthLinks and the Internet. Most people (74% of respondents) felt they knew everything they needed or wanted to know about H1N1. Half of the respondents (51%) were not worried about H1N1 during the outbreak; 86% were not worried at the time of the survey. Despite the advent of social media, conventional media (e.g. television, newspapers) and passive internet usage remain the most common sources of information. However, conventional media sources are not generally rated as the most useful or credible. Implication for future pandemic communication efforts will be discussed.

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### **INTERNATIONAL DIFFERENCES IN RISK TOLERANCE AND IMPLICATIONS FOR GLOBAL CLIMATE POLICY**

Evaluation of public policies with uncertain outcomes requires an accurate characterization of social preferences regarding risk. Unfortunately, the preference models used in most integrated assessments of climate policy do not adequately describe the risk attitudes revealed by typical investment decisions. Here, we adopt an empirical approach to social preference description using global historical data on investment returns and the occurrence of rare economic disasters. We improve on earlier analyses by employing a Bayesian inference procedure that allows for nation-specific estimates of disaster probabilities and preference parameters. This provides a stronger test of the underlying investment model than provided by global calibrations

and generates some compelling hypotheses for further study. Specifically, results suggest that society is substantially more averse to risk than typically assumed in integrated assessment models of climate change. Additionally, there appear to be systematic differences in risk preferences among nations. We use a recently-developed model of multi-attribute negotiation to explore the implications of these international differences on the chances of reaching a global climate treaty.

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### **WARNING DECISIONS IN EXTREME WEATHER EVENTS: FORECASTERS' PERCEPTIONS AND PERSPECTIVES ON HURRICANE FORECASTS, WARNINGS, DECISIONS AND RISKS**

Most forecast and warning information for hurricanes and flash floods originates in the hydrometeorological community. Weather researchers and forecasters tend to focus on analysis of hydrometeorological data, forecast production, and forecast dissemination as the primary function of their professional responsibilities. Although they are interested in communicating forecasts in ways that aid effective decision making, the expertise and data necessary to support this is lacking. Because of this limited focus, most members of the hydrometeorological community currently have limited understanding of how the information they provide is and could be used by individual and organizational decision makers. This lack of understanding significantly limits researchers' and forecasters' ability to provide information encouraging appropriate decision making and self-protective action in extreme weather events (e.g., Morss et al. 2005). To begin to address this gap, this paper reports forecasters' understanding and perceptions of the hurricane forecast and warning system. Based on individual mental models interviews and a group decision modeling session with forecasters from the National Hurricane Center and the Miami-Dade Weather Forecast Office, the study explores how forecasters (a) conceptualize hurricanes (including exposure, effects, mitigation), use information in creating warnings, and then communicate hurricane warnings, and (b) perceive how flash flood forecast and warning information (including uncertainty) is interpreted and used by public officials, media personnel and the general public. Findings are summarized in the form of a decision-focused model of the forecast and warning system. As anticipated, forecasters' hurricane hazard and risk perceptions differ by level of experience, are detailed with regard to storm development and tracking and sparse with regard to the physical and social consequences of storms.



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### **ESTIMATION OF HUMAN INFECTION RISKS FOR FOODBORNE VIRUSES DUE TO CONSUMPTION OF FRESH PRODUCE, PORK AND MUSSELS IN EUROPE**

Human pathogenic viruses can contaminate food and thus pose a foodborne risk to humans, especially for food items that are consumed raw or moderately cooked. These viruses can be of human or animal origin and can contaminate foods intrinsically (inside the food item), or extrinsically (on the surface). Along these lines virus contamination was monitored in the food production chains of fresh produce (soft fruits and salad vegetables), pork and mussels within the project VITAL. For mussels, virus concentrations at point-of-sale were assessed and used to estimate human exposure. For the other foods the entire production chain was studied additionally. Human pathogenic viruses examined were norovirus (NoV) genogroup I and II, hepatitis A virus (HAV) and hepatitis E virus (HEV) by PCR. NoV, HAV and HEV can contaminate fresh produce extrinsically and mussels extrinsically and intrinsically, whereas HEV can contaminate pork products intrinsically when pigs experience a HEV-infection. Potential virus sources were identified per production chain using questionnaires for each production site. For fresh produce these were: irrigation water, animal manure, harvesters' hands, conveyor belts, food handlers' hands, cutting knives and rinsing water. For pork production, these were: pig meat, pig faeces pig liver, meat mincers. The sources were sampled longitudinally, screened for virus presence and indeed pathogenic viruses were found. Distributions of virus concentrations were estimated for each potential source by maximum likelihood. Probabilistic risk assessment models resembling the food chain were used to estimate virus contamination of end-products and the eventual food-related exposure to viruses of humans.

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### **ENERGY SYSTEMS AND CLIMATE CHANGE: CANADIAN PERSPECTIVES AND EVALUATIONS OF TRADE-OFFS AND VALUES**

Canada is one of the largest producers and exporters of energy in the world. The country also possesses a diverse portfolio of energy resources. The extraction and consumption of these resources has resulted in increasing greenhouse gas (GHG) emissions throughout Canada. A number of strategies and policies have been put in place to encourage the development of innovative low emitting GHG energy technologies and climate change reductions plans. Public input and acceptance is critical to the success of these plans. A nation wide survey was administered in July 2010 to better understand the views and understanding of climate change and energy systems. The survey was administered via Internet and phone to a representative

sample of 1,479 Canadians recruited by a market research firm. The survey was delivered in both French and English to represent both official national languages. Results indicate that respondents primary considerations when making choices about energy systems include: (1) possible impacts on human health (69%), (2) level of pollution (64%) and; (3) reduced environmental impacts (62%). Less salient factors included job creation (23%), effects on landscape (31%), and impacts on nearby communities (36%). The majority of respondents (77%) agreed that climate change is a serious problem and 66% of respondents agreed that human beings are primarily responsible for climate change. We also explore respondents' perceptions of risks associated with energy systems and what sources they think generate electricity. We conclude by discussing various perceptions among different regions of the country and the policy challenges associated with energy developments.

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### **FRONT PAGE OR 'BURIED' BENEATH THE FOLD? MEDIA COVERAGE OF CARBON CAPTURE AND STORAGE**

Media can greatly affect public views and opinions on science, policy and risk issues. This is especially true of a controversial emerging technology that is relatively unknown to the majority of the public. The study presented here employs a media content analysis of carbon dioxide capture and geological storage (CCS), one potential strategy to reduce greenhouse gas emissions that has attracted much international interest and media coverage. CCS refers to the capture of carbon dioxide emissions from industrial sources and the long-term storage of these emissions in stable underground reservoirs. To date, there has been very little research completed on CCS representations in news media, especially within North America. For that reason the research presented here can offer beneficial insights into the prevailing public response to CCS risk and possible adoption of the technology. The authors analyzed media coverage from two leading Canadian national newspapers and two major western regional Canadian newspapers as part of the study. Relevant articles were categorized to determine the frequency and themes of media. An in-depth content analysis was then conducted to examine factors relating to risk from CCS and if coverage was negatively or positively biased. Results demonstrate that the majority of coverage is general news and business stories. However coverage also suggests inherent risks and economic issues associated with CCS. The number of articles about CCS has increased greatly, including front page stories, especially since the announcement of \$2 billion in financial support for the technology from the Province of Alberta. We conclude by discussing the possible impact of media coverage on support or opposition to CCS adoption in Western Canada and speak broadly about the changing role of the media in understanding risk associated with technology.



## **QUANTIFYING HEALTH IMPACTS IN LIFE-YEARS: A BRIDGE BETWEEN TWO METHODS**

Methods for quantifying health impacts can be categorized in a number of ways. In the air pollution literature two categories of approach appear to predominate: (1) the cross-sectional approach and (2) the period life-table approach. The cross-sectional approach quantifies impacts (e.g., attributable deaths or years of life lost) that accrue within a specified calendar year (with health impacts first being computed by age-strata, and then summed). The period life-table approach quantifies impacts by tracking the differential prognosis of two hypothetical birth cohorts (unexposed versus exposed). While there are clear distinctions between the two approaches, they draw upon the same underlying input data, and thus ought to be related to one and another. We contrast the two approaches, and offer a mathematical relationship linking them together (enabling conversion between the two). The performance of this approximate relationship is demonstrated using age-stratified death and population counts from 194 countries. The conversion relationship, which is to the best of our knowledge new, should prove useful; enabling conversions of impact estimates between the two approaches, and in better understanding the circumstances under which impacts obtained under the two approaches will converge/diverge.

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## **MICROENVIRONMENT TRACKER (MICROTRAC) FOR INDIVIDUALS IN HEALTH STUDIES: ESTIMATION OF TIME-MICROENVIRONMENT PROFILES FROM GPS DATA LOGGERS**

In epidemiological studies, various ambient generated air pollutants are associated with increased risk for adverse cardiopulmonary events. Due to challenges with personal measurements, health studies often estimate exposures using central-site ambient measurements. However, ambient levels do not necessarily reflect personal exposures since indoor and outdoor microenvironments (ME) levels can differ from ambient levels, and people spend considerable time in these MEs. To reduce this exposure error, which adds uncertainty and bias to risk estimates, we are developing an exposure model for individuals (EMI) in cohort health studies. A critical aspect of EMI is estimation of time spent in various MEs, which are needed to predict individual exposures and other exposure metrics (e.g., time spent in-transit during peak traffic periods). A classification algorithm (MicroTrac) was developed to estimate time-of-day and duration spent in seven MEs (in-transit, indoors and outdoors at home, work, and other locations) from position and speed timelines derived from GPS data loggers, and marked boundaries of individual buildings (i.e., home and workplace)

obtained from Google Earth. In a pilot study, MicroTrac estimates were evaluated with concurrent 24-hour GPS and diary data on a workday. The MicroTrac-predicted and diary-reported time spent in the seven MEs correspond reasonably well, with an absolute difference of 6% for the home-indoor ME. Limitations of MicroTrac are due to the GPS spatial resolution (3 m) and spatial errors near large buildings. However, the small, lightweight, low cost, high performance GPS devices, and the automated classification algorithms provide MicroTrac with the potential to reduce the participant burden, low resolution, inaccuracies, and missing data associated with diaries. This study demonstrates the feasibility of using MicroTrac to estimate time spent in various MEs, in support of developing exposure metrics for individuals in health studies.

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## **WEIGHING THE RISKS OF IMMUNIZATION: A REVIEW OF PUBLIC AND STAKEHOLDER PERCEPTIONS OF VACCINE RISK TO INFORM POLICIES AND PROGRAMS**

At the heart of immunization controversies is how the public and stakeholders weigh the risks of certain diseases versus the potential (but statistically rare) adverse event as a result of the vaccine administered. The Keystone Center, in partnership with the Centers for Disease Control and Prevention and the Association of State and Territorial Health Officials, has designed and facilitated nearly ten years of public and stakeholder engagements aimed at better understanding why and how the public makes these decisions. This session is designed to share qualitative and quantitative risk-related data collected to best inform Federal government policies and programs - including CDC's vaccine safety research agenda, CDC's H1N1 response and communication strategy, and the prioritization of limited vaccines during a pandemic crisis. The various engagement efforts each had a customized approach and took place in different cities across the U.S., including those with typical vaccination rates such as Indianapolis, Indiana as well as those with a high number of exemptions such as Ashland, Oregon. While there were many similarities in how risks were evaluated by the public-at-large, important collective cultural experiences that influenced particular geographies also emerged. Lastly, as designers and conveners of these engagement sessions, The Keystone Center wondered if talking about the risks and benefits of vaccines with meeting participants for five to six hours would actually heighten their perception of vaccine-related risks. Instead, the data showed that participants had no change in their pre-meeting views, and in some cases, they felt more confident after the day of dialogue.

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## **EVOLVING REGIONAL NATURAL DISASTER RISK IN THE INTERNATIONAL DEVELOPMENT CONTEXT**

Most regional natural disaster research focuses on a relatively short time period just before and after an event, always to prepare for disasters that may occur in the near future and short-term impacts of those events. Even risk assessments that describe the potential for future disasters are typically conducted as static analyses, providing a snapshot of risk in time. In actuality, a city's natural disaster risk is continually evolving in a process that is intertwined with its development trajectory. To fully understand the root causes of risk and the most effective, long-term, sustainable solutions, a broad decision frame is needed that considers disasters over a long time frame and fully captures the many interactions between normal development processes and the ongoing cycle of mitigation preparedness, response, and recovery. For example, while it may be obvious that a city's risk is driven by the many vulnerable, poorly constructed concrete buildings, it may be more challenging to understand how those buildings came to be built and why efforts to make the infrastructure less vulnerable have suffered persistent policy resistance. A broader, dynamic perspective may help examine those questions. In this paper, we introduce a systems dynamics model developed to quantitatively describe how a city's disaster risk changes over many years. Disaster risk is treated as a latent characteristic of a city that evolves over time, subject to many development forces and feedback loops. We conceive of disaster risk broadly, considering not only the potential for damage to the physical infrastructure but also social and economic vulnerability and government capacity, which can affect how well a city can absorb or recover from damage. The model was created for earthquake risk in Port-au-Prince, Haiti, but the approach is intended to be adaptable to other regions. While this perspective could be useful in any context, it is particularly important in rapidly changing cities in developing countries.

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## **ANALYSIS OF INLAND CRUDE OIL SPILL THREATS, VULNERABILITIES, AND EMERGENCY RESPONSE IN THE MIDWEST UNITED STATES**

Although coastal oil spills tend to be highly publicized, the majority of large crude oil spills in the United States affect inland areas. Spills to inland areas often affect sensitive environments and can have greater impacts to health and welfare than spills to coastal areas. For these reasons, the authors investigated inland crude oil spill threats, vulnerabilities and emergency response in the Midwestern United States of Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin. These are the states that work with the Region 5 Offices of the US Environmental Protection Agency

(Region 5). Region 5's geospatial data in the Inland Sensitive Atlas were turned into metrics indicating inland crude oil spill threats and vulnerabilities among Region's sub-watersheds. These threats and vulnerabilities were weighted using data from the National Response Center and the Department of Energy's Environmental Restoration Priority System. The locations of the Region's emergency responders were geocoded in ArcGIS. ArcGIS calculated the emergency response times to the Region's sub-watersheds. The resulting scatter plots are connected to the sub-watersheds in the map so stakeholders can 1) see the outlying sub-watersheds of concern and 2) better understand how reducing threats and better response time can reduce the risk of inland crude oil spill threats.

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## **THE INFLUENCE OF INTEGRITY-BASED AND COMPETENCE-BASED TRUST ON PUBLIC ACCEPTABILITY OF ELECTRICITY GENERATION SOURCES: THE CASE OF CHILE**

Chile will need to double its electricity generating capacity every 10 years in order to comply with the projected economic growth for the next two decades, forcing authorities to decide which electricity generation sources will be implemented to meet the projected energy demand for the country. Considering this scenario, our main goal was to characterize social acceptability regarding different alternatives of electricity generation, considering two dimensions of trust: Integrity Based Trust and Competence-Based trust. Based on previous studies, a causal trust-acceptability model was hypothesized to explain the relationships between trust in regulatory agencies, perceived risk, perceived benefit and public acceptability for ten energy sources. A survey to characterize public perceptions was conducted, interviewing 243 Chilean university students between October 2009 and January 2010. Each respondent assessed their level of trust in regulatory agencies, perceived risk, perceived benefit and public acceptability for ten electricity generation sources. Our results show that energy sources currently in the national energy matrix (except hydropower and geothermal) are perceived as highly risky with low benefits, thus reflecting a low degree of public acceptability. For non conventional renewable energy sources, the benefit-risk balance was positive, suggesting a greater degree of acceptability over their use. Results from Confirmatory Factor Analysis suggest Integrity-Based Trust determines the degree of public acceptability of an energy option in Chile, rather than Competence-Based Trust. By using Structural Equation Mode, it was demonstrated that the hypothesized trust-acceptability causal model fits particularly well for energy sources showing a low level of Integrity-Based Trust (fossil fuels, nuclear and hydropower). In the case of non-conventional renewable energy (solar, wind, geothermal and tidal), the model didn't adjusted to the data.

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### **SPATIO-TEMPORAL ANALYSIS OF BLACK SPOTS OF TRAFFIC ACCIDENTS IN SANTIAGO, CHILE**

Traffic accidents are a serious public health problem and a major cause of death in Chile. Agencies with competence in this matter have conducted spatial analysis of accidents in Chile's capital, Santiago. However, to date no studies have been conducted to assess the spatio-temporal component of risk, precluding the development of longitudinal studies that identify trends and evaluate the effectiveness of preventive actions adopted by authorities. To fill this gap, this study was conducted with the aim to identify and analyze spatial and numerical behavior in the time of black spots in Santiago, Chile, using statistical analysis and Geographic Information System. Data for traffic accidents in Santiago between 2003 and 2009 was analyzed. Using GIS, a total of 98,060 accidents were geocoded, so accidents that took place in or near an intersection could be identified. Intersections where 6 or more accident occurred annually were considered black spots. Spatial distribution of black spots was analyzed using Kernel density analysis and relations of black spots' evolution in time, using Person's correlation. Our results indicate that at least 1,365 black spots existed in the time period under study, accounting for 35,697 traffic accidents and 29% of traffic-related fatalities in about 8% of the total set of intersections in Santiago. Of the total number of black spots identified, 67 existed through the entire period 2003-2009. Spatial correlation of black spots through time yield significant and increasing Pearson coefficients of correlation, indicating that black spots have a growing tendency to concentrate in the same places from one year to another. These results constitute a useful tool for authorities, as it aids in the complicated decision-making process related to investment in traffic safety, and the community, by providing relevant information with which to properly assess and interpret the risks associated with motor traffic in critical points in the city.

T2-B.4 Brown A, Rodriguez J, Hagood G, Kang X, Armbrust K, Jewell J, Diaz D, Gatian N, Folmer H; abrown@bch.msstate.edu  
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### **THE STATE OF MISSISSIPPI'S RESPONSE TO THE GULF OIL SPILL**

Following the sinking of the Deepwater Horizon, the state of Mississippi began sampling and monitoring crabs, shrimp, oysters and several species of fish from numerous locations within Mississippi State Waters. From the end of May 2010 to date, over 300 samples have been analyzed by the State for Polycyclic Aromatic Hydrocarbons (PAHs) as listed in the NOAA method for analysis of PAHs in seafood. Additional samples were also collected and submitted to the NOAA laboratory in Pascagoula, MS to support the reopening of state waters in accordance with the pro-

cedure jointly developed by the gulf coast states, FDA and NOAA. PAHs have not been detected in any sample collected to date at levels above the Level of Concern (LOC) as established in the reopening protocol. The levels measured in seafood were also consistent with or below levels of PAHs detected in food items (smoked turkey, ham, chicken, catfish and barbecued pork) purchased at major retail supermarkets and restaurants. Additionally, we have developed a sensitive GCxGC-MSq method for chemically fingerprinting crude oils and tar balls. Crude oil is an extremely varied complex chemical mixture of organic compounds creating a unique ion signature for rapid identification.

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### **MODELING RETAILER AND CONSUMER BEHAVIOR IN A FOOD CONTAMINATION EVENT**

A mathematical model describing consumer and retailer behavior (i.e., awareness of and compliance with a recall, advisory, or warning) during a food contamination event has been developed as part of the Chemical Terrorism Risk Assessment (CTRA), a DHS CSAC funded program. The scope of the model begins with awareness of a contamination event (i.e., a cluster of illnesses has been reported to a local or state health department) and concludes when a steady-state behavior is reached among both consumer and retailer compliance. The model has three core components: the time delay to recall after a cluster of illnesses has been identified, information diffusion of the recall event, and compliance efficacies for consumers and retailers. Dimensional analysis has been applied to previous recall events to construct the distribution of recall delays. Once a recall is initiated, information pertaining to the event spreads through the general population and retailer chains. The diffusion of information regarding a recall is modeled from awareness data from previous food recall events with additional considerations of awareness data from the 9/11 attacks, 1982 Tylenol cyanide poisonings, and several presidential assassinations in order to incorporate information spread of potential large-scale catastrophes. Once aware of an event, the proportion of consumers and retailers actually complying with the recall depends on data from consumer surveys and retailer effectiveness checks. Simulations of the proposed model are run for a range of input conditions and contaminants to illustrate the mean time to recall and the time to reach 95% of steady-state efficacies for consumers and retailers. This tool can be utilized to prioritize investments in mitigating consequence during a food contamination event, provide insight into the relative benefits of enhancing investigations in order to identify recalls, and improve risk communication of recalls to retailers and consumers to maximize compliance.



M4-H.5 Buede DM, Ezell BC, Guikema SD, Lathrop JF, Mahoney SM, McLay LA, Post JM, Rothschild C; bezell@odu.edu

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### **PLURAL MODELS FOR ADAPTIVE ADVERSARY MODELING**

This presentation describes work performed by Innovative Decisions, Inc. (IDI) on modeling adaptive adversaries for Terrorism Risk Assessments (TRAs) for the U.S. Department of Homeland Security (DHS). Terrorists are not homogeneous but differ widely in terms of motivations; decision making information, skills, and processes; and organizational or personal psychology. In addition, there will likely be some interaction between what the terrorist (Red) does and what the United States or home government (Blue) does. We are focus on strategic risk analyses of one to three years in the future. Our approach uses multiple modeling methods, plural modeling. These modeling methods will consider motivations or objectives of the adaptive adversaries, will address multiple decision making styles, and will be conditioned on Red's perceptions of Red's capabilities as well as Red's perceptions of the defensive actions that Blue may take. This approach is founded on the principle that has been learned many times in the military/intelligence communities: that Blue should not assume that Red will do what Blue would do in a given situation, often called "mirroring".

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### **EXPOSURE AND RISK RELATIONSHIP BETWEEN SELENIUM AND MERCURY IN FISH: VARIATIONS AMONG AND WITH SPECIES**

Understanding potential risk to sensitive populations requires understanding contaminant levels in food, as well as potential protective effects of constituents. The exposure of most people to mercury comes from consuming fish, and mercury levels can be sufficiently high to provide a risk to predators that consume them, including humans. Selenium offers some protective benefit against mercury toxicity. In this paper we examine the variations in selenium and mercury levels within and among species of saltwater fish from the Aleutian Islands and from the Atlantic coast of North America. Although there is a generally negative relationship between the selenium:mercury molar ratios and mean mercury levels for species overall, the relationships within a species are highly variable, and are independent of fish size. These relationships indicate the need for more information on selenium:mercury molar relationships, while their implications for risk communication may be limited.

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### **AN ECOLOGICAL, MULTIDISCIPLINARY APPROACH TO NUCLEAR FACILITIES: PROTECTING SOCIETY, HUMAN HEALTH AND THE ENVIRONMENT.**

The USA and other countries have been moving towards a greater reliance on nuclear energy, but recent events in Japan illustrate the need to ensure health and safety around these facilities, as well as the integrity of nuclear waste disposal sites and repositories for the Department of Energy and commercial nuclear facilities. It is increasingly important to characterize the environment around such facilities to protect society, human health, and the environment. This paper presents an ecological, multidimensional approach to gathering the information needed to establish baselines, site new nuclear facilities, to protect existing nuclear facilities and wastes (from both legacy and commercial wastes), to improve the basis for emergency planning, to devise suitable monitoring schemes to ensure continued protection, to provide data to track local and regional response changes, and for mitigation planning. We suggest that there are five categories of information or data needs, including 1) geophysical, sources, fate and transport, 2) biological systems, 3) human health, 4) stakeholder and environmental justice, and 5) societal, economic, and political. These categories are influenced by temporal and spatial patterns, vulnerabilities, and global changes. These informational needs are more than the traditional site characterization, but encompass a suite of physical, biological, and societal needs to protect all aspects of human health and the environment, not just physical health. Indicators for assessment and monitoring can be selected from these lists, and although each site will vary in which indicators are selected, uniformity in some indicators across the country will allow comparability in hazards and risks. We suggest that technical teams be established for each of the major informational categories, with appropriate representation of a range of governmental personnel, natural and social scientists, Native Americans, environmental justice communities, and other interested and affected stakeholders.

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*US Environmental Protection Agency*

### **AN UPDATE ON ADVANCING THE NEXT GENERATION OF RISK ASSESSMENT (NEXGEN)**

Risk assessment remains the fundamental approach used by the US EPA to analyze potential risks from exposure to environmental contaminants and mixtures of chemical and non-chemical stressors. As new and emerging technologies in cellular, molecular, and systems biology are developed and applied to health and safety, their impacts on and utility in risk assessment need to be characterized. In 2010, the National Center for Environmental Assessment at the US EPA started the Ad-



vancing the Next Generation of Risk Assessment project (NexGen) in collaboration with other Federal and State partners including the National Institutes of Health, the Centers for Disease Control and Prevention and the Agency for Toxic Substances, the Department of Defense, and the State of California's Environmental Protection Agency. NexGen is using six data-rich chemical prototypes (i.e., ozone, chlorine, endocrine disruptors, polycyclic aromatic hydrocarbons, conazoles, and benzene) to determine 1) whether enough next generation data exist to perform a risk assessment; 2) if differences exist between the existing hazard assessments, and those made using the next generation data; 3) the levels of uncertainty associated with next generation data; 4) how to incorporate next generation data into future risk assessments. This talk will provide an update on the NexGen effort, discuss the outcomes of our public workshop, and inform participants of our future directions and timeline. This abstract has been reviewed and approved for release by the Environmental Protection Agency but does not necessarily reflect the views of the Agency.

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*United States Geological Survey, Department of the Interior*

### **ANTICIPATING AND ADAPTING TO CLIMATE CHANGE IN COASTAL DELTAS**

The Intergovernmental Panel on Climate Change ranks heavily populated coastal deltas among the world's most vulnerable regions to the effects of climate change. The IPCC classifies deltas as "hotspots of societal vulnerability" with nearly 300 million people inhabiting deltas globally. In addition to serving as a land base for many of the world's most densely populated cities, deltaic wetlands and the estuaries they fringe are among the most biologically productive systems in the world. Their high fertility and biological productivity account for a large percentage of world fisheries landings and many have been drained, deforested, or impounded for agriculture and aquaculture. Even in the absence of a changing climate, 70% of the world major deltas are deteriorating as a result of human activities that have affected their natural flood pulses and sedimentary processes. Climate change has the potential to amplify the decline of deltaic systems through several mechanisms, but the most important drivers are sea level rise, increased storm intensity, and changes in rainfall and runoff to the coast. This presentation will provide an overview of how climate change affects deltaic land forms and alters the processes that created and sustain them. It will examine how human development patterns can accelerate or ameliorate the impacts of climate change.

W1-A.4 Burns WJ; bburns@csusm.edu

*Decision Research*

### **PUBLIC RESPONSE IN THE U.S. TO THE JAPANESE CRISIS: REACTIONS TO THE EARTHQUAKE AND TSUNAMI VERSUS THE NUCLEAR ACCIDENT**

There is much research suggesting that the public reacts differently to natural disasters versus technological accidents or terrorism. Studies appear to suggest perceived risk, emotional reactions and risk-related behaviors (e.g. avoidance of impacted areas) are typically less for natural disasters. Two studies are reported. The first involves university students who were surveyed online every day from February through April 2011 (74 data points). Among a wide range of questions they were asked about their perceptions of threats like terrorism, the financial crisis and natural disasters. Following the triple disaster in Japan during March 2011 there was a clear spike in perceived threats from natural disasters with a gradual decay thereafter. There was no corresponding change in perceived threats from terrorism or the financial crisis. The second involves two nationwide surveys conducted in March and April 2011 (about 30 days apart) that compared response to the earthquake, tsunami and nuclear disasters on a variety of measures. There were strong reactions to all three disasters but response to the nuclear disaster was more pronounced. Likewise, reaction to all three mishaps decreased between the first and second surveys. Two respondents in three indicated that the nuclear disaster in Japan increased their perceptions of risk regarding nuclear reactors in the U.S.

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### **DO THEY PRACTICE WHAT THEY PREACH? USING PUBLICATION RECORDS AS A PREDICTOR OF SCIENTISTS' ATTITUDES TOWARD THE REGULATION AND COMMUNICATION OF NANOSCIENCE**

Two of the more important and persistent issues facing the nanotechnology industry in recent years have centered on the regulation of nanoscience research (Berube, Cummings, Cacciatore, Scheufele, & Kalin, forthcoming; Murashov & Howard, 2008) and the communication of this research with the public at large (Corley & Scheufele, 2010; Project for Emerging Nanotechnologies, 2006). Unfortunately, despite growing social science research in these areas, we remain largely unaware of how leading U.S. nanoscientists form opinions about the regulatory framework for nanotechnology and the communication of its key scientific findings. Moreover, there are - to our knowledge - no studies exploring the extent to which the opinions expressed by nanoscientists in public opinion surveys match their actual practices. To address these issues, we have combined a public opinion survey of leading U.S. nanoscientists' attitudes toward nanotechnology regulation and communication with data of these

same scientists' environmental health and safety (EHS) publication records. First, we compare those scientists with at least one EHS publication to those without any EHS publications on a number of demographic and attitudinal variables. The results show that scientists with EHS publications are not markedly different from scientists without such publications. Next, we inserted this information into a pair of hierarchical ordinary least squares regressions predicting attitudes toward nanotechnology regulations and the communication of scientific findings. Our results confirm that the nanoscientists with EHS publications are generally the same people pushing for revised nano regulations. More importantly, our findings show that these same scientists are also more supportive of the immediate communication of scientific findings with the general public. This latter point suggests an avenue for EHS risk information to find its way into public discourse and is the focal point of our study.

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*Health Canada*

#### **THE INFLUENCE OF AIR POLLUTION ON CARDIOVASCULAR AND PULMONARY FUNCTION AND EXERCISE CAPACITY: CANADIAN HEALTH MEASURES SURVEY (CHMS)**

**Background.** Air pollution has been associated with adverse cardiovascular effects. **Objective.** To measure the association between air pollution, spirometry, blood pressure, and exercise capacity. **Methods.** We used data from 5604 subjects collected during the Canada Health Measures Survey to test the association between air pollution measured on the day of the survey and spirometry (n=5011 subjects), blood pressure, and exercise capacity (n=3789 subjects). **Results.** An interquartile increase in ozone (17.0 ppb) was associated with a 0.883% higher resting heart rate, a 0.718% higher systolic and 0.407% higher diastolic blood pressure, a 0.393% lower FEV1/FVC expressed as a percentage of predicted, and a 1.52% reduction in the aerobic fitness score ( $p < 0.05$ ). NO<sub>2</sub> and PM 2.5 were associated with higher resting diastolic and systolic blood pressure and lower percent predicted FEV1 ( $p < 0.05$ ). An increase in PM 2.5 was associated with a decrease in percent predicted FVC. **Conclusion.** Exposure to higher concentrations of air pollution was associated with higher resting blood pressure, lower ventilatory function, and for higher ozone, lower aerobic fitness.

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*Concordia University*

#### **DECISION MODEL FOR MANAGEMENT OF SEWAGE PLUMES IN A TIDAL ENVIRONMENT**

We propose a decision model for the management of degraded water quality in a tidal environment. The complex and unsteady hydrodynamics of estuaries and tidal rivers greatly complicates water quality assessment and prediction and hence impact valuation and decision-making. A rational analysis requires an understanding of

underlying hydrodynamics, principles of water quality in unsteady environments, impact valuation methods and decision analysis techniques. Two-dimensional numerical models of sewage plumes in tidal environments illustrate the high sensitivity of water quality to input parameters such as seasonal stratification and tidal condition that vary continuously with time. Probabilistic methods are needed to translate discrete snapshots of water quality under time-variable conditions into a quantitative, constant description of water quality that can be used to evaluate the costs of ecological and economic impacts. As inputs, we use output of a numerical water quality model of Burrard Inlet near Vancouver, Canada, under discrete combinations of input conditions. We use probabilistic methods to weight the discrete snapshots of sewage plumes into an overall description of water quality. We then use impact valuation methods to approximate the environmental and economic costs of the water quality model output. In order to allow for comparison of management alternatives in terms of each one's net costs (infrastructure investment and the associated ecological and economic impacts), we nest the quality/impact valuation model into a decision analysis framework. We explore expansion of the quality and impact valuation model in the direction of stochastic hydrodynamic models that will allow for consideration of uncertain model parameters with no periodicity such as wind shear. Our preliminary results indicate that the greatest source of decision uncertainty lies in the valuation of sewage impacts, rather than the water quality model.

W2-I.2 Calkin DE, Wibbenmeyer MJ, Hand MS, Thompson MP, Venn TJ; [decalkin@fs.fed.us](mailto:decalkin@fs.fed.us)

*US Forest Service Rocky Mountain Research Station, The University of Montana*

#### **RISK PREFERENCES AND PROBABILITY WEIGHTING IN STRATEGIC WILDFIRE DECISION-MAKING: A CHOICE EXPERIMENT OF US WILDFIRE MANAGERS**

In the United States, wildland fire events are managed for numerous competing objectives in an environment of considerable uncertainty and political pressure. Federal wildfire management policy dictates that the magnitude of suppression response should be commensurate with the values at risk, and has embraced risk management as the appropriate paradigm for wildfire management. Therefore significant efforts have been directed towards development of decision support systems capable of assisting managers in assessing and managing wildfire risk. Economic theory suggests that over repeated wildfire events, a policy of risk neutrality will generate optimal wildfire management outcomes. Nevertheless, it is well-established that human factors, including sociopolitical constraints and pressures, incentives facing fire managers, and decision biases, have substantial influence over the ways in which individual fire events are managed. In particular, fire managers may be risk averse and may overweight low probability events within their decision analysis. Over time, such behavior is likely to lead to inefficient uses of fire management resources. This paper uses a

choice experiment questionnaire to measure attitudes among US wildland fire managers toward several sources of risk. It represents one of the first stated choice studies to incorporate probability weighting, which allows for nonlinear effects of probability on utility. Results provide a means for comparisons among wildfire managers' risk preferences and the risk preferences of professionals in other fields. Additionally, we demonstrate that the efficiency of fire management over repeated wildfire events can be improved through decision environments that allow for and encourage reduced risk aversion among managers.

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*Food and Drug Administration, Center for Food Safety and Applied Nutrition*  
**RISK ANALYSIS DURING FOOD SAFETY EMERGENCIES**

Conducting risk assessments, making risk management decisions and communicating risk during urgent food safety incidents with serious public health implications pose unique challenges for risk analysis professionals. Each food safety incident or emergency is likely to be unique in terms of the nature of the incident as well as the amount and quality of information available and therefore may need to be approached on a case-by-case basis. However, robust methods for conducting risk assessments and making risk management decisions, regardless of the level of pressure associated with a particular food safety incident or emergency are critical to ensure that timely decisions are based on a logical and knowledgeable understanding of the situation rather than an emotional (or intuitive) basis. This presentation will focus on the US FDA participation in work to develop the FAO/WHO guide for application of risk analysis during food safety emergencies, including outcomes and lessons learned from this project.

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*The Pennsylvania State University*

### **SORTIT - AN ONLINE MULTIPLAYER ADVENTURE GAME FOR PAIRWISE RANKING OF RISKS**

We present the design and evaluation of a serious online browser game called SortIT for eliciting pairwise comparisons of risks. SortIT is a two-player collaborative game that rewards players depending on whether they match the responses of their partner (i.e., an output-agreement game). Each round of SortIT presents players with a choice. Such choices include an assessment of which of two risks is more or less risky, whether a risk is considered voluntary or involuntary, etc. SortIT is built atop of an adventure game platform - in the game, players work together to defeat a series of monsters in a dungeon. The goal is to defeat the monsters and move on to the next dungeon. Each correct response (e.g., both players agree on the same risk as being more risky among the two presented to them) produces a hit on the monster, whereas an incorrect match results in the monster hitting the players. A successful kill of the monster may yield treasures such as weapons and protective armor. In our

initial test of SortIT, we considered an array of cyber-oriented risks and a full set of psychometric dimensions thought to influence perceptions of these risks. Our results enabled us to display how individuals and groups playing the game rank order a set of risks and how they label individual risks. Players found the experience playing SortIT to be very fun to the point where they expressed disappointment about having to stop when the experiment was over. In this talk, we present the full details of SortIT, including game design, concept, test, and results. Future directions are also discussed.

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*Concurrent Technologies Corporation*

### **METHODOLOGY FOR USING LIFE CYCLE ASSESSMENT TO MINIMIZE ENVIRONMENT, ENERGY, WATER, AND CHEMICAL LIABILITIES**

Domestic and foreign policies (i.e., EO 13514, REACH and RoHS) have placed pressure on the U.S. Department of Defense (DoD) to implement more sustainable practices for weapon system acquisition. As part of its sustainability efforts, the DoD seeks to use Life Cycle Thinking (LCT) to ensure that decisions regarding weapon system design consider potential impacts to human health and the environment across the system's life cycle. To guide this effort, commonly-used Life Cycle Impact Assessment (LCIA) methods and the components of those methods (e.g., impact categories, metrics, characterization factors, weighting mechanisms) were reviewed and summarized with regard to their applicability to DoD's LCT efforts. Gaps identified included the absence of assessment methods for quantifying potential impacts to worker health and site-specific weighting mechanisms. This presentation will highlight the current progress toward resolving these challenges and the unique considerations that large government institutions, such as the DoD, face when embracing LCT. This presentation also will present the current state of the life cycle impact assessment methodology being proposed.

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*Vanderbilt University*

### **CLIMATE CHANGE IMPACTS ON FREIGHT TRANSPORTATION INFRASTRUCTURE - ADAPTATION STRATEGIES AND CHALLENGES**

One key aspect of our livelihood that is threatened by climate change is the integrity and performance of our freight transportation systems. In the U.S., the freight transportation network is a complex mosaic of highways, railroads, waterways, airports and pipelines, covering millions of miles and involving interactions at thousands of terminals. Sufficient climate changes are and will be taking place that require an adaptive response. Potential changes of interest include warmer temperatures, sea level rise, more frequent and violent storms, and greater weather extremes. The impacts of these changes can range from imposing minor delays in the delivery of goods to the consumer, to rendering entire regions of the country impassable for long



periods of time. Successful adaptation can be achieved by reducing vulnerability (susceptibility to adverse effects of climate change) or by enhancing resilience (capability to survive climate-induced events with minimal damage). The focus of this paper is on the performance of transportation infrastructure in the face of a changing climate. Three fundamental questions are examined: (1) at what climate change thresholds will freight transportation adaptation be necessary, (2) what types of adaptation strategies would be most responsive to societal needs under these circumstances, and (3) what is a sensible path forward in terms of information and research needs, strategic initiatives and short-term actions that will enable us to be better prepared to address these considerations? These questions are addressed in the context of various climate scenarios. Highlighted in the discussion are the challenges of both decision making under uncertainty associated with the limitations of currently available information to assess scenario likelihood and consequences and evaluation of the benefits and costs of candidate adaptation strategies. Findings from a national summit recently hosted by the authors are used as a resource in addressing these challenges.

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*The Hammer Institutes, RTP, NC, Syngenta, LLC*

#### **PBPK MODELING WITH ATRAZINE: SIMULATION OF THE DYNAMIC CHANGES IN AN IN VITRO SYSTEM TO SUPPORT IN VITRO TO IN VIVO EXTRAPOLATION ACROSS SPECIES**

A published PBPK model for atrazine (ATZ) in rats (McMullin et al., 2007) was expanded with new time-intensive pharmacokinetic data collected from female Sprague Dawley rats (Kim et al., 2011) and cynomolgus monkeys (Yi et al., 2011). Partition coefficients, measured by in vitro equilibration or estimated with QSAR methods, were validated against tissue concentration measurements from in vivo studies in rodents. Phase I metabolism of ATZ including the generation and clearance of desethyl ATZ (DEA), desiso ATZ (DIA) and di-dealkylated, diaminochlorotriazine (DACT) was studied in whole rat and human hepatocyte suspensions. Phase II metabolism was characterized in the cytosolic fractions from Sprague-Dawley rat, cynomolgus monkey and human liver. A one compartment model was developed for the hepatocyte incubations. The ability to incorporate in vitro metabolic parameters from the in vitro test system to the in vivo PBPK model was greatly improved by including competitive inhibition of metabolism among ATZ, DEA and DIA and by adjusting the number of viable hepatocytes in the system by the reported time-variant viability. Metabolic parameters from this in vitro model were incorporated into the PBPK model by scaling based on the hepatocellularity of the liver. Prediction of the time-course disposition and elimination of ATZ and the chlorotriazine metabolites across the dosing regimens and the range of doses for rat, monkey and human were improved with the incorporation of the metabolic rates derived from the in vitro systems into the in vivo PBPK model. This extended PBPK model can predict plasma

time-course and urinary elimination data for ATZ and the chlorotriazine metabolites collected in rats, monkeys and humans after intravenous, oral or dietary exposure to ATZ. The PBPK model can also characterize pharmacokinetic differences across species and dose levels and support a human risk assessment based on internal dose.

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*Exponent*

#### **SEEING THE FOREST THROUGH THE TREES: NRD AND DYNAMIC ECOSYSTEMS**

Under certain federal and state statutes, public agencies can claim economic damages resulting from injuries to natural resources. The principles for estimating the reduced value of services provided by natural resources are similar to those for estimating damages associated with any resource or asset. An important source of debate and uncertainty about these estimates, however, is whether there are net losses in ecological services following man-made disturbances that mimic natural disturbances. Ecological processes include photosynthesis, energy flow, nutrient cycling, water movement, disturbance, and succession. Disturbances such as wildfire, floods, or windthrow are natural and integral processes in many systems. Organisms that make up the biotic component of such systems have evolved in response to environmental changes triggered by disturbances. Disturbances often move ecosystems towards earlier successional stages, stimulating renewal processes and short-term increases in productivity. Large-scale disturbance may move an ecosystem to a new system state from which it may, or may not, return to its predisturbance condition. Measuring the net change in ecosystem resources and services and the resulting natural resource damages (NRD) is complicated by the positive ecosystem benefits that large-scale disturbances often provide. In recent litigation, public agencies have used valuation methodologies for NRD that attempt to simplify the analysis by associating damages with the loss of some countable resource such as fire-killed trees. We show in the case of wildfires that this approach fails to recognize the dynamics of the ecosystem services and in specific circumstances, grossly overestimates the damages from the disturbance. Our analysis indicates that in order to properly value ecological baseline and recovery from disturbances that mimic natural processes, the NRD framework must reflect not only levels of ecosystem services, but also their dynamics.

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*USDA-APHIS, Consultant, USDA-ARS*

#### **QUANTIFYING AN EXAMPLE SYSTEMS APPROACH USED TO MITIGATE THE RISK OF ESTABLISHMENT OF FRUIT FLIES**

We used a probabilistic model to investigate how an example systems approach may be used to mitigate the risk of establishment of fruit flies via imported fruit for consumption. In this example, we considered an import scenario with the following



mitigations: 1) fruit is coming from an area of low prevalence of the pest, and 2) fruit are treated with a procedure that is 99.9 percent effective (i.e., less than probit 9, or 99.9968 percent). We defined low prevalence as 5 adult fruit flies per 10,000 fruit (rate = 0.0005), and created a distribution for that using the 95 percent confidence level limits for the proportion. Treatment survival was a binomial process with the probability of survival = 0.001. Using a uniform distribution of imported fruit with a mean of 100,000 fruit per container, we simulated the risk of getting at least one mating pair (i.e., a male and female adult) per container. We compared results to a formulaic estimate of treatment efficacy using the means of the above distributions. The probability of a mating pair being present was 0.00066, or about 0.07 percent. That compared to a formula estimate of 0.00061, or close agreement. The probabilistic model further informs that the proportion of shipments with more than one surviving adult was only 0.00132, or 0.13 percent. The estimated mean number of containers to the first mating pair is 1515 ( $= 1/0.00066$ ), with a five percent chance that the first pair would arrive in the first 78 containers. Using the probabilistic model can help managers decide if the proposed mitigations meet their phytosanitary requirements or if additional measures should be required. We are using this and other models to help define standard systems approaches for exporting nations.

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*The Pennsylvania State University*

#### **LINKIT - A GAMING APPROACH FOR ELICITING MENTAL MODELS ABOUT RISK**

In recent years, a mental models approach has become a leading strategy to develop risk communications. As it current stands, the mental models approach involves a time and labor-intensive interview process to develop an understanding of how both experts and laypeople understand risk. We propose that the similarity ratings approach for structural knowledge elicitation can be adopted to support the risk mental models approach. The LinkIT game, inspired by Games with a Purpose, or GWAP, technology, is designed to group level mental models of risk represented as influence diagrams in a more enjoyable and endurable manner when compared to traditional approaches. In order to examine the external validity of LinkIT, we conducted a study to compare its performance with respect to a more conventional questionnaire-driven approach. Two network metrics, distance between two networks and self-uncertainty, are calculated for a network-level comparison. We conclude that no significant differences exist between the two group mental models elicited from the two approaches. Also, LinkIT was twice as productive as the questionnaire in terms of data elicitation. Although participants playing the game have not reported more enjoyment than those answering the questionnaire, we find significant evidence that LinkIT, compared to the questionnaire, maintains participants' interest and attention longer. However, the durability is still a concern for LinkIT because participants

had a difficult time playing the game for longer than 15 minutes. This presentation summarizes the design and evaluation of the LinkIT game and suggests areas for future work.

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*Battelle*

#### **DEVELOPING PLANNING SCENARIOS AND RESOURCE REQUIREMENTS BASED ON QUANTITATIVE RISK ASSESSMENT**

Homeland Security Presidential Directive (HSPD) 18 (Medical Countermeasures against Weapons of Mass Destruction) requires a risk assessment of Chemical, Biological, Radiological, and Nuclear terrorism for the purpose of risk based decision support in the area of medical countermeasure acquisition and development. The Department of Homeland Security's (DHS) Science and Technology Directorate has completed a number of risk assessments in support of this directive. The Department of Health and Human Services and other Federal agencies are developing requirements and planning scenarios partly based on the risk assessment results. Multiple strategies and recommendations for developing resource requirements and planning scenarios from a probabilistic risk assessment will be discussed using the DHS terrorism risk assessments as an example. In addition, the benefits of turning the risk assessment into a risk management tool beyond the planning scenarios will be presented.

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*Massachusetts Institute of Technology*

#### **SYNTHETIC BIOLOGY APPLICATIONS: HEALTH AND THE ENVIRONMENT**

I will discuss current progress in the field of synthetic biology, from my own research (e.g. imparting alternate genetic codes to microbes) and that of others. One of our great long-term hopes is to provide engineered organisms that work in the human body to fight disease and that work in the environment to remediate toxic chemicals. But in addition to achieving our technical objectives, we need a framework for assessing the corresponding risks. How we will (researchers, policy makers, and the public) decide together when the benefits outweigh these risks? Can a staged series of laboratory and field experiments produce a sufficient evaluation of the stability of a genetic control system? Of the environmental competitiveness of an engineered microbe? The quantitative approaches of synthetic biology give us an opportunity to look at these issues from more than simply a hand-waving set of arguments. However most of us in this field lack the context we need to experimentally support high quality risk assessment. It is my hope that this symposium will provide the beginnings of very productive conversations between synthetic biologists and advanced assessors of risk.

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*HealthRisk Strategies, Gradient*

### **ARSENIC IN APPLE JUICE: MYTH VERSUS REALITY**

Naturally occurring arsenic occurs at trace concentrations in apple juice. Since 2009 there have been isolated reports of arsenic concentrations in commercial samples of apple juice that exceed USEPA's maximum contaminant level (MCL) for arsenic in drinking water. Public concern became focused on such reports in September 2011 in response to a feature presentation on a popular daytime television show. In response to that concern, USFDA and the juice producers retested the apple juice samples and reported results that exceeded neither USEPA's arsenic MCL nor USFDA's level of concern for arsenic in juice. This presentation will compare the different arsenic concentrations reported in apple juice, the federal agencies' different health-based exposure limits, and the conclusions about risk that were drawn, evaluating the sources of the differences. In this case, risk communication messages were influenced strongly by the analytic methodologies used and the federal contaminant limit comparisons chosen.

T2-J.3 Chatterjee S, Abkowitz MD; chatterjee.samrat@gmail.com  
*CREATE- University of Southern California, Vanderbilt University*

### **A FRAMEWORK FOR REGIONAL ALL-HAZARDS RISK ASSESSMENT AND MITIGATION**

Accidents, natural disasters, and terrorist acts occurring worldwide are heightening society's concern for the risks affecting our lives. It has also led to the realization that a more systematic and holistic approach to risk management is needed. The authors have addressed this issue by initiating development of an all-hazards risk management (AHRM) approach, taking multiple disaster risks into consideration. The methodological framework includes truck transportation of hazardous materials, earthquakes, and terrorist acts as three risks threatening a government jurisdiction. The paper describes the AHRM methodology and presents its application in a case study region in the United States. In addition to demonstrating how disaster risks compare within a region, the paper discusses how a risk manager can use these results to establish risk priorities and develop mitigation strategies that offer the greatest return on investment.

T4-A.4 Chauvet S, Boudier FE, Le Louet H; f.boudier@maastrichtuniversity.nl  
*Maastricht University*

### **PERCEIVED AND MANAGED RISKS OF BIOTECHNOLOGIES IN THE MEDICAL FIELD: A STUDY OF FRENCH EXPERTS' VIEWS**

In France, claims have been made that up to 40% of all medical errors may be attributed to prescription/medication errors (Le Parisien, 2009). Medical errors have been subject to numerous investigations in hospitals (Leape et al 1994; Bates et al, 1995; Dean et al, 2002; von Laue et al 2003; Knudsen et al, 2007; Aronson,

2009a). Yet, specific information about the risks of highly innovative products, for example biotechnologies, remains more limited. In addition, and unlike biological food products, little is known of expert views and public perceptions of medical biotechnologies. How should risk managers deal with biomedicines? Can they maintain the right balance between innovation and acceptable levels of safety? Is the current risk management approach likely to build or destroy trust? What about the new risks associated with innovative - and often complex- treatments administered in hospitals? This article conveys the results of a pilot study that focussed on the risks of medical biotechnologies in France. The study was developed in 2010-2011 and concentrated on collecting and analysing the views of key experts, primarily within Paris hospitals (Assistance Publique-H&ocirc;pitaux de Paris -AP-HP), which are one of the largest medical complexes in Europe. The study used a mental model approach to elicit expert views as a first steps towards defining an effective communication strategy to accompany the medical applications of biotechnologies. The study shows that, although most experts were aware of significant risks, they maintained a strong optimism bias. Broader perceptions or critical views about biotechnology were largely ignored, which suggests that medical professions are not prepared to face public worries. These results led us to provide key recommendations to support risk-based communication approaches that pay more attention to the wider social context.

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### **FROM EXPERIMENTAL INFECTIONS IN ANIMALS TO QUANTIFYING SUBTYPES IN FOODS: ADVANCEMENTS AND CHALLENGES OF DATA COLLECTION FOR LISTERIA DOSE-RESPONSE**

Data from multiple research fields contributes to the understanding of the complex dose-response relationship for listeriosis in humans. Participating experts at the Listeria Dose-Response Workshop co-sponsored by IRAC/JIFSAN shared recent data and knowledge about the physiopathology of *L. monocytogenes* infections and differences among human and animal hosts, distribution of *L. monocytogenes* subtypes in ready-to-eat foods, and fetal mortality and systemic infections in animals. Significant advancements have been made in the characterization of *L. monocytogenes* subtypes and elucidation of *L. monocytogenes* invasion of epithelial cells upon interactions between the bacterial internalins and specific host receptors. While humans express functional receptors, different expression of these receptors occurs in animals (e.g., guinea pigs, mice, and gerbils) at different host barriers (e.g., intestinal and placental barriers). A diverse range of *L. monocytogenes* subtypes with different in vivo virulence potential, as well as varying prevalence and concentration distribution, has been found in ready-to-eat foods. Virulence-attenuated subtypes (e.g., with mutations in the gene encoding internalin A) are commonly found in foods but only rarely associated with human cases. Dose-response data were reported for fetal

mortality or systemic infections using rhesus monkey and guinea pig models, where *L. monocytogenes* strains with different virulence were delivered in a high fat food or low fat medium. Recent advancements greatly enhance our understanding of the multiple facets of *L. monocytogenes* dose-response relationship. However, challenges remain in (1) collecting and relating data from diverse research fields to listeriosis in humans for use in models, and (2) reducing uncertainties especially for extrapolating from high to low doses, strain virulence variability, application to specific at-risk subpopulations (i.e., elderly and neonates) and food matrix effects.

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#### **PREVALENCE OF VARIANT CREUTZFELDT-JAKOB DISEASE IN THE UK: ESTIMATION FROM DIETARY EXPOSURE TO BOVINE SPONGIFORM ENCEPHALOPATHY DURING THE PERIOD 1980 TO 1996**

Although the incidence of new variant Creutzfeldt-Jakob disease (vCJD) has decreased in recent years, great uncertainties remain regarding the prevalence of vCJD infections. We described the probability of the number of potential infections due to dietary exposure to the bovine spongiform encephalopathy (BSE) infectious agent through a Poisson process throughout the time course of the BSE epidemic period, from 1980 to 1996. Birth cohorts and gender-specific exposure intensities of the BSE infectious agent were estimated in the U.K. for the two major periods: from 1980 to the specified bovine offal (SBO) legislation in 1989; and from the SBO ban in 1989 to the Over Thirty Month Rule (OTMR) in 1996. The number of potential vCJD carriers was then obtained by multiplying the numbers from different birth cohorts with the probability of dietary exposure and survival through the end of 2009; the calculations were performed under various scenarios of contamination rate (CR) in the production of mechanically recovered meat (MRM) containing the BSE infectious agent. The estimated numbers of infections drastically increased with the assumed CR. The total estimated numbers ranged from approximately 22,000 (CR = 0) to 3,310,000 (CR = 0.001) due to the consumption of burgers, sausages and other meat products during the period 1980-1996. The prevalence of vCJD infections may still pose a serious public health problem in the U.K. Further studies are needed to predict future vCJD incidence.

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#### **THE PROBABILITY STATISTICS ANALYSIS OF FOOD INTAKE INPUT DISTRIBUTION BY SENSITIVITY GROUPS (YOPI) OF FOODBORNE DISEASE FOR QUANTITATIVE MICROBIAL RISK ASSESSMENT**

Quantitative microbial risk assessment (QMRA) can be used to evaluate food safety as a scientific tool. Recent QMRA methodologies have been rapidly developed

to take into consideration the complexity of the food intake. However, to allow for a more realistic and accuracy QMRA, it requires that the study of probability statistics analysis for food consumption distribution by sensitivity group of foodborne disease i.e. YOPI; younger, older, pregnant and immunodeficiency group. The purpose of this study was to present the proper probability distribution models that functions as the input variables to the further QMRA model based on the data about food intake input distributions; example of consumption data of sausage products in Korea. The amount of intake data of sausage products was calculated based on 2009 Korea National Nutrition Survey. Probability distributions were created using BestFit (version 5.5 including “@RISK”, Palisade, Newfield, N.Y.) based on the obtained data. Statistical ranking was determined by the goodness of fit (i.e., the Kolmogorov-Smirnov [KS] test etc) to determine the proper probability distribution model. The proper probability distribution model for consumption of whole population, younger (< 3 year-old), older (>65 year-old), and immunodeficiency group for sausage products were determined as InvGauss (35.728, 24.276), LogLogistic (0.589, 11.332, 1.6119), Logistic (16.2822, 7.1872) and LogLogistic (23.039, 12.957) distribution model, respectively. There was not enough data for fitting in pregnant group. The QMRA have to be presented as the probability distribution model that can be showed on uncertainty and variability of input values such as amount of intake data. The results of this study can be directly used as the input variables in exposure evaluation for conducting QMRA of sausage products.

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#### **AN IN VITRO TO IN VIVO EXTRAPOLATION APPROACH FOR CONDUCTING A CUMULATIVE RISK ASSESSMENT FOR PHTHALATE ESTERS**

Phthalate esters, a group of industrial chemicals extensively used as plasticizers and additives, have been associated with adverse effects on the male reproductive development of laboratory animals. Epidemiological studies have raised concern for potential phthalate-related developmental toxicity in humans. While current assessments have focused on a single phthalate, it will be necessary to consider cumulative exposure to the endocrine active phthalates considering potency and metabolism differences across varying side chains. We have used a PBPK model, coupled with in vitro assays, to provide in vitro to in vivo extrapolation of compound-specific kinetic and potency differences to assess the cumulative risk of phthalate exposures. Phthalates selected comprise di-n-butyl phthalate (DBP), di(2-ethylhexyl) phthalate (DEHP), di-n-octyl phthalate (DnOP) and butyl-benzyl phthalate (BBP). In vitro potency assessment was conducted on monoester metabolites including mono-n-butyl phthalate (MBP), mono-(2-ethylhexyl) phthalate (MEHP), mono-benzyl phthalate (MBzP) and mono-n-octyl phthalate (MnOP) with two cell lines (MA-10 and R2C)



derived from mouse and rat testes tumors. The ability of the monoester to decrease in testosterone in the culture system was compared at the IC50 to set toxic equivalents. The toxic equivalency factor was based on MBP (MBP-TEF) to utilize the rich database on the anti-androgenic effects of DBP. An existing rodent PBPK model for DBP and DEHP was extrapolated to the other phthalates using in vitro estimates in hepatocytes. The predictive ability of the model was tested against published human data for a single dose of labeled phthalate and the fraction of administered compound excreted in urine over 44 hr. The cumulative risk was then defined as the sum of the target tissue dose for each phthalate multiplied by its corresponding potency factor. The approach used for phthalates could, in principal, be broadened to estimate a cumulative risk for all anti-androgenic compounds for which there is evidence of human exposure.

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### **WATER SYSTEM RELIABILITY UNDER HURRICANE IMPACT CONSIDERING ELECTRICAL GRID INTERDEPENDENCY**

In 2008, Hurricane Ike provided a direct hit on Galveston Island along the upper Texas Gulf Coast, and impacted most every major infrastructure system in its path. Unfortunately, such events are common along the Texas coast, and the impacts can be financially, socially and psychologically devastating to local communities as well as the state and national economies. This research considers the application of network science analysis techniques to an actual small town water distribution network to determine system reliability given a direct hit from a hurricane. In this system simulation, the water network proved to be resilient to storm damage when studied in isolation. However, the water network is also dependent upon the electrical grid to provide operating power for water system pumps. To consider the interdependencies between the power and water networks, this paper introduces a scenario-based two-stage simulation method to decouple system interdependencies which increases analysis flexibility and effectively reduces the computational complexity. The system reliability realizations generated by this method are then used as input to a hydraulic model to simulate the resulting water system pressure at consumption nodes throughout the network. The simulated system pressures are compared against a minimum pressure criteria to determine if the water network is resilient or not. As this work demonstrates, survival of the electrical system network is the most important factor in determining the reliability of the water system. Preliminary analysis results are consistent with observed water system pressures following Hurricane Ike, which impacted this water system as a Category 2 hurricane. Utilizing the results from this case study, the local water system operator and emergency responders can become better prepared for future disaster events, and the residents can be more confident that minimum water services can be provided as future hurricanes make landfall.

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### **SYNTHETIC BIOLOGY: EVALUATION USING INTEGRATED RISK ASSESSMENT, LIFE CYCLE ASSESSMENT AND MULTI-CRITERIA DECISION ANALYSIS**

Synthetic biology is a rapidly expanding field that has the potential to provide mankind with unprecedented benefits, ranging from bioremediation to new pharmaceutical development methods. As an emerging technology, however, the risks and possible effects of synthesized organisms and components are widely unknown. The availability and development of the technology itself along with the potential evolution of organisms created with the technology means that present risk governance may be insufficient to properly evaluate the risks inherent in synthetic biology. Governments and policy makers will have to make informed decisions regarding the tradeoffs between potential risks and benefits. To facilitate decision making and policy options, a multi-attribute-decision-analysis (MCDA) approach integrating risk analysis (RA) and life cycle assessment (LCA) is recommended. The framework uses LCA and RA to evaluate and assess the different risks associated with synthetic biology, including biosafety, biosecurity, and ethical issues at different material life cycle stages. MCDA is then be used to compare the risks and benefits of different technologies or products. Based upon the results of the model, decision makers can focus their attention and structure policy.

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### **NEW INITIATIVES FOR EPA'S INTEGRATED RISK INFORMATION SYSTEM (IRIS) PROGRAM**

EPA's Integrated Risk Information System (IRIS) program is moving forward on several fronts: increasing the rate at which assessments are completed, finishing several major health assessments with important public health impacts, increasing the clarity and transparency of its assessments, streamlining first-draft assessments to make them more concise and easier to follow, and building a foundation to bring next-generation approaches into risk assessment. EPA has embraced the recommendations of a National Research Council committee that provided a "road-map" for bringing greater clarity and transparency into its assessments. EPA is restructuring the standard IRIS document format in order to focus on better characterization of the rationale for identifying informative studies and for evaluating the weight of evidence. EPA's immediate objective is to increase the rate of production of new IRIS assessments, to update older IRIS assessments that have significant new information that could change toxicity values, and to maintain high scientific quality through rigorous peer review.



## **INVESTIGATING THE ROLE OF IDENTITIES AND OPINION LEADERSHIP ON RISK INFORMATION SEEKING AND SHARING ABOUT PROPOSED NATURAL GAS DRILLING IN NEW YORK'S MARCELLUS SHALE**

Potential development of Marcellus Shale natural gas reserves in New York State has spurred passionate debate and provided opportunities for gathering and exchanging information about perceived impacts. This project investigates the role that identities, specifically opinion leadership, play in motivating risk information seeking and sharing about such risk controversies. Thirty-six interviews explore the novel premise that an opinion leader identity and the contexts in which it emerges (including group membership and social roles) helps people negotiate a complex risk message environment and shapes communication behavior over time. Interviewees perceived and sought and exchanged information about a variety of potential impacts and reported a variety of meanings associated with opinion leadership (including staying informed about particular impacts) and reasons for seeing themselves/being seen in this light (i.e., belonging to organizations such as local Legislatures and occupying particular positions, such as an elected official). For some, these contexts shaped the types of information about which they felt social or personal pressure to remain informed and/or sought and shared. Theoretical and practical implications of this research are discussed, including (1) measuring how people look for and exchange information about controversial, polarizing risk issues and (2) harnessing the power of opinion leaders - themselves a diverse group - to encourage communication behavior about contentious natural resource management issues as part of public participatory processes.

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## **GENOMIC CHANGES IN PRIMARY HUMAN UROEPITHELIAL CELLS FOLLOWING 24 HOUR EXPOSURE TO MIXTURES OF ARSENITE AND ITS TRIVALENT METHYLATED METABOLITES**

Expression changes in arsenic-exposed primary human uroepithelial cells were evaluated to identify genomic biomarkers of cell signal pathway perturbations potentially associated with bladder carcinogenicity. Human uroepithelial cells from 10 kidney-donor ureter segments were treated in culture with mixtures of inorganic arsenic and its trivalent metabolites for 24 hours at relative proportions (1:1:4) typically observed in the urine of individuals exposed to arsenic in drinking water. Total arsenic concentrations ranged from 0.06 to 18 micromolar. Similar responses were

obtained for mixtures containing pentavalent or trivalent metabolites. Principal component analysis indicated that the variation across individuals was substantially greater than the changes in expression elicited by arsenic treatment. However, a suite of gene changes was identified that reflects the effects of sub-micromolar arsenic on a number of key signaling pathways across nearly all subjects: HMOX1 (oxidative stress), FKBP5 (protein folding), LGALS8 (growth regulation), MT1E (metallothionein regulation), DDB2 (DNA damage sensing), TXN/TXNRD1 (thioredoxin regulation) and THBD (immune response). The concentration/response for DDB2 and THBD were non-monotonic, with reversal in direction of effect around 0.1 micromolar. Together, these genes may serve as an early biomarker of effects for arsenic. Work is underway to investigate changes in gene expression over time.

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## **USE OF CONSUMPTION DATA TO INFORM HUMAN ILLNESS SURVEILLANCE DATA**

Regulatory decision-making needs to be informed by probability-based risks of foodborne disease at the food source or commodity level. However, food source attribution estimates rely heavily on human illness surveillance data collected by public health agencies, and the majority of these data lack food exposure information. Consequently, models of food source attribution need to incorporate consumption information into estimates of population-based risk of foodborne illness outcomes. Consumption-based models can approach the issue using various underlying assumptions and outputs. For example, a foundation for considering population-level attribution is to start with an assumption that all food is contaminated uniformly. In this case, the illness attribution fractions for each commodity are simple functions of consumption estimates for each commodity. From this naïve hypothesis a variety of data sources can be incorporated to better reflect the true variation of contamination across food commodities. An example of this is the use of microbial data from commodity sampling to inform estimates of foodborne illness derived from consumption. These and other options for using consumption-based approaches to estimate food source attribution and to inform decisions based on these estimates will be presented.

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## **PARTNERSHIP OPTIMIZATION DECISION SUPPORT SYSTEM (PODSS): IMPROVING PARTNERSHIP DEVELOPMENT AND RESOURCE ALLOCATION IN DISASTER RECOVERY OPERATIONS USING GAME THEORY**

The Partnerships Optimization Decision Support System (PODSS) approach provides a dynamic planning and coordination tool for surviving agencies to allocate

resources under any circumstance in an accessible and scalable way. Disasters have increasingly become a dominating phenomenon in the last 10 years, including the 2010 Haitian earthquake and the 2011 United States tornadoes. Such disasters have also resulted in increasing publicity for ineffective agencies that have failed to cooperate and coordinate during relief and recovery operations. With an eye towards disasters at all scales, including global catastrophes, it is clear that a new, more effective paradigm for coordinated response is needed. It is essential that relief efforts focus on how to optimize in a dynamic environment and do not rely on extensive a priori mitigation. Agencies (e.g. organizations, militaries, governments, and businesses) and individuals have come to recognize the need for an adaptive approach to response, regardless of the type or size of the disaster. Combining game theory with multi-period optimization, the proposed system provides a scalable approach to partnership and resource management. Using utility functions to predict interagency partnership payoffs, PODSS applies game theory to solve a mixed integer program that provides recommendations for resource allocation at the agency level. This system allows agencies to identify what partnerships to form and, once formed, how much of their resources should be dedicated to each project. By placing an effective tool in the hands of individuals, governments, and all other agencies, our system provides a framework for survivor-centric recovery.

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### **ASSESSING THE NONCANCER CHEMICAL RISK OF 1,3-DIBROMO-BENZENE: PRELIMINARY SURROGATE APPROACHES AND QSAR MODELS EMPLOYING LONG-TERM LOAELS AND CHEMICAL STRUCTURES OF HALOGENATED BENZENES**

Halogenated benzenes (HBs) are used as solvents, herbicides, antiseptics, and pesticides. Due to high environmental persistence and often associated adverse effects, these compounds are chemicals-of-concern at Superfund waste sites. There is not enough toxicity data for a traditional risk assessment of 1,3-dibromobenzene (1,3-DiBB), a HB chemical-of-concern. Hence, we employed two alternative methods to assess the chemical risk of 1,3-DiBB: (1) a surrogate approach, and (2) a quantitative structure-activity relationship (QSAR) approach. The surrogate approach considered four bromobenzenes (BBs) in relation to supporting data including toxicokinetic and chemical class-specific toxicity data. Deductive reasoning was used to identify a suitable representative compound, and the toxicity value of the identified compound could serve as the surrogate value for 1,3-DiBB. Through our analysis, hepatotoxicity was found to be an endpoint of greatest concern amongst BBs. The specific endpoint permits the subsequent QSAR approach to quantitatively correlate 13 HBs, including the four BBs used in approach (1), and toxicity data, assuming similar mode of action and effect. Peer-reviewed hepatotoxic long-term lowest-observed-adverse-effect levels (LOAELs) of 13 HBs were acquired from public databases (e.g., IRIS), and these

were employed for both (1) and (2) to assess the chemical risk of 1,3-DiBB. These two alternative methods to assessing chemical risk led to the following conclusions: (1) based on the trend of increasing toxicity with the number of bromine atoms and observation that ortho- and meta- positions are generally more toxic, the point-of-departure (POD) of 1,2,4-triBB could serve as a surrogate POD for 1,3-diBB and (2) a hepatotoxicity QSAR model ( $r^2 > 0.8$  and  $q^2 > 0.7$ ) was developed and used to predict a reasonable liver-specific LOAEL for 1,3-DiBB. The views expressed in this presentation are those of the presenters and do not necessarily reflect US EPA policy.

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### **STAKEHOLDER ENGAGEMENT IN THE DREDGED MATERIAL MANAGEMENT PLAN FOR LONG ISLAND SOUND**

Typically, decisions regarding the method and location for the disposal of dredged materials have only considered site-specific constraints such as capacity, funding, and transportation, and have ignored the values held by local stakeholders. In Long Island Sound, the decision of where to place dredged materials, some of which contain contaminants, has historically been highly politically charged between New York and Connecticut. In fact, the US Army Corps of Engineers had to redo the original Dredged Material Management Plan, costing millions of dollars, due to dissatisfaction among the various stakeholders with the original plan. Clearly, a method for integrating stakeholders into the decision making process is required if a mutually acceptable decision is to be reached. This presentation will outline a methodology in which values were elicited from stakeholders representing competing interests and applied to the placement of dredged materials in Long Island Sound. Stakeholders included representatives from government agencies, economic associations and environmental groups from New York and Connecticut. Through a series of interactive working groups and interviews, a comprehensive list of criteria, sub-criteria, and metrics was built, and values were gathered regarding tradeoffs between risks and benefits related to environmental, ecological, economic, social welfare, and human health and safety impacts. A model was built in which disposal sites for dredged materials were prioritized based on both site-specific constraints as well as stakeholder values.

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### **PHARMACEUTICALS IN THE ENVIRONMENTS: WATER OCCURRENCE ASSESSMENT**

As part of its assessment of pharmaceuticals in water, EPA's Office of Science and Technology (OST) is reviewing information on health effects and the their actual and potential environmental occurrence, to identify data gaps and help priori-

tize information needs. A meta-analysis of published occurrence data and publically available data on production and use is underway. As part of the assessment, OST has been developing an inclusive “universe” of active pharmaceutical ingredients (APIs), registered pharmaceuticals, as well as collecting, publically available marketing research, and published occurrence data. This effort produced a list of about 3,000 drugs - prescription and over the counter drugs, human and animal drugs, and select elicit drugs. However, this includes many redundant variants (e.g., salts) of the same prime API. OST removed these redundancies because analytical methods target the prime organic-chemical component. This refinement reduced the universe to a list of about 1,800 prime APIs. Linking the universe with the occurrence data shows that only about 10% of all prime APIs have been identified as target analytes (either directly or through a degradation product) in water, waste waters, or biosolids. Only about 20% of the “top drugs” (from commercial prescriptions or sales over a 3 year period) have been targeted. Many occurrence studies were driven more by analytical methods than risk characterization. The pharmaceuticals on the OST list are being linked to WHO Anatomical Therapeutic Categories (ATCs) to assess which therapeutic/mode-of-action classes have/have NOT yet been included in analytical studies of occurrence. The ATC information will be related to toxicological data to help identify research needs and develop an informed approach for assessing human health risks of pharmaceuticals in water. This presentation is based on the views and opinions of the authors and does not necessarily reflect EPA policy.

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### **PHARMACEUTICALS IN THE ENVIRONMENT: HEALTH EFFECTS SCREENING**

Pharmaceuticals have been detected in water at very low levels. Pharmaceuticals have robust datasets that characterize pharmacological and toxicological attributes at and above clinically relevant dose levels, but data gaps exist that affect possible extrapolation to health risks at low levels of exposure. Pharmaceuticals are designed for use in specific subpopulations under controlled exposures, and consideration of chronic, low-level exposures among the general population is not part of the drug approval process. Therefore, health risks, if any, from such exposures remain uncharacterized. Significant challenges exist related to estimating human health risks associated with pharmaceutical occurrence in drinking water. A pilot study between EPA and FDA is underway that utilizes publicly available therapeutic information to conduct an initial screening assessment. Data sharing between agencies is key to this screening approach. Drug-specific NOAELs and LOAELs were identified based on data from pre-clinical studies for four classes of drugs. Screening-RfD (S-RfD) and Screening Maximum Recommended Safe Dose (S-MRSD) values were derived based on EPA

and FDA guidance, respectively, for each drug. The S-RfD and S-MRSD values for the same drug were similar, within an order of magnitude in most cases, as long as both points of departure were based on a NOAEL or both were based on a LOAEL. Environmental occurrence data also are being reviewed to evaluate useful ways to screen and prioritize classes of drugs for risk assessment. Many occurrence studies are driven more by analytical methods than risk characterization. The results of this risk characterization process will be compared with clinical data and this comparison used to develop an informed, long term strategy for assessing human health risks of low level pharmaceuticals in water. This presentation is based on the views and opinions of the authors and does not necessarily reflect EPA or FDA policy.

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### **THE STABILITY OF RISK AND BENEFIT PERCEPTIONS: A LONGITUDINAL STUDY ASSESSING THE PERCEPTION OF TECHNOLOGICAL RISK**

In recent years there has been an increased interest in involving the public in decision-making processes about science and technology. In Switzerland, such a decision-making process was the endorsement of the biotechnology moratorium in 2005. Thus, the commercial cultivation of genetically modified crops (GM) and growth of GM animals is prohibited until 2013. However, only if public attitudes and perceptions remain constant over time will policy makers be able to take public preferences into account to make sound policy decisions. To date there are no longitudinal studies directly assessing changes in people’s perception of risk regarding technological hazards. We investigated, therefore, the stability of people’s risk and benefit perceptions of biotechnology over a period of two years. The same sample of participants filled out an identical questionnaire in spring 2008 and in spring 2010. Results were analyzed using structural equation modeling and revealed that risk and benefit perception of biotechnology are stable ( $r = 0.5-0.7$ ). The results of the present study show that for a well-known and well-established technology such as biotechnology, people’s perceptions are stable; we would also expect similar results for e.g. nuclear power since people became familiar with the technology and formed their opinions over time. In this case, it can be assumed that preferences are not arbitrarily constructed when responding to questionnaire questions. In contrast, for novel technologies such as nanotechnology, risk and benefit perception might be less stable and it is likely that people construct their opinions at the time of responding to questionnaires. Therefore, risk research should regularly examine people’s risk perceptions in order to gain a clearer picture of the dynamics of their perception and preferences so that policy makers and risk communication scholars have a clearer picture of the trends in people’s perceptions.



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### **DECISION-DRIVEN RISK ASSESSMENT OF THE PHARMACEUTICAL SUPPLY CHAIN**

It is widely recognized that most prescription (Rx) and over-the-counter (OTC) drugs consumed in the US are manufactured in foreign countries. Drug imports enter the country in bulk as active pharmaceutical ingredients (APIs), finished dose form (FDF) drug products for final packaging in the US, or FDF products in the final packaging for wholesale or retail marketing. While potentially less expensive, drugs with ingredients originating from different countries carry various levels of risk depending on health and safety regulations in that country. Some drugs may be counterfeits, possessing especially severe health risks to the user. We have developed a model for assessing risks at different steps of the pharmaceutical supply chain for ranking policy options (e.g. allow entry, inspect, destroy) at ports of entry that minimize risks to public health in the US from either personal or expanded commercial importation of drug products. The exposure-hazard-vulnerability risk model considers all the steps in the production and commercialization of pharmaceuticals. The decision is focused on the port of entry and is supported by a threshold based multi-criteria decision analysis (MCDA) model. A drug-independent threshold is used to select the policy option regarding the importation of pharmaceuticals.

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### **EXPERT JUDGMENT AND STAKEHOLDER PREFERENCE MODELING WITH PROBABILISTIC INVERSION**

Rational decision theory involves not only uncertainty quantification but also valuation. The utility side of decision theory has languished. This is partly because the community has been sent on a fool's errand. As we have known since Arrow's impossibility theorem – if not from Condorcet's voting paradox, it is not possible to characterize a set of rational agents as a rational agent whose preferences can be represented as expected utility with non-dictatorial preference aggregation. All attempts to find “the” utility function characterizing a group must fail. The alternative is to characterize a group via a distribution over the set of utility functions. Recently, techniques have been developed to do this, and are gaining some traction in applications. Recent applications include valuing health states, ecosystem threats, great lake ecosystems, risks from zoonoses and risks from nano enabled foods. The stakeholders may be domain experts, but they may also be from the policy or media domains, or may be interested citizens. Given  $N$  choice alternatives, stakeholders rank order preferences or state preferences pair wise, or choose the  $k$  out of  $N$  - there are a

great number of formats. Under mild assumptions we can find a distribution over all utility functions that best reproduces the discrete choice data. In other words the distribution over utility functions is such that  $x\%$  prefer alternative A to B,  $y\%$  prefer B to both C and A,  $z\%$  prefer C to A, etc. with the percentages from the stakeholder data. Linear or higher order utility models based on attributes of choice alternatives are easily accommodated. Finding a best fitting distribution over utilities is a problem of probabilistic inversion, which has been a focus of the risk/mathematics group in Delft for a number of years. Good algorithms exist and freeware is or will soon be available on the Risk and Environmental Modeling website.

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### **RISK COMMUNICATION AND TRUST IN DECISION-MAKER ACTION: LESSONS FROM FIRST NATIONS, INUIT AND METIS CASE STUDIES IN CANADA - THE THEORETICAL AND METHODOLOGICAL FRAMEWORK**

This research seeks to develop a better understanding of the roles that risk communication has played in influencing individual and social trust in decision-maker action on key public health issues. The work is being conducted via the development and application of a standardized evaluative framework to three unique cases of past events involving risk communication and management in select areas of Canada. The importance of trust in risk management is generally acknowledged. Incorporation of a fair, open process of public participation and dialogue has been advocated as an important means of increasing public trust. Trust is not automatic, nor everlasting - it is difficult to gain, even harder to maintain, and once lost almost impossible to regain. A common evaluative framework has been developed to assess the impact of risk communication activities on public trust in decision-maker action. This framework is based on two established conceptual methodologies for assessing trust in risk communication. The first methodology assesses the degree to which negative bias (trust asymmetry) and prior attitudes affect trust in risk messages. The second conceptual methodology assesses the dual-mode model of trust and confidence. This presentation will focus on the development of this common evaluative framework and the challenges associated in the application of trust models as applied to vulnerable communities whose education and literacy levels require different strategies to engage participants in meaningful ways. This mixed-methods project design embeds the responses to a survey instrument in a focus group discussion to enable participants to both provide individual and group responses to different aspects of the case study under reflection. This presentation lays the methodological and theoretical grounding for the three case studies presented during this symposium.



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### **THE CHEMICAL TERRORISM RISK ASSESSMENT**

The Department of Homeland Security's Chemical Security Analysis Center (CSAC) is responsible for science based knowledge management and characterization of chemical risk to the nation from a terrorist event. In this capacity, the CSAC has been tasked with conducting a biennial assessment of risk associated with such an event. In 2008, the CSAC published the inaugural Chemical Terrorism Risk Assessment (CTRA). The CTRA is a probabilistic risk assessment that allows the threat, vulnerability, consequences, mitigation techniques and their associated uncertainties to be processed together to yield a comprehensive risk to the nation for the compounds of concern. In 2008, the risk from 57 chemicals was assessed; in 2010 the list grew to 100 chemicals. For the 2012 iteration of the CTRA, a total of 137 chemicals will be analyzed. These chemicals include chemical warfare agents, toxic industrial chemicals, and other chemicals of high concern. The results from the CTRA aids policy makers and other officials in making risk informed decisions regarding detectors, countermeasures, consequence management plans, and capabilities; the results also help identify crucial knowledge gaps for future research. This poster will give an overview of the methodology being utilized to conduct the 2012 CTRA including chemical listing, potential targets, scenarios, and dissemination techniques that make up this end-to-end probabilistic risk assessment.

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*Cox Associates, University of Colorado*

### **REASSESSING THE EVIDENCE ON HEALTH BENEFITS OF CLEANING AIR**

EPA recently estimated that the 1990 Clean Air Act Amendment (CAAA) produces estimated human health benefits far greater than its compliance costs. In the year 2020, for example, EPA projects health benefits from reduced mortality valued at nearly two trillion dollars, for compliance costs of 65 billion (0.065 trillion) dollars. Although compliance costs are real, the health benefits are hypothetical: they depend on a series of uncertain assumptions. Among these are that there is a 100% probability that a positive, linear, no-threshold, causal relation exists between PM<sub>2.5</sub> concentration and increased mortality risk; and that progress in medicine and disease prevention will not diminish this relationship. We present an alternative uncertainty analysis that assigns a positive probability of error to each major assumption. This discrete uncertainty analysis suggests (with probability > 99% under plausible alternative assumptions) that the costs of CAAA far exceed its benefits. Thus, instead of suggesting to policy makers that CAAA benefits are almost certainly far larger than its costs, we believe that accuracy requires acknowledging that a relatively certain cost

purchases a relatively uncertain, and possibly much smaller, benefit. The difference between these contrasting conclusions is driven by different approaches to uncertainty analysis, i.e., excluding or including discrete uncertainties about the main assumptions required for non-zero health benefits to exist at all.

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*Merck & Co.*

### **CHINA'S NEWLY PROMULGATED REGULATION ON THE ENVIRONMENTAL MANAGEMENT OF NEW CHEMICAL SUBSTANCES**

Pioneered in 1976 in the USA with passage of TSCA, the requirement to evaluate new chemicals for potential human and ecological risks is now commonplace among nations around the world. Many nations are adopting or enhancing regulations on new and existing chemical substances. In 2010, China's Ministry of Environmental Protection promulgated and implemented an update of their previous regulation for new chemical substances with the issuance of Ministry Order No. 7, Regulations on the Environmental Management of New Chemical Substances. The regulation uses a tiered risk-based approach that requires increasingly more mammalian and ecotoxicological testing of new compounds as yearly production volumes increase. Simplified and Research filings are allowed for volumes less than one ton/year. The wealth of data on new chemical substances that will be created from this and similar regulations will be valuable to industry and regulators in assessing and communicating potential risks associated with new chemicals and their effects on human health and the environment. The poster will discuss the use of a management system approach to facilitate compliance.

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*Rutgers, The State University of New Jersey*

### **REASSURING THE PUBLIC AFTER A CONTAMINATION INCIDENT: PUBLIC PERCEPTIONS OF MICROBIOLOGICAL TESTING AND RECONDITIONED FOOD PRODUCTS**

After a foodborne illness outbreak or recall resulting from microbial contamination, public confidence in the safety of the affected products tends to drop. A national Internet survey of 1,204 American adults was used to understand consumer perceptions of two potential approaches to restoring confidence - microbial testing to ensure that products are unlikely to contain pathogens, and further processing the food products through cooking or pasteurization to make them safe to consume (reconditioning). To understand perceptions of microbiological testing, an experiment was conducted, using a 2 (numeric format of testing information) X 3 (production level of food company) X 2 (company's history of recalls) mixed design. Using ground beef and eggs as cases, the results indicate that while there was no effect of the company's recall history, both the numeric format of the testing information and the production level of the company affect how much testing the public believes should be done. In

addition, over 10% thought that every pound of ground beef and every egg should be tested, even though it was explained that once tested the product could not be sold or consumed, and would result in an increased cost to the consumer. In terms of re-conditioning, fewer than 20% thought it was okay: a) to eat fully cooked recalled eggs at home, b) to sell potentially contaminated eggs that had been pasteurized to other food producers, and c) to sell potentially contaminated eggs that had been pasteurized directly to consumers. A between-subjects analysis focused on the potential impacts of disgust, and indicated that describing the pathogen in contaminated ground beef as originating in feces had no significant effect on the percentage of consumers who felt it was okay to consume it after it had been safely cooked.

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### **EXPERIMENTAL INVESTIGATION INTO PUBLIC RESPONSE TO FOOD TERRORISM VS. ACCIDENTAL CONTAMINATION**

A primary goal of food terrorism is to undermine confidence in the food system. A national Internet survey of 1,204 American adults was conducted to test the likely impact of intentional food contamination. Respondents read a scenario about a nationwide contamination incident affecting multiple foods and were then randomized into 1 of 3 conditions: “intentional” where it was caused by someone who “knowingly and purposefully tried to hurt people;” “accidental” where it was the result of “natural causes in the course of producing the food;” and control in which no cause was given. Manipulation checks indicated that the intervention worked: those in the intentional condition were significantly more likely to believe that the contamination was purposeful and less likely to believe that it was accidental, normal, caused by technology, or natural than those in the other conditions; and, those in the accidental condition were more likely to believe the contamination was accidental. Ratings of how widespread the contamination was, how serious the illness, and how risky it would be to eat the food did not vary by condition, indicating that the intentionality of the event did not influence respondents’ objective impact assessments. Although those in the intentional condition were significantly more likely to feel angry and less likely to feel neutral, there were no differences across condition on the majority of the other emotional responses measured (e.g., how frightened, worried, or happy they feel while thinking about the situation). Additional analyses indicated that there were main effects of gender and education level on many of the dependent variables, but these did not interact with the intentionality factor. Although a limitation of the study is its hypothetical nature, these data suggest that the public’s objective assessment of the risks posed by a food contamination incident may not be significantly affected by the perceived intentionality of the contamination.

T2-F4 Cullen A, Smoliak B, Po-Chedley S, Anderson CL; alison@u.washington.edu

*Evans School of Public Affairs, Department of Atmospheric Sciences, Program on Climate Change, University of Washington*

### **ASSESSING CLIMATE AS A FACTOR IN CROP YIELD IN SUBSAHARAN AFRICA**

Food insecurity is an integral part of poverty in Sub-Saharan Africa. Risks to livelihood result directly from changing or unreliable cultivation conditions, which pose particularly severe challenges to small-scale farmers. Climate variability has been predicted to affect agriculture in vulnerable regions of Sub-Saharan Africa by altering yields and shifting the area suitable for cultivation. In fact, the combination of climate factors and plant physiological responses affects cultivation in complex ways, both positive and negative. Under an emissions scenario consistent with current development trends, IPCC-coordinated climate model results project a high likelihood of warming in this region during the twenty-first century. In 11 Sub-Saharan African countries, the coincidence between current growing season temperature and projected future conditions (overlap) is projected to be less than 20% by 2050. In other words, the hottest growing seasons of the late twentieth century would appear anomalously cool with reference to the projected climate of 2050. The factors affecting precipitation are considerably more complicated, and involve small-scale phenomena that are not resolved in general circulation models, GCMs. Despite pronounced uncertainty, GCMs predict both wetter and drier conditions, depending on geographic location within the region. We use historical data and climate model projections to provide regional estimates of climate and growing condition variability. We link these to observed historical crop yields and generate expected yield responses based on projected temperature and precipitation trends. We use regression and factor analytic techniques as a means of identifying internal structure in the relationships between precipitation and temperature. We also assess the role of climate as a driver of yield for pivotal crops upon which local populations rely for sustenance.

M4-A.3 Cummings CL; christopherlcummings@gmail.com

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### **STRATEGIC FRAME ALIGNMENT AND THE COMMUNICATION OF RISK**

In the past 30 years, the concept of framing has emerged and taken various shapes in attempting to explain how risk messages come to be understood by individuals. Through its varied use, the concept of framing has become muddled, composed of profuse components borrowed, reappropriated and distorted from competing theorists among distinct disciplines. In the communication of risk, framing studies have been dominated by investigations of mass media which posit that the public comes to learn about risks through broad-based communication about hazards and risk events.

However the concept of framing is more extensive than its common treatment in the field of risk communication. In an effort to enrich the theoretical foundations of framing within the field of risk communication it is the goal of this panel presentation to critically examine and differentiate the multiple conceptual foundations and manifestations of framing. This presentation also features lesser known strategies of frame alignment employed by social movement organizations that may be used prescriptively by risk communicators to further their goals in supplying the public with needed information to make informed and independent decisions about risk. Frame alignment strategies including frame bridging, frame amplification, frame extension, and frame transformation are discussed as potential loci for furthering risk communication efforts.

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*Woods Hole Group, Alpha Analytical, The Science Collaborative, North Shore*

### **DIFFERENTIAL BODY BURDENS OF VARIOUS COMPOUNDS IN CO-OCCURRING BIVALVES**

Research over the past ten years has demonstrated that bioaccumulation of chemicals depends variously on the chemical properties, the species of organism, temporal differences, environmental conditions, and the exposure history of an organism. There is ample evidence that under field and laboratory conditions, contaminant concentrations in tissue are often species-specific. For example, investigators have observed species differences in bioaccumulation of: Zinc between two filter feeding co-located epibenthic organisms (mussels and barnacles); PCBs between a deposit feeding and a filter feeding bivalve in laboratory uptake experiments; Various metals and PCBs between mussels and oysters observed in long term regional monitoring data in San Francisco Bay; Cadmium and copper among grass shrimp, mussels, and quahogs in controlled multi-element laboratory exposures; PAHs among various benthic species. These authors comment upon the implications of differential uptake and accumulation when selecting organisms for toxicity testing, bioaccumulation testing, or monitoring. These differences pose an uncertainty of generally unknown magnitude in ecological and human health risk assessments which often depend upon a small number of representative species. Risk assessors commonly select representative species to represent various trophic levels or vulnerabilities (ecological risk assessors) or ingested food types (human health risk assessors) with uncertain knowledge regarding the range of differences in bioaccumulation that may occur even among species of the same feeding type or taxonomic family. This work measures the range of tissue concentrations for various metals and organic chemicals among co-located bivalves that are both prey for local animal species and a regular food source for recreational shell fishers. We discuss the implications for selecting representative species in ecological risk assessment and selection of recreationally caught species in human health risk assessment.

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### **EVALUATION OF DIFFERENT DATA SOURCES USED TO POPULATE ENVIRONMENTAL STRATEGIC RISK APPRAISAL FRAMEWORK**

Different data sources (expert opinion and published data) are often used to inform decisions. This work seeks to evaluate and compare these two data sources used to populate an environmental strategic risk assessment tool (SRA). Previous examples of SRA assessments have used non peer-reviewed sources (i.e. low reliability evidence). However, the use of peer-reviewed inputs provides a more defensible body of evidence for assessments. The developed SRA framework has been used for assessing and comparing thirteen environmental threats, including flooding, coastal erosion, avian influenza and genetically modified organism. The SRA framework was populated using a comprehensive literature search of published literature (i.e. reviewed journal and governmental report) or through data produced by identified experts ( $n \geq 3$ ). Information was categorised by theme and the quality of the information was assessed using a standard process. The data were selected based on their high level of scientific quality, as well as the importance given to it within the literature (i.e. frequency of citation of the information in the publications). The SRA outcomes from the literature were compared to the expert assessment and the relative importance of attributes was considered. The initial results show that the two information sources provided slightly different risk assessment outcomes. The difference can be partially explained by the exposure of experts to unpublished data and reports. Additional variation may be due to individual bias and gaps in evidence selection, which will be explored in more depth. Further investigation is required to support this theory. 1. Prpich et al. (submitted 2011) *Env. Sci.Tech.*,

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### **YOUNG KIDS POTENTIALLY AT GREATEST RISK DUE TO EXPOSURES TO PERFLUORINATED COMPOUNDS THROUGH WATER CONSUMPTION**

The human health risks derived from the exposure to perfluorinated compounds (PFOS, PFOA and PFDA) through water consumption were assessed for different age groups of general population in Taiwan using probabilistic approach. Based on available data on concentrations of PFCs in river water, exposure to PFOS, PFOA and PFDA via water consumption for different age groups were calculated using deterministic and probabilistic risk assessment methods. The oral non-cancer risks from PFOS, PFOA and their combination, expressed as a Hazard Index (HI), was determined by comparing oral exposure dose (through water intake) with the oral



Reference Dose (RfD). The average exposure to PFOS via water consumption for adults ranged from 0.16 to 220.15 ng/kg-bw/day and for children 0.13 to 354.3 ng/kg-bw/day. The average exposure to PFOA for adults varied from 0.43 to 12.5 and for children 0.35 to 20.17 ng/kg-bw/day. The average exposure to PFDA for adults ranged from 0.43 to 2.36 ng/kg-bw/day and for children 0.35 to 3.79 ng/kg-bw/day. Probabilistic values of hazard indexes (HIs) due to exposure to the contaminants and their combination from water consumption for all age groups only reside near to Keya River exceeded the threshold value 2.4 to 4.8 times, corresponding mainly to PFOS with a percentage of 97%. In conclusions, children aged 1 to 3 years old and the residents reside near to Keya River are at the highest risk of exposure to PFCs via water consumption.

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*Dana & Sharpe Risk Associates*

### **COMPREHENSIVE ENVIRONMENTAL ASSESSMENT OF SYNTHETIC BIOLOGY APPLICATIONS**

The Woodrow Wilson Center's Synthetic Biology Project is piloting a Comprehensive Environmental Assessment (CEA) tool to test its ability to identify key research areas needed to support ecological risk assessments of synthetic biology applications. This could be an organism containing novel genetic material or a product containing the organism. CEA combines a life-cycle analysis approach with a risk assessment framework and is one tool used by the US EPA to evaluate nanomaterial risks and identify research directions; it is also applicable to synthetic biology applications at early stages of research and development. We report on the first pilot exercise of CEA (held in July 2011), where engineers and ecologists used the CEA framework to consider how a cyanobacterium engineered for use as a biofuel feedstock may enter, travel through and impact the environment at different life-cycle stages. Participants worked through the steps necessary for the cyanobacterium to enter the environment (e.g., discharges from open pond systems), what it might come in contact with (e.g., animals, plants, microorganisms), what the potential impacts may be (e.g., gene flow, disruption of ecological processes), and what factors influence these actions (e.g., pH, species behavior, biosafety protocols). We report on the CEA's ability to systematically identify areas of research to support future ecological risk assessments, as well as opportunities for improving existing (or design new) biosafety measures.

M4-G.5 David RM; raymond.david@basf.com  
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### **MANAGING RISKS OF CNTS IN A LARGE COMPANY**

Managing risk for substances for which the hazards are not completely understood typically default to the most protective measures. BASF has developed a matrix that helps drive decisions on risk management by illustrating the need for either greater hazard information or exposure reduction. The company has also developed

short-term screening tests for substances such as CNTs that can provide insight into the long-term systemic and pulmonary effects. These tools as they have been applied to products that contain CNTs will be presented.

W4-I.2 DeAngelo BJ, Gilmore EA, Sarofim MC, Waldhoff ST, Martinich J, Cardamone K, Ohrel S, Ragnauth S, Birnbaum R; deangelo.ben@epa.gov  
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### **QUANTIFYING AND COMMUNICATING BENEFITS AND RISKS OF GHG EMISSION SCENARIOS**

The Environmental Protection Agency's Climate Change Division (CCD) is developing a methodology that will provide policy-relevant analysis about the US domestic benefits and risks from different climate change scenarios. The methodology consists of four main components: 1) Establishing a consistent set of socio-economic and climate scenarios that can be applied across models of differing temporal and spatial resolution; 2) Coordinating and integrating general and partial equilibrium and sectoral models; 3) Describing and quantifying uncertainty; and, 4) Presenting and communicating a range of impacts and risks through multiple metrics and indicators. Here, we describe our progress and planned future work on developing and implementing this methodology for a benefits analysis that articulates the benefits of alternate GHG mitigation targets. We start with developing scenarios of some of the fundamental drivers of GHG emissions: population, economic growth and technology assumptions. These scenarios are run through integrated assessment (IA) models that produce estimates of future temperature and sea level rise. We identify approaches to produce consistent input data across modeled impacts, including downscaling tools and adapting more detailed inputs to our scenarios. Recognizing that no one model will provide answers to all questions and that multiple modeling approaches will often provide different insights, we describe the coordination of several models through these scenarios and how we maintain consistency and avoid double counting. Finally, we present the structure for communication of results for a range of impacts and risks for different audiences, including descriptions of uncertainty. We conclude by presenting a preliminary description of the benefits and risks of climate scenarios and the long-term vision for this framework.

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### **RISK PERCEPTION, PUBLIC OPINION AND THE ACCEPTABILITY OF PUBLIC DECISIONS IN QUEBEC (CANADA)**

Public risk perception can disrupt the completion of major government projects. Projects such as regulating the shale gas industry, reopening a nuclear power plant, or implementing a vaccination program may create public concern, thus resulting in resistance or even rejection. Risk perception depends on many factors, making it important to identify those that are most likely to incite resistance and thus inhibit



policy implementation. Determining the public's risk perception is an essential step in evaluating overall risk, especially with regard to sensitive projects. This study aims to inform Quebec's public decision-makers about the socio-political issues surrounding large-scale projects. In addition to measuring risk perception, the study evaluates confidence in public project management and in the information related to the project, each of which has an influence on risk perception. To evaluate these variables, we have designed a groundbreaking province-wide survey. We probe public opinion and risk perception on projects and issues related to the environment, technology, health and the economy. A survey was conducted in June 2011. This presentation will analyze the responses of 1130 representative people living in Quebec. We first present descriptive results (risks categories that are of greatest concern, top 3 of riskiest projects, etc..) and then expose differences in responses in relation to different socio-demographic criteria (age, sex, region, language, education, income, employment, etc.). Given the large spectrum of our inquiry, our results will be a valuable reference for the Quebec government and public decision-makers. Our findings may also incite governments to consider communications as an important tool of risk management, leading them to draw from our study when announcing a big decision or developing a communication plan for a new project.

P.104 Demichelis SO, Cermignani L, Segal-Eiras A, Giacomini N, Croce MV; sandrademichelis@yahoo.com

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#### **BREASTFEEDING AND NUMBER OF CHILDREN ARE RELEVANT RISK FACTORS IN BREAST CANCER PATIENTS FROM AN ARGENTINE COASTAL MIDCLASS POPULATION**

Background: In Argentina, it has been estimated that there are 17.000 new cases of breast cancer diagnosed each year; this tumor localization is the commonest cause of cancer death among women reaching 5.400 deaths per year, the second rate of mortality in Latin America. Purpose: to analyze the relationship among different risk and prognostic factors in invasive breast cancer patients in order to highlight their possible clinical relevance. Patients and methods: 360 patients from La Plata area (Buenos Aires Province, Argentina) with invasive breast cancer were included. Risk factors were age, number of children, breast feeding, menopausal status and menarche age while prognostic factors were histological type and grade, tumor size, number of metastatic nodes, disease stage, mitotic figure counts, Nottingham Prognostic Index (NPI), vascular invasion (VI) and estrogen and progesterone receptors. Statistical analysis: Multiple and simple correlation, frequency analysis and ANOVA were performed ( $p < 0.05$ ). Results: Breast feeding and number of children were inversely correlated to NPI; also, lactated patients showed lower number of metastatic nodes respect to non-lactated women. High disease stages (III and IV) predominated in patients <50 years old at diagnosis while old women (>50 years) showed small size

tumors and consequently, low NPIs. On the other hand, NPI was inversely correlated with ER. Mean age at diagnosis was significantly higher in ER+ patients than ER-; furthermore, women with a history of late menarche and early menopause showed more frequently ER+ tumors. NPI correlated directly with tumoral cellularity and with HER2neu expression. Finally, VI was directly associated with number of metastatic lymph nodes. Conclusions: Prognostic factors were significantly associated with risk factors. Despite previous contradictory reports, in this study, breastfeeding and number of children emerge as relevant risk factors in Argentine breast cancer patients.

P.114 Demichelis SO, Di Fonzo CI, Dopchiz LP, Zappala CM, Rosa GA, Genovese G, LO Nostro F, Lavarias SML, Guiralde MC, Ansaldo M; sandrademichelis@yahoo.com

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#### **RISK ANALYSIS BASED ON COASTAL BIOMONITORING: SINERGIC EFFECT OF GLOBAL CHANGE ON STRESS GENERATED BY XENOBIOTICS IN ANTARCTIC KEY SPECIES OF TROPHIC WEBS.**

In spite of the Antarctic continent was considered for decades a pristine area, pollutants from a wide kind of sources were detected: 1) chemical compounds from antarctic activities at scientific stations and 2) xenobiotics which are globally distilled and distributed by air masses as a consequence of industrial and agricultural activities around the world. PAHs, pesticides, polychlorinated biphenyl and organo-metals are the best known PTS found in the Antarctica. The presence of these contaminants threatens the stability of the Antarctic marine resources, since many PTS are bioaccumulated in the tissues of diverse organisms. The determination of the levels and of the potential toxicity of these compounds, in key species of the Antarctic ecosystem, is very important in order to understand and to elucidate the biological impact in the organisms. The Antarctic trophic web is relatively simple: zooplankton eats phytoplankton, and top animals as fish, birds, seals and whales. It has been suggested, that a decrement in the reserves of fish and krill, would cause a devastating impact on the marine ecosystem. The general target of this project is to determine and to characterize the Antarctic organisms that can be the most sensitive to the perturbations of the environment, and the main biological responses effective to detect them. As result we will have identified sentinel organisms and reliable biomarkers. There must be taken into account the influence of factors related to sex, reproductive phase, weather and seasonality. Therefore, the present project contemplates the development of experimental works with coastal zones and open sea organisms, which will be essential to increase the knowledge of the marine Antarctic ecosystem interactions. By this way it will be possible to determine the most efficient and preventive mechanisms, necessary to preserve the Antarctica biodiversity.

W2-H.2 Demuth JL, Morss RE, Morrow BH, Lazo JL; jdemuth@ucar.edu

*National Center for Atmospheric Research*

### **COMMUNICATION SUCCESSES AND CHALLENGES OF THE HURRICANE WARNING SYSTEM: A CASE STUDY**

Hurricanes pose significant physical, emotional, and financial risks to the people they threaten. One way to reduce risks and promote more effective public decision-making is by evaluating the process through which hurricane information is generated and communicated. This jointly funded NSF and NOAA project advances understanding of hurricane warning system communication via a case study approach of four key actors in the Miami area: National Weather Service (NWS) National Hurricane Center forecasters, NWS Weather Forecast Office forecasters, emergency managers, and radio and television media. Based on task-activity observations of the forecasters and semi-structured interviews with all groups, we examine the groups' job roles and goals, how information is generated and flows among the groups and to the public, and group members' perceptions of each other and of the public. This presentation will discuss key inter-organizational successes and challenges of the hurricane warning system that emerged from this study, and it will discuss their implications for the hurricane risk information that is ultimately communicated to the public.

M2-C.2 DeVito MJ, Tice R; devitom@niehs.nih.gov

*National Institute of Environmental Health Sciences*

### **TOX21: ACTIVITIES OF THE U.S. NATIONAL TOXICOLOGY PROGRAM (NTP)**

The National Institute of Environmental Health Sciences/NTP entered into a Memorandum of Understanding with the NIH Chemical Genomics Center and the Environmental Protection Agency's National Center for Computational Toxicology in 2008 on the research, development, validation, and translation of new and innovative in vitro and lower organism test methods that characterize key steps in toxicity pathways. This collaborative effort, known informally as Tox21, now includes the U.S. Food and Drug Administration. As part of the Tox21 efforts, the NTP has (1) produced a large library of environmentally relevant compounds for screening across toxicity pathways; (2) identified and/or supported the development of assays suitable for use in quantitative high throughput and high content screens (qHTS); (3) established a Worm-Tox Screening Facility with the goal of developing toxicological assays using the nematode *Caenorhabditis elegans*; (4) developed statistically-based approaches for distinguishing between active, inactive, and inconclusive responses in these screens and informatic tools for identifying predictive toxicity patterns; (5) expanded the NTP's publicly accessible Chemical Effects in Biological Systems (CEBS) database to contain all Tox21-related data as well as the NTP historical data; (6) conducted qHTS studies to probe mechanisms of inter-individual susceptibility to toxicants; (7) evaluated molecular tools for mining the formalin fixed, paraffin embedded animal tissues in the NTP Tissue Archives for predictive gene signatures; (8) support-

ed assay and informatic developments through the NIEHS Small Business Innovative Research contract award process; and (9) developed a targeted testing program that evaluates predictive models built on Tox21 approaches. Advantages and limitations of these activities will be presented.

T2-B.2 Dickey R; robert.dickey@fda.hhs.gov

*FDA, Gulf Coast Seafood Laboratory*

### **A RETROSPECTIVE ON THE MULTIAGENCY RESPONSE TO SEAFOOD SAFETY FOLLOWING THE 2010 DEEPWATER HORIZON OIL SPILL**

During the period of April 20 through July 15, 2010 approximately 210 million gallons of crude oil spilled into the Gulf of Mexico (GOM) following the explosion and sinking of the Deepwater Horizon (DWH) drilling platform. The magnitude of the DWH spill threatened all 5 states bordering the Gulf of Mexico, and crossed statutory boundaries at state and federal levels. Federal and State Agencies responded to the spill in a coordinated manner to institute a unified seafood safety protocol for the testing and re-opening of GOM fisheries. The seafood safety risk assessment, an integral component of the protocol, followed the approach taken by FDA in 1990 after the Exxon Valdez oil spill in Prince William Sound, Alaska. Polycyclic aromatic hydrocarbons (PAH) are recognized internationally as the most appropriate chemical indicators of the potential human health risk posed by crude oil residues in seafood. A toxicologically representative subset of 13 PAH and their alkylated homologues was selected for critical analysis of impacted seafood in the aftermath of the DWH spill. A set of calculations was used to determine seafood PAH tissue concentrations above which a conservatively estimated 10-5 upper-bound risk level for low dose lifetime cancer is exceeded. Levels of concern for non-cancer risks were evaluated based on EPA IRIS reference dose values. Values for other event-specific variables in the calculations were selected from the most recent information available, and historic data from oil spill outcomes dating back to Exxon Valdez. More than 10,000 seafood specimens were sampled through the periods of fishery closures, re-openings, and extended surveillance after fishery re-opening. Analyses were conducted at 7 laboratories from the National Marine Fisheries Service and Food and Drug Administration. Result of analyses from all performing laboratories are consistent and 100 to 1000-fold below levels of concern established in the unified seafood safety protocol.

T2-B.3 Dickhoff WW, Walker C, Ylitalo G, Wilson S, Stein J; walton.w.dickhoff@noaa.gov

*NOAA Fisheries*

### **ASSESSING SEAFOOD SAFETY DURING THE DEEPWATER HORIZON OIL SPILL MC252**

The 2010 Deepwater Horizon oil spill raised widespread concern about the safety of Gulf seafood. In response, the Food and Drug Administration (FDA) and

National Oceanic and Atmospheric Administration (NOAA) led the effort to coordinate with other federal and Gulf state agencies to develop seafood safety criteria, monitoring procedures, re-opening protocols, and extended seafood surveillance. Thousands of seafood samples collected from Gulf waters, dockside and in the marketplace were tested for oil and dispersant contamination. Results of chemical and sensory testing showed that all samples were below the contamination levels of concern. Seafood testing for reopening of federal waters continued until the last grid around the wellhead was opened on April 19, 2011. Reopened areas were subject to two additional surveys after reopening to assure continued seafood safety. Lessons learned include: 1) A rapid spill response is essential, 2) Regulators and scientists must work together to identify key questions that must be answered and criteria for data that will be collected, 3) Care must be taken to design a sampling and analysis plan that provides environmental managers with data from which to make decisions, e.g. reopening fisheries, 4) A tiered approach to analysis is cost-effective and allows an adaptive approach to sampling, 5) Rapid turn-around of analytical results allows managers to take action to mitigate damage and injury.

W3-A.1 Diebol JK, Zikmund-Fisher BJ, Ross PT, Turkelson A, Weber I, Franzblau A, Parker E; jangstro@umich.edu

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#### **RELATIONSHIP BETWEEN JUDGMENTS OF HEALTH RISK AND SATISFACTION WITH HAZARD AND EXPOSURE COMMUNICATIONS**

In many risk communication contexts, including those following community exposure assessment studies, a full risk assessment may be incomplete or infeasible. Available data may instead be limited to hazard and exposure information. A lack of information regarding health risk in such situations could cause receivers to be dissatisfied with communications. However, empirical research on this topic is limited. We are examining this question, and more specifically whether satisfaction with communications is related to the subjective ability to judge health risk, as part of the Community Perceptions of Dioxins (CPOD) study. The CPOD study is following up with participants (both exposed and control) and nonparticipants in a community exposure assessment study of dioxin contamination in Michigan's Midland and Saginaw counties. In the second phase of data collection, open-ended, qualitative interviews and post-interview questionnaires were conducted with exposed participants, control participants, and nonparticipants (n=50, total). Questions were included about respondents' satisfaction with information they had received or gathered about dioxins, their subjective judgments of health risk from dioxins, and how difficult it was for them to make these risk judgments. Preliminary analysis of these interviews and questionnaires supports the hypothesis that those who feel they are able to make subjective judgments about their health risk (regardless of whether they think their risk

is high or low) are more satisfied with the information they have received. To more quantitatively assess this hypothesis, a third and final phase of data collection will include similar questions in a closed-ended questionnaire mailed to a larger sample of the populations of interest. Results will have important implications for community exposure assessment studies and for other contexts in which hazard and exposure information is communicated, including worker and community right to know.

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#### **EXPLORING THE USE OF EVALUATIVE LABELS TO INCREASE THE SALIENCY OF UNCERTAINTY INFORMATION**

Presenting numerical representations along with evaluative labels (e.g., Excellent-Poor or color coding) has been suggested as a way to simplify the comprehension and use of uncertainty information in the risk management context. In two experiments we explore the effects of adding evaluative labels to improve the understanding and use of uncertainty. Participants were presented with scenarios and consequence tables describing environmental management problems. Our main goal was to examine how laypeople perceive and use numerical uncertainty information with and without evaluative labels. We also explored whether people who vary in numeracy perceive and use this uncertainty in different ways. Our results suggest that evaluative labels provide a very salient source of information for a lay user. In Study 1, we showed that the evaluative labels were perceived as easy to use and appeared to be used even in the presence of a numerical uncertainty range. In Study 2, we found that people with economically leaning values, that should prefer the option with the best outcomes in terms of costs, were drawn by the evaluative labels to choose the option that was least favorable in terms of costs. This effect was particularly strong for the less numerate. Thus, lay people may put undue weight on information highlighted by an evaluative label even if it is not the most important factor with respect to a decision makers values. The simplicity and power of evaluative labels is a double-edged sword. Communicators need to think hard about how different uncertainty representations can lead to different reasoning strategies on the part of decision makers. Both numerical presentations and evaluative labels are important tools. The best presentation method depends on what you want people to know and what types of decision strategies you want to prompt.



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### **PUBLIC HEALTH RESPONSE SENSITIVITY STUDY TOOL (PHRSST): A RISK-BASED DECISION SUPPORT TOOL FOR ASSESSING PUBLIC HEALTH RESPONSE STRATEGIES**

Homeland Security Presidential Directive (HSPD) 18 (Medical Countermeasures against Weapons of Mass Destruction) requires a risk assessment of Chemical, Biological, Radiological, and Nuclear terrorism for the purpose of risk based decision support in the area of medical countermeasure acquisition and development. Under this directive, the Department of Homeland Security's Science and Technology Directorate is developing a prototype tool to support studies of public health response strategies across threat areas (CBRN). This tool is called the Public Health Response Sensitivity Study Tool (PHRSST). The prototype PHRSST incorporates public health response (PHR) models used as part of the Chemical Terrorism Risk Assessment (CTRA), Bioterrorism Risk Assessment (BTRA), and the Radiological and Nuclear Terrorism Risk Assessment (RNTRA) as well as probability distributions estimating the risks of terrorist attacks of different sizes. Parameters to the models are accessible to the user via a graphical user interface (GUI); these parameters can be manipulated to implement various "what if" scenarios. The models for the different threat areas can be run to estimate consequences and the results compared side-by-side. This talk focuses on the development of the tool and its capabilities. Examples of its utility will be presented. All results will be notional with respect to event sizes.

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*US Food and Drug Administration*

### **EXPOSURE ASSESSMENT FOR FOR CAFFEINE IN THE UNITED STATES**

Caffeine up to a level of 0.02% is GRAS when used in cola-type beverages in accordance with good manufacturing practice (21 CFR 182.1180). Historically, caffeine has been added to certain foods, beverages, dietary supplements, and medications. Recently however, caffeine has found use in non-traditional food sources: chewing gum, chocolate, other candies, "energy" drinks, and alcoholic beverages. The United States Food and Drug Administration estimated daily caffeine intake in the U.S. population by summing contributions from the different foods that can be caffeinated (natural and added). These contributions were calculated by combining food consumption from 2-day (2003-2006 National Health and Nutrition Examination Survey, NHANES) and 14-day consumption data surveys (National Product Database-National Eating Trends, NPD-NET) with the highest caffeine concentration for each food obtained from available sources. The intake analyses also included data from the National Coffee Association and the Beverage Marketing Corporation. The results from these surveys will be discussed to understand the overall dietary exposure of caffeine in United States.

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### **MEDIA COVERAGE, "FALSE BALANCE," AND THE AUTISM-VACCINE CONTROVERSY: A PRELIMINARY EXPERIMENT**

Parental concern over the claim that vaccines cause or trigger autism has many healthcare officials blaming the media for perpetuating a controversy that they assert should not exist. A prominent journalistic norm is to highlight all relevant viewpoints regardless of how well known or influential they may be (i.e., balance as quantity) or focus on identifying the two most influential perspectives by presenting them in a point-counterpoint format, where each are afforded equal attention (i.e., balance as quality). However, the commitment to balance may come at the expense of accuracy, in terms of producing a discourse at odds with an established scientific consensus. In the case of the autism-vaccine issue, where the evidence strongly favors one side (the mainstream medical community), there is concern that presenting news stories in a point-counterpoint format gives readers the impression of scientific uncertainty when in fact there is a high degree of certainty and agreement among scientists. Does this "false balance" have a significant effect on people's view of this issue (i.e., perceived uncertainty) as well as vaccine-related attitudes, risk perception, and intentions? In the present study, we randomly assigned participants to news articles about the vaccine-autism controversy. Articles were coded as either balanced (discussing both pro-causal and anti-causal claims), anti-link (anti-causal link only), or pro-link (pro-causal link). We measure post exposure variables including (1) perception of scientific certainty, (2) vaccine risk perception, and (3) behavioral intention. Theory of Planned Behavior variables are included to control for added variance in behavioral intention. To our knowledge, this study is the first to examine the impact of "balanced" media coverage of an issue on attitudes and behavior. Data collection is ongoing, but we anticipate that our results will have implications related to effective vaccine risk communication strategies.

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*Food Safety and Inspection Service, US Department of Agriculture*

### **RAPID RISK EVALUATION: AN IMPORTANT TOOL FOR ADDRESSING FOOD CONTAMINATION INCIDENTS AND EMERGING FOOD SAFETY CONCERNS**

When responding to chemical contamination in the food supply, FSIS risk managers make rapid decisions, often with limited information or data. These decisions include whether to withhold the mark of inspection, institute a recall, or take other public health action. To ensure a more rapid and consistent approach, a new, modular, farm-to-fork, and rapid risk evaluation process is being developed to address specific contamination incidents or environmental contaminants detected more broadly at



any point in the food chain. The five modules are animal exposure, animal pharmacokinetics, processing, human consumption, and comparison values. The first module will calculate total chemical doses from multiple exposure pathways for cattle, swine, and poultry. The animal pharmacokinetics module estimates the chemical distribution among the animals' edible tissues, based on the dose received and the physical and metabolic characteristics of the chemical. Tissue concentrations and common production practices are used by the processing module to predict contaminant concentrations in various retail products. The module can also incorporate in-plant contamination or data from residue testing of products. The human consumption module uses NHANES data to estimate human exposure from contaminated product. Finally, the exposure is compared to available reference doses or other regulatory and public health exposure limits. The modules are being developed simultaneously by USDA scientists, some in cooperation with external partners, and are connected and integrated within a novel risk evaluation framework. This model is flexible, allowing for either a full, farm-to-fork analysis, or a streamlined analysis, using only the relevant modules, if contamination is detected during processing. These models have wide application, from a strategic tiered approach, to evaluating a wide array of chemical residues, to guiding laboratory detection and risk management decisions during chemical incidents.

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### **LET THE DATA SPEAK: EXTRAPOLATING INFORMATION FOR BIOTHREATS**

As the US Army Public Health Command (USAPHC) establishes Biological Military Exposure Guidelines (BMEGs) many different types of data are examined, notably scientific data for predicting dose-response relationships for adverse health effects in humans. Typically biological agent data are sparse and extrapolation from those animal data is fraught with both variability and uncertainty. Published data sets on pneumonic tularemia were of particular interest to USAPHC due to rich, but confounded, datasets for diverse primates including human volunteers. These datasets were studied using neural networks and other statistical modeling techniques. Data were examined using statistical techniques to provide some guidance on the uncertainty bounds for estimates when developing interspecies scaling for dose-response models. As expected, uncertainty and variability are overwhelming in these models, and mechanistic knowledge for biologically-based scaling is fragmentary. The information gleaned from this study will inform the USAPHC as BMEGs are established and updated and high priority research needs are identified for reducing uncertainty in predictions for likelihood and severity of illness in humans.

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*University John F. Kennedy of Argentina, National University of La Plata*

### **ANALYSIS OF COASTAL POLLUTION: LOOKING FOR WATER QUALITY INDEX WHICH CORRELATES PHYSICOCHEMICAL PARAMETERS AND BIOMARKERS IN NATIVE AQUATIC PLANTS USED AS SENTINELS**

The goal of the present project is to characterize the coastal pollution and its possible effect on the biota along a thousand km of coast from navigable rivers Del Plata Basin in the second from the continent It receives effluents from 128.718.445 inhabitants. Their waters arrive at the sea through Río de la Plata river The goal of the present project is to characterize the coastal pollution and its possible effect on the biota along a thousand km of coast from navigable rivers. In this sense surface water, sediments and vegetation samples from several localities were analyzed. *Echinodorus uruguayensis* Arechav. (Alismataceae), *Eichornia crasipes* (Mart.) Solms (Pontederiacae), *Pistia statiotes* L. (Araceae), *Scirpus giganteus* Kunth (Cyperaceae) were used and some biomarkers were considered. Chromosome count, characterization as well as Mitotic Index were analyzed. *Pistia statiotes* showed  $2n=28$ ; the Mitotic Index calculated as  $(IM = \frac{nro \text{ total of cells in divisi3n}}{nro \text{ total of observed cells}} \times 100)$  remain under  $(MI=1)$  and abnormalities were not recorded. The chromosomal counts in *Eichornia crasipes* was  $2n=32$  whereas in *Scirpus giganteus* Kunth (Cyperaceae)  $2n \text{ ca.} = 28$  without any previous publication. The IM in both cases were very under  $(IM \text{ ca.} = 1)$ . Abnormalities in the studied localities of both species were not registered either. Nevertheless, *Echinodorus uruguayensis*, with  $2n=22$  informed for the first time, presented an outstanding rank of anomalies in the analyzed locality (anaphases diagonals, prophases disorganized, metaphases disorganized, c metaphases). The occurrence of spontaneous clastogenic and aneugenic effects in species of some localities contrasts with the absence of them in others areas. Other cytogenetic biomarkers are under study. This information compared with physicochemical characterization of water were included in multivariate analysis in order to adequate water quality indexes to Del Plata basin and estimate risk associated to human activities

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*TERA*

### **USE OF GENOMICS DATA AND OTHER EARLY EFFECT BIOMARKERS IN RISK ASSESSMENT: OPPORTUNITIES AND CHALLENGES**

Significant research is ongoing developing and validating high- and medium-throughput methods as an enhancement of traditional toxicology testing. This burgeoning effort suggests the need for equivalent effort to develop risk assessment methods for the meaningful application of such data. This project outlines key risk

methods research priorities and potential areas of new development. The new methods in molecular toxicology have substantial potential to aid in risk assessment, both in hazard characterization and dose-response assessment. Near-term applications include identification of target organs and target biological pathways, and aiding in mode of action determination, first as part of hypothesis generation, and then, in more detailed analyses, as part of hypothesis testing. The use of such data in hazard characterization will require new interfaces between decision science and risk assessment tools to formalize value of information and weight of evidence decisions. Data from new molecular toxicology assays will also enhance dose-response assessment by decreasing the need for extrapolation to doses well below the data, and offers the potential for testing in cells from the species of interest. Key challenges in such applications include the need to “anchor” the results of in vitro testing by comparing results with those from classical toxicity tests, and determining how to identify what an adverse change is, and where homeostasis is disrupted sufficiently to result in an adverse effect. A hierarchical suite of approaches for addressing these issues from the biological perspective and for using modeling approaches (e.g., linked exposure-effect modeling) is presented.

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#### **SCREENING CARGO CONTAINERS FOR NUCLEAR MATERIAL USING A LAYERED, RISK-BASED SCREENING SYSTEM**

Interdicting nuclear weapons is an issue of vital national interest. In this talk, we focus on interdicting nuclear weapons on cargo containers using port security screening methods, where the nuclear weapons would presumably be used to attack a target within the United States. We provide a model that simultaneously identifies optimal primary and secondary screening policies in a risk-based paradigm, where incoming cargo containers are classified according to their perceived risk. The proposed optimization model determines how to utilize primary and secondary screening resources in a risk-based cargo container screening paradigm given a screening budget, prescreening classifications, and different device costs. We examine the structural properties of the model in order to shed light on the optimal screening policies. The model is illustrated with a computational example. Sensitivity analysis is performed on the ability of the prescreening in correctly identifying risk and secondary screening costs. Results reveal that there are fewer practical differences between the screening policies of the risk groups when prescreening is inaccurate. A comparison between current and hypothesized next-generation screening devices suggests that improved screening technologies will not substantially improve nuclear detection capabilities of the resulting system.

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*University of Manitoba*

#### **FINDING A VOICE FOR THE METIS: RISK COMMUNICATION AND TRUST DURING THE MANAGEMENT OF PANDEMIC H1N1**

While many Canadian cases of confirmed H1N1 were characterized as mild, Indigenous communities located in the more remote areas of Northern Manitoba were hit with more severe outcomes of the outbreak, particularly in the first Wave of its spread. The provision of health services to Indigenous peoples has always been a contentious issue in Canada. In Canada, of the three main groupings of Aboriginal peoples, the Metis are frequently forgotten because they are not the primary “responsibility” of Indian and Northern Affairs Canada for the provision of health and other social services. One way that the Manitoba Metis Federation sought to ensure that there was Metis relevant and appropriate risk communications messaging was to be part of a tri-partite negotiation to ensure that Metis members knew how to protect themselves from contracting H1N1. This presentation will examine through focus groups and individual key informant interviews how the Metis trusted (or not) the messaging that they received. Mixed gender focus groups were conducted with about 265 Metis in different parts of Manitoba and Winnipeg between October and November 2010 with the following age categories: 18-34, 35-54, and 55+. Key informant interviews have been conducted with federal, provincial, and regional key informants that have been involved in the management of pandemic H1N1 between April and July 2011. Overall, participants were skeptical of public health messaging around H1N1. While many could identify protective behavior strategies to avoid contracting H1N1 (e.g. handwashing, staying at home while sick, getting immunized, etc), few did not feel they had adequate information about H1N1 to protect themselves and their family. Moreover, although the Manitoba Metis Federation made great efforts to provide tailored communications to its members, these efforts could not be recalled during focus groups. The presentation will comment on what factors may have impeded the communications strategies of public health officials and the Manitoba Metis Federation.

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*Federal University of Pernambuco (UFPE)*

#### **A METHODOLOGY TO QUANTIFY ECOLOGICAL RISKS ORIGINATING FROM INDUSTRIAL ACCIDENTS: APPLICATION IN A REFINERY NEAR AN AQUATIC ECOSYSTEM IN BRAZIL**

Recent industrial accidents such as toxic spills have caused catastrophic damage to ecological environments (plants and animals), so an effective method to assess ecological risks has been demanded. Firstly, this work aims at proposing a methodol-

ogy capable of quantifying ecological risks related to rare events such as industrial accidents. We use population modeling to simulate future changes in the population abundance of key species at risk and therefore estimate their probability of extinction or decline, time to extinction and other measures, for each accidental scenario. Thus, it was possible to develop an approach that links the ecological damage (predicted via ecological modeling) with the frequency of occurrence of the accidental scenario (estimated via historical data and reliability analysis). The result is a FN risk curve similar to the result of a human quantitative risk assessment for industrial accidents. However, in our context, N is the average population decline number and F the cumulative frequency of accidents with N or greater abundance decline. Secondly, the work presents an application of the methodology using a project of a petroleum refinery to be constructed in the Northeast of Brazil, which estimates a processing of 200 thousand barrels of oil per day. This facility is located near a very rich aquatic ecosystem with a high biodiversity. A population of a key species was strategically chosen to represent the ecosystem, some accidental scenarios of a great amount of oil spill were simulated and their frequencies of occurrence estimated. For each scenario, the concentration of oil that reaches the population was predicted via fate and transport modeling. Finally, the ecological risks were quantified and presented as a FN curve.

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### **REGULATORY SCIENCE AND POLICY - A CASE STUDY OF THE NATIONAL AMBIENT AIR QUALITY STANDARDS**

This paper will explore the motivations and institutional incentives of participants involved in the development of regulation aimed at reducing health risks, with a goal of understanding and identifying institutional solutions to what the Bipartisan Policy Center has characterized as “a tendency to frame regulatory issues as debates solely about science, regardless of the actual subject in dispute, [that] is at the root of the stalemate and acrimony all too present in the regulatory system today.” We will focus our analysis with a case study of the procedures for developing National Ambient Air Quality Standards under the Clean Air Act, and attempt to identify procedural approaches that bring greater diversity (in data, expertise and experience) into the decision process.

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### **ENABLING ECO-FRIENDLY CHOICES BY USING HUMAN PSYCHOLOGICAL BIASES**

Ecological (eco) taxes are promising mechanisms to enable eco-friendly decisions; however, they do not enjoy popular support. In this study, we make use of two psychological biases to enable more eco-friendly choices: loss aversion and the tendency to respond linearly to non-linear problems (i.e., proportional thinking). Par-

ticipants were asked to choose between two eco-tax increases in two decision problems: in one, the smaller eco-tax increase resulted in greater CO<sub>2</sub> emissions reduction, while in the other, the smaller increase resulted in lesser reduction. Although larger eco-tax increases did not always save more CO<sub>2</sub> emissions, a majority of participants preferred the smaller eco-tax increases, while judging larger tax increases to cause greater reductions in CO<sub>2</sub> emissions. Therefore, participants rely on loss aversion and proportional thinking biases in their preferences and judgments about eco-taxes, and eco-tax policies might benefit by presenting information such that smaller tax increases cause greater CO<sub>2</sub> emissions reductions.

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### **APPLICATION OF A DATA FUSION FRAMEWORK TO INTEGRATE TOXICITY DATA FOR A PETROLEUM HYDROCARBON MIXTURE**

A modified Joint Director Laboratories (JDL) data fusion (DF) framework was developed to integrate exposure and toxicity data from disparate sources for human health risk assessments (HHRA). The framework was used to detect patterns and integration of various toxicological datasets from the F1 group of hydrocarbons. F1 toxicological data were fused where available. The objective of our research was to demonstrate the suitability and applicability of the proposed DF HHRA framework. Traditionally, health risk assessments of mixtures are evaluated using a surrogate of chemical mixture data (current practice of F1 hydrocarbons assessment) or through components of mixture data. Neurotoxicity response analysis, neurotoxic metabolites toxicological data were fused with predictive toxicological data. Probability-boxes (p-box) were developed to represent the toxicity of each compound. The neurotoxic response was given a rating of “low”, “medium” or “high”. These responses were then weighted by the percent composition in the F1 hydrocarbon mixture. The resulting p-boxes were fused according to Dempster-Shafer Mixture rule of combination. The p boxes were fused again with toxicity data for n-hexane. Furthermore, n-hexane datasets were requested for curation from the Comparative Toxicogenomics Database for preliminary analysis and integration of system biology datasets. Key interacting genes (BAX, BCL2, CASP3, CYP1A1, and CYP1A2 in rats; CYP2E1 in mice, and CYP2B1, CYP2B6, and CYP2E1 in humans) were identified. Additional analysis were conducted for altered protein expression, metabolic changes, and gene polymorphisms in CYP2E1 leading to potential chemical susceptibility to n-hexane exposure. Further analysis of other health effects end points such as respiratory irritancy, respiratory lining and lungs inflammation, peripheral nervous system and hepatic diseases are required. Some preliminary results were presented at the Alliance for Risk Assessment workshops.



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*DECISION PARTNERS*

### **A STRATEGIC RISK COMMUNICATION PROCESS FOR BIOSOLIDS PROFESSIONALS: ADVANCING THE FIELD**

The long-term sustainability of biosolids land application depends on continuously earning local community stakeholders' trust and support. This requires biosolids professionals' ongoing and effective outreach and dialogue with these stakeholders about the use of biosolids in their communities. The authors customized their Strategic Risk Communication Process, though a research project for the Water Environment Research Foundation, to meet the unique and often unmet communications needs of biosolids professionals. The process was applied in collaboration with two teams of biosolids professionals in Oklahoma and Virginia. The authors worked with each team to identify the communications opportunities, then conduct and analyze in-depth mental models research interviews with a) local landowners who receive biosolids (one case); b) neighbors to local land application sites (both cases); and c) regional public health officials (one case). Actionable communications plans, pretested communications materials and further recommendations were developed based on the research findings and the specific needs of each biosolids program. Materials developed included guiding principles, a dialogue presentation for use at community meetings, a community-specific brochure and prototypes for on-site signage. Building on the case study results, the authors developed a Primer that offers biosolids professionals step-by-step guidance, supporting tools and sample materials. Continued applications can advance the process as a leading management practice for biosolids professionals. They can also add significant contribution to other public and environment management sectors, by serving as a model for efficiently and effectively engaging community stakeholders in dialogue about their operations in the local communities.

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*IPC*

### **HOW TO DEAL WITH GENE-BIOHAZARD INTERACTION?**

Laws should be as clear, stable, and foreseeable as possible. The Genetic Information Nondiscrimination Act (GINA) is indeed a huge step towards modernity as it removes societal threats and thus, lets scientific achievements driving us to health improvement. The fear of unsounded or unfair discrimination makes wise to ban employers from using a person's genetic information in making job assignments. However, more and more publications focus on gene-environment interactions. It will not be surprising if we'll find more and more genetic characteristics making some hazard exposure a greater risk, while the same exposure in someone without the genetic variation will be lower. This is already proven for the often quoted case

of beryllium and HLA-DPB1 but also more recently for other interactions such as polymorphism of DNA repair genes and benzene exposure or immune gene variation and organochlorine exposure. There is, therefore, for job assignment, a dilemma between the willingness to avoid gene-based discrimination and letting someone exposed to a higher risk of dreadful diseases. I will argue that more sophisticated laws or different wording might be required concerning genetic information management at this point. If scientific data aimed at information, which might be applied in different backgrounds, in contrast the social outcome (such as legal regulation) of these debates depends critically of economical and cultural background.

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### **THE EXTENT OF UNCERTAINTY ANALYSIS FOR MAJOR PROPOSED REGULATIONS**

When executive branch agencies propose major regulations, executive orders require them to assess uncertainties about benefits, costs, and the nature of the systemic problem the regulation seeks to solve. This paper presents the results of a project that assesses how extensively agencies have analyzed these uncertainties over the past several years for proposed, economically significant regulations. It reveals the extent of uncertainty analysis, presents best and worst examples, and explores differences across types of regulations.

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### **VISUALIZING RISK AND UNCERTAINTY: AN EXPERIMENTAL STUDY**

Many efforts have been made to visualize risk and uncertainty. Most of these efforts have proven unsuccessful or at least problematic. This study reports on an experimental study investigating how individuals link these abstract concepts to concrete visuals. Risk and uncertainty have two common characteristics; They are both real, but invisible. To make these concepts visual, both require either a numerical description, such as 1 out of 3 people will die from breast cancer, or there is a 30% chance of rain, or alternatively, they are given a concrete association. A hurricane is both a risk and is uncertain, but is visible, thus, abstract (uncertain) and concrete. The Gulf oil spill was concrete, damage being caused, and abstract, amount of oil. Most abstract concepts require a visual metaphor, an association with a concrete object. The visual then evokes the abstract concept, for example birds covered in oil may evoke the idea of environmental risk. The concern with risk and uncertainty is that they are broad terms with many associations. What, then, is the most common concrete object association for risk and uncertainty? To test this, three groups of students were used to explore how individuals associate risk and uncertainty with concrete visualizations. The first group was given the words uncertainty and risk,



separately, and asked to write down words that they associate with them. The second group was also given the words uncertainty and risk, separately, but asked to draw images associated with them. The last group was given a group of images, and asked to check whether it is associated with risk or uncertainty. The study aims to understand how the public visually ties risk and uncertainty to concrete objects. The results suggest that individuals tie abstract concepts to concrete objects that are either geographically available or experienced.

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*Texas Commission on Environmental Quality*

### **AN UPDATED INHALATION UNIT RISK FACTOR FOR ARSENIC AND INORGANIC ARSENIC COMPOUNDS BASED ON A META-ANALYSIS OF EPIDEMIOLOGY STUDIES**

The United States Environmental Protection Agency (USEPA) developed an inhalation unit risk factor (URF) of  $4.3 \times 10^{-3}$  per  $\mu\text{g}/\text{m}^3$  for arsenic in 1984 for excess lung cancer mortality based on epidemiological studies of workers at two smelters: the Asarco smelter in Tacoma, Washington and the Anaconda smelter in Montana. Since the USEPA assessment, new studies have been published and exposure estimates were updated at the Asarco and Anaconda smelters and additional years of follow-up evaluated. The Texas Commission on Environmental Quality (TCEQ) has developed an inhalation URF for lung cancer mortality from exposures to arsenic and inorganic arsenic compounds based on a newer epidemiology study of Swedish workers and the updates of the Asarco and Anaconda epidemiology studies. Using meta-analysis on the URFs from these three epidemiology cohort studies, the final inhalation URF is  $1.5 \times 10^{-4}$  per  $\mu\text{g}/\text{m}^3$ . The de minimis concentration level (i.e., air concentration at 1 in 100,000 excess lung cancer mortality) is  $0.067 \mu\text{g}/\text{m}^3$ . This value will be used to evaluate ambient air monitoring data so the general public in Texas is protected against adverse health effects from chronic exposure to arsenic.

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### **DEFENDER-ATTACKER MODEL FOR COMPUTER NETWORK SECURITY**

We propose a general defender-attacker model for security of computer networks, using attack graphs to represent the possible attacker strategies and defender options. The defender's objective is to maximize the security of the network under a limited budget. In the literature, most network-interdiction models allow the attacker only one attempt (assuming that the attacker is captured and disabled after a single failure); other models allow multiple attempts, but assume that any subsequent attempt begins at the point in the network where the previous attempt failed. These models are not appropriate for computer security, where the attacker could be

operating from the safety of a foreign country, and the cost of starting over with a completely different attack strategy may be quite low. To represent the ability of the attacker to launch multiple attempts, we represent the attacker's success or failure on any one arc of the attack graph probabilistically, and formulate the resulting security problem as a multiple-stage stochastic network-interdiction problem. In the resulting game, a non-myopic defender anticipates both the attacker's strategy choices, and the probability of success or failure, and chooses a single defensive strategy (i.e., a set of arcs in the attack graph to be protected) by which to defend against multiple attempted attacks. The attacker then launches an optimal attack against the system, based on knowledge of which arcs have been protected. If the attacker fails at the first attempt, a second-stage optimal attack strategy is chosen, based on a revised attack graph showing which arcs have already been successfully traversed (now assumed to have success probabilities of 1), and which arc led to failure of the first-stage attack (now assumed to have a success probability of 0). We solve the resulting stochastic-optimization problem using two-stage stochastic optimization with recourse.

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*Association of Schools of Public Health, National Center for Environmental Assessment, Office of Research and Development, US Environmental Protection Agency*

### **A CUMULATIVE EXPOSURE ASSESSMENT OF NOISE AND VOLATILE ORGANIC COMPOUNDS**

Although humans are exposed daily to multiple chemical, biological, and physical stressors, epidemiological studies and risk assessments typically examine them individually. Occupational studies show that concurrent exposure to elevated levels of noise and organic solvents (e.g. toluene, ethyl benzene, styrene, xylenes) have a synergistic effect on hearing loss. In this research, we characterize concurrent exposures of volatile organic compounds (VOCs) and noise among population subsets in the urban area, San Francisco County, CA. Demographic variables, personal VOC measurements and exposure factors were extracted from the 1999-2000 National Health and Nutrition Examination Survey dataset. 2000 census block group population demographics (aggregated by race- gender-educational attainment) were extracted from the National Historical Geographic Information System for all census block groups within the county. Personal exposure measurements of 10 VOCs (benzene, toluene, ethylbenzene, m,p-xylene, and o-xylene, 1,4-dichlorobenzene, chloroform, trichloroethylene, tetrachloroethylene, and methyl tert-butyl ether) were available for 851 individuals from passive samplers worn for 48-72 hours. Census block group level noise exposures were estimated using ArcGIS from a noise map of San Francisco (Seto et al., 2007) based on traffic-induced noise levels estimated from the Federal Highway Administration's Traffic Noise Model 2.5 model. Exposure differences were detected by races gender, and education for noise and VOCs. Hazard Indices (based on permissible exposure levels in occupational settings and inhalation reference concentra-

tions) were  $< 1$  for sub-populations with highest 90th percentile ethylbenzene and toluene exposures. This case study addresses an important research need and exemplifies some of the data gaps that may impact cumulative exposure assessment efforts. The views expressed in this abstract are those of the authors and do not necessarily reflect the views or policies of the US EPA.

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### **A NEW YORK (OR PENNSYLVANIA) STATE OF MIND: CROSS-STATE DIFFERENCES IN PRINT MEDIA COVERAGE OF DRILLING FOR NATURAL GAS IN THE MARCELLUS SHALE REGION**

Hydraulic fracturing for natural gas in shale formations throughout the United States is a rapidly proliferating means of fossil fuel extraction. The injection of millions of gallons of water deep into the ground to release natural gas offers potentially lucrative economic gain for individuals leasing land and collecting royalties, but also creates potential for environmental hazards and threats to social well being (e.g., municipal services, infrastructure, community character) in areas subject to large amounts of drilling. We conducted a content analysis of newspaper media coverage of hydraulic fracturing in four major local newspapers in the northern tier of Pennsylvania and the southern tier of New York. We examined the extent to which media coverage framed issues related to drilling as environmental, economic, and/or social issues. We then analyzed the valence with which these issues were discussed. Coverage in Pennsylvania focused substantially more on economic issues and contained a much higher percentage of positively valenced articles compared with coverage in New York. NY coverage focused substantially more on environmental issues and contained a much higher percentage of negative or mixed valence articles compared with PA coverage. We discuss several possible explanations for these notable differences and offer implications for risk communication.

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### **A CAMPYLOBACTER QMRA (QUANTITATIVE MICROBIOLOGICAL RISK ASSESSMENT) FOR PETTING ZOOS**

The relative importance of petting zoos for transmission of *Campylobacter* to humans as an example direct contact route was estimated while including the effect of interventions. For this, a mathematical model including variability was built describing the transmission of *Campylobacter* in animal feces from the various animal species and fences and the playground to humans. This transmission involves visitors touching these so-called carriers, subsequently touching their lips and possibly ingesting *campylobacters*. Many data were not available and therefore extensive field and laboratory research was done to fulfill the needs. The distribution of fecal contamina-

tion on all carriers was measured by swabbing in ten petting zoos, using *Escherichia coli* as an indicator. The transmission rate from carrier to hand and from hand to lip was measured using pre-applied cow feces to which *E. coli* WG5 was added as an indicator. Carrier-hand and hand-lip touching frequencies were estimated by in total 13 days of observations of visitors by two observers at two petting zoos. Combining the exposure distributions with a Beta-Poisson dose response function gives estimations of the probability of illness after a petting zoo visit due to *Campylobacter* of  $4.94E-5$  for children and  $8.63E-6$  for adults. For the whole of the Netherlands in a year this implies 232 and 38 cases for children and adults, respectively, so 270 cases in total. Comparison with the 12,000 *Campylobacter* cases due to consumption of chicken filet as estimated by a previous QMRA shows that petting zoos are not an important transmission route for *Campylobacter*. Cleaning the fences proves to be an advisable intervention, as a scenario of 90% reduction of contamination gives an 84 % reduction in the number of petting zoo *Campylobacter* cases. Cleaning only goat fences gives a 71% reduction, whereas the playground plays a minor role. The model can easily be adapted for other fecally transmitted pathogens.

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### **SITE VISITS: A NOVEL MEANS OF FILLING-IN THE DATA GAPS**

Assessing and then managing risks has always been an integral part of food safety throughout history. Quantitative microbial risk assessment techniques are helping to advance the scientific basis of our food safety regulation. The accuracy of these risk assessments is dependent on the amount of data available to develop the risk assessment models. However, the high degree of variability in the food supply system makes filling those data gaps very difficult and challenging, requiring new and creative means for increasing our knowledge of the system to be modeled in a risk assessment. The U.S. Food and Drug Administration's Center for Food Safety and Applied Nutrition (CFSAN) continues to seek new methods to obtain this data and fill valuable data gaps needed for food safety risk assessments that have the desired level of accuracy to assist with decision-making. One of the more novel, successful methods involves bringing the risk assessment team to visit all phases of the food supply system, including locations involved in food preparation, processing, manufacturing, harvesting, and consumption. For example, site visits were made to a cruise ship, a U.S. navy ship, produce processing plants, produce farm, spice processing and manufacturing plants, dairy processing plants, and retail delis to help the teams develop an understanding of means of microbial transmission, and the pros and cons of potential mitigation strategies. Each site visit produced expected and unexpected lessons learned. The biggest surprise to the teams was the value of the unexpected lessons learned in filling risk assessment data gaps, and helping the teams better un-

derstand benefits and problems with potential mitigation strategies. The value of these site visits in filling quantitative risk assessment data gaps has been recognized by CFSAN and is now being implemented as an important step in developing future accurate food safety microbial risk assessments.

T4-E.2 Fazil A, Ruzante J, Davidson V, Caswell J, Nguyen T, Cranfield J, Henson J, Anders S, Schmidt C, Farber J; aamir.fazil@phac-aspc.gc.ca  
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### **A MULTIFACTORIAL RISK PRIORITIZATION FRAMEWORK FOR FOODBORNE PATHOGENS**

The development of a prioritization framework for foodborne risks that considers public health impact as well as three other factors (market impact, consumer risk acceptance and perception, and social sensitivity) will be presented. In order to make the tool more usable and efficient, a database and analysis tool using Analytica software has been developed to facilitate in the calculation and storage of information related to the criteria. In addition, the flexibility of the framework to accept inputs to the criteria from other sources such as process risk models like iRisk to generate public health impact will also be discussed. The final prioritization is facilitated through the use of an outranking multicriteria decision analysis (MCDA) approach. Overall, the tool can support policymakers in complex risk prioritization decision making when different stakeholder groups are involved and when multiple pathogen-food combinations are compared.

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### **QUANTITATIVE RISK MODEL FOR FOODBORNE PATHOGENS IN HERBS AND SPICES**

Recent recalls and outbreaks have raised questions about the potential for herbs and spice seasonings to cause illness, particularly in food products which receive minimal treatment prior to consumption. A quantitative risk model was developed using Analytica® (Lumina Decision Systems, Inc.) to estimate the potential for spices to cause illness in a high risk food-pathogen combination (Salmonella spp. in dairy-based dips). The exposure model considered contamination levels and prevalence in the spice ingredients as well as intrinsic and extrinsic factors during preparation and storage of the product which would result in changes in levels of contamination over time. Monte Carlo simulation was used to account for uncertain model variables. The model framework was used to generate per serving rate of illness estimates for different scenarios and to identify risk minimization strategies. Model outcomes suggested that initial contamination levels and storage times were the most important variables in terms of influencing per serving rate of illness. Future directions include expanding the model to characterize risks from spices in additional food-pathogen combinations and investigating the effects of spice decontamination treatments.

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### **TIME INCONSISTENCY OF RISK PERCEPTION**

In this paper we investigate inter-temporal changes of risk perceptions in decisions under uncertainty. Time inconsistency of preference has been well documented in the literature, but any possible time inconsistency of risk perception has not received much attention. Two competing theories predict opposite results. The risk-as-feelings hypothesis (Loewenstein et al., 2001) states that payoffs and probabilities have different roles: when more emotional, people are less sensitive to variation in probability and more sensitive to variation in payoffs. Thus it predicts that an increment in time delay before receiving a binary gamble will lead to a higher impact of probability and a lower impact of payoff on risk perception when judged in the present time, assuming larger temporal distance leads to less emotional reactions. However, construal level theory (Lieberman et al., 2002) and time-dependent gambling (Sagristano et al., 2002) proposed that probability is subordinate to payoff in preferences for gambles, which means payoffs can be regarded as being at a higher level of construal in gambles while probabilities can be regarded as at a lower level. This predicts temporal distance increases the influence of payoffs and decreases the influence of probability on preferences. In this study, we propose that temporal distance has different influences on attributes of a decision alternative with respect to risk perception as well. Experiments are conducted with hypothetical scenarios to examine this proposition where either probability (payoff) is controlled to estimate the influence of time and the payoff (probability) and provide a detailed discussion of our empirical results. Research results will help in developing a useful framework for evaluating anticipated risk consequences, which can be used by DHS to deliver information on anticipated consequences of future societal or natural risks to the public. Possible implications on risk perception of terrorism risks and natural disasters are discussed.

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### **FACTORIZING OUT BIAS AND OVERCONFIDENCE: ADVANCED BIAS CORRECTION IN RISK ANALYSIS**

Numerical estimates produced by experts and lay people alike are commonly biased as a result of self-interest on the part of the persons making the estimates. There is also empirical evidence that expressions of uncertainty are much smaller than justified. Simple scaling, shifting or inflating corrections are widely used to account for such biases and overconfidence, but better distributional information is usually available, and fully using this information can yield corrected estimates that properly express uncertainty. Corrections can be made in two distinct ways. First, predictions can be convolved with an empirical distribution or p-box of observed errors (from data quality or validation studies) to add uncertainty about predictions as-



sociated with model error. Second, predictions can be deconvolved to remove some of the uncertainty about predictions associated with the measurement protocol. In both of these cases, the structure of errors can be characterized as a distribution or p-box with arbitrary complexity. We illustrate the requisite calculations to make these corrections with numerical examples. We conclude (1) the notion of ‘bias’ should be understood more generally in risk analysis to reflect both location and uncertainty width, (2) self-interest bias and understatement of uncertainty are common, large in magnitude, and should not be neglected, (3) convolution can be used to inflate uncertainty to counteract human psychology, and (4) deconvolution can be used to remove some of the uncertainty associated with measurement errors.

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### **NONE OF THE OCCUPATIONAL EXPOSURE LIMITS REVEAL RISK INFORMATION: A QUANTITATIVE “NUDGE” COULD SAVE LIVES**

For ambient air, water, and food, lists of the potencies of contaminants are readily found, and derive from the two dose-response regimes in widespread use for the past 30 years (continuous functions for presumed carcinogens, and “margins of safety” below low-risk levels for non-carcinogens). But by far the greatest exposures to these substances occur in the workplace, where no authoritative body has set levels that rely on risk assessment techniques. In particular, the few Permissible Exposure Limits that OSHA has set may reference elaborate risk assessments, but ultimately are set based on (pessimistic) assumptions about feasibility; thus, every PEL reflects a different risk level. The ACGIH Threshold Limit Values (TLVs) reflect expert judgment in light of extensive toxicologic and/or epidemiologic evidence, but employ no risk assessment techniques, and incorporate almost as many different implicit “margins of safety” as there are TLVs. Ready access to scientific knowledge about the relationship between exposure and risk should not be hidden from those exposed. Therefore, we offer a detailed proposal for government and academia to collaborate to generate the first list of (roughly several hundred) “risk-based exposure goals” for the workplace. Each exposure goal would correspond to a common probability of harm (we suggest 1-in-1000 excess working-lifetime risk), based on common computational methods and common ways to handle uncertainty. We recommend a “unified” paradigm that treats non-carcinogenic endpoints as having estimable non-zero risks at the population level, in the spirit of the recommendations in the recent Science and Decisions report of the National Research Council. We will discuss the value of such a compendium of exposure goals for right-to-know and product substitution purposes, and explore how OSHA could change its inspection and enforcement policies to encourage employers to achieve acceptable risk levels, even though the guideline levels would be unfettered by information about the aggregate costs of any specific control measures.

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### **ASSESSING LONG-TERM FLOOD RISKS TO COASTAL LOUISIANA UNDER DEEP UNCERTAINTY**

Louisiana is in the midst of updating its Master Plan for a Sustainable Coast, which specifies a set of structural protection projects to be implemented over the coming decades to protect coastal communities from the effects of catastrophic hurricanes. These projects need to be evaluated on a variety of criteria but primarily on the extent to which actions will reduce risk from flooding. We have developed the Coastal Louisiana Risk Assessment Model (CLARA) to evaluate this risk under a wide range of uncertain scenarios about future regional growth; sea level rise and subsidence; and nonstationarity in future hurricane characteristics. CLARA is a down-scaled version of previous models developed by the Interagency Performance Evaluation Task Force (IPEF) and Louisiana Coastal Protection and Restoration project (LACPR). The model is designed to be useful for long-range planning over a 50 year time horizon and large-scale scenario analysis rather than design-level analysis. To flexibly compare the risk reduction achievable by many potential projects, we have developed innovative methods for storm sampling and the estimation of flood levels interior to a protection system based on the probability distributions of surge levels at points along the exterior of the system. These provide the computational and statistical efficiency that allows evaluation of many scenarios within feasible limits on computing resources. The model incorporates system fragility by estimating the probability of multiple modes of failure, and we also consider the impact of nonstructural mitigation policies such as floodproofing, home elevation and buyouts. Flood depths and residual economic risk are reported as 50-, 100-, and 500-year exceedance values. We discuss these new methodologies and present key insights from model results.

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### **U.S. ENVIRONMENTAL PROTECTION AGENCY RISK ASSESSMENT FORUM ACTION PLAN FOR ADVANCING HUMAN HEALTH RISK ASSESSMENT**

In response to recommendations from the National Research Council (NRC) reports Science and Decisions, Phthalates and Cumulative Risk Assessment, and Toxicity Testing in the 21st Century, and considering the Agency’s cross-cutting fundamental strategy of working for environmental justice and children’s health, the Risk Assessment Forum hosted a Human Health Risk Assessment Colloquium in October 2010. The Agency only Colloquium brought 120 risk assessors and risk managers together to develop an Action Plan to Advance Human Health Risk Assessment. Colloquium discussions focused on, Agency senior managers risk assessment needs for decision making, uncertainty and variability, dose-response assessment, use of



defaults, cumulative risk assessment, and development of a framework for human health risk assessment to inform decision making. The Action Plan for Advancing Human Health Risk Assessment will be the guide to development of the future direction of human health risk assessment at EPA. This presentation will present details of the Action Plan and highlight the progress to date on specific projects included in the Action Plan.

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### **INFORMED PUBLIC CHOICES FOR LOW-CARBON ELECTRICITY PORTFOLIOS USING A PORTFOLIO-BUILDING COMPUTER DECISION TOOL**

Public perceptions of low-carbon electricity generating technologies, such as nuclear, wind, natural gas, and coal with carbon capture and sequestration (CCS), may affect the feasibility of their widespread deployment as part of a national energy policy. In this study, we asked 69 members of the general public to use an interactive computer tool to construct a portfolio of low-carbon electricity technologies that would reduce CO<sub>2</sub> emissions while reliably meeting future increases in electricity demand for Pennsylvania. As participants made changes to their portfolios, the tool provided immediate feedback about projected CO<sub>2</sub> emissions, electricity cost, as well as health, land and water impacts. Participants also received comparative and balanced information about the costs, risks, benefits and limitations of each of the ten electricity technologies. Overall, our informed participants designed diverse portfolios including energy efficiency, nuclear, integrated gasification combined-cycle (IGCC) coal with CCS, natural gas and wind. While most participants included only a relatively small amount of IGCC with CCS, natural gas and wind in their portfolio designs, they did include much larger amounts of nuclear and energy efficiency. Participants scored well on computer tool comprehension questions. Moreover, their portfolio designs were consistent over time and with the technology preferences that they provided prior to using the computer tool. Our results suggest that the computer tool and its supplemental materials can help to educate people about the challenges the U.S. faces in trying to achieve a low-carbon energy future, and to elicit their preferences for national energy policies.

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### **USING INFORMATION FROM ALTERNATIVE MODELS TO GUIDE RESEARCH IN MIXTURES: A CASE STUDY ON INTERACTIONS BETWEEN POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) WITH DIFFERENT MECHANISMS OF ACTION IN ZEBRAFISH**

Chemicals commonly occur in the environment in complex mixtures in which additive, synergistic, and antagonistic interactions can occur, potentially resulting in toxicity that is difficult to predict without knowledge about the interactions between the individual chemical constituents. Experiments assessing interactions can be costly due to the high number of treatment groups needed. Zebrafish (*Danio rerio*) provide a useful model for such studies due to their small size, inexpensive maintenance, rapid breeding cycle, large number of offspring, and transparent early life stages. We present a case study using developing zebrafish to assess potential mechanisms of binary interactions between PAHs. PAHs have historically been assumed to act additively in mixtures due to the limited information about interactions between PAHs. In zebrafish, PAHs that act as aryl hydrocarbon receptor (AhR) agonists (benzo[a]pyrene (BaP), benzo[k]fluoranthene,  $\beta$ -naphthoflavone) and PAHs that inhibit CYP1A activity (fluoranthene, carbazole, dibenzothiophene, 2-aminoanthracene,  $\alpha$ -naphthoflavone) interact synergistically to induce developmental toxicity. Inhibition of CYP1A activity by morpholino (antisense oligonucleotide) or by hypoxia also increases the toxicity of some AhR agonist PAHs. However, hypoxia and CYP1A-morpholino microinjection were both shown to protect from the embryotoxicity of pyrene, a weak AhR agonist. There is some evidence of the relevance of these interactions in rodents. CYP1A1 knockout mice treated with BaP show elevated levels of BaP-DNA adducts, immune suppression and liver toxicity compared with wild type mice. This case illustrates the utility of zebrafish as a high-throughput, inexpensive screening tool to guide future research on mixtures in mammalian systems. The views expressed in this abstract are those of the authors and do not necessarily reflect the views or policies of the US EPA.

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### **A MATHEMATICAL COMPARTMENT MODEL FOR ESTIMATING DONOR LOSS DUE TO CHANGES IN THE INTER-DONATION INTERVAL**

Current policy in the United States requires donors of a red blood cell unit to wait at least 56 days between blood donations to allow adequate red cell recovery, and reduce the risk of anemia among frequent donors. Recent Blood Products Advisory Committee (BPAC) meetings have discussed the risks and benefits of increasing the

inter-donation interval to mitigate iron deficiency in frequent blood donors while preserving an adequate blood supply. Increasing the inter-donation interval allows more time for recovery of iron stores, but the concern is that such a change may negatively affect the blood supply by reducing the donation rate of frequent donors. A related issue is that data have been presented that suggest the current hemoglobin thresholds for donation may allow potentially iron deficient males to donate blood and a significant number of female donors considered 'normal' may be deferred from donation. Low hemoglobin concentration is the most common cause of donor loss, and hemoglobin deferrals have a negative effect on donor return rates. In order to address this complex issue, CBER investigators explored what the potential blood donor loss would be due to changes in the inter-donation interval. An Ordinary Differential Equation (ODE) compartment model, which defined rates at which eligible donors donate, depending on the inter-donation deferral time, and rates at which deferred donors become eligible, was developed. The sum of the two compartments represented the total number of potential donors, while a counter described the total number of donations accumulated. Results from the model applied to empirical data and data gathered from the American Red Cross (ARC) showed that the compartment model is a useful tool for investigating potential changes in the blood donor loss.

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#### **ULTRAFINE PARTICLES IN COMBUSTION SOURCE EMISSIONS: THE ROLE OF WASTE-TO-ENERGY FACILITIES**

Over the past decade, information about potential adverse human health effects of ultrafine particles has raised concerns about human health risks from ultrafine particle emissions from many industrial and commercial sectors, and all types of combustion sources including waste-to-energy (WTE) facilities. This paper presents ultrafine particle number concentrations reported from numerous recent studies worldwide for a wide variety of different sources, including WTE facilities, power plants, motor vehicles and household activities, and in ambient air. For example, measured particle number concentrations in WTE facility stack emissions have been reported to range from roughly 60 - 200,000 particles/cm<sup>3</sup>. Concentrations in fossil fuel and biomass combustion emissions have been reported to range from 140,000 - 600,000,000 particles/cm<sup>3</sup> and in vehicle emissions at 5,000 - 10,000,000 particles/cm<sup>3</sup>. Concentrations along roadways have been reported at roughly 800 - 1,000,000 particles/cm<sup>3</sup> and in ambient air from roughly 2,000 - 130,000 particles/cm<sup>3</sup>. The paper also discusses challenges related to estimating exposures and potential risks, in a risk assessment framework, associated with combustion source emissions of ultrafine particles. While more research is still needed, available data indicate that ultrafine particle emissions from WTE facilities have a minor impact on ultrafine particle concentrations in ambient air compared to many other stationary combustion sources and motor vehicles. Potential downwind ambient air concentrations associated with

WTE ultrafine particle emissions are also substantially lower than concentrations resulting from some household cooking activities and concentrations already present in background ambient air.

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#### **IMPACTS OF SCIENCE AND TECHNOLOGY CITIZENS' SCHOOLS ON EXPERT PRESENTERS**

Science and technology make possible much that wasn't just 10 years ago 'longer, healthier lives; bigger, faster-growing foods; cheaper, cleaner power,' but these advances carry risks non-experts often don't expect or understand. Deficits in the "public understanding of science" can lead to unrealistic expectations and prevent citizens from effectively engaging in science policy making. Helping citizens understand their work has challenged the scientific community, which rarely prepares its members for such work or rewards them for it. Researchers studying the ways scientists speak about science to nonscientists have called for a shift from a "deficit model" of science communication, in which experts perceive their role as communicators of information to lay publics lacking science knowledge, toward a more interactive model. Ideally, such a dialogic or deliberative approach has impacts on the experts' ways of knowing and speaking about their work, as well as on the public's understanding and expectations of that work. A number of studies have explored experts' perspectives in the risk communication process, but most have featured perceptions of scientists who had little or no experience with public engagement. The proposed presentation will draw on in-depth interviews with experts (n=21) from a variety of disciplines who participated in a series of public engagement forums called Citizens' Schools (covering environment, energy, and nanotechnology issues). With the purpose of evaluating an existing model of science and risk communication, this research explores benefits/drawbacks of the Citizens' Schools forums in promoting effective communication between experts and lay citizens. Initial analysis of the data suggest that this type of communication has the potential to make experts better (and more willing) communicators by teaching them to listen as well as talk, and to make them better researchers by allowing them to see their research from the perspectives of non-scientists.

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#### **ATSDR APPROACHES FOR INCREASING TRANSPARENCY, SPEED AND STAKE-HOLDER INVOLVEMENT IN CHEMICAL RISK ASSESSMENTS**

The science of risk assessment is a rapidly evolving field which is expanding to include a number of both technical and social considerations in order to reach

conclusions that are robust in both scientific and socially acceptable terms. There is a growing need to assure the transparency of the processes by which risk assessment values are developed so that the evolution of these values may be followed by persons with limited technical backgrounds. There is also an increasing need for production of risk assessment values in a timely manner, particularly for emergency situations such as the Gulf Oil Spill and for sensitive subpopulations such as children in relation to cadmium exposures. ATSDR is in the process of addressing the above issues through an increasing reliance on computational toxicology modeling methods which are both transparent and rapid. Computational toxicology methods are being used increasingly as an adjunct approach to traditional methods. Stakeholder involvement has been a cornerstone in the development of ATSDR Toxicological Profiles and attendant Minimal Risk Levels (MRLs) since the inception of this program with solicitation of extensive public comments during the peer-review process prior to the final release of these influential scientific documents that are used on a global basis in many countries. External peer review and solicitation of public comments on draft Toxicological Profiles under development are not held at the same time. In summary, ATSDR has moved in a concerted manner to address these aspects of current risk assessment practice in a timely and rigorous scientific manner.

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### **ASSESSING THE RISK OF ASIAN GYPSY MOTH, LYMANTRIA DISPAR (LINNAEUS), INTRODUCTION INTO THE UNITED STATES ON MARITIME SHIPMENTS**

The Asian gypsy moth (AGM) is an invasive forest pest of substantial phytosanitary significance that can infest maritime ships and cargo. We generated pest risk assessments, each comprised of three analyses, which characterized the risks to the United States associated with AGM moving on maritime shipments from Japan and China. The first analysis characterized ports for AGM infestation risk based on surrounding landcover and U.S. bound shipment volumes. The second analysis estimated the annual number of infested ships coming to the United States by country and port based on shipment volumes and infestation likelihoods. The third analysis characterized the risk to the United States from AGM using risk assessment guidelines that conform to international standards. Our pest risk assessments were used in technical discussions to provide scientific justification for AGM pre-shipment inspection programs.

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*Resources for the Future*

### **UNCERTAINTY AND ESTIMATES OF THE BENEFITS OF REDUCING FINE PARTICLE POLLUTION**

EPA's estimates of the benefits of its regulations to reduce air pollution related to fine particles are quite large, so large they exceed the benefits and costs of all other federal regulations. EPA has developed its estimates while incorporating uncertainty in only a limited way. As a result, it cannot claim that any particular estimate of benefits reflects an expected value, and it cannot develop a range of values corresponding to a given confidence interval. We depart from the EPA's approach and follow recommendations of the National Research Council (2002) suggesting that EPA incorporate uncertainty into estimates of the benefits of improved air quality. In particular, focusing on the pathway responsible for the overwhelming majority of benefits, we incorporate uncertainty in the form of distributions for the following critical components. In EPA's benefits model the product of these components yields monetized benefits. 1. the marginal value of reductions in mortality risk, 2. the marginal reduction in mortality risk due to reductions in ambient fine particle concentrations, and 3. the marginal reductions in fine particle concentrations due to reductions in emissions. We use this model to characterize air quality benefits and contrast the benefits and resulting estimates of uncertainty with those previously reported by EPA.

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### **EXPLAINING RADIATION RISKS: A COMPARISON OF MEDIA COVERAGE OF FUKUSHIMA, CHERNOBYL AND TMI**

After the Three Mile Island nuclear accident in 1979, journalists, nuclear industry personnel and government experts had many lessons to learn about how to explain the intricacies of plant operations and potential radiation risks to the public. The Public's Right to Information Task Force of the President's Commission on the Accident at TMI called the radiation coverage of the accident "abysmally inadequate" and charged reporters who covered it with providing insufficient background information and making improper comparisons and factually impossible statements. The Task Force provided guidelines about how to better inform the public about radiation risks, and some of these guidelines were followed in coverage of the Chernobyl accident, according to a 1987 study of five U.S. newspapers and three television networks by Friedman et al. These media outlets provided more detailed explanations of nuclear plant operations but less detailed radiation information. In particular, they rarely provided specific radiation measurements or explanations of health and environmental concerns or long-term effects. This presentation will explore explanations of radiation issues and potential health and environmental risks that appeared in the



Fukushima nuclear accident coverage in online versions of selected major U.S. newspapers and compare them to the TMI and Chernobyl coverage and the TMI guidelines. While use of online graphics should have improved explanations of complex technical information, these graphics and accompanying text explanations may still not have been enough to adequately inform the public about potential radiation risks from the Fukushima nuclear accident.

M4-J.1      Fristachi A, Rice G, Little J, Xu Y, Adams W, Impellitteri C; tony@eriskresources.com

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### **UPDATED ESTIMATES OF HUMAN ORGANOTIN EXPOSURES DUE TO LEACHING FROM PVC PIPE INTO DRINKING WATER**

Organotin (OT) additives are widely used as thermal and light stabilizers in the processing of polyvinyl chloride (PVC) piping. The leaching of OT from PVC pipes used in residential drinking water systems may affect the quality of drinking water. This work updates our previous OT exposure estimates based on a recent leaching rate study of two neurotoxic OTs, dimethyl tin and dibutyl tin, from PVC pipe. The recent leaching rate estimates were integrated into an exposure model that estimated the probability distribution of OT concentrations in tap waters. A probabilistic drinking water exposure model was then employed to estimate potential human OT exposures via tap water consumption. Sensitivity analyses were conducted to determine the relative importance of model input parameters in determining OT concentrations as well as exposure estimates. In addition, a hazard quotient was estimated using screening values estimated from values published by the World Health Organization.

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### **RISK SCREENING ASSESSMENTS AT LOS ALAMOS NATIONAL LABORATORY (PART 1. HUMAN HEALTH)**

Los Alamos National Laboratory (LANL) is a multidisciplinary research facility owned by the U.S. Department of Energy. The Laboratory's Environmental Programs is part of a DOE nationwide effort to ensure that past operations do not pose unacceptable risks to human health or the environment. All potentially impacted sites require an assessment of potential human health risk(s)/dose(s) to determine the need for corrective actions. Human health risk-screening assessments are conducted using soil screening levels (SSLs) for the several scenarios. The industrial and residential SSLs are obtained from New Mexico Environment Department (NMED) based on a hazard quotient of 1 and a cancer risk of  $1 \times 10^{-5}$ . If SSLs are not available from NMED guidance, U.S. EPA regional screening levels are used and adjusted to the NMED target cancer risk level of  $10^{-5}$ . Recreational SSLs are obtained from LANL guidance and have the same risk bases as the NMED and EPA values. Radionuclide

screening action levels are obtained from LANL guidance for each scenario based on a 15-mrem/year dose. Depending on the potential risks to human health, subsequent action may include additional data collection, remediation, monitoring, and/or engineering and institutional controls.

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### **RISK SCREENING ASSESSMENTS AT LOS ALAMOS NATIONAL LABORATORY (PART 2. ECOLOGICAL)**

Los Alamos National Laboratory (LANL) is a multidisciplinary research facility owned by the U.S. Department of Energy. The Laboratory's Environmental Programs is part of a DOE nationwide effort to ensure that past operations do not pose unacceptable risks to human health or the environment. Ecological risk assessments evaluate the potential for adverse impacts on the environment. The ecological risk assessment process is a phased approach that progresses from a generic risk screening assessment to a site-specific assessment. Ecological risk screening assessments uses ecological screening levels (ESLs) for a variety of receptors, including plants, soil invertebrates, aquatic communities, and wildlife. ESLs are derived from values for no observed adverse effect concentrations and conservative intake parameters for each receptor. The ecological risk screening assessment results are used to determine if adverse impacts might be present. If potential impacts are identified a series of laboratory and field studies may be proposed to confirm whether receptors have been affected. Possible actions to mitigate and understand the effects may include continued surveillance and/or monitoring as well as remediation.

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### **NANOMATERIAL RELEASE FROM PRODUCTS IS NOT RELATED TO HAZARD DATA: METHODS AND DATA LACKING**

Advances in incorporation of engineered nanomaterials (ENM) into composites have occurred in tandem with the identification of possible hazards of the pristine ENM prior to compositing. However, review of research of release of ENM from nano-composites conducted for the NanoRelease project ([www.ilsi.org/ResearchFoundation/Pages/NanoRelease1.aspx](http://www.ilsi.org/ResearchFoundation/Pages/NanoRelease1.aspx)) shows little attention is being paid to ENM release from the composites. Consequently, it is not clear whether potential risks of that material are informed by current ENM hazard research. A crucial finding of the review is that our understanding of the risks associated with uses of nanomaterials will continue to be insufficient until substantial progress is made on methods to measure ENM release from uses of ENM. In the available reports, consumer products containing nano-silver, nano-titania and carbon nanotubes have been investigated under several exposure scenarios, including, weathering, abrasion, UV and washing. The data show three possible release scenarios: nanoscale particles of some



kind (almost always, similar to the material without added ENM), nano-scale particles with some carrier matrix and some ENM (often), and finally, ENM alone (rare). This review of the nanomaterial release literature illustrates a data gap relevant to the field of environmental risk assessment. Perhaps most critical, our review suggests that fate and transport modeling, exposure assessment, and risk assessment frameworks in general for ENM uses should not be based on pristine engineered nanoparticles, but rather should be based on the released composites of ENM and the carrier matrix.

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### **EVALUATING TRUST OF CONTAMINANTS AND FOOD MESSAGING IN INUIT COMMUNITIES**

The presence of contaminants (heavy metals and organic contaminants) in the Canadian Arctic environment has received increasing attention over the past few decades, most notably due to the potential risks to human health from country food (food from the land and water) contamination and in utero exposure to the fetus. Since the late 1970s federal, and more recently, Territorial and regional health authorities have been providing advisories and advice to northern Aboriginal populations regarding their consumption of these food items as a result. Initially premised solely on the understanding of the risks posed to adult, and then adult and fetal and child health, these messages have had to evolve to consider the growing and substantial evidence supporting the nutritional, social and other benefits of consumption of these food items as well as the current knowledge of risks posed by the consumption of such things as fish containing methyl mercury or marine mammal blubber containing PCBs. The decision making process and communication of this evolving body of knowledge poses significant challenges for environmental and public health professionals. This case study looks at the factors influencing trust in decision maker actions associated with the release of information on country food consumption and environmental contaminants in the Inuit community of Kuujjuaq, Nunavik. Kuujjuaq is a regional centre of the Inuit region of Nunavik, northern Quebec. While being a regional centre with higher than regional average levels of participation in wage earning employment and access to store foods, the Inuit population is still strongly connected to the land and sea through hunting, fishing, collecting and other subsistence activities. As a result, communication messaging around country food safety strikes at the heart of Inuit culture and daily life. Preliminary results from the pilot testing and initial focus groups with community residents assessing factors influencing trust in health messaging on this topic will be discussed.

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### **UP IN THE AIR: COMPARISON OF EXPOSURE TOOLS FROM ACROSS THE GLOBE THAT CAN PREDICT WORKER INHALATION EXPOSURES**

A number of regulatory authorities across the globe, to include the U.S Environmental Protection Agency (USEPA) and the European Chemicals Agency (ECHA) have integrated exposure estimation tools into their risk assessment programs. For example, ECHA has specified several tools to evaluate worker inhalation exposures for compliance with their Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation. These tools include the European Centre for Ecotoxicology and Toxicology of Chemicals Targeted Risk Assessment tool (ECETOC TRA), the Stoffenmanager exposure model, and the Advanced REACH Tool (ART). Similarly, the USEPA uses the Chemical Screening Tool for Exposures & Environmental Releases (ChemSTEER) to estimate conservative, occupational inhalation exposures and to assess the potential risks that chemicals may pose to workers. A host of additional tools, such as the Exposure-Fate Assessment Screening Tool (E-FAST), the Multi-Chamber Concentration & Exposure Model (MCCEM), the Wall Paint Exposure Assessment Model (WPEM), and The Netherland's National Institute for Public Health and the Environment ConsExpo consumer tool are also available to predict inhalation exposures, but were designed primarily to estimate risks to consumers when using products and articles in residential settings. Some of these tools, however, may be adapted for use in predicting worker inhalation exposures. A thorough comparison of each of these tools was made: • To identify the minimal input data set required for implementation, • To clarify the context in which each tool is relevant, • To define the limitations of each tool, and • To ascertain if adaptations are possible for expanding the tool's applicability. Based on this evaluation, a series of decision trees were developed to facilitate the selection of the proper tool for predicting worker inhalation exposures dependent on the risk assessment requirements for a particular situation.

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### **INCORPORATING UNCERTAINTY WHEN EVALUATING RISK ASSESSMENT METRICS: MODELING LISTERIA MONOCYTOGENES CONTAMINATION IN READY-TO-EAT DELI MEATS**

In order to investigate uncertainty inclusion in food safety metrics, a second order Monte Carlo model of *Listeria monocytogenes* in ready-to-eat deli meats that simulated *Listeria* concentrations from the food processing plant through transport, retail, the consumer's home, and consumption was developed. The model accounted

for growth inhibitor use and retail cross contamination, and used Latin Hypercube sampling for uncertainty iterations. The FAO/WHO dose response model was used for evaluating illnesses. A fixed appropriate level of protection (ALOP) risk metric was established as a risk of illness per serving. For each uncertainty iteration, Brent's root finding algorithm was used to solve for the corresponding performance objective (PO) risk metric as an allowable *Listeria* concentration (cfu/g) at the processing plant where regulatory monitoring would occur. Over all 240 uncertainty iterations, an uncertainty distribution of this PO was formed. Points on this distribution represent the probability that the resulting risk per serving is less than or equal to the target ALOP for a given PO. Deconvolution testing confirmed that regulatory PO setting would have the impact expected. Assuming the most likely industry response, no dose response uncertainty, and a target ALOP of  $-6.38 \log_{10}$  risk of illness per serving (the median of the current estimated risk of illness distribution), a plant PO of  $-1.74$ ,  $-2.75$ , and  $-3.39 \log_{10}$  cfu/g would be required for 60%, 70%, and 80% confidence respectively that the target ALOP is not exceeded. These are all more stringent than the current typical monitoring level  $-1.40 \log_{10}$  cfu/g. In general, uncertainty from the dose-response portion of the model and from the nature of the industry response dominated the uncertainty. This work highlights some of the difficulties of the current risk metric framework with regard to uncertainty.

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### **RISK ASSESSMENT OF NANOMATERIALS - TITANIUM DIOXIDE (TiO<sub>2</sub>) -**

Nanoscale titanium dioxide (TiO<sub>2</sub>) has been used for many years for various purpose, particularly, as cosmetics and photocatalysts. Although TiO<sub>2</sub> itself is considered inactive, there is concern that nanoscale TiO<sub>2</sub> might pose a nonnegligible risk owing to its small size and resulting high specific surface area. Since risk assessment and proposal for acceptable exposure limits of nanomaterials including TiO<sub>2</sub> have been limited, the industries that produce or use nanoscale TiO<sub>2</sub> have been facing difficulties in developing strategies on controlling the exposure to and resulting risk of nanoscale TiO<sub>2</sub>. As one of the outputs of the NEDO (New Energy and Industrial Technology Development Organization) project "Research and Development of Nanoparticle Characterization Methods - Evaluating Risks Associated with Manufactured Nanomaterials" (FY2006-2010) in Japan, we have developed a risk assessment report on TiO<sub>2</sub>. Considering the mechanism of action of TiO<sub>2</sub> nanoparticles, lung inflammation was considered as a health-protective endpoint for assessing health risk in the workplace. The NOAEL determined from the inhalation experiment using rat by Bermudez et al. (2004) was converted to the corresponding exposure concentration for workers, and the uncertainty factors applied were prudently determined.

The acceptable exposure limit was proposed as 0.6 mg/m<sup>3</sup> (respirable dust, 8 hours TWA). Note that the value was set as a period-limited value from the viewpoint of adaptive management, that is, it aims at protecting workers against subchronic exposure (approximately 15 years) and should be subjected to revision in the next 10 years. Although the risk levels in most of the workplaces where nanoscale TiO<sub>2</sub> is handled are not significant, it is considered that installing appropriate exposure controls is necessary depending on the type of nanoscale TiO<sub>2</sub> and the handling processes.

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### **AN EXPOSURE INDEX ESTIMATION FRAMEWORK FOR THE NATIONAL CHILDREN'S STUDY (NCS)**

Exposure Indices (EIs) are designed to capture and summarize, in a small set of numerical values/ranges, complex distributions of potential exposures to multiple contaminants. Typically, an EI is defined in relation to health risks associated with common health endpoints, and takes into account location-specific contaminant information on multiple media and exposure pathways. The EI estimation framework developed for the NCS is intended to support formulation and testing of specific exposure-based hypotheses, to maximize the use of databases and location-specific extant data in exposure estimation, and to rank different NCS locations in relation to the potential for environmental exposures. The NCS EI framework utilizes an Exposure Information System (EXIS) that has been developed by aggregating, processing, and integrating diverse extant databases containing field data on environmental, demographic, behavioral, biological, etc. attributes at the Federal, regional, State, and local level. Within the EXIS, these data are supplemented by estimates from numerical model simulations of environmental quality and population exposures. The EXIS has been designed to support and to take advantage of the MENTOR (Modeling ENvironment for TOtal Risk studies) and PRoTEGE (Prioritization/Ranking of Toxic Exposures with GIS Extension) systems. Initial EI applications have focused on inhalation exposures potentially relevant to pregnancy outcomes such as low birth weight and pre-term birth rates. This framework is demonstrated here through its application (a) for the set of all counties selected for the NCS, and (b) for NCS study segments for Queens County, NY. These applications demonstrate the feasibility of the EI analysis in conjunction with extant data; however, they also illustrate various challenges due to heterogeneities and gaps in data. Systematic analyses of these challenges will help prioritize future information collection efforts for specific NCS study components.

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### **AGENT-BASED MODELLING OF THE LINKED ENERGY, ECONOMIC, AND CLIMATE SYSTEM FOR SCENARIO GENERATION AND ROBUST DECISION-MAKING**

Society's response to climate change is a global, collective decision-making problem unprecedented in scale and complexity. Formally analyzing the role of a non-trivial number of stakeholders in shaping climate policy has been elusive because the inherent heterogeneity precludes tractable analysis by traditional models. An alternative approach is represented by agent-based modeling, which employs the concept of discrete actors, each possessing a set of defining characteristics and behavioral rules. Rather than focusing on equilibrium or rational choice outcomes, agent-based models are primarily concerned with the evolution of large-scale properties that naturally 'emerge' from a system of heterogeneous, boundedly rational agents. We have been developing a multi-level, agent-based model that simulates both international negotiation and the domestic dynamics of the economy, energy, and climate change. Rather than claiming predictive precision, the objective of our model is to support robust decision-making under uncertainty by serving as a policy and scenario discovery tool. In the first capacity, policy formation is endogenous to the model and allows for investigation of the co-evolution of policy formation and system structure. This allows one to address questions such as, "What are the likely enhancing or retarding factors for minimizing climate risks?" In the second capacity, as a scenario discovery tool, the model allows one to engage in fully integrated scenario creation for exogenously supplied policies. A relevant question is, "What are the conditions under which a given policy performs poorly?" A particularly useful aspect of the scenario discovery mode is that policy solutions from other modelling frameworks can be used as inputs, providing a test of policy robustness. This makes agent-based modelling an important complementary tool in the risk analyst's toolbox.

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### **VARIABILITY IN AIR QUALITY MODELS INFLUENCES SOCIAL COST ESTIMATES FOR AIR EMISSIONS**

Choosing between alternative products, processes and policies requires credible information about both the private and social costs. For air quality, an impact pathway approach is frequently employed to estimate this social cost. This entails converting the emissions to ambient concentrations, translating the concentrations to their equivalent human health effects and applying willingness to pay estimates to avoid these outcomes. Since this approach can be time consuming, literature values are used in many analyses. The assumptions in the air quality models that are used to derive

the literature values, however, are rarely evaluated and may introduce error. Here, we develop new estimates of the social cost for air emissions in \$/ton through an impact pathway approach. Using a 'state of science' 3-D chemical transport model, the Particulate Matter Comprehensive Air Quality Model with extensions (PMCAMx), we model changes in fine particulate matter (PM<sub>2.5</sub>) from emission precursors for two urban and two rural sites in the summer and the winter for area and point sources. We calculate social costs that range from two to more than ten times higher than other values in literature for both reactive and non-reactive compounds, suggesting that model variability in both transport and chemistry can have an important influence on the estimates. Applying new models that reflect an improved understanding of the formation of secondary organic aerosols (SOA), we find that the social costs for the non-methane hydrocarbons precursors can also vary by a factor of ten depending on the formation mechanism. Our results suggest caution in the use of literature values for the social cost of air quality emissions for benefit-cost analysis and externality pricing.

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### **TOMORROW'S GOVERNMENT: BUILDING A RISK MANAGEMENT CULTURE AT THE DEPARTMENT OF HOMELAND SECURITY**

In accordance with the Department of Homeland Security's (DHS) Quadrennial Homeland Security Review, homeland security is considered tantamount to managing risks to the Nation. Instituting a risk management program is about establishing efficient and effective processes throughout an organization that allows the promulgation and use of risk information to inform many types of decisions. It is also about building a culture of risk management and changing the way members of an organization think about risk. Working to instill a culture of risk management is an important aspect of any organization's risk management efforts, and DHS is using a multi-pronged approach to promote risk management concepts and institutionalize risk management practices throughout the organization. DHS is currently building participation in risk management decisions through a central governing body called the Risk Steering Committee, developing a risk management training program, conveying a common language through a risk lexicon, distributing guidance on risk management practice, and providing tailored risk analysis and consultation to partners. While there is much work to be done, in this session we will discuss some of the endeavors DHS has embarked upon and how DHS continues to strive for a risk management culture. In addition, we will discuss some of the challenges and lessons learned encountered during the implementation of a risk management program at DHS.



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### **THE PANTOXIN PROJECT: A VALUE OF INFORMATION FRAMEWORK FOR COMBINING INFORMATION OF DIFFERENT TYPES IN CHEMICAL RISK DOSE-RESPONSE ASSESSMENTS**

Contemporary dose-response assessment confronts numerous challenges including: 1) a vast proliferation of chemicals to assess; 2) a flood of new information from new types of studies that offer more and different kinds of data and present new types of analysis; 3) demands for more coherence in addressing uncertainties. Risk analytic efforts over the past decades have accumulated a substantial body of information on chemical toxicity relevant to these challenges. EPA's IRIS compilation, for instance, contains detailed information on toxicity for more than 500 chemicals. We describe here a value of information framework intended to facilitate the incorporation of new findings and new or different types of information in dose-response risk assessments. The two key ideas are very simple. Potential usefulness of new information can be evaluated by ascertaining its explanatory power in ensembles of chemicals for which we already have rich sets of toxicological information. And the uncertainty in extrapolating to chemicals for which the information base is limited can be examined by observing generic properties of information-rich data sets. We describe our progress in creating data sets and analytic tools to make this effort practical. Details of a specific illustration of the approach are provided in our presentation. "The "straw man" system for replacing uncertainty factors with empirical distributions for traditional systemic toxicants, "examples and use for value of information analysis of in vitro measurements" by D. Hattis, et al.

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### **A REVIEW OF SEAFOOD SAFETY AFTER THE DEEPWATER HORIZON BLOWOUT**

The Deepwater Horizon (DH) blowout resulted in fisheries closings across the Gulf of Mexico. Federal agencies, in collaboration with impacted Gulf states, developed a protocol to determine when it is safe to re-open fisheries based on sensory and chemical analyses of seafood. Most waters have been re-opened, yet concerns regarding the robustness of the protocol to identify all potential harmful exposures and protect the most sensitive populations have been raised. We aimed to assess the protocol based on comparisons with previous oil spills, published testing results, and current knowledge regarding chemicals released during the DH oil spill. We performed a comprehensive review of relevant scientific journal articles and government documents concerning seafood contamination and oil spills and consulted with academic and government experts. Protocols to evaluate seafood safety before re-opening fisheries have relied on risk assessment of health impacts from polycyclic aromatic

hydrocarbon (PAH) exposures, but metal contamination may also be a concern. Assumptions used to determine levels of concern (LOCs) following oil spills have not been consistent across risk assessments performed after oil spills. Chemical testing results after the DH oil spill suggest PAH levels are at or below levels reported after previous oil spills, and well below LOCs, even when more conservative parameters are used to estimate risk. We recommend use of a range of plausible risk parameters to set bounds around LOCs, comparisons of post-spill measurements with baseline levels, and the development and implementation of long-term monitoring strategies for metals as well as PAHs and dispersant components. In addition, the methods, results, and uncertainties associated with estimating seafood safety after oil spills should be communicated in a transparent and timely manner, and stakeholders should be actively involved in developing a long-term monitoring strategy.

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*Government*

### **EVALUATION OF OUTBREAK DATA AS REPRESENTATIVE OF FOODBORNE SPORADIC ILLNESS DATA FOR THE PURPOSE OF ESTIMATING ATTRIBUTION**

This project investigates the representativeness of outbreak illness data for making inferences about attribution of particular foods to sporadic foodborne illnesses. Currently, federal agencies use outbreak data from the CDC Foodborne Disease Outbreak Surveillance System database to estimate pathogen-specific fractions of illnesses resulting from consumption of various food products. Nevertheless, the validity of this approach hinges on the assumption that the frequency at which specific foods cause outbreaks is the same frequency at which specific foods cause sporadic illnesses. Because food attribution information is not available for sporadic illnesses, we cannot directly compare attribution estimates between outbreaks and sporadic illnesses. We can, however, evaluate similarities in the distributions of illnesses reported in the outbreak and laboratory-based surveillance systems (i.e., FoodNet sporadic illnesses) with respect to serotypes, temporal trends, regional, and seasonal characteristics. The degree to which outbreak and sporadic illnesses behave similarly with respect to these indirect measures modulates our confidence about the applicability of outbreak-derived attribution fractions to sporadic illnesses.

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### **FACILITATING PARETO-OPTIMAL COORDINATION BY SUBSIDIES IN DETERMINISTIC AND STOCHASTIC PAYOFF SETTINGS**

Can subsidies promote Pareto-optimal coordination? We studied subsidy effects in coordination games with both stochastic and deterministic payoffs. In the



stochastic game, players coordinated to reduce uncertain losses; in the deterministic game, the payoff equaled the expected value in the stochastic game. Each of 6 players chose Strategy A (with positive cost) or Strategy B (free). Two Nash equilibria existed: All-A&All-B. All-A yielded higher payoffs and was Pareto-optimal, but a rational player should choose A if and only if at least 4 of the other players chose A. 48 groups of 6 players were assigned to a 2x2 design: Game Type (stochastic/deterministic) and Subsidy (present/absent). Play was repeated for 20 periods for each group. In the Subsidy-present condition, 2 out of 6 players were randomly assigned in each period to pay a lower-than-normal cost for A. Players, including the unsubsidized players, were more likely to choose A with Subsidy present. Social Welfare was 7% higher in this condition. In addition, following the subsidy-present game, we ran a second game with subsidy removed. High coordination continued in most groups with stochastic payoffs, but declined for groups with deterministic ones. A post-game survey showed that in the deterministic game, 43% of players believed that subsidy was the only reason to choose A, and that others would choose A only when subsidized. In the stochastic game, only 22% of players held this view: most regarded A as a safer option, and assumed that others also preferred reduced risk, once the subsidy helped the group reach a higher coordination level. Thus, subsidy crowded out other possible reasons for cooperation in the deterministic setting, but safety was the principal reason for coordination in the stochastic setting. The above results imply that a limited budget might best be used to support temporary subsidies in stochastic settings, spread among many groups. In deterministic settings subsidies might need to be maintained indefinitely and might crowd out cooperation based on social expectation.

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### **WHY META-ANALYSES AND SYSTEMATIC REVIEWS COME TO DIFFERENT CONCLUSIONS ABOUT FORMALDEHYDE AND LEUKEMIA**

Meta-analyses and systematic reviews can be helpful tools for assessing causation. A meta-analysis goes beyond a systematic review in that it is a quantitative synthesis of the results of individual studies that can lead to a greater precision of risk estimates and reduces the probability of false negative results. Because meta-analyses combine study outcomes, they are only appropriate if studies are testing the same hypothesis. When heterogeneous studies or those with different hypotheses being tested are meta-analyzed, the overall risk estimate can be misleading. To use the results of a meta-analysis in a risk assessment, one must take these factors into account. This will be demonstrated by recent meta-analyses and systematic reviews of formaldehyde and leukemia risk, which come to different conclusions.

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### **SECURING IMPROVED RISK GOVERNANCE FOR WATER UTILITIES**

Water utilities are charged with a central role in public health protection (1). International initiatives reasserting the value of preventative risk management within the water sector have generated an improved commitment to better risk governance. But what does it take to make good risk management 'stick' within the international water sector? Here we summarise our research to date, reflecting on the use of risk analysis tools, the risk management architecture constructed within water utilities, what makes for mature risk governance and the cultural items required for a pervasive culture of mindfulness (2).

Regarding the state of risk management and risk governance in water utilities, the findings show that utilities often see risk at the corporate level and not really beyond, rather than aspiring to put risk management into the long term plan. Many senior managers are reluctant to make a decision unless they are completely certain about it. Yet they recognise that effective risk management can positively influence the ability to achieve support from regulators and customers.

Reporting on recent research specifically addressing higher levels of risk management maturity, we discuss aspects of risk reporting and visualisation, the role and content of Board level debate on risk and the importance of managing risk knowledge. The water sector is shown to be at a crossroads between reactive and proactive risk management and we offer a forward road map that will allow it to breakthrough and secure better operational, reputational and strategic value from its risk management efforts.

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### **PREFERENCES RELATED TO URBAN SUSTAINABILITY UNDER RISK, UNCERTAINTY, AND DYNAMICS: A COMBINED ELICITATION AND MODELING APPROACH**

Numerous older cities in the US are experiencing a state of decline, due to shrinking populations, economic hardship, and many other factors. Large areas of these cities are comprised of contaminated and vacant land. We explore the decision context around land redevelopment approaches focused upon reducing risk, improving quality of life, and fostering sustainability. Characterizing the preferences and objectives of diverse stakeholders in a multi-attribute framework may improve decisions and planning. However, traditional decision analytic approaches tend to be 'static', and do not capture the temporal and spatial dynamics of this problem. We propose a framework that integrates stated and revealed preferences in a dynamic modeling environment designed to capture key attributes of urban sustainability identified by

stakeholders. The utility of this model will be demonstrated through an observational experiment. Key attributes and preferences will be elicited from a population of stakeholders in a Web environment. After eliciting these preferences, the participants will then engage in a dynamic modeling exercise in which they are able to interactively explore land use decisions considering the complexities of urban dynamics; the numerous tradeoffs, risks, and uncertainties; the resource constraints; and so on. We call this model DMASE (for Dynamic/Multi-Attribute/Spatially-Explicit). Preferences over the key attributes will then be elicited again. We hypothesize that the key attributes and preferences will change appreciably based upon interaction with the DMASE model. Additionally, the model can be modified in an iterative fashion to capture the decision context and preferences of the participants in a more meaningful way. This work will lead to a decision support tool that will allow stakeholders and decision-makers in declining cities to make more informed decisions about changes in the complex urban environment.

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#### **IDENTIFYING AND EVALUATING DRINKING WATER CONTAMINANTS OF EMERGING CONCERN: A STATE PERSPECTIVE**

Contaminants of Emerging Concern (CECs), substances for which human health risks are not well understood (whether due to new toxicity or exposure information, or a lack of information on risks), pose a challenge to public health agencies working to ensure the safety of drinking water. The Minnesota Department of Health (MDH) has completed its first two years of work under a new initiative to proactively identify drinking water CECs, evaluate the potential for human exposure, and develop health-based guidance values to assist risk managers in making public health decisions. During that time, MDH has devised a multi-stage process for screening chemicals based on both toxicological and exposure-based criteria. MDH elicited CEC nominations from other state and federal agencies, from the public, and from within the department. Nominated chemicals represented a variety of chemical classes, including pesticides, industrial chemicals, pharmaceuticals, and personal care products. All nominated chemicals meeting a broadly defined definition of CEC underwent a screening level review for toxicity (potency, severity, endocrine activity) and exposure potential (occurrence, persistence/fate, patterns of use.) Chemicals identified as high priority underwent a higher-level toxicological evaluation, including the development of guidance values where feasible, and further characterization of the potential for human exposure. Development of the program in its first two years has been characterized by (1) an emphasis on process development; (2) thorough analysis of toxicological data for the development of guidance values; (3) comparison of known or potential exposures to guidance values; (4) input from external workgroups

on chemical assessment and communication with the public; and (5) research into new methodologies suitable to the unique requirements of CECs. Project outcomes will be presented for ten chemicals, including triclosan, DEET, TCEP, acetaminophen, and carbamazepine.

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#### **SAFETY DATA SHEET ALTERATION DURING ALIGNMENT WITH THE GLOBALLY HARMONIZED SYSTEM OF CLASSIFICATION (GHS) AND IMPLICATIONS FOR CHEMICAL MANUFACTURERS, SUPPLIERS, AND DISTRIBUTORS**

The Occupational Safety and Health Administration (OSHA) has issued a notice of proposed rulemaking to align its current Hazard Communication Standard (HCS) with provisions set forth by the United Nations' Globally Harmonized System of Classification (GHS). Among the changes expected to be made by OSHA when it adopts the GHS guidelines, safety data sheets (SDSs) will be developed or existing OSHA material safety data sheets (MSDSs) will be modified to reflect the explicit environmental, physical, and health hazard criteria set by the GHS. This presentation will discuss in detail the changes to SDSs resulting from adoption of the GHS. Whereas the current performance-based HCS requires inclusion only of broad categorical information, the specification-based GHS SDS will require that 16 specific headings be included in each chemical SDS, with each section providing a more detailed description of its relevant components than is currently required by OSHA. Covered under the new 16 heading format will include topics related to product and hazard identification, chemical composition and reactivity, regulatory and transportation information, and extensive health and safety guidelines. Implementation of these requirements is expected to decrease incidence of worker illness and injury compared to the current HCS, but may pose challenges to manufacturers, suppliers, or distributors attempting to comply with the new GHS SDS provisions.

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#### **HEALTH AND CLIMATE BENEFITS OF COOKSTOVE REPLACEMENT OPTIONS**

The health and climate impacts of available household cooking options in developing countries vary sharply. Here, we develop and apply a simple, extensible analytical framework to compare stove options across multiple impacts (health; climate) and quantify the potential co-benefits from upgraded fuel and stove combinations. Health impacts are quantified via estimated personal PM intake and a recently proposed log-linear intake-response relationship applicable to PM concentrations well above typical urban levels. Climate impacts are estimated using the global warming commitment on a 100 year time horizon, which gives a conservative (low) estimate

of the short-term climate impacts of stove emissions. Our results indicate that health and climate impacts span 2 orders of magnitude among the technologies considered. Indoor air pollution is heavily impacted by combustion performance and ventilation; climate impacts are influenced by combustion performance and fuel properties including biomass renewability. Emission components not included in current carbon trading schemes, such as black carbon particles and carbon monoxide, contribute a large proportion of the total climate impact. Multiple 'improved' stove options analyzed in this paper yield roughly equivalent climate benefits but have different impacts on indoor air pollution. Improvements to biomass stoves can improve indoor air quality, which nonetheless remains significantly higher than for stoves that use liquid and gaseous hydrocarbons. LPG- and kerosene-fueled stoves have unrivaled air quality benefits and their climate impacts are also lower than all but the cleanest stoves using renewable biomass. Recent data from in-use testing of cookstoves in rural India are also presented.

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#### **GENE-ENVIRONMENT INTERACTIONS IN EXPOSURE-RESPONSE BETWEEN ORGANOPHOSPHATE PESTICIDE EXPOSURES AND THE PHENOTYPIC ANCHOR OF ACETYL-CHOLINESTERASE INHIBITION IN FARMWORKERS**

Our studies in the Yakima valley of Washington state follow 100 farmworkers (orchard workers) and 100 non-farmworkers to investigate potential exposures to organophosphate pesticides (OPs) by collecting urine samples, blood samples, and home and vehicle dust samples. We assayed the urine samples for the 6 diacyl non-specific metabolites of OPs and used a Bayesian Markov chain Monte Carlo method to estimate the multivariate joint distribution of the metabolites. Since urine samples were collected on three days we could separate within person variability and obtain more precise estimates of between person variability. We found that DMTP, a metabolite of dimethyl OPs, had the highest concentration in urine compared to other metabolites of OPs, and that azinphosmethyl, a dimethyl OP had the highest concentration in home and vehicle dust compared to other OPs. In addition, we collected data on the inhibition of acetyl-cholinesterase (AChE), a neurotransmitter that is used as a biomarker in EPA and Washington state standards to remove pesticide handlers from work. AChE inhibition significantly increased with the concentration of DMTP. To investigate gene-environment interactions on the exposure response between DMTP and the phenotypic anchor of AChE inhibition we obtained genotypes on 80 subjects for cytochrome P450 (CYP450) metabolizing enzymes. We found that a single nucleotide polymorphism of CYP450 3A5 (6986A>G, rs776746) significantly changed the slope with the heterozygote having an intermediate effect to

the two homozygotes. In the past gene-environment interactions have been difficult to interpret not because of the lack of genetic information but rather the lack of robust exposure information. These results illustrate the importance of gene-environment interactions for prediction of risk. (Supported by grants P01 ES009601, P30 ES007033 from NIEHS and RD-834514, RD-831709, RD-832733 from US EPA. Contents are authors' responsibility.)

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#### **USE OF RANDOM FOREST FOR ESTIMATION OF SIGNIFICANT EXPOSURES IN CASE CONTROL STUDIES OF FOODBORNE DISEASES**

Foodborne diseases are a major public health concern in the U.S., causing an estimated 48 million illnesses annually. Estimating the disease burden attributable to specific foods is essential for development of targeted intervention programs. Case-control studies have been used to identify significant exposures and calculate population attributable fractions using logistic regression models. However, logistic regression may become unreliable in the presence of many correlated exposure variables and missing values in data, especially where the number of ascertained exposures is comparable to the number of observations. The technique of random forest possesses desirable properties to accommodate interactions between covariates and missingness. We investigated the performances of logistic regression and random forest in variable selection and prediction using data from a case-control study of *Escherichia coli* O157 conducted by the CDC Foodborne Diseases Active Surveillance Network (FoodNet) in 1996. Data obtained from adults (age>19 years) was used, resulting in analysis of 71 cases and 135 matched controls. Univariate logistic regression was used to evaluate over 100 exposure variables to select plausible candidates for variable selection by stepwise logistic regression models. R package randomForest was used to construct an ensemble of 500 trees for estimation of variable importance, with simultaneous imputation of missing values. We found that the two methods identified different significant exposure variables. For example, the settings of pink hamburger exposure were differently identified by random forest (restaurant) and logistic regression (home). Accuracy of prediction was examined by cross validation. Random forest improved predictive accuracy by 20 percent (measured by AUC under ROC) compared to logistic model. In conclusion, our results suggest that random forest provides a more rigorous tool than conventional logistic regression in estimation and prediction of significant exposures for case control studies with missing values and correlated covariates.



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## **ENTERPRISE- AND WORKPLACE-LEVEL RISK MANAGEMENT AND THE DEMING CYCLE**

Risk management in the workplace is a form of process improvement and can be managed as such. Influenced by the UK Health and Safety Executive and the international popularity of the “control banding” approach to managing common hazards, occupational health and safety professionals have adopted a risk management approach. (The terminology is somewhat different than in mainstream risk science.) The general approach of enterprise-based risk assessment and management which underlies control banding and other specific applications and the general approach of quality improvement (and many other management techniques) are based on a common theory of process improvement codified by the American statistician W. Edwards Deming (1900 - 1993). This connection is not explicit in the occupational health management literature and is rarely mentioned in the process improvement literature. The risk cycle reduces to the familiar “Deming Cycle” of quality improvement [Plan -> Do -> Study -> Act], which is already management policy at many employers. The Deming cycle can be used to integrate risk management across domains and to align safety management with overall management. Enterprise-level risk assessment and management can be readily integrated into enterprise quality improvement and Six Sigma by making links to the Deming Cycle. Worksite-level risk assessment and management, which can appear complicated to the uninitiated, can be easily reported in “Deming” terms for rapid management comprehension. Corporate policies regarding continuous process improvement can be harmonized with policies on occupational health protection and safety, realizing practical gains. Occupational health protection measures and outcomes could even be developed as “key performance indicators” for the entire organization, since they reflect adherence to the Deming model and are summary indicators of risk-related performance. Recognizing this link may open opportunities for making gains in occupational health and risk management in large organizations.

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## **EFFECTS OF NETWORK TOPOLOGY ON VULNERABILITY DURING TARGETED ATTACKS**

In addition to protecting infrastructure systems against traditional threats such as natural disasters, it is becoming increasingly important to strengthen such systems against intentional attacks (i.e. terrorism). In this talk, we compare the effects of network topology on system reliability when subjected to various types of targeted attacks. Using a large set of random networks encompassing a wide range of sizes and topological characteristics representative of real-world networks, we simulate network

element failures. We examine the cases of attacks based on nodal degree (initial and recalculated) and nodal betweenness (initial and recalculated). We develop statistical models relating initial topological characteristics of the networks to network performance after attacks. This work provides insights into the types of networks most resilient to various types of targeted attacks.

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## **EPA'S ENDOCRINE DISRUPTOR SCREENING PROGRAM: LESSONS FROM AN INERT SUBSTANCE CONSORTIUM**

EPA developed the EDSP in response to a Congressional mandate passed in 1996 “to determine whether certain substances may have an effect in humans that is similar to an effect produced by naturally occurring estrogen, or such effects as [EPA] may designate”(21 U.S.C. 346a(p)). EPA's EDSP consists of two tiers: Tier 1 focuses on evaluating chemicals for interaction with the estrogen, androgen and thyroid systems, and Tier 2 focuses on determining adverse effects. As part of the EDSP, EPA issues test orders to collect certain test data on selected chemical substances. In general, EPA intends to use the data collected under the EDSP, along with other information, to determine if a chemical may pose a risk to human health or the environment due to disruption of the endocrine system. The determination that a chemical does or is not likely to have the potential to interact with the endocrine system will be made on a weight-of-evidence basis, taking into account data from the Tier 1 assays and/or other scientifically relevant information. Chemicals that go through Tier 1 screening and are found to have the potential to interact with the estrogen, androgen, or thyroid hormone systems will proceed to the next stage of EDSP where EPA will determine which, if any, of the Tier 2 tests are necessary based on the available data. Data from a Tier 1 screening battery are presented and provided in a weight-of-evidence summary. Problems and issues encountered in performing the required Tier 1 assays are described. Recommendations for improvements in Tier 1 and Tier 2 are provided. Finally, perspectives on EPA implementation of the EDSP for List 2 chemicals are provided.

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## **A SYSTEMIC APPROACH TO BRIDGE SENSING AND MONITORING SYSTEMS**

Highway bridges constitute an important part of transportation infrastructure and the lifelines of commerce. The condition of highway bridges is continuously deteriorating due to the lack of appropriate maintenance, with 26% of America's bridges are structurally deficient or functionally obsolete. Bridge inspection evaluates bridge conditions and provides information for efficient planning of maintenance and repair activities. Increasingly, automated structural monitoring sensor systems



are being used to collect real time information together with manual inspection of bridge systems. Despite the mandate of the National Bridge Inspection Standards by FHWA, many bridges receive insufficient inspection due to limitations of funding, equipments, manpower, and the reliability of current sensing technology. A bridge is a system with many interdependent functional elements, and the purpose of inspection is to discover evidences of deterioration of individual elements in a timely fashion and to evaluate the consequences. Assuming that the underlying condition of each individual element is not directly observable, we treat inspection as a detection process with considerable uncertainties during the assessment process. Fault tree analysis is used to provide a link between the evolving deterioration conditions of each element of the bridge and a specific failure mode, a process that requires accuracy and reliability of the sensing and inspection system, which can be quantified by identifying time-critical elements in minimum cut sets. A systemic approach is developed to integrate multiple models for the ultimate purpose of developing risk management strategies for improving inspection and monitoring, and for an effective resource allocation process. The developed methodology is expected to help bridge owners to efficiently prioritize and plan for inspection, maintenance, and remediation activities to reduce the risk of bridge failure.

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#### **ALTERNATIVE METHODS FOR AGGREGATION OF EXPERT JUDGMENTS**

Uncertainty is a key feature of many important technical assessments involving health and safety risks. This is particularly true for models of large-scale, complex, multidisciplinary systems with many unknown elements (e.g., models for climate change). Experts' judgments regarding key model and related risk parameters are not always fully aligned with each other. While it may be argued that characterizing the variation across experts is more important than determining a single "best estimate", such estimates do have utility when considered in the proper context. For these applications different methods have been proposed for aggregating expert judgments, typically involving linear weights. These methods use special measures to evaluate the "quality" of experts and the "appropriateness" of the way their opinions are expressed, and as a result, the weighting schemes applied to expert judgments differ depending on the aggregation method used. All aggregation methods have advantages and disadvantages under different circumstances. This paper uses simulation to compare three popular approaches for expert judgment aggregation: likelihood method (equivalent to Bayesian weighting when experts are assumed to have equal prior weights), "classical" method, and equal weights. Both the likelihood and the "classical" method determine weights by evaluating the consistency of each expert's judgments with the "observed" evidence. This is done using a set of "seed" questions to

evaluate the performance of the experts. The "classical" method is non-parametric, comparing the consistency of the experts' uncertainty quantiles with the observed values, applied through a scoring rule developed by Cooke et al. The likelihood method is parametric, requiring an assumed or expert-elicited probability distribution function for their estimation error. This paper evaluates these approaches under different circumstances and discusses the implications for characterizing uncertainty.

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#### **WHERE THE RUBBER MEETS THE ROAD: A PRACTICAL METHODS COMPENDIUM FOR RISK ASSESSORS**

A wide variety of dose-response approaches exist that apply increasingly data-informed methods and can be used to address a range of problem formulations. However, many risk assessors may not be aware of the range of tools that are available to address specific needs and questions. To aid in communicating the methods that can be used to address different issues, we developed a framework, building off of the framework in the NAS (2009) report, to organize risk assessment methods and guidances in a practical methods compendium. This internet-based framework addresses qualitative and quantitative screening approaches and in-depth assessment methods, and includes active links to additional resources. Application of the methods to address specific issues raised by the NAS (2009) report will be introduced, and addressed in greater detail in the remaining talks in the symposium.

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**REVIEW OF ISSUES RELEVANT TO AMBIENT AIR QUALITY CRITERIA**

The Ontario Ministry of the Environment is reviewing the science supporting air quality criteria development as part of an effort to document its process and enhance clarity and consistency for stakeholders. The review is also intended to identify opportunities to refine the methods for developing ambient air quality criteria. Areas of particular interest include 1) factors affecting the choice of averaging times for sampling and setting of air standards; 2) definitions and applications of chronic, subchronic, and acute exposure and effects; 3) uncertainty factors and the interplay between uncertainty factors and the determination of the point of departure; 4) allocation of exposure across routes and consideration of combined exposures; and 5) linear vs. non-linear/threshold vs. non-threshold dose response. In support of this effort, we reviewed the approaches used by a variety of jurisdictions in Canada, and US Federal and State agencies, as well as international and national authoritative bodies to identify approaches, issues, and best practices. Areas of controversy within the scientific community and areas needing additional research were also identified.

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### **CHALLENGES IN INTERPRETING AND COMMUNICATING HUMAN BIOMONITORING RESULTS**

In Canada, national level surveys and studies, community-based Northern and First Nations programs, and other targeted studies are generating human biomonitoring data for a wide range of chemicals. Advancements in laboratory methods allow for an increasing number of chemicals to be measured at lower detection levels, but our ability to interpret biomonitoring results in relation to the risks these concentrations may pose to human health is limited. Current approaches for interpreting biomonitoring results rely largely on the availability of population-based reference values (e.g., 95th percentile) and health-based tissue guidelines against which tissue concentrations can be compared to determine if levels are elevated or associated with increased health risk. With the exception of lead and mercury, few tissue guidelines or screening approaches exist for interpreting biomonitoring data. This highlights the importance of developing new tools to support scientists, health professionals and policy makers in interpreting and communicating biomonitoring data. Alternative approaches that translate existing health-based exposure guidance values, such as a tolerable daily intake (TDI) or reference dose (RfD), into concentrations of chemicals in biological media, are being considered. These offer a number of opportunities to interpret and communicate what biomonitoring results mean, at the population level, with increased accuracy and clarity. Such approaches have the potential to inform risk assessment and management decisions about possible health risks associated with tissue levels of chemicals. Further research and development are required to account for physiological properties of chemicals, and characteristics of different subpopulations such as pregnant women, infants and children. These efforts will increase the value and use of biomonitoring data.

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### **CHANGING PERCEPTIONS OF RISK APPETITE THROUGH THE USE OF SIMULATIONS AND SCENARIOS**

Risk assessment models and methodologies have often failed to provide optimal decisions in the corporate world in which we operate. Gut reaction and intuition, combined with decision making through the use of internalised mental models ultimately account for the final decision in many cases. Within the environment in which the author operates, decision making is a manual process using risk assessment methodologies and models to inform decision making under situations where incomplete information exists, and decisions are required within tight timescales. The study explores how the use of scenarios within such an environment can be used to improve risk assessment and decision making at little financial cost to the business, and how

such scenarios have led to changes and alignment in risk appetite amongst two diverse organisations which were merged in 2009. As part of the study, individuals from different parts of a financial services organisation were brought together to participate in a range of scenarios. These were used to develop a better understanding of how perception and risk appetite were linked to decision making. The study revealed that intelligence does not always provide a good indicator or the ability to make a robust decision and a lack of ambiguity in processes can lead to a blinkered approach to risk management. The ability of individuals to evaluate information from diverse source, often presented in a unique pattern is critical to effective risk decision making, and the study offers insights on how this might be achieved outside of the classroom.

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### **EGG RECALL OF 2010: HIGH AWARENESS DID NOT MATCH BEHAVIORAL IMPACT**

In August, 2010, over 500 million eggs were recalled because of a Salmonellosis outbreak. A national Internet survey of a sample of 1,204 American adults conducted in late September through October, 2010, found that 91% of Americans had heard about the recall, including 93% of people who eat eggs (79% who do not eat eggs had heard about it). Although the recall affected 23 states, only 36% of the national sample thought the eggs sold in their state were affected. Of those who consume eggs, 50% reported that they checked their homes for the recalled eggs. However, only 3% said that they found recalled eggs and 5% were not sure if they had found recalled eggs. Unlike the spinach recall of 2006, this recall does not seem to have had a significant effect on consumer behavior, with over three-quarters (77%) of Americans reporting that the egg recall had not really affected the way they purchase, prepare, or consume eggs. Only 3% said they stopped eating eggs as a result of the recall, and of those who cite doing something different as a result of the recall, the most common responses were that they only eat eggs cooked through (10%) and that they wash their hands more thoroughly when preparing eggs (6%). Some respondents believe that certain types of eggs are less likely to be contaminated than others, possibly indicating a naturalness effect. While most indicated that they believed eggs to have an equal risk of Salmonella contamination, there was the belief that there was more risk associated with eggs from chickens raised in cages inside a building than from those not raised in cages (31% vs. 9%), eggs from chickens fed conventional vs. organic diet (24% vs. 2%), and white compared to brown eggs (12% vs. 2%). In addition, 50% said they weren't sure what a "shell egg" is, a term repeatedly used by government agencies and news outlets. This highlights the need for continuously testing the messaging used for food recalls and other contamination incidents.

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## **IDENTIFICATION, PRIORITIZATION, AND MANAGEMENT OF RISKS FOR ENERGY SYSTEMS ACQUISITION AND PORTFOLIO OF ASSETS**

There is an urgent need for improving reliability, efficiency, conservation, and environmental protection for energy systems at a range of industrial and military installations. Stakeholders of energy investments are faced with a complex asset management challenge. Using traditional finance theory such as a discounted cash flow to analyze capital investments in energy does not properly account for intangible benefits that are difficult to monetize such as environmental benefits, risk reduction, and many others. Furthermore, while new technologies offer themselves continually, the investment rationale is complicated by deep uncertainties including technology, environment, regulatory, socio-demographic, political, economic, and many others that may effect the lifecycle valuation and resource requirements associated with various investment alternatives. This motivates the need for an evidence-based, systematic process to identify and assess the implications of future emergent conditions and stakeholder perspectives. This research focuses on identification, ranking, and management of risks to energy assets through a multi-layer approach. First, a multiple criteria processor of emergent conditions and scenarios is used to identify which combinations of emergent conditions are the most pivotal to the valuation of energy investments at installations. The multiple criteria are generated from both installation missions and energy conservation and sustainability goals. Next, lifecycle cost analysis is performed for key scenarios identified in the previous step to determine which combinations of emergent conditions have the largest impacts across the investment lifecycle. The research describes lessons for energy managers, systems analysts, and risk managers who are engaged with comparison and selection of energy technologies. A case study is presented concerning several options for investment at a military installation with multiple criteria.

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## **COMBINING EXPERTS' JUDGMENTS: COMPARISON OF ALGORITHMIC METHODS**

Expert judgment (or expert elicitation) is a formal process for eliciting judgments from subject-matter experts about the value of a quantity, such as an input to a risk-assessment model. Experts provide judgments in the form of subjective probability distributions for the quantity of interest. Judgments are typically solicited from several experts, raising the question how best to combine the information from multiple experts. A number of algorithmic approaches have been proposed, of which the one most commonly employed is the equal-weight combination, a simple unweighted

average of the experts' distributions. We evaluate the properties of five combination methods (equal-weight, best-expert, performance, frequentist, and copula) using simulated expert-judgment data for which we know the relationships among the experts' judgments and the true values. We examine cases in which experts are of equal or unequal quality and their judgments are independent, positively, or negatively dependent. Overall, the copula, frequentist, and best-expert approaches perform better and the equal-weight combination worse than alternatives.

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## **AVIATION RISK MANAGEMENT: THE IMPORTANCE OF GOVERNMENT/INDUSTRY COLLABORATION**

In the mid-1990s commercial aviation, already an extremely high reliability system, faced the possibility of unacceptably high accident and fatality rates due to projected growth in the demand for commercial air transport. The old risk management paradigm, of regulators identifying a problem based on historical results and then imposing a solution on the regulated industry, was recognized as being inadequate to meet projected risk management needs. The Federal Aviation Administration had to develop a new approach to managing risk in an increasingly complex and dynamic system-of-systems environment. The new approach features collaboration, proactive identification of potential problems involving those with the best information - pilots, mechanics, other airline employees - and ways of adopting necessary fixes that bypassed the delays associated with the old regulation-heavy approach. In the decade following the adoption of the new approach (1997-2007), commercial aviation saw a 65% decrease in the fatal aviation accident rate, fueled largely by "system think" and pro-active safety information programs. This approach has potential applicability to other endeavors involving large system-of-systems problems, such as offshore oil drilling and aspects of homeland security.

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## **AVOIDING BOOMERANG EFFECTS WITH MORAL APPEALS**

In recent years, a number studies have examined how moral appeals may be used to increase donations to those in need. Several of these studies, however, have found that the use of a moral appeal can boomerang and lead to a reduction in donations. In a series of previous studies, participants were shown a moral argument developed by philosopher Peter Singer in which they were told that just as they would risk ruining their clothes to help save a drowning child directly in front of them, they are equally obligated to help children who are in need abroad. Participants exposed to this argument contributed significantly less in response to a subsequent donation appeal than participants who were not given a moral argument. We build from this previous research in the present study by offering the following change - instead of



providing normative information of how individuals ought to respond, participants were allowed to generate their own moral conclusions. 60 undergraduate students at a university in the Northeastern United States were recruited to participate. Participants were randomly assigned to either a control group or a stimulus condition. In the control group, participants were given a solicitation for a real donation to an African child desperately in need of aid. In the stimulus condition, participants were first asked if they thought they had an obligation to rescue a drowning child in front of them even if it would ruin their clothes; they were then given the same appeal for the African child as the control group. Participants in the stimulus condition gave significantly more money to help the African child in need than participants in the control group. The contrast between this result and that of previous research is discussed in terms of reactance and the potential negative consequences of providing normative conclusions for moral arguments instead of allowing message recipients to freely generate their own moral responses.

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#### **MODELING HEALTH CARE SURGE CAPACITY REQUIREMENTS DURING AN ATTACK ON THE FOOD SUPPLY**

Intentional attacks on the food supply can potentially have catastrophic impacts on the health of the population. In localized events the ability to expand health care to sudden, and potentially prolonged, demand is of great concern. We have developed a simulation-based tool that enables the exploration of current surge capacity demands under a variety of forms of attack on the food supply. It considers both treatment oriented capacity (such as access to treatment facilities, equipment and medicinals) and laboratory capacity (in terms of testing and identification of the agent). The tool is designed such that varying magnitudes of incident can be explored for a range of potential threat agents with differing health outcomes (for example the number of people affected, the severity of health outcomes, and their geographical density). The underlying discrete-event simulation considers both the spatial and temporal aspects of the population affected by an attack and simulates the resulting demand on the health care system. Use of the tool allows the exploration of the impact of different responses to an incident, for example different protocols addressing the emergency standard of care, or response strategies such as the implementation of temporary or mobile care facilities. Such explorations provide insights into the ability of the health care system to provide the required level of patient care for intentional attacks. This in turn provides information and data that can be used in the development of emergency preparedness plans aimed at minimizing the impact of an attack on the food supply. This presentation will summarise the structure and mathematical architecture of the tool and illustrate the use of the tool through a scenario involving botulinum toxin.

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#### **THE VALUE OF KNOWLEDGE-BASED DECISIONS: IMPROVING TERRORISM DEFENSE BY INTEGRATING MULTI-CRITERIA DECISION ANALYSIS, GAME THEORY, AND THE VALUE OF INFORMATION**

Decision-making is a vital component of effective homeland security policy making. The efficiency of current counterterrorism techniques has been widely questioned. New approaches to risk assessment are needed to combat the evolving threat of terrorism. In this work, we expand on previous contributions of game theory in counterterrorism. We propose a two-player attacker-defender game, introducing three new elements to the standard problem. Using Multi-Criteria Decision Analysis (MCDA) techniques, we provide a different perspective on strategy development. By introducing a framework that allows for a consistent approach to expert elicitation, we attempt to maximize current data utilization. In addition, we added a feedback loop for investment of resources towards improving scientific knowledge using the Value of Information (VoI) framework. This addition makes it possible for the defending actor to advance the current set of knowledge relating to tactics and countermeasures while mounting an active defense. Finally, once the defender's resources are invested in defense and knowledge advancement, an attacker with perfect information develops and attempts an attack, predicted by maximizing payoff in the game. Game theory has been used to effectively model and predict the behavior of entities interacting, with applications in fields as broad as economic policy, military planning, bargaining structures, and even business planning optimization. By expanding MCDA to incorporate game theory in counterterrorism policy selection, we believe that our approach will expand a defender's capability for analysis of unique and robust terrorist actors by adapting these powerful tools in a new integrated application. In this presentation we attempt to show that prioritization of defense policy techniques, using a combination of MCDA and VoI, could have a profound impact on the efficiency of the decision-making process.

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#### **THE "STRAW MAN" SYSTEM FOR REPLACING UNCERTAINTY FACTORS WITH EMPIRICAL DISTRIBUTIONS FOR TRADITIONAL SYSTEMIC TOXICANTS' EXAMPLES AND USE FOR VALUE OF INFORMATION ANALYSIS OF IN VITRO MEASUREMENTS**

Some key recommendations of the NRC "Science and Decisions" report include (1) specifying criteria for RfDs in terms of a "Risk Specific Dose" (no more than X risk of harm with Z confidence) and (2) replacement of the arbitrary single-



point uncertainty factors with distributions derived from empirical data for sets of chemicals and endpoints that are putatively analogous to the chemical and biological response being considered for standard setting. This paper first reviews past experience in the application of a “Straw Man” system developed to accomplish these objectives. It then uses this system to create a value of information framework for evaluating the amount of reduction in uncertainty obtainable from different in vitro and in vivo tests, quantifying the reduction in uncertainty in expected risks obtained after adding progressively sophisticated and expensive types of toxicological information. An initial illustration uses correlations between in vitro measures of chemical potency for different endpoints (AC50’s) with more familiar LOAEL potency data.

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### **USING EXPERT JUDGMENT TO UNDERSTAND THE RARE EVENT THREAT SPACE OF HOMELAND SECURITY: PRACTICES, CHALLENGES, AND OPPORTUNITIES**

The Department of Homeland Security (DHS) manages risks to the Nation arising from such threats as terrorism, natural and manmade disasters, cyber attacks and transnational crime. The nature and unpredictability of acts of terrorism present unique challenges. DHS performs separate biennial Terrorism Risk Assessments (TRAs) for chemical (CTRA) and biological (BTRA) threats as required by Homeland Security Presidential Directives (HSPDs) 22 and 10, respectively. DHS also performs an Integrated Terrorism Risk Assessment (ITRA), mandated by HSPD 18, which incorporates, integrates and expands upon the BTRA and CTRA and establishes similar analyses for radiological and nuclear threats (RNTRA). In addition, the Department’s Risk Assessment Process to Inform Decision-making (RAPID), in support of the DHS Policy for Integrated Risk Management (May 27, 2010), provides an all-hazards risk analysis by incorporating the information from all of these TRAs and addresses additional risks such as those from natural disasters and other threats. All of these analyses are probabilistic risk assessments. Due to the rare event nature of many of these threats and/or the scarcity of data, some of the key inputs for the TRAs and RAPID have been elicited from the intelligence community and program experts. These inputs have a very high degree of unavoidable uncertainty. To obtain these judgments DHS has adapted an expert elicitation process originally developed for the nuclear power sector. This presentation will describe how that elicitation process has been adapted by DHS, and discuss the state of the science as it relates to elicitation of judgment for rare or highly uncertain events in key areas such as: de-biasing, quantifying and handling uncertainty, relative versus absolute judgments, treatment

of conflicting results from multiple experts, and validation. The presentation will put forth a research agenda to contribute toward progress in these key areas.

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### **CHEMICAL INFRASTRUCTURE RISK ASSESSMENT**

The Department of Homeland Security’s Chemical Security Analysis Center (CSAC) is responsible for the science based knowledge and characterization of chemical risk to the nation. The CSAC has completed the first phase of the Chemical Infrastructure Risk Assessment, a study of the acute risk to human health and the national economy due to a terrorist initiated event within the chemical supply chain. The probabilistic risk assessment, which examines 46 toxic industrial chemicals, considers different types of terrorist groups with varying levels of financial and technical resources, multiple attack modes and target types. The targets include various features within a chemical facility such as storage vessels, process units, process control systems, etc as well as transportation modes such as rail, bulk and non-bulk highway, barges and pipelines. The study was based on a comprehensive synthesis of Department of Homeland security chemical facility location data, GIS population data, and GIS data for rail lines, roadways and navigable waterways along with an extensive dataset to provide location specific meteorology to produce an accurate estimate of consequences. The impacts of security and mitigation features were also included in the analysis, as well as the distinction between insider and outsider threats and the likelihood of interdiction. The baseline study, as well as evolving sensitivity studies can be used to understand the main contributors of risk from the US chemical supply chain, where the greatest impacts can be achieved, as well as areas where there appear to be diminishing returns with additional efforts to buy down risk.

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### **A TALE OF TWO SYSTEMS: SYNERGY IN MANAGING RISKS TO PEOPLE AND TO MUSEUM COLLECTIONS**

The two systems of managing health and safety and of managing preservation of cultural property have many parallels. Either, or both, can exist as predominantly habit-based systems. However, when managed from a proactive perspective, they can be considered goal-directed systems. In the first case, the goal is to maintain health and avoid accidents to people. In the second case, the goal is to avoid damage and loss to cultural property. Both goals are clear, widely accepted, and even in-arguably noble and worthy, seemingly a great advantage for both systems. However, this in-arguable goodness of the goals can lead to unquestioned, habit-based systems rather than rational, strategic approaches. Habit-based and goal-based approaches are not mutually exclusive. A well-managed goal-based system will foster adoption of good habits that

then allow both systems to operate as effectively and economically as possible. Both health and safety and cultural property preservation systems will operate best when they are mutually supportive. In many instances, this mutual support arises automatically as a consequence of the basic similarities of the systems—both strive to avoid any unnecessary and harmful interaction of people, energy and materials. Examples of natural alignment, potentials for better alignment, and conflict between the two systems are given through cartoon depictions. Viewing health and safety and cultural property preservation as parallel and closely related risk management systems opens the way to improvements in both. Combining the two encourages synergies that can lead to effective risk management and resource allocation by custodians of our collected heritage.

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#### **UPDATING DATA FOR THE DEPARTMENT OF HOMELAND SECURITY'S BIOTERRORISM RISK ASSESSMENT**

Homeland Security Presidential Directive 10 (HSPD-10), titled Biodefense for the 21st Century, identified the need for a rigorous and technically sound methodology for assessing the bioterrorism risk to the nation. In response, the Department of Homeland Security (DHS) Science and Technology Directorate developed the Bioterrorism Risk Assessment (BTRA). By definition, the attack scenarios in the BTRA model involve biological agent production, subsequent bioagent dispersion, and the potential for public health consequences. A large set of bioagent specific data is required to facilitate modeling of these scenarios. To ensure that the best available science and expert judgments are used in the assessment, the data are periodically updated through comprehensive review of the published scientific literature, government reports, and interactions with relevant Subject Matter Experts (SMEs). Presented here is a summary of the data update efforts performed following submission of the 2010 BTRA report. These efforts included an extensive data collection effort and review of the data by SMEs from across academia, industry, and the government. The impact of the ~1,200 additional references reviewed for the 38 biological agents currently considered in the BTRA along with the over 500 input datasheets reviewed by SMEs are summarized. Knowledge areas in which the literature and SME input continue to show the need for additional research efforts will also be discussed.

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#### **SOURCES OF VARIABILITY IN BIOMONITORING DATA: TEMPORAL VARIATION IN SPOT SAMPLE CONCENTRATIONS**

Conventional external dose exposure assessments (e.g., measuring chemicals in air, water, food, soil, consumer products, etc. and assuming intake/contact rates to es-

timate average and peak intake of a chemical) are increasingly being supplemented or supplanted by internal dose-based assessments using biomonitoring data. However, biomonitoring studies generally rely upon single spot urine samples or single blood samples. This provides, at best, a snapshot in time of the concentrations of chemicals in a particular person, which may be difficult to interpret for short-lived chemicals. For most chemicals, understanding chronic average exposures is more relevant to risk assessment. Understanding how chemical concentrations in spot urine or blood samples compare to 'average' chemical concentrations in people's (individuals and population) blood and/or urine is critical to assessing chemical-specific public health risks. While numerous sources of variability in spot samples exist (magnitude of exposure, pharmacokinetics and temporal variability), this presentation focuses on the issue of temporal and inter-individual variability. By understanding the factors that govern temporal variability in chemical concentrations, researchers can better understand how to design biomonitoring studies and interpret individual and population distribution biomonitoring data. This presentation explores recent datasets for phthalates and BPA concentrations in spot samples in individuals over time. These data improve our understanding of the factors governing variation in levels of these compounds in blood and urine within a day, across days and across individuals. Datasets for numerous other compounds (metals, PAHs, etc.) help inform the chemical- (e.g., half-life) and exposure source-specific (frequency and route of exposure) factors that govern the degree of variability that might be expected for a given compound.

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#### **ATTACKER-DEFENDER GAMES IN CYBER-PHYSICAL NETWORKS**

A number of critical network infrastructures rely on cyber and physical components that are both subject to natural, incidental or intentional degradations. In this paper, the strategic interactions between an attacker and a defender of such infrastructures are studied using a sequence of game theoretic models. We formulate the cyber-physical infrastructure problems as games between an attacker and defender attempting to optimize individual utilities consisting of the sum of costs and system gains. The probability of a system's survival is a function of both the attackers' and defenders' options: (a) binary options correspond to attacking/defending entire cyber and physical parts; and (b) discrete options correspond to attacking/defending a number of cyber and physical components. Nash equilibrium and subgame-perfect Nash equilibrium strategies are derived for the simultaneous-move and sequential-move games, respectively. Both analytical and numerical results were provided to illustrate the models. Finally, simulation results of cloud and high-performance computing examples are presented to complement the analytical results. Our results provide insight into the survival of such infrastructures under various costs and the knowledge that players have of the infrastructure and each other.

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### **TOWARDS MORE RISK- AND PERFORMANCE-BASED U.S. GOVERNMENT STANDARDS FOR PROTECTING BUILDINGS FROM VEHICLE BOMB ATTACKS**

The threat of vehicle bomb attacks against buildings has led several U.S. government agencies (including GSA, DHS, DoD, and State Department) to formulate building standards (codes) with provisions related to blast protection. The recommendations contained in these standards, however, while well-considered, are not the product of explicit cost-benefit considerations. These standards are instead designed so as to provide what is believed to be a reasonable amount of protection, based on costs and a largely qualitative, judgment-based risk assessment. This has led many to question the cost-effectiveness and true impact of the standards. To explore these issues, structured interviews were conducted with 11 individuals - from government, industry, and academia - who are knowledgeable of these standards and the groups that formulate them. The specific interview goals were to gauge: how the standards might be made less prescriptive and more risk- and performance-based, what the potential pros and cons of doing this might be, and what factors (institutional and otherwise) might impede this. From this, a series of recommendations are presented, including that these groups: expand their membership to include one or more persons with a wider knowledge of risk analysis and risk management, beyond the context of weapons effects and military defensive design singularly; incorporate more uncertainties explicitly into their analyses; make the linkages between costs and avoided damages more concrete, and use this as one input to the decision-making process; rework the analysis so that it is determined how likely an attack would have to be for mitigation to be worthwhile, rather than assuming an attack will necessarily occur; and conduct detailed performance analyses on a small scale (e.g., for a single building or a small representative sample of buildings), and then extrapolate the results to other situations.

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### **OZONE EXPOSURE IS ASSOCIATED WITH CARDIOVASCULAR DISEASES MORTALITY BASED ON BOTH ACUTE AND LONGER TERM ANALYSES**

Air pollution-associated cardiovascular mortality is a major concern in public health. It has been shown that ozone can play an important role in elevating cardiovascular diseases mortality risk for both acute and long term exposure. The objective of this study is to assess the cardiovascular disease mortality risk of ozone exposure by using both daily (Time-stratified case-crossover design) and monthly (Poisson-

distributed repeated measures regression model) mortality analyses. The national mortality registry data, from the period 2006-2008, concerning mortality in sixty-four Taiwanese townships with Environment Protection Agency (EPA) air monitoring stations was analysed. The results indicated that increased ozone exposure was associated with higher cardiovascular disease mortality. Both the daily mortality analysis (Time stratified case-crossover design) and monthly mortality analysis (Poisson-distributed repeated measures regression model) showed the consistent health effects of ozone related cardiovascular diseases mortality. Increasing an interquartile range (IQR) ozone exposure could be related to increasing 2-5% mortality risk of cardiovascular diseases based on both daily and monthly analyses. The results of this study indicate that increased ozone exposure is associated with higher cardiovascular disease mortality. The acute and longer term effects of ozone exposure related to cardiovascular diseases mortality can be consistent and significant, 2-5% increased mortality risk with an interquartile range (IQR) ozone exposure. Further study is suggested.

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### **MEETING NEAR-TERM NEEDS FOR THE ESTIMATED ATTRIBUTION OF FOODBORNE ILLNESS TO FOOD COMMODITIES**

A comprehensive approach to estimating the attribution of foodborne illnesses to food commodities is a long-term activity that requires assembling and organizing multiple bodies of disparate scientific information. While methods are being developed, regulatory agencies require interim guidance. That guidance should be methodologically consistent with planned future attribution outputs. We describe a project within the broad scope of attribution activities that will (1) differentiate food commodities according to whether they fall under the authority of FDA or FSIS, and (2) provide near-term summary descriptions through estimated attribution values for specific pathogen-commodity pairs. The outputs can inform decision-making about policy. Our approach uses structured elicitation and draws on diverse sources of information, including case-control studies, outbreak investigations, expert elicitations, consumption-based models, and risk assessments. The framework described in (2) could be applied repeatedly because pathogen ecology, food contamination risk, and food consumption are all dynamic. With periodic reassessments, the near-term outputs can be harmonized with the ongoing product of the comprehensive attribution effort.

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### **PRODUCE CONSUMPTION PATTERNS IN THE U.S.: IMPORTANCE FOR PRODUCE RISK ASSESSMENTS**

A great variety of fruits and vegetables are available in the U.S., produced by a highly diverse industry. Produce has been increasingly identified as vehicle for infec-



tious disease outbreaks. Several classification schemes have been proposed to group similar produce commodities, thus facilitating activities such as risk assessments, outbreak data analysis or source attribution. Consumption habits are one principle determinant of microbial risk, but studies focused on produce consumption habits have been scarce. Here we provide an in-depth analysis, for the total U.S. population, of consumption frequencies, serving sizes and processing forms for a large variety of produce commodities using 1999 - 2006 data from 'What we eat in America', the dietary interview component of the National Health and Nutrition Examination Survey. Produce consumption estimates were compared to U.S. food availability estimates available from the Economic Research Service of the United States Department of Agriculture. We also evaluated produce consumption habits at the individual consumer level, and explored demographic predictors of produce consumption. Our data clearly supports the potential usefulness of consumption patterns to distinguish between produce commodities. Commodities can be grouped based on serving size, consumption frequency, typical processing forms, and prevalence as ingredient in complex foods. Marked differences were apparent between fruits and vegetables. Notably, for the same commodity, serving sizes often differed by processing form. Demographic characteristics and individual predilections clearly impact produce consumption patterns, but pronounced differences between produce commodities exist. In conclusion, produce consumption patterns differ by commodity type, food form, and consumer demographics. These results represent valuable information for produce risk assessments.

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#### **NGO COMMUNITY PERSPECTIVES ON SYNTHETIC BIOLOGY**

Abstract: NGOs, Civil Society, and Social Movements have diverse and different views on synthetic biology and emerging technologies. Even so, there tends to be growing concern around developments in synthetic biology and the lack of proper regulation and risk analysis for these technologies. These concerns are rooted in the same issues seen around earlier biotechnologies - namely genetic engineering in agriculture. Without proper oversight, risk analysis, and democratic participation in the development of synthetic organisms and products from synthetic biology these actors will continue to challenge developments in synthetic biology. This discussion will highlight the concerns shared by many of the NGOs following synthetic biology and ways technologies should develop that involve democratic participation and public input from the beginning of the process, not just as an afterthought before products are brought to market.

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#### **INTRAHOUSEHOLD BARGAINING AND STATED-CHOICE EXPERIMENTS: MOTHERS', FATHERS', AND COUPLES' WILLINGNESS-TO-PAY TO PROTECT THEIR CHILDREN FROM ENVIRONMENTAL NEUROTOXINS**

Children are often a primary set of beneficiaries from environmental health policy. Since children, especially young children, do not participate fully in the market place and do not have a mature capacity for judgment, most researchers believe that parents' willingness to pay (WTP) for reduction in risks to their own children's health should be part of benefits assessment for programs protecting children's health. Most studies valuing parental WTP to protect children's health typically assume that household choice can be represented as though made by a single decision maker. A large body of literature in household economics, cognitive psychology, and sociology argues for seeing family decisions as a bargaining process. This paper reports results from a stated-choice survey of 300 Minneapolis area families designed to test the applicability of unitary household models for environmental health valuation. The survey is administered to two-parent households with young children of an age susceptible to lead paint hazards. In half the sample, each parent is asked to respond to the survey individually. Spouses are then asked to take the survey again as a couple. In the other half of the sample, spouses take the survey only as a couple. We find patterns of stated choice that challenge existing theoretical models and are more consistent with mutual learning than bargaining. The study then estimates parental willingness to pay for reduction in risk of IQ loss and attention deficit disorder. We examine the relationship between mothers' and fathers' willingness to pay as a class and within couples. We find that while in general couples resolve differences within the bargaining space determined by their individual choices, there are cases in which couples' choices fall outside those of the individuals in the couple, indicating a process of learning rather than compromise and bargaining. We discuss the implications of these findings for cost benefit analysis, particularly as it affects assessment of benefits to children.

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#### **RANKING THE US PUBLIC HEALTH IMPACT OF 14 MAJOR FOODBORNE PATHOGENS BY PATHOGEN AND BY FOODS**

As part of development of a risk prioritization model, the Foodborne Illness Risk Ranking Model, this study develops estimates of the cost of illness and QALY loss associated with 14 major foodborne pathogens in the U.S. (Scallan et al. 2010).



These fourteen pathogens account for over 95% of the foodborne illness for which pathogen causes have been identified. The study estimates that these pathogens cause \$14.1 billion in cost of illness and loss of 61,000 QALYs each year. The study also developed estimates of the fraction of these illnesses associated with specific foods. This food attribution exercise shows that the burden of foodborne illness within the U.S. with known pathogen cause is highly concentrated. The highest ranking 10 food/pathogen combinations are responsible for \$8.2 billion in cost of illness and loss of 36,915 QALYs.

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### **RISK GOVERNANCE OF NANO-GEOENGINEERING**

Geoengineering includes the large-scale and intentional manipulation of climate and is under consideration to counteract anthropogenic climate change. Nanotechnology is another emerging technology involving the manipulation of matter at the atomic and molecular scales to impart novel properties. To our knowledge, no formal studies of risk governance for the convergence of nanotechnology and geoengineering (NanoGeo) have been conducted. This paper's goals are to explore the convergence of NanoGeo, examine risk analysis and societal issues pertaining to it, and ultimately assess the adequacy of existing international governance frameworks that may be applicable to the marriage of these two novel and rapidly-developing fields. Three analytical frameworks are used for our analysis. First, an upstream oversight assessment (UOA) approach is employed to examine how references to nanotechnology have emerged in geoengineering literature and media, and to select relevant case studies of NanoGeo for further analysis. Second, existing and potentially-relevant international governance mechanisms are identified and judged based upon a multi-criteria decision analysis (MCDA) approach to determine their applicability and effectiveness for risk governance of the NanoGeo case studies and NanoGeo more broadly. Finally, the International Risk Governance Council's (IRGC) framework for stakeholder involvement is used to assess the adequacy of international governance mechanisms for dealing with complexity, uncertainty, and ambiguity associated with NanoGeo.

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### **IDENTIFIABILITY OF BIOAEROSOL SIZE FRACTION FROM ENVIRONMENTAL SAMPLING**

In the aftermath of a release of a microbiological agent, environmental sampling must be conducted to characterize the release sufficiently so that mathematical models can then be used to predict the subsequent dispersion and human health risks. Because both the dose-response and environmental transport of aerosolized microbiological agents are functions of the effective aerodynamic diameter of the

particles, environmental sampling should identify not only the total amount of agent but also the size distribution of the aerosolized particles. In this study a completely mixed compartment model is evaluated for the identifiability the amounts of different size fractions of particles initially released. Different sampling schemes are considered and condition numbers are calculated to assess the identifiability of the initial release. The results indicate that if samples are taken in a single well-mixed room then neither a 4-particle-size model nor a 3-particle-size model can be identified by aggregate sampling of available environmental compartments. If sampling is extended to a second room, which has been contaminated by air flow through the HVAC system, then it is still not possible to identify a 4-particle-size model. However, it is possible to identify a 3-particle-size model. The three particle sizes proposed for modeling are 1  $\mu\text{m}$  particulates, which would account for much of the risk outside the building due to their potential for long range transport, 3-5  $\mu\text{m}$  particles which are respirable but are removed more readily by deposition and HVAC filters than smaller particles, and 10  $\mu\text{m}$  particles which are not readily respirable and settle relatively quickly. Modeling these three categories is proposed as a means to distinguish between the hazards posed by different sizes of aerosols while reducing model complexity to a point where necessary inputs can be identified by aggregate sampling methods.

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### **JAPANESE CONSUMERS' RISK PERCEPTION OF BEEF: THE EFFECT OF NUCLEAR EXPLOSION**

The Tohoku earthquake and Tsunami on March 11, 2011 and the following accident at Fukushima 1st Nuclear Power Plant affected a lot on Japanese daily life and future perspective. Soon after the explosion of the nuclear plant, public concern on radiation risk has spread. Radioactive iodine and cesium that exceed the regulating level has detected since March 19th from variety of vegetables fruits, and animal products especially at the surrounding area of the power plant. Measures have been taken to ensure that such foods are not supplied to the public to eat, however consumer anxious about the risk and hesitate to buy food from the affected area. In this project, we're trying to investigate the following topics; 1) Consumer knowledge on radioactive, BSE and E.coli O157. 2) Comparative risk level of radiation among food related risks 3) The condition that affect beef purchasing behavior 4) Develop a communication tool on radiation risk in beef through participatory method.

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### **THE INFLUENCE OF SOCIAL MEDIA ON RISK PERCEPTION AND REPUTATION RISK**

Nowadays, companies are evolving in an informational environment in which social media such as Facebook, Twitter, Blogster and many more, have grown rapidly. Their role in making and influencing public perception and trust about a company must be considered. Reputation risk is the potential loss that negative publicity regarding an Institution's business practices, whether true or not, will cause a decline in the customer base, costly litigation, or revenue reductions. Social media could have a positive or negative influence on corporate reputation. The risk of risks, reputation is one the most important corporate assets. In this new informational environment, it has become one the most difficult to protect. As a case study of reputation risk, we could analyze the serious social media controversy over Nestlé's policy of buying palm oil. In 2010, Nestlé's Facebook page had been under persistent pressure from Greenpeace who accused Nestlé of threatening the Orang-utans towards extinction. 40% of what was written about Nestlé was about this specific event. Following this misfortune, Nestlé's share price started to take a dent. Nestlé's reputation was damaged as a consequence. In trying to recuperate the situation, Nestlé's efforts were counter-productive. They made several mistakes. Similar events are happening across the world and causing a negative influence on corporate reputation. The threat on corporate reputation can come from anywhere in the world. Large multinationals with subsidiaries all over the world where they may have less managerial influence are even more exposed. Therefore, corporations have to adapt to this new international informational environment due to the rise of social media. The key purpose of this paper is to study the influence of online social media on public risk perception and reputation risk. After a theoretical approach, we will present a case study of the influence of social media on Nestlé's reputation.

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### **DETECTION OF LOCAL CLIMATE CHANGE THROUGH INDIVIDUAL EXPERIENCE**

A challenge for climate change risk communication is that evidence of global warming is typically conveyed descriptively rather than being experienced directly. For some people, such descriptive information may not lead to changes in beliefs and attitudes or proactive mitigation behaviors. As global warming continues to accelerate, local climates in many places are changing in ways that may be directly perceptible through individuals' everyday experiences of weather. Personal experience of abnormal weather presents a case for both direct perception of global warming and a proxy

for what future weather may resemble if global warming continues. However, certain questions remain about the process of individual detection of climate change, namely in how people aggregate their memories of local weather to form an impression of local climate; which climate indicators people perceive most readily; and if people perceive climate anomalies in absolute or probabilistic terms. In this presentation, I address how people perceive local climates and the possible patterns of local climate change that would be detectable through personal experience. Employing a spatial model of responses from a multi-country collection of public opinion surveys combined with global historical climate data, I investigate the relationship between instrumentally observed climate indicators and public perception of local climate change. Results suggest that perceptions of local climate rely more heavily on weather events within the most recent 3 months, indicating a possible recency effect in climate perception. Respondents also tended to perceive local climate change more accurately in places with low monthly to interannual temperature variability, suggesting that probabilistic assessments of current weather, rather than absolute temperature anomalies, may play a role in climate change detection.

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### **HEALTH RISK ASSESSMENT OF METAL TOXICITY FROM THE CONSUMPTION OF FISH FROM DIFFERENT WATER LAYERS: APPLICATION OF MIXTURE RISK ASSESSMENT METHOD**

Aquaculture is one of the important sources for fish consumption in Taiwan. However, due to urbanization and industrialization, metal contamination problems for fish ponds is a public concerned. This study, therefore, conducted field surveys of fish farming located in the costal area where aquacultures are densely located. Metal content in two cultured fishes, tilapia and milkfish, are examined, and cumulative metal concentrations between these two species with different water layer habitats are compared. By taking coexisting multiple metals toxicity into consideration, assessment of the human health risks on the interaction of metals is evaluated. In terms of human health risks, we used the 95th percentiles of HQadd and HQint to assess risk on humans. The 95th percentiles of HQadd and HQint (where binary interaction between metals are excluded and included, respectively) both exceed 1, indicating that consumption of both tilapia and milkfish have potential health risk. However, when interactions between metals were taken into consideration, the modified HQint was lowered for most metals in this study. This is because most metals have antagonistic effects thus decreasing their original toxicity levels. Therefore in risk assessments of human consumption of cultured fish, binary interactions between metals should be taken into account, and furthermore ensure the accuracy of the risk assessment.

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### **DOSE-RESPONSE STUDY FOR MICE EXPOSED TO SINGLE AND MULTIPLE DOSES OF FRANCISELLA TULARENSIS TYPE A STRAINS**

Interest in *Francisella tularensis* has been raised due to its high infectivity, ease of dissemination, and consequently potential use as a biological weapon. To study the effects of single and multiple exposures to *F. tularensis*, we conducted a dose-response study where mice were orally infected with *F. tularensis* type A strains at various time schedules for the multiples doses. In the phase I of the study, each animal was inoculated with single dose of strain SCHU S4, WY96-3418, or MA00-2987. Dose-response modeling and pooling analysis were performed and a LD50 of  $4 \times 10^6$  was estimated based on the pooling analysis. In the phase II of the study, for schedule 1 mice ingested the total dose in one challenge, while those in schedules 2 and 3 were each given repeated challenges on five occasions at the intervals of two hours and one day respectively. Animals under schedule 4 were inoculated twice on day 0 and day 5. The analysis showed that from schedules 1 to 4, the interval between individual exposures was increasing, as was the ID50 for both the infection and illness data. The exception was for the data under schedule 3 (one-day interval). This may demonstrate that the greater interval between challenges could lead to higher degree of immune response. However, such differences were not statistically significant, and the data for individual schedules could be pooled with the exception of the data for schedules 3 (one day between challenges) and 4 (five days between challenges). Time between inoculations and the observation periods may not be sufficiently long. Further experiments are in preparation to address the multiple exposure issue further.

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### **DYNAMIC RISK ANALYSIS IN THE LIFE CYCLE OF COMPLEX INFRASTRUCTURE SYSTEMS**

Civil infrastructures are inexorably marching towards greater complexity that makes it difficult to assess risk. Conventional approaches of risk analysis work well when a system under consideration has historical or actuarial data on failure rates and respective consequences. Complex infrastructure systems, however, have no fixed and well-defined boundary; their elements are interrelated and interdependent. The application of the current approaches appears to have constraints that need to be addressed. Increasingly, rather than focusing on individual components or physical structures, we may have to emphasize how networks of infrastructure behave together as an integrated “living organism” that grows and evolves to serve the society’s needs. Problems in this field typically involve a great deal of uncertainty, multiple economical objectives, and oftentimes conflicting political interests. To ensure sustainable development in such a complex setting, the technical aspects of civil infrastructure

engineering must be understood in the cultural, economic, and socio-political context in which they exist, and must be considered over a long-time horizon that includes not just their normal life cycles but also performance in face of extreme natural conditions and other catastrophic events. Our research contributes to this endeavor by reexamining the very nature of risk in an ever-changing system and suggested that we look beyond the current paradigm of the risk of chance and start analyzing the risk of change for such a system. Understanding the various patterns of system dynamics are the key to increasing our ability to balance the risk of change and make systems resilient. The holistic approach we set forth challenges the field of risk analysis to address issues concerning the sustainability of civil infrastructure systems before they are widely deployed and before irreversible consequences have occurred. It is an interdisciplinary undertaking and a challenge not to be taken lightly.

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### **QUANTIFYING THE INTERDEPENDENCE BETWEEN BRIDGE CAPACITY AND LOAD**

Aging public infrastructures, including the system of bridges, contribute to the degradation of essential services and quality of life of surrounding communities. The condition of bridges in the U.S. has been rated as “C” according to ASCE report and the continued shortfall of funds allocated to maintain or improve serviceable conditions are likely to accelerate the deterioration of bridge structures. Therefore, an accurate evaluation of the structural condition of a bridge system is a requisite to its effective maintenance. Numerous sources of uncertainties, both epistemic and aleatory influence our accurate assessment of the permissible load capacity of a bridge system. In this paper we use the following methods to compensate for these uncertainties: Finite Element Analysis (FEA) associated with Weigh-in-Motion (WIM) data, and the Fault Tree Analysis (FTA). We also account for the deterioration of the bridge capacity by integrating condition ratings (CR) with load ratings (LR) available from the National Bridge Inventory (NBI). FEA provides an empirical distribution of live loads based on the truck configurations from the WIM data, and the combination of CR and LR generates an empirical distribution of capacity. As the bridge’s structure experiences numerous load cycles affecting its structural capacity, there is a need to minimize the overlap between the two distributions (bridge capacity and demand load placed on the bridge system), which could lead to a failure of a bridge component, with a bridge failure and dire consequences. Evaluating the trajectories of the capacity and load distributions of a bridge system over a serviceable period enables us to revise the failure rates of basic events in FTA and to reflect on temporal factors.



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### **CHARACTERIZATION OF UNCERTAINTIES ASSOCIATED WITH SCREENING LEVEL EXPOSURE-BASED PRIORITIZATION OF TOXIC CHEMICALS USING PROTEGE**

The PROTEGE (Prioritization/Ranking of Toxic Exposures with GIS Extension) system facilitates screening level characterization of human exposures to multiple chemicals, via realistic semi-quantitative and quantitative population-based metrics, while allowing analysis at increasing levels of detail. PROTEGE is designed to provide screening procedures for tiered exposure characterization when information is not available at the level of detail required by comprehensive systems such as MENTOR (Modeling ENvironment for TOveral Risk studies), from which PROTEGE is derived. It utilizes over fifty available “information bases” (including measurements, model estimates, metadatabases, literature surveys, etc.) of environmental releases, multimedia environmental concentrations, and age- and gender-specific population distributions of major physiological and behavioral patterns. PROTEGE supports exposure characterization at two “tiers,” both providing population-oriented metrics for exposure to each chemical via the routes of inhalation, ingestion, and dermal contact. “Tier 1” analysis utilizes measures such as pervasiveness, persistence, severity, and efficacy of exposures. “Tier 2” probabilistic exposure analysis utilizes metrics such as percentages of population above specific threshold average daily intakes, as well as different percentiles of total daily intakes of chemicals for the general US population. Uncertainty characterization using PROTEGE is demonstrated through application to a test set of 55 diverse environmental prioritization (challenge) chemicals. Specific focus is on characterization of uncertainties in chemical prioritization/ranking that arise due to model/structural uncertainties (screening level versus detailed modeling), due to output metric uncertainties (choice of exposure metrics), and due to input/data uncertainties (limitations and uncertainties in available exposure-relevant data for individual chemicals).

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### **A MODELING FRAMEWORK FOR ASSESSING RISK FROM ENGINEERED NANOPARTICLES IN THE ENVIRONMENT**

Engineered nanomaterials (ENMs) are being increasingly produced in the global market and used in many aspects of everyday life, resulting in an increased potential for exposure and risk. However, currently there is a lack of mechanistic understanding of exposures and biological effects of ENMs. A prototype generalized risk analysis framework for engineered nanomaterials (ENMs) is under development

by implementing, adapting, and expanding two state-of-the-art multiscale modeling systems for the exposure-to-dose-to-effect sequence: the Modeling ENvironment for TOveral Risk studies (MENTOR) and the DOse Response Information and ANalysis system (DORIAN). This framework, MENTOR/DORIAN-ENM, is aimed at supporting analysis of major physical, chemical and biological factors and uncertainties associated with multiple stages in the life cycle of ENMs: sources, fate and transport, accumulation in microenvironments, human exposure, bioavailability and target tissue dose, toxicodynamic processes, and relevant pathophysiological endpoints. Novel modules have been developed to address various aspects within this framework: (a) material flow-based life-cycle analysis models for characterizing environmental concentrations, (b) human inhalation dosimetry models, (c) physiologically based toxicokinetic (PBTK) models for humans, and (d) toxicodynamic models focusing on reactive oxygen species (ROS). This framework is complemented by a “Knowledge Base” to support Risk studies for Engineered NanoMaterials (RENM-KB) that is being developed by assembling and organizing diverse sources of information on ENM manufacturing, usage, physicochemical and biological properties, etc. with focus on carbon nanotubes and silver nanoparticles. Demonstration case studies are presented focusing on these two classes of ENMs.

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### **A NOVEL MODELING SYSTEM FOR STUDYING THE EFFECTS OF CLIMATE CHANGE ON EXPOSURES TO AEROALLERGENS AND CO-OCCURRING GAS POLLUTANTS**

A novel modeling system is presented that is aimed to support mechanistic studies for characterizing the mechanisms governing impacts of climate change on allergic airway disease. It also facilitates simultaneous modeling of co-exposures to pollen and air pollutants such as ozone that can have synergistic adverse health effects. This system consists of (a) regional dynamic models of pollen emissions and transport, (b) dynamic models of land use/land cover changes in the future, and (c) a mechanistic population exposure and dose model for multiple co-occurring aeroallergens and air pollutants. This system utilizes outputs from global climate and regional weather simulation models for predicting future atmospheric pollen levels dynamics under different climate change scenarios. Case studies are presented for multiple types of pollen, including birch (representing tree pollen common during Spring) and ragweed pollen (representing weed pollen common during late Summer and Fall). The pollen emissions model is parameterized based on Bayesian analysis of historical pollen data from multiple locations, while the land cover module is parameterized based on statistical analysis of historical land use/land cover data. Model simulations are performed for two past years (2002 and 2007) using high resolution meteorologi-



cal fields developed from meteorological observations and meteorological modeling. Subsequently, the model is applied for two future years (2040 and 2065) assuming a representative climate change scenario from the Intergovernmental Panel on Climate Change (IPCC). These pollen simulations for multiple years are used to characterize inter-annual variability in pollen emissions and ambient concentrations. These simulations also highlight the feasibility of this environmental and exposure modeling system in studying co-exposures to multiple contaminants such as gas pollutants and pollen.

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#### **MODELING OF LANDSCAPE AND METEOROLOGICAL FACTORS INFLUENCING THE PROBABILITY OF PATHOGEN ISOLATION FROM AN ENVIRONMENTAL LOCATION: LISTERIA SPP. IN THE NATURAL ENVIRONMENT AS A MODEL SYSTEM**

*Listeria monocytogenes*, *Escherichia coli* O157:H7, and *Salmonella* spp. are among the most important pathogens of relevance to produce food safety. These and many other pathogens have the ability to survive and multiply in abiotic environments, including on produce farms, representing a possible reservoir and source of human exposure. Our objective was to develop a methodological framework to study spatially explicit environmental and meteorological factors affecting the probability of pathogen isolation from a location. Isolation of *Listeria* spp. from the natural environment was used as a model system. Logistic regression and classification tree methods were applied and their predictive performances were compared. Analyses revealed that precipitation and occurrence of alternating freezing and thawing temperatures prior to sample collection, loam soil, water storage to a soil depth of 50 cm, slope gradient and cardinal direction to the North are key predictors for *Listeria* isolation from a spatial location. Different combinations of factors affected the probability of *Listeria* isolation from the soil, vegetation and water layers of a location, indicating that the three layers represent different ecological niches for *Listeria*. The predictive power of classification trees was comparable to that of logistic regression. However, the former were easier to interpret, making them more appealing for field applications. Our study demonstrates how the analysis of a pathogen's spatial distribution improves understanding of the predictors of the pathogen's presence in a particular location and could be used to propose novel control strategies to reduce human environmental exposure. Implication of these findings to produce food safety will be discussed using an ongoing study of spinach contamination with *L. monocytogenes*, *E. coli* O157:H7, *Salmonella* spp, and indicator microorganisms (*Listeria* spp., generic *E. coli*, and coliforms).

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#### **ADAPTIVE ADVERSARY RISK ANALYSIS: LINKING MODELS TO PRIMARY DATA ON TERRORIST BEHAVIOR**

Addressing adversary adaptation in risk analysis requires understanding the ways they can respond to new defensive or other changes. They have a variety of options, each with distinct direct and indirect risk effects. We demonstrate how adversary preferences among those options can be assessed through illustrative analyses of open source descriptions of past group behavior, content analysis of jihadist internet communications, and declassified seized al-Qa'ida documents.

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#### **GOVERNMENT'S PERSUASION STRATEGIES AND ACCEPTANCE/REACTANCE EFFECT IN RISK CONFLICTS**

In risk communication studies, government is generally one of key actors to persuade the public. In the persuasion process, it mobilizes the diverse persuasive strategies such as highlighting the higher benefit/low cost, trust worship and positive image about risk objects. However, there are few studies the effects of government's persuasion strategies. Such fewer studies come from lack of appropriate theory and method about government's persuasion strategies under risk communication literature. Our studies will explore what kinds of and how much persuasion strategies take effects on changing the public by using survey experiment method. Survey experiments construct natural situation by using survey questionnaire in which respondents' original attitude toward specific topics is checked and then rechecked the attitude change after giving intended stimuli to respondent. Even if survey experiment can't control all of exogenous factors, it has take advantage of well explaining the realistic situations with strong validity. We will apply the survey experiment to the case of Mad Cow Disease which made serious social conflicts in Korea, 2008. In this case, although government tries to persuade the public that there are no risks related with Mad Cow, it faces the strong resistance from the public. In the survey experiment, we will first check, in survey questionnaire, the respondents' original position toward Mad Cow and then recheck their attitude change (acceptance or reactance) after giving them stimuli, all of which the government used as persuasion strategies. Those persuasive stimuli include mitigating or reacting the perceived risk, increasing the benefit, building up the trust, providing the knowledge and attenuating the negative stigma, all of which are related with MCD. By comparing the original attitudes with those which are measured after giving those stimuli, we will know the degree of the effectiveness which each persuasion strategy has.

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### **EVOLUTION OF TRUST IN RISK COMMUNICATION: THE DEVELOPMENT OF THE GIANT MINE REMEDIATION PLAN AND THE YELLOWKNIVES DENE FIRST NATION**

Giant Mine is a former gold mining operation located five km north of Yellowknife in the Northwest Territories in Canada. The mine produced more than 7 million ounces of gold over 50 plus years of operation. However, during the roasting of the ore to release the gold, toxic arsenic trioxide dust was produced. When activity at the mine ceased, the Government of Canada entered into a Cooperation Agreement with the Government of the Northwest Territories to remediate the site. The Remediation Plan, developed using a team of external experts, called for the long-term storage and maintenance of the 237,000 tonnes of arsenic trioxide dust using the “frozen block method”, whereby designated areas around and within each of the underground chambers and stopes will be frozen and kept frozen over the long term using thermosyphons. The plan was submitted to the Mackenzie Valley Land and Water Board as part of a water licence application in October, 2007. The Yellowknives Dene First Nation (YKDFN) opposed the immediate approval of the licence on the basis that “the technology which is being proposed is relatively new, is untried and must be examined in depth...” Through entering into an unprecedented partnership with the City of Yellowknife and a local environmental advocate, the YKDFN were successful in forcing the proposed remediation plan to undergo a full environmental assessment. This ongoing case study looks at how various factors have intersected to produce community distrust of (and lack of cooperation with) the risk remediation process: (1) a historical legacy of mistrust between the community and responsible agency; (2) limited community control over the risk decision; (3) a consultation process that involved complex and overwhelming information; and (4) a perceived bypassing of the regulatory process. The challenges created by the complexity of this issue in the development and application of the common evaluative trust framework will be discussed.

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### **BLOOD MERCURY CONCENTRATION AND FISH CONSUMPTION: RISK AND PERCEPTIONS OF RISK AMONG URBAN AND COASTAL MOTHER IN TAIWAN**

This study was designed to examine mercury concentrations in maternal blood, cord blood, and placental tissue of urban and coastal mothers in Taiwan, in relation to their perception of risk associated with fish consumption. Base on calculated a hazard quotient (HQ) to evaluate the impact of the consumption of fish commonly eaten by pregnant women and assess their exposure to mercury. We also assess which

media are more effective for providing useful risk information to the public in Taiwan. The average mercury concentration in maternal blood, cord blood, and placental tissue was  $9.02 \pm 3.22 \mu\text{g/l}$ ;  $12.18 \pm 5.92 \mu\text{g/l}$ ;  $19.88 \pm 11.07 \text{ ng/g}$  for the metropolitan mothers and  $3.46 \pm 2.62 \mu\text{g/l}$ ;  $8.62 \pm 4.90 \mu\text{g/l}$ ;  $10.07 \pm 7.97 \text{ ng/g}$  for the mothers living on the coast. The differences between the two groups were significant ( $p < 0.05$ ). Cord blood mercury concentrations exceeded the USNRC recommended limit of 5.8 mg/l in 94.8% and 66.7% of cases of the urban and coastal mothers, respectively. Maternal blood mercury concentration among women who consumed fresh fish more than three meals per week was two times higher than that of the group who never consumed fish ( $p < 0.05$ ). Altogether, 55% of the HQ estimates exceeded 1.0 and the 5.8 mg/l recommended limit. We found more than 67.2% and 76.2% of mothers in the two groups did not know that “some fish contain high levels of mercury such as shark, swordfish, king mackerel, and tilefish that may be harmful for unborn babies.” Of the urban mothers, 57.4 and 85.7% choice “TV News” and “newsletters,” respectively, as their gathered media for receiving messages about risk. Of women living on the coast, 27.9 gathered information about risk through “TV News” and 38.1% through “newsletters,” respectively. The high blood mercury concentrations among pregnant women in Taiwan are a cause for concern, due to the know effect on babies’ brain development. These findings provide some evidence and contribute to improving the effectiveness of government communication about public health issues.

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### **ASSESSMENT OF INTER-INDIVIDUAL, GEOGRAPHIC, AND SEASONAL VARIABILITY IN ESTIMATED HUMAN EXPOSURE TO PM2.5**

Exposure to PM2.5 may cause a variety of serious health problems, especially for older adults over 65 years old. Time-series PM2.5 epidemiological studies that focus on the relationships between short-term or long-term PM exposures and health-related outcomes often use ambient PM2.5 concentration as a surrogate for the personal exposure to ambient PM2.5. However, this may cause negative bias in the estimated health risk coefficients. Since individual PM2.5 exposure varies considerably, there is a need to quantify and characterize inter-individual exposure variability by region and season, and to aid the interpretation of available epidemiological studies. The paper is based on case studies of scenario-based PM2.5 exposure modeling for people over 65 years old in six counties of North Carolina along I-40, Harris County in Texas, and New York City. The Stochastic Human Exposure and Dose Simulation for Particulate Matter (SHEDS-PM) model developed by the US Environmental Protection Agency is used here to estimate distributions of outdoor and indoor PM2.5 exposures for a specified population based on ambient concentrations and indoor emission sources. Inter-individual variability in the daily average ratio of ambient exposure to ambient

concentration (Ea/C) among climate zones and seasons were compared and assessed. Substantial inter-individual variability in Ea/C was estimated for all areas and seasons. The results indicate that the average exposure to ambient PM2.5 is substantially less than the ambient concentration. This implies that concentration-response functions developed in epidemiological studies are biased when compared to exposure concentrations. Regional or seasonal differences in the average Ea/C ratio may confound or help explain variations in concentration-response functions among cities. Exposure, and not just concentration, should be considered in developing risk management strategies.

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### **COMPARING AND PRIORITIZING PATHOGEN RISKS**

The aims of this research were to: (1) compile the most current and accurate data on the occurrence, dose-response, and decay parameters for as many pathogens as possible; (2) prioritize and classify pathogens as high, medium, or low risk infection based on a novel metric that integrates information on these parameters; and (3) determine which parameter contributed the most uncertainty. Special attention was given to biosolids as an exposure medium. Results imply that special attention should be focused on Giardia, Adenovirus, Ascaris, Hepatitis A, and Rotavirus as they may present a high risks based on their dose-reponse and environmental persistence. An uncertainty analysis showed that dose-response and decay parameters contributed the most uncertainty. Although occurrence was shown to not contribute as considerably as dose-response and decay, in specific cases, additional data may still be a priority. This is particularly true for adenovirus which had high estimates of occurrence based on an extremely limited sample size (N=5).

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### **VALUE FOCUSED MODELING OF ADAPTIVE ADVERSARIES FOR INFORMING COUNTERMEASURE DECISIONS**

The US has implemented numerous anti-terror countermeasures in response to perceived threats over the past decade, and efforts are underway to develop others. Unlike natural or accidental man-made disasters, terrorists are adaptive, and may shift their attack strategy when a new countermeasure is employed. This adaptive nature of adversaries creates unique challenges for a defender who must select among competing portfolios of countermeasures under resource constraints. Current methods for terrorism risk assessment focus on target vulnerability, terrorist capability and resources, and attack consequence, ignoring the importance of terrorist group values and beliefs in selecting a particular attack strategy. Understanding the objectives and motivations that drive adversary behavior is critical to the task of assessing the

effectiveness of countermeasures designed to deter or mitigate an attack from an adaptive adversary. Modeling adversary values and beliefs has the potential to inform probabilistic estimates of adaptive attack behavior, and aid in the design and selection of anti-terror countermeasures. Using a value-focused decision framework, we assess values and beliefs from an adversary value expert (AVE) for specified terrorist leaders. Adversary motivations and values are represented formally in an objectives hierarchy specific to the context of attacking a transportation system. We then use a random utility modeling approach to compare the risk profiles of alternative transportation attack strategies and estimate the relative likelihood of an adversary (terrorist leader) selecting a particular attack strategy, conditional on various countermeasures selected by the (US) defender. Since we cannot collect information directly from terrorists, individuals who have studied contemporary terrorism as well as Islamic terrorist groups (such as Al Qaeda) served as AVEs for particular adversary group leaders. Results from this demonstration analysis are presented, and potential insights from the proposed analysis are highlighted.

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### **CHALLENGES OF MANAGING SMALL SUBURBAN NATURAL AREAS: PUBLIC BELIEFS, ATTITUDES AND BEHAVIORS REGARDING ECOLOGICAL EFFECTS**

Urban and suburban ecosystems can be important for local biodiversity, ecosystem services, psychological health and support for conservation (e.g., via communion with nature), and even public (human) health. Yet the understandable focus of ecologists and conservationists on larger, more “pristine” ecosystems has left us with little knowledge about suburbanites’ relationships with small local “natural areas.” Surveys were conducted of near neighbors of five small forested wetlands in central New Jersey. Results indicate a generally positive stance toward conservation of such areas, but complex and inconsistent patterns of preferred management approaches to them, with limits on over-browsing deer populations standing out as evoking resistance from many of the people who otherwise espouse biospheric values and support “conservation.” Beliefs (e.g., about site biodiversity; human impacts on it) and attitudes (e.g., importance of natural uses of the site) towards these sites tended to most influence management preferences, although general environmental values and beliefs (e.g., biospheric values; whether extinctions are occurring and a problem), personal actions (e.g., experience of environmental activism and conservation), and demographics (e.g., gender, age) also played a role. Survey results imply that finding management strategies for these small suburban natural areas that are simultaneously consistent, ecologically sound, and publicly supported will not be easy.

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### **TRUST AND RESPONSIBILITY ATTRIBUTIONS: VARIATIONS ACROSS HAZARD MANAGERS IN ACCIDENTAL AND INTENTIONAL FOOD CONTAMINATION INCIDENTS**

Sources of trust in hazard managers have been studied in detail over many years, but reasons for attributing responsibility for hazard system performance have not. This study examines the role of factors in the salient value similarity (SVS) and intuitive detection theorists (IDT) models of trust, as well as awareness of problems and freedom to act to deal with those problems (AWFR), in predicting both trust and attributions of responsibility. The context used is a hypothetical contamination of food by Salmonella bacteria, either accidental or intentional, and these judgments are assessed for food producers, processors, “watchdogs” (government), sellers, preparers, and consumers. Results show that trust is primarily positively predicted by an index combining SVS and IDT items, with AWFR playing a trivial role of varying sign. However, initial attributions of responsibility are positively predicted by AWFR, with SVS/IDT as a secondary and largely negative predictor. These relative roles persist in logistic regressions of final attributions of responsibility, which control for the initial attributions. Modest differences occur across hazard managers and contamination cause in both trust and responsibility attributions, but these do not affect the relative influence of SVS, IDT and AWFR variables.

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### **BP'S USE OF TWITTER AS A CRISIS COMMUNICATION TOOL DURING THE GULF OF MEXICO OIL SPILL RESPONSE PHASE**

On April 20, 2010, British Petroleum's Deepwater Horizon drilling rig in the Gulf of Mexico exploded, creating the largest oil spill in U.S. history. BP launched a major public relations response targeting BP's online audiences through strategic use of its corporate website, Twitter feed, Facebook page, YouTube channel and Flickr photostream. This content analysis examines BP's use of Twitter during the crisis response phase of the oil spill. All 1,161 of BP's tweets from the 14-week period, from the time of the explosion to the capping of the well, were analyzed. The tweets reflected reputation repair strategies, responsibility attributions, and public risk perceptions during different emergency management phases. Reputation repair strategies were reflected in 29 percent of the tweets, with the strategies of “compensation” and “reminder” appearing most often. About 97 percent of the tweets indicated an accident crisis, and 90 percent reflected a high level of crisis responsibility. Public risk perceptions were implied in 72 percent of the tweets. The most common perception was that the oil spill response had strong political attributes tied to it.

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### **POLYCYCLIC AROMATIC HYDROCARBONS ANALYSIS USING CHEMICAL MASS BALANCE MODEL**

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous organic chemicals that persist in the environment. PAHs are formed through an incomplete combustion of most organic material and also occur naturally at low levels in crude oil and coal. Elevated concentrations of PAHs were found in residential areas near an inactive chemical facility. The Chemical Mass Balance model (CMB-8.2) developed by EPA is used to identify the source(s) of anthropogenic PAH contamination in the residential areas. CMB is a fundamental receptor model based on the use of the mass balance concept. Twelve parent PAHs are used in CMB to generate PAH source profiles because they are frequently detected in soil samples and are included in many source profiles available in the literature. CMB consists of a least squares solution to a set of linear equations which expresses each receptor concentration of a chemical species as a linear sum of products of source profile species and source contributions. The model assumes that: (1) the composition of each source emission is consistent over the period represented by receptor data, (2) chemical species do not react with each other or with the environment, (3) all sources that contribute significantly to the receptor have been identified and their chemical profile is known, (4) the composition of each source is linearly independent of other sources, and (5) measurement uncertainties are random, uncorrelated, and normally distributed. CMB attempts to derive source profiles from the covariation in space and/or time of many different samples of atmospheric constituents that originate in different sources. These profiles are then used in CMB to quantify source contributions to each ambient sample. As a result, CMB is used to determine whether historical processes at the chemical facility that may relate to the deposition of contaminants in the residential areas.

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### **VARIETIES OF EMOTIONAL JUDGEMENT AND ITS DETERMINANTS IN CASE OF THE NUCLEAR POWER**

In our study, we analyze the structure and determinants of emotional judgment about nuclear power. A lot of previous studies have found that emotion is one of important factors in judging the nuclear power acceptance. There are great divides between rational thinking and irrational thinking in judging risk objects; the former stresses perceived benefit/risk's role in judgment and the latter focuses on the feeling and stigma reflecting image of risk. We will specify the emotional thinking in case of judging the nuclear power. At first, to test the causal factor to bring out emotional thinking, we will analyze how the emotional judgment occurs according to demographic variables. We prove the previous study's main results that the younger, more



educated, being female rather than the older, more educated and being male do. Additionally we explore the relations between dependent emotional judgment and independent social-constructed variables such as trust, benefit/risk and knowledge. Second, there are varieties of emotional response, we will analyze how the different kinds of emotion, for examples gloomy/good, weak/strong, dirty/clear, retrogressive/progressive, are determined by different causal factors. In short, we expected that this study would contribute to elaborating the structure and content of emotion in judging the nuclear power.

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### **RAPID RISK EVALUATIONS: APPLICATIONS, CHALLENGES AND LIMITATIONS**

Various government agencies develop risk assessments to characterize the nature and magnitude of health risks to humans from chemical contaminants and other stressors that may be present in the environment. The development of complete quantitative risk assessments can require extensive resources and time. Rapid Risk Evaluation (RRE) is an important tool used by risk assessors under certain circumstances to provide a qualitative and/or quantitative risk assessment within a very short time (usually minutes to a few weeks). The current presentation will explore the tools that are under development at the EPA's National Center for Environmental Assessment (NCEA) which may be useful in implementing a successful RRE. These include use of graphical tools to array the available dose-response data and/or health effect reference values available for the agent being considered, or those that are closely related in structure or function. Principles for developing toxicity values using structural-surrogates for chemicals that lack adequate human or animal studies will be presented. Some semi-quantitative methods are being developed and will be described. The challenges and limitations to the use of these tools in RRE will be discussed in detail. The views expressed in this abstract do not necessarily reflect the views or policies of the US EPA.

M3-I.2 Kaul S, Boyle K, Pope J, Parmeter C, Kuminoff N, Moeltner K\*;  
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### **ROBUST META-ANALYSIS USING MEDIAN-QUANTILE AND NON-PARAMETRIC REGRESSION PROCEDURES: INVESTIGATING THE VALIDITY OF BENEFIT TRANSFERS**

In 2005 the U.S. EPA sponsored a forum to inform the practice of benefits transfer. Interest in this topic was demonstrated by presenters from Australia, Canada, France, Spain, Singapore, United Kingdom and United States. U.S. interest in benefit transfer is motivated by Presidential Executive Order 12866 (1993) that requires federal agencies to assess "costs and benefits" of regulations based "on best reasonably

obtainable scientific, technical, economic, and other information." Previous research on validity of benefit transfers suggest that function transfers are more accurate than value transfers and similarity between study and policy cases favors transfer applications. Despite these suggested points, Johnston and Rosenberger (2009) claim that "complexity and relative disorganization of the (academic) literature may represent an obstacle to the use of updated methods by practitioners." In this paper we conduct a robust meta-analysis of existing convergent-validity studies to identify benefit-transfer practices that effect validity of transfer applications. We investigate the robustness of baseline models (ordinary least squares and weighted least squares) by employing quantile and nonparametric regression techniques. Data from 31 convergent validity studies was used to estimate a reduced form meta-analysis equation. Our baseline models were sensitive to the influence of outliers and there was little consensus between baseline and nonparametric results. However, the analyses present some clear results (function transfers are more accurate than single value transfers) and identifies areas of research to improve transfers (defining study similarity between study cases and policy cases). While these robustness analyses are done in the context of benefit transfers, the application of these methods is generalizable to any reuse of existing data for risk analyses and valuation of alternative outcomes.

W1-B.2 Kause J, Dearfield K, Ebel ED, Golden NJ, LaBarre D, Disney T; janell.kause@fsis.usda.gov  
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### **USE OF RISK ASSESSMENT WITH RISK MANAGEMENT METRICS TO LINK PUBLIC HEALTH ESTIMATES TO FOOD SAFETY PERFORMANCE**

In 2008, the Codex Alimentarius approved the use of newer risk management metrics that would help link public health estimates to food safety performance. The traditional metrics used before this time, i.e., microbiological criteria (MC), process criteria (PcC), and product criteria (PdC), provided both a means of articulating the level of stringency expected of a food safety control system and verifying that this level of control is being achieved. However, these traditional risk management tools have generally not been linked directly to a specific level of public health protection. New food safety risk management metrics, i.e., the food safety objective (FSO), performance objective (PO), and performance criteria (PC), are intended to provide a bridge between traditional food safety metrics (MC, PcC, PdC) and the expected level of public health protection. These new metrics provide a potential means of articulating the level of stringency required of a food safety system at different points in the farm-to-table continuum and provide a more direct link to the appropriate level of protection (ALOP) concept presented the World Trade Organization Sanitary and Phytosanitary (SPS) Agreement. USDA's Food Safety and Inspection Service is exploring approaches to utilize microbial risk assessments to elucidate the use of these

metrics to provide risk management with options to attain a specific level of public health protection in meat and poultry products.

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### **USING THE PORTFOLIO DECISION QUALITY FRAMEWORK TO GUIDE RISK ASSESSMENT**

Value-of-information methods can be applied to the information derived from various assessments. By mapping a portfolio of risks to a portfolio of decisions, we can use this decision analytic tool to simulate the impact of different assessment strategies and reveal the degree to which they increase expected value. Likewise, it is possible to anticipate the cost of an assessment strategy by tabulating the frequency and difficulty of each type of assessment required. Good assessment strategies add a lot of value relative to their cost.

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### **THE INFLUENCE OF RISK COMMUNICATION FORMATS ON BENEFIT PERCEPTION OF MEDICAL TREATMENTS**

In medical risk communication, the benefit of a treatment is often conveyed as relative risk reduction. A particular medical drug is described as reducing the risk of dying from a particular disease by 42%. As the risk of dying without taking the drug is missing, it is unclear how big the risk reduction is. To improve the understanding, it was recommended to provide information about the risk of dying without the treatment (starting risk) and the risk of dying with the treatment (modified risk). However, there is little empirical evidence available concerning the effect of providing information about risk reduction in combination with starting and modified risk. Utilizing a random sample from the general population (N=748), we examined the effect of six risk reduction information formats about a drug on individuals' benefit perception. The results of a study with two groups were described, one of which received the drug and one a placebo. The risk of dying of a heart attack within 5 years was reported for the placebo group and the treatment group. The information formats consisted of six different combinations of information about relative and absolute risk reduction, all of which included starting and modified risk. A 6 (format of risk information: 6 combinations) x 2 (subjective numeracy: high/low) experimental design was used. A significant effect of format of risk reduction was found. Post hoc testing revealed that participants in conditions receiving information about the relative risk reduction perceived significantly higher benefit than participants in conditions receiving information about the absolute risk reduction. This was true independently of the numerical format of the information about the starting and modified risk (ratio, percentage, and frequency). No effect of numeracy was found. Although participants were provided with the information about absolute risk, participant's benefit

perception was influenced by the relative risk information but not by the absolute risk information such as they associated the larger number with higher benefit.

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### **INTEGRATED MODELING FOR RISK AND DECISION ANALYSIS OF SHORELINE-DEPENDENT SPECIES THREATENED BY SEA-LEVEL RISE**

Climate change (via sea-level rise and altered weather patterns) is expected to significantly alter low-lying coastal and intertidal areas, which provide significant seasonal habitats for a variety of shoreline-dependent organisms. Many coastal military installations in Florida have significant coastal habitats and shoreline-dependent bird data that strongly illustrate their seasonal importance for birds. This research effort has utilized the Sea Level Affecting Marshes Model (SLAMM), the MaxEnt species distribution model and the RAMAS-GIS metapopulation model to explore the current and future habitat/spatial distribution/population states as well as the spatial and temporal patterns of these uncertain results with Global Sensitivity and Uncertainty Analysis. Joint simulations of sea level rise at 0.2, 0.5, 1.0, 1.5 and 2.0 meters were conducted at 30m horizontal grid resolution for the Eglin Air Force Base/Santa Rosa Island areas and for the entire Florida Gulf Coast (Pensacola to Naples) at 120m grid resolution. While uncertainty levels are high, consistent simulation results from this integrated model show key results in two areas (1) potential habitat losses and (2) Snowy Plover population dynamics. The integrated models projected that the population size will decline faster than the area of habitat or carrying capacity, demonstrating the necessity of incorporating population dynamics in assessing the impacts of SLR on coastal species. The results were most sensitive to uncertainties in survival rate and fecundity, and suggested that future studies on this species should focus on the average and variability of these demographic rates and their dependence on population density. Results from these simulations were integrated into a multi-criteria decision analysis framework to assess tradeoffs in habitat restoration/protection and species-focused alternatives.

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### **EFFECTS OF ATRAZINE DOSE DISTRIBUTION ON PHARMACOKINETICS AND PHARMACODYNAMICS IN THE RAT**

There is limited quantitative information on the pharmacokinetics of ATZ metabolism, and no research on the effects of the route of administration on its pharmacokinetics and pharmacodynamics. The purpose of this work was to compare 1) the kinetics of hepatocyte metabolism of ATZ in two species (female Sprague-

Dawley rat and human), 2) the metabolism kinetics of ATZ given as a bolus gavage vs. distributed dietary dose, and 3) the effect of gavage (bolus) vs. dietary (distributed) dose administration on the suppression of the luteinizing hormone (LH) surge in rats administered high doses of ATZ via gavage. Studies performed in rat or human hepatocytes and in intact Sprague-Dawley female rats showed rapid kinetics of ATZ oxidative metabolism. Rat hepatocytes mainly converted ATZ to its desisopropyl metabolite (DIA) whereas the human hepatocytes preferentially converted ATZ to its desethyl metabolite (DEA). Both rat and human hepatocytes further metabolized DIA and DEA to the diaminochloro metabolite (DACT). Comparison of chlorotriazine plasma concentrations after bolus vs. distributed dosing (equivalent doses) showed that peak concentrations of all analytes from the bolus dosing were 10-fold greater than the peak concentrations from distributed administration of ATZ. Distributed dietary administration of ATZ for four days did not suppress the LH surge at 500 ppm (43 mg/kg/day) whereas a single bolus gavage dose of 50 mg/kg/day for four days suppressed the LH surge (consistent with published data). The results indicate that the pharmacodynamics of ATZ is dependent upon the pharmacokinetics and the method of dose administration. These data were utilized to refine an existing ATZ PBPK model to estimate internal doses in rat, non-human primates, and humans.

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## **MODELING THE SAFETY AND EFFICACY OF VACCINES THROUGH THE LIFE CYCLE**

The U.S. Food and Drug Administration (FDA) uses a multi-layered system of regulations involving both pre-market clinical trials and multiple post-market safety surveillance systems to ensure that the benefits of the influenza vaccine clearly exceed the risks. There has been much research into the performance of individual components of the FDA system for evaluating safety and efficacy; however, we are not aware of any research that examines how effectively the overall system performs. Our project takes a systems approach to improve our understanding of the FDA evaluation system. We are developing a computer simulation of the FDA lifecycle evaluation system for influenza vaccines that will serve as a framework for rapid exploration of the functional relationship between regulatory decisions and the risk / benefit balance in terms of overall public health impact. To help model various risks and benefits, we have designed a computer simulation model based on a set of stochastic differential equations similar to the standard Susceptible Exposed Infective Recovered disease model and which will simulate the disease dynamics taking place in the overall population. The model simulates the spread of influenza epidemics given a certain set of pre-defined characteristics associated with both the vaccine and virus. High performance computing is utilized both to simulate many hypotheti-

cal flu seasons as well as to implement Bayesian Markov Chain Monte Carlo inference procedures. Our model utilizes stochastic state space methodology whereby the number of people in each disease state is governed by the system model and a second measurement model relates the noisy measurements to the state of the system. For parameter estimation, our model makes use of a Bayesian approach to dynamic state estimation for partially observed Markov processes whereby we construct a posterior probability for the state given the observed. Simulation results and methods will be discussed for several case scenarios.

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## **INTERPRETING NHANES DATA ON ARSENIC LEVELS IN URINE USING BIOMONITORING EQUIVALENTS**

The National Health and Nutrition Examination Survey (NHANES) reported data on concentrations of speciated and total arsenic in urine for a sample of the general population. Adverse effects associated with arsenic exposures are thought to be from exposure to inorganic species, which are excreted in urine in a variety of forms: inorganic arsenic (iAs), monomethyl arsenic (MMA), and dimethyl arsenic (DMA). A Biomonitoring Equivalent (BE) has been derived for inorganic-derived arsenic species in urine, which provides an estimate of the concentration of iAs, MMA, DMA and their sums in urine that are consistent with reference values, such as the US EPA reference dose (BERfD). The BE can be used to interpret the arsenic biomonitoring data in the context of the RfD. The sum of all inorganic derived arsenic species (iAs, MMA and DMA) from the NHANES 2007-8 collection period exceed the BERfD at around the 50th percentile, although the proportion exceeding the BERfD was affected by the treatment of non-detects. A significant proportion of the summed urine concentrations is due to DMA, which is assumed to result predominantly from exposure to inorganic arsenic exposure. However, the NHANES biomonitoring data indicate a correlation between DMA and seafood-derived organic arsenic species (arsenocholine and arsenobetaine), suggesting that DMA in urine may also arise from seafood consumption. When DMA is omitted from summed inorganic arsenic species (sum of iAs and MMA), 90% of the NHANES biomonitoring data are below the BERfD. The BE associated with the 1E-4 cancer risk is a factor of ten lower than the BERfD and is below the limit of detection for the NHANES analyses. This presentation will explore the various advantages and disadvantages of analyzing the various arsenic species in urine in a risk assessment context and make recommendations for future efforts. The opinions are those of the authors and do not necessarily reflect policies of U.S. EPA.



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### **DEVELOPMENT AND USE OF TOXICITY BASED HUMAN BIOMONITORING (HBM) VALUES BY THE GERMAN HUMAN BIOMONITORING COMMISSION**

Human biomonitoring (HBM) data is a very useful metric for assessing human's exposures to chemicals in commerce. To assess the potential health risks associated with the presence of chemicals in blood, urine or other biological matrix requires HBM assessment values. While HBM assessment values based on human exposure-response data remain the most highly valuable and interpretable assessment values, enough data exists for such values for very few chemicals. As a consequence, efforts have been undertaken to derive HBM assessment values in which external dose based guidance values such as Tolerable Daily Intakes have been translated into equivalent biomonitoring levels. The development of HBM values by the German HBM Commission and Biomonitoring Equivalents by Summit Toxicology has resulted in conceptually similar assessment values. The review of the development of these values provided here demonstrates examples and approaches that can be used to broaden the range of chemicals for which such assessment values can be derived. Efforts to date have resulted in the publication of HBM assessment values for more than 80 chemicals, and now provide tools that can be used for the evaluation of HBM data across chemicals and populations.

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### **EXAMINING THE POTENTIAL FUTURES OF PLANT TARGETED GENETIC MODIFICATION**

From anticipatory governance to the study of plausibility, how experts involved with emerging technologies conceive of possible futures for these technologies is of growing importance. Practically with regards to risk analysis, identifying plausible risks is essential to the problem formulation step of risk assessment, as only identified risk hypotheses can be further examined. More broadly, how experts discern among potential futures influences what meanings of and concerns around these technologies will be privileged and marginalized. Recent work has emphasized the importance of examining the conflicting futures offered for these technologies by interrogating the differing logics and understandings that underpin these futures (e.g., Selin 2008). We contribute to this growing area of work through a study of experts involved with the targeted genetic modification (TagMo) of plants. Targeted genetic modification is a novel genetic engineering technique that employs homologous recombination and has the potential, in plants, to allow for the genetic engineering of new traits and new organisms. In this paper, we present the findings from 30 in-depth interviews with a variety of plant TagMo experts, from those developing the technology to those

thinking about its potential societal impacts. Through these interviews, we asked: what potential futures and concerns do experts articulate concerning TagMo plant products? What differences underlie conflicting futures? We pay particular attention to how interviewees reinforce and challenge risk analysis frameworks as a means to study the potential harms from TagMo plant products. Our findings point to needed areas for reflection as TagMo plant products become addressed through ecological risk assessment and governance processes. Additionally, we provide insights on the challenges that a diversity of expert views poses for risk analysis.

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### **A STUDY ON ALTERNATIVE RISK ASSESSMENT SCHEME OF FRAME RETARDANTS**

When a chemical is identified to impact on human health or poses ecological risk, it might be banned and replaced depending on availability of substitutes. With such a replacement policy, risk from the replaced chemical is naturally reduced, but risk from its substitute increases. This is called risk-trade-off between replaced chemical and its substitute. It is important to prove that the substitute chemical poses less risk than the one it replaced. In which case, how can we compare the risk of replaced chemical and its substitute? In this study, we focused on a frame retardant, Hexabromocyclododecane (HBCD) and assumed its substitutes as a case study of alternative risk assessment for chemicals in consumer products. This research has two objects; first, to predict exposure volume using mathematical models on alternative scenario. And second, to investigate variation in outcome when different risk assessment methods are used. To achieve the first objective, exposure assessment on alternative scenario was undertaken within a framework of uniform incombustibility between HBCD and its substitutes. If emission rate from products of replaced chemical is known, it is possible to estimate that of the substitute. Exposure volume of the substitute could also be estimated based on information of performance of frame retardant and physico-chemical property. To achieve the second objective, we compared the results of deterministic risk assessment and probabilistic risk assessment. The method of deterministic risk assessment provided information regarding whether risk exists or not on average or worst scenario. On the other hand method of probabilistic risk assessment quantified in detail if probability of exposure volume exceed reference-dose (RfD). The findings suggested that each approach might lead to a different conclusion.



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### **CHEMICAL HAZARDS EMERGENCY MEDICAL MANAGEMENT (CHEMM): MENTAL MODELS APPROACH TO IMPROVING PROVISION OF EMERGENCY PREPAREDNESS AND RESPONSE INFORMATION**

Presenting relevant and actionable information to stakeholders and decision makers is especially challenging in emergency situations. Understanding stakeholder needs and concerns is very important in designing automated communication and data management platforms. The National Library of Medicine (NLM) and its partners are developing the Chemical Hazards Emergency Medical Management (CHEMM) online tool, designed to provide access to comprehensive sets of information needed in preparation for, and in response to a mass casualty chemical hazards emergency. The goal of the Tool is to optimize effective decision making enabled through an effective Tool design and user interface. To achieve this goal, NLM is using an expert models/mental models research approach to gain insight into how potential users think through and make decisions in such an event. Decision Partners has conducted 40 mental models interviews in three cohorts: first responders, first receivers, and other potential Tool users including trainers, planners and researchers. Interviews focused on users' perceptions of the characteristics of mass casualty chemical hazards emergencies where such a Tool might be used (e.g., industrial and transportation accidents and terrorist incidents), users' informational needs at various stages of an emergency (e.g., personal protection, site control and logistics, and triage, assessment and handling of casualties), and the corresponding functional and usability requirements for the CHEMM Tool (e.g., actionable, decision making focus and usable design that allows for quick access to needed information). These interviews build upon expert models developed in earlier research through informal interviews and a workshop with a small number of experts and potential CHEMM Tool users. Interview results were coded and analyzed against the expert model and are being used to further Tool informational and functional design and establish Tool development priorities.

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### **FOOD SUPPLY CHAIN SAFETY AND SECURITY RISK MANAGEMENT: AN INNOVATIVE INFORMATION INTEGRATION APPROACH**

Facilitating and capturing decision-critical risk information that is customized to the needs of several levels of decision-makers throughout and across multiple organizations and sources of risk alert information systems is critical to a successful implementation of "mission"-critical food safety risk management (RM) and

risk-informed decision management (RIDM). There are major challenges in making time-critical and cost-conscious decisions related to mitigation options for reducing specific food safety risks-both systems-wide or within specific organizations. A key challenge is timely incorporation and integration of information related to identified food safety risks from a complex array of sources. These sources may include complicated scenarios like statistical, event-based failure modes models of a food transport or supply chain systemic risks, or deterministic scenarios that account for microbial hazards and projections of outbreak adverse events in play, or it may include more anecdotal and qualitative risk data that relies on public knowledge-sharing and associated projected safety risks. This challenge may be addressed by using a combination of customized and facilitated risk management process deployment with a novel, risk communication, documentation, and information management platform - based on the Integrated Risk Management Application™ methodology. Once this structured approach is in place the criteria to streamline information, prioritize risks and make rapid mitigation decisions is established, and then resources may be optimally applied to reduce, or even eliminate, adverse consequences. This presentation will discuss a step-by-step, field-tested set of processes and methodologies to successfully deploy a risk-informed decision-making strategy that may be used for food supply chain safety and security risk management assurance.

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### **METHODS AND UNCERTAINTIES IN CARBON NANOTUBE RISK ASSESSMENT**

Risk assessment of nanomaterials is needed to develop occupational exposure limits and to evaluate the effectiveness of exposure controls. Limited data of carbon nanotubes in animals and no data in humans present challenges to selection of appropriate methods and evaluation of uncertainty. Two subchronic inhalation studies of multiwall CNTs in rats were used to evaluate different approaches to CNT risk assessment including: no/lowest observed adverse effect level (N/LOAEL); benchmark dose (BMD) estimation; and comparative potency to other particles with chronic data in animals or humans. Additional short-term studies in rats and mice treated with single or multiwall CNTs with different metal content were also examined using BMD methods. Sensitivity of results to assumptions in dose estimation and extrapolation to humans were evaluated. BMD-based risk estimates varied by two orders of magnitude across the different studies and types of CNTs; however BMD estimates (associated with 10% excess risk of early-stage pulmonary inflammation or fibrosis) from all studies resulted in low estimated working lifetime airborne mass concentrations (as 8-hr time weighted average). The results indicate >10% excess risk of developing early-stage lung effects over a working lifetime if workers are exposed at the limit of quantification (LOQ) ( $7 \mu\text{g}/\text{m}^3$ ) of the analytical method to measure CNT airborne concentrations [NIOSH method 5040]. N/LOAEL-based OEL estimates (with un-

certainty factors) and comparative potency analysis to crystalline silica with human risk estimates also indicated exposure limits below the LOQ. Evaluation of alternative assumptions did not substantially change these estimates. These findings indicate the need for more sensitive measurement methods (e.g., CNT count concentrations using electron microscopy) and implementation of effective exposure controls to protect workers from airborne exposure to CNTs.

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### **PERCEPTION OF CAUSES OF DEATHS FROM DISEASES, ACCIDENTS AND SUICIDE IN PERSONS OF YOUNG AND SENIORS**

The purpose of this study was to examine subjective probabilities of causes of deaths from diseases, from accidents and from suicide. Twelve kinds of diseases (e.g., stomach cancer, hepatitis, influenza, etc), twelve accidents (e.g., fire, traffic accident, murder, etc), and suicide were listed. Respondents were university students (108 males, average age 20.25; 75 females, average age 20.16) and seniors (73 males, average age 69.45; 83 females, average age 67.98). Their targets of estimation were respondents themselves, average Japanese of the same sex and of the opposite sex. Respondents were required to express their estimation as a percentage allowing use of number of digits after decimal point. The results were as follows: (1) respondents generally underestimated mortalities of the diseases, particularly among seniors, (2) on the other hand, respondents overestimated the deaths from accidents, especially, young people exaggerated mortality of the same sex and underrate the deaths probability of the opposite sex, (3) concerning suicide, underestimation, particularly among seniors, was generally observed when the target of estimation was respondents themselves. However, this tendency was not clear among female young peoples. (4) optimistic bias (the tendency for people to report that they are less likely than others to experience negative events and more likely than others to experience positive events) was observed in suicide and in diseases, however, this bias was not found in accidents. These results appear to reflect respondents' perceived control about different causes of deaths.

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### **DIYBIOSAFETY: RESPONSIBLE SCIENCE FOR DO-IT-YOURSELF BIOLOGISTS**

Abstract: Remember chemistry sets, ham radio, amateur astronomy, and early computing? Well, now it is biology's turn. Today, over 2,000 people from around the world belong to the Do-It-Yourself Biology (DIYbio) community, working on designing everything from microbial fuel cells, low-cost lab equipment, environmental surveillance techniques, personal bio-monitoring devices and methods, to new treatments for diseases. The Synthetic Biology Project at the Woodrow Wilson Center is partnering with DIYbio.org (an organization dedicated to making biology an acces-

sible pursuit for citizen scientists, amateur biologists and biological engineers who value openness and safety), on a project to ensure safety within the rapidly expanding community of amateur biologists. The project will identify relevant biosafety guidance and work with members of the biosafety community to distill that information into user-friendly guidelines. A series of Congresses were held in May and June of 2011 bringing together delegates from existing DIYbio regional groups in the U.S. and Europe to collaborate on the development of a draft DIYbio "code of conduct" that may serve as a framework for helping us achieve a vibrant, productive and safe global community of DIYbio practitioners, regional groups, and community labs. Preliminary results from the congresses suggest that a voluntary, localized aspirational code may be the most suitable type of code for the community based on regions of the world, philosophies and missions of each individual group. We will discuss the latest developments of the aspirational code, biosafety and biosecurity concerns and how it relates to risk management of this growing amateur community.

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### **EXPLAINING RISK INFORMATION SEEKING: FOOD RISK VERSUS INDUSTRIAL RISK**

Models to describe the conditions in which people will engage in information seeking behaviour, and the factors that determine this behaviour, are being put forward. The poster will contrast information seeking behaviour and its determinants related to risks associated with industrial use of hazardous materials, with that related to a food risk. In recent years, in Germany improperly manufactured meat products have been introduced into the food chain ("Gammelfleisch"). These products which are hard to recognize by the consumer, form a threat to the individual's health, and the scandal has received much media attention. To compare information seeking behaviour and its determinants in the case of this food risk and industrial use of hazardous materials, a survey has been carried out among residents of Germany (n= 161). Subjects were questioned regarding their information seeking behaviour, information sufficiency, affective response, informational subjective norms, risk perception and involvement. It was found that the subjects reacted differently to both situations. Risk perception and involvement were found to be higher for the food risk than for hazardous materials. Nevertheless, in the case of the food risk, individuals were more satisfied with their level of knowledge and less inclined to search for information. Regression analysis showed that, for both risks, informational subjective norms and affective response were the most important determinants of information seeking behaviour. Structural equation modeling is applied to test a model, describing the relationships between the variables, using AMOS. Results will be presented and consequences for risk communication will be discussed.

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### **THE POTENTIALLY ALARMING EFFECT OF COMMUNICATING CCS MONITORING**

An online experiment (N = 200) was conducted to investigate the influence of information about monitoring measures at CO<sub>2</sub> storage sites on laypeople's perceptions of Carbon Capture and Storage (CCS). One experimental group received only a basic introductory text, while the other group received additional information about CO<sub>2</sub> monitoring. Men in the monitoring condition exhibited significantly lower acceptance, significantly higher levels of negative affect, and marginally higher risk perception of CCS; no significant effects were observed in the female subsample. We conclude that information about monitoring activities does not exert a reassuring effect and may even be alarming when actively communicated. The gender difference may be explained by a difference in the salience of mental concepts between men and women regarding CCS. Implications for communication about CCS and for future research are discussed.

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### **DEVELOPING A BAYESIAN APPROACH TO DOSE RESPONSE ASSESSMENT: AN APPLICATION TO TRIHALOMETHANES IN DRINKING WATER**

Pervasive uncertainty is a dominant analytical difficulty that continues to hinder the EPA's risk assessment process for setting standards for environmental contaminants, particularly within the dose-response step. Currently, the EPA handles this by applying deterministic factors referred to as safety or uncertainty factors. This approach has long been criticized as arbitrary, obscuring the true uncertainty, and limiting the ability of policy-makers to make adequately informed risk management decisions. We propose a hierarchical Bayesian model approach to synthesize evidence from toxicological and epidemiological studies, allowing for explicit statement of uncertainty assumptions in the prior distributions, and pre-processing data using Bayesian Model Averaging (BMA) to account for model uncertainty. We apply this model to a case study of chloroform, a disinfection byproduct, in drinking water. We use the same data set considered by the EPA when setting their regulatory standards for chloroform, exploring four different health outcomes that were either cancer or considered pre-cursors to cancer. Final model estimates demonstrated that incorporating more scientific information into the priors had minimal impacts on mean estimates, but reduced the uncertainty surrounding the final estimates. Benchmark dose (BMD) and lower-bound benchmark (BMDL) dose estimates from the model were mostly lower than those estimated by the EPA, indicating that not considering the full body of scientific evidence fails to capture the true uncertainty surrounding the

final estimate. As a result, Maximum Contaminant Level Goal (MCLG) estimates using the Bayesian model were consistently lower than EPA estimates, and in particular were lower than the MCLG standard for chloroform currently in place. This Bayesian model provide an alternative approach to incorporating and quantifying various sources of uncertainty in the dose-response step, and may be applicable in other aspects of risk assessment.

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### **ASSESSMENT OF COMPLEX ADAPTIVE SYSTEM THEORY FOR HOMELAND SECURITY RISK MANAGEMENT**

This presentation will provide the results of a preliminary examination of the state of the art and knowledge in Complex Adaptive System (CAS) theory, risk analysis and risk management strategies. This study was driven by the dual beliefs that most of the problems falling within homeland security arise within CASs and that many of the most widely used risk analytic methodologies are either inadequate for use with CASs or are being misapplied therein. Risk assessment leading to risk management as a means for informing decisions is central to homeland security planning, and policymaking. Prevailing homeland security risk problem designs and analytical methods inadequately address important complexities that affect risk assessments and therefore risk management. Addressing threats to our security requires considering the complex interaction between the homeland security enterprise actors and the body of threats. For example, terrorism risk assessments require an estimation of behaviors for both sides over time and consideration of their opposing capabilities. Analyzing these complex dynamic interactions, many of which are not well understood, requires simplification. Unfortunately, too much simplification produces results which may be useless, or even worse, badly misleading. Complex Adaptive System concepts - their theoretic underpinnings and potential applications — may present opportunities for improving the quality of homeland security risk management. Accordingly, the purpose of this task is to research the current “state of the art” with respect to both the theory and application of CAS concepts to terrorist-driven risk assessments and provide an evaluation of its potential utility as a tool for enhancing homeland security risk management. This paper and presentation are intended to alert the academic research community to the issue, to emphasize DHS interest in the topic and hopefully to spur further exploratory and developmental work in applying CAS theory and practice to improve DHS risk management.



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### **BROADENING THE DISCOURSE ON INFRASTRUCTURE INTERDEPENDENCE BY MODELING THE ‘ECOLOGY’ OF INFRASTRUCTURE SYSTEMS**

Interdependencies among infrastructure systems arise for many reasons, including geographic proximity inducing common cause failures, direct dependence for physical flows of information, and common maintenance and repair actions. However, existing modeling of the risk and reliability of interdependent infrastructure generally deals with a limited subset of these sources of dependence, often focusing only on physical flows and geographic proximity. In this paper we show how a modeling construct recently proposed for ecological modeling can be used to give a broader picture of dependencies between infrastructure systems and system elements. This approach is based on Muir webs, a modeling approach first proposed for modeling complex interdependencies in a pre-European ecological-human community in the U.S. by Sanderson 2009. Muir webs generalize from traditional predator-prey relationships to consider broader interactions such as dependencies on biotic but not directly consumed factors (e.g., shade for certain species of trees). They also include interdependencies due to abiotic factors (e.g., soil types and climate) and human ‘management’ of the environment. These factors are considered through a dependency network describing (1) what factors a given organism depends on and (2) what other organisms and factors depend on a given organism performing its role in the environment. In this paper we show how a Muir web can be used to model interdependent infrastructure system reliability. Here, each ‘organism’ in the infrastructure Muir web is either a component of the system (e.g., a pump or valve in a water distribution system) or is a factor needed by some element(s) of the system for it to perform its intended role (e.g., for a water pump: stable soil, a water supply, and proper maintenance). We use this expanded representation of the dependencies and interdependencies and demonstrate how to estimate system reliability through a simulation-based approach.

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### **THE MODELER MEETS THE EXPERT ON TERRORIST DECISION MAKING: RISK MANAGEMENT BASED ON TWO CULTURES**

This paper will be delivered as a dialog between a “Modeler” and an expert, an “SME” on terrorist decision making. Terrorism risk management offers unique challenges to risk management Modelers and terrorism SMEs. Those challenges call for a new paradigm in analysis. You can’t address the problem by the modeler building the model then going to the SME to populate it. The SMEs know more about the necessary structures of the models than the Modelers do. Before the Modeler

starts building his model, he should elicit the architecture from the SME, starting at a narrative level, build his model upon that architecture, then populate it with SME judgments. This risk management problem needs the information collection and aggregation structure of PRA, but there needs to be an analytic strategy surrounding PRA to make full use of the information from the SMEs to advise Blue risk management. The Modeler and the SME come from two different cultures, but they have to work together: The SME needs the Modeler to transform his knowledge into forms useful for risk management advice; The Modeler needs the SME first to provide him his model architecture, then to provide the data with which to populate the model. Four fundamental considerations: 1.) Don’t Fight the Last War: as if Red behavior is predictable by a simple equation, as in the Cold War, and don’t key on currently known Reds (e.g. al Qaeda, McVeigh) when the bulk of the threat is future Reds. 2.) Don’t Play the Wrong Game, examples: don’t play the game at the defend-each-target level if Red is playing at a higher level, and don’t play as if Red maximizes fatalities if Red is maximizing terror. 3.) Avoid Mirror Imaging: assuming Reds behave/decide in a linear, rational, “Modeler’s” manner. 4.) Maintain Epistemological Modesty: Avoid any false precision of a model result, which could e.g. over-focus on defending high-scoring cities. This presentation will end with suggested strategies for addressing the challenges presented.

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### **IDENTIFICATION, MONITORING AND MANAGEMENT OF RISKS IN THE SPICE INDUSTRY**

The American Spice Trade Association published in the spring of 2011 a guidance document aimed at reducing the risk for contamination of spices with *Salmonella* and other pathogens. The guidance contains five key recommendations. 1) Minimize risk for introduction of filth throughout the supply chain 2) Prevent environmental contamination, cross-contamination, and post-processing contamination during processing and storage 3) Use validated microbial reduction techniques 4) Perform post-treatment testing to verify a safe product 5) Test to verify a clean and wholesome manufacturing environment The recommendations were based on the best practices from the industry. Hear how one firm, McCormick & Company, has been applying these as part of their on-going commitment to food safety. McCormick has been in the business of sourcing ingredients globally since 1889. Few companies have their know-how and experience in sourcing pure, wholesome and safe food products from around the world. Join McCormick as they share a case study of the company’s experiences and strategies for developing programs that meet the import challenges of today. Learn how it successfully manages the sourcing of material from China, India, Indonesia and other developing nations that have historically been challenged to meet the standards of good agricultural and manufacturing practices.



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### **INUNDATION OR IGNORANCE? PERCEPTION AND COMMUNICATION OF STORM SURGE RISK**

The National Weather Service (NWS) issues a wide array of text and graphical products to communicate the forecasted conditions associated with storm surge (defined as an abnormal rise in sea level accompanying a tropical or extratropical cyclone). The serious threat to life and property posed by storm surge suggests that this threat be specifically communicated to members of the public so that they can make better proactive and protective decisions. We report on two recent surveys exploring and assessing awareness and understanding, or lack thereof, concerning storm surge and currently available storm surge information. First we report on an analysis of the general public's actual and perceived risk of inundation, their stated intended behavioral responses to hurricane risks, and their information preferences. Second we report on a survey of coastal emergency manager's preferences for storm surge risk communication. This work is designed in part to assess whether the National Weather Service (NWS) should consider developing new storm surge informational approaches to improve the communication and decision-making with respect to storm surge risk. We discuss ongoing and future efforts to support NWS efforts.

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### **LANDSLIDE RISK ASSESSMENT IN FUNDAMENTAL ROADS OF BOLIVIA USING MULTI-CRITERIA AND GEOGRAPHIC INFORMATION SYSTEMS ANALYSIS**

One of the mayor risks in Bolivia is the landslides that occurs on roads. This paper present the results of landslide risk assessment in fundamental roads of Bolivia using multicriteria and Geographic information systems analysis.

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### **NATURAL RESOURCE DAMAGE ASSESSMENT, RISK ASSESSMENT, AND DECISION ANALYSIS: WHY CAN'T WE ALL BE FRIENDS?**

Natural resource damage assessment (NRDA) is conducted under the United States Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or the Oil Protection Act to quantify economic compensation for current and future environmental damage in cases such as oil spills or other CERCLA-regulated releases. Risk assessment (RA) is typically conducted under CERCLA or similar regulations to inform whether environmental toxicants or other stressors are causing or will cause adverse effects on human health or the environment, and whether action should be taken. Decision analysis (DA) coupled with economic analysis may be conducted to decide what the best course of action might be to mitigate or prevent

adverse health effects or environmental damage, but is not currently a routine or explicit component of environmental regulation in the US. These three broad areas of quantitative assessment are often conducted in isolation and in response to separate regulatory and legal requirements. However, there are no compelling scientific or analytic reasons that the three disciplines cannot inform each other; and ultimately they can perhaps be harmonized. We discuss NRDA, RA, and DA in turn; including the regulatory and legal contexts, typical applications, methodology, and role in informing environmental decision-making. We also present a case study in which these different approaches could be combined. We conclude with recommendations with regard to a harmonized approach, which consists of an overarching DA framework that incorporates NRDA and/or RA.

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### **EXPOSURE ASSESSMENT OF METAL CONCENTRATION AND RELEVANT FACTORS ON WOMEN REPRODUCTIVITY ABILITY**

This cross-sectional study investigated the level of blood mercury, arsenic, lead and relevant factors on women reproductivity ability. Study participants consisted of 79 polycystic ovary syndrome (PCOS) and 259 non-PCOS infertility women recruited at the center for reproductive medicine and 58 pregnant women at the department of gynecology and obstetrics in Taipei, Taiwan. Between August 2008 and March 2010, there are 396 participants recruited from a hospital and written informed consent. The participants were interviewed face-to-face by a trained interviewer who collected information about sociodemographic characteristics, occupation, pregnancy and reproductive history, fish intake, and other lifestyle characteristics. Mercury, arsenic, lead concentrations in blood were measured by inductively coupled plasma mass spectrometry (ICP-MS; Thermo X-series II). The results were: the median concentration in blood was mercury:  $1.67 \pm 1.35$  /  $1.79 \pm 1.18$  ppb, arsenic:  $13.58 \pm 15.47/12.99 \pm 4.22$  ppb, lead:  $16.51 \pm 0.43/15.68 \pm 8.19$ ppb respectively for PCOS /non-PCOS infertility women and mercury:  $1.57 \pm 0.98$ ppb, arsenic:  $10.81 \pm 2.9$  ppb, lead:  $11.62 \pm 4.79$  ppb. A multiple logistic regression model is shown that women with taking herb medicine 1~3 times per month associated with a 3.91 fold risk for infertility of PCOS women (adjusted odds ratio = 3.91, 95%CI = 1.13-13.46). Women with exercising 1-2times per week were associated with a 0.39 fold risk for non-PCOS infertility women (adjusted odds ratio = 0.39, 95%CI =0.17-0.88), thus exercise may play a protective role in ability of pregnancy. Blood lead and arsenic level in infertility women were higher than pregnant women with adjusted odds ratio 1.14(1.06-1.23) and 1.24(1.1-1.39) fold for PCOS and non-PCOS infertility women respectively. These findings suggest of taking herb medicine, without exercising habits and higher lead, arsenic concentrations in blood would play an important role in the risk of infertility in women.

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### **RISK COMMUNICATION IN MULTI ORGANIZATIONAL COMPLEX CRISIS: EXPERIENCES FROM KEY DECISION MAKERS**

Crisis risk communication is one core element of response and mitigation efforts of complex multi organizational crisis and extreme events. During these incidents the levels of uncertainty, complexity and risks increase, and so do the challenges entailed in conveying the multiple stakes implicated throughout the risk decision making development. Given that the levels of risk and uncertainty cannot be avoided, the objective of this work is to bring forth facilitators for inter organizational communication during crisis to overcome the many fold barriers found in these complex events. Ten interviews were run with senior decision makers from organizations governed by dissimilar command structures, who have managed complex events and crises such as H1N1, SARS, the G8-G20 summits, and the 2003 Blackout. The interview guide design was based on a modified version of the critical decision method, under a semi-structured format. Relational and phenomenological analyses were used to elicit trends and patterns from the interviews' verbatim transcripts with the use of the NVivo software. Results indicate that communication is one of the main challenges to overcome during emergencies, should information pieces be missing, the process of strategic risk decision making could potentially be blocked. Therefore, in the experience of the interviewees, information sharing plays a major role in the negotiation needed for the risk decision making process. On the other hand, patterns elicited, showed a positive relationship between organizational resources shared and communication levels, similar patterns were found in the interaction between power and authority with inter-organizational communication. The expected contribution of this work is to provide knowledge tools to enhance organizational capabilities that allow efficient risk communication between organizations from dissimilar governance and command structures, during complex extreme events. With financial support of DRDC, NSERC and CONACYT.

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### **EFFECTS OF EARLY LIFE EXPOSURE TO AIR POLLUTION ON CHILDHOOD ADHD AMONG NEWBORN INFANTS IN TAIWAN**

Several animal and epidemiological studies have suggested that air pollution may have adverse neurologic effects. However, the studies of neurobehavioral effects in children were limited. In this study, the aim was to examine the association between air pollution exposure and its effects on attention deficit hyperactivity disorder (ADHD) in children based on a longitudinal birth cohort. The subjects were participants in National Health Insurance program of newborn infants who were born

between January 2000 and December 2004, and followed until December 31, 2009. Incident ADHD was defined as ever having had medical records of ADHD diagnosis confirmed by a physician during the study period. Incidence density was calculated with the Poisson assumption and the cumulative incidence assessed by Kaplan-Meier analysis over the follow-up period. Furthermore, the relative hazards of childhood ADHD in relation to prenatal and postnatal air pollution were evaluated by Cox proportional hazard model, adjusted with demographics and potential confounding factors. The cumulative incidence of childhood ADHD was 7.28% (1505 events) and 2.37% (456 events) for boy and girl, respectively. After controlling for gender, birth year, urbanization status, the adjusted relative hazard ratios (HR) for ADHD was 1.05 (95% confidence interval, CI: 1.03 - 1.07) for nitrogen dioxide per unit increased. The similar effect also found in ozone (HR: 1.03; 95% CI: 1.01 - 1.05). Our findings suggest that early life exposure to air pollution were associated with development of ADHD in early childhood.

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### **GETTING CONSENSUS ACROSS INTERAGENCY STAKEHOLDERS: APPLICATION OF MULTI-CRITERIA DECISION ANALYSIS TO PRIORITIZE SKILLS REQUIRED FOR FUTURE DIPLOMATIC MISSIONS**

Various situations arise within federal government departments and agencies where several stakeholders wield a significant amount of the organization's decision making ability. Oftentimes, disagreements amongst these stakeholders creates gridlock in the agency's ability to act, and prevents federal agencies from gaining a full understanding of risks facing the organization through risk-informed decision making. Such an example includes the U.S. Department of State's Civilian Response Corps, where the 9 stakeholder agencies which comprise the Corps' membership disagreed on how to reorganize their employment scheme to meet the current and futuristic needs and prepare for the potential risks in their international engagements overseas. To resolve such instances of high-level stakeholder disagreement, multi-criteria decision analysis (MCDA) may be employed as a method to incorporate value judgments into the decision making process and resolve stakeholder disagreements through a quantitatively robust and scientifically-defensible methodology. This method ensures that all stakeholder opinions and preferences are accounted for in a transparent manner and are included in the final decision making process. For the Civilian Response Corps, MCDA was used method to engage their 9 interagency partners in order to elicit an understanding of the 'ideal' proportion and types of civilian skills for inclusion in the Corps. Where the 9 interagency partners who comprised CRC's membership could not initially agree on how to restructure their employment structure to

meet existing and futuristic challenges, use of MCDA was able to resolve this decision making problem in an efficient and transparent manner as befits the needs of a federal agency.

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### **CUMULATIVE RISK ASSESSMENT TO EVALUATE COGNITIVE DEFICITS CONSISTENT WITH IQ REDUCTION IN CHILDREN**

People are exposed to a wide variety of chemicals throughout their daily lives in the foods they eat, the air they breathe, the soil they contact, and the water they drink. The combined threats from exposure via all relevant routes to multiple stressors including biological, chemical, physical, and psychosocial entities can be organized and analyzed through cumulative risk assessment. Cumulative risk assessment is a tool to examine, characterize, and possibly quantify the combined adverse effects on human health from multiple environmental stressors. For the assessment of exposure to multiple chemicals, EPA recommends that chemicals be grouped based on their potential for co-occurrence and joint toxic action, with an assumption that chemicals in these groups could produce toxicity by the same mode of action or affect the same target organ. Currently, three dose addition methods are used by the EPA: relative potency factors, toxic equivalency factors, and the hazard index. The EPA cumulative risk assessment approach is limited to chemicals that are closely related to each other, that are similar in individual and combined target organ, mechanism of action, toxicokinetics, and toxicodynamics. However, people are exposed to thousands of chemicals in daily life, and some of these chemicals, although operating through different mechanisms of action, may result in the same effects. For example, lead, methylmercury, and PCBs are widely distributed environmental contaminants and low levels of persistent exposures to each have been linked to impaired cognitive ability and IQ deficits in children. There is ample evidence to suggest the potential for concurrent exposure to lead, methylmercury, and PCBs within the U.S. population. Cumulative risk assessment can be used to account for risks from combined exposures to these chemicals in multiple media, rather than characterizing risks on the premise that exposure to one chemical via one pathway, occurs in isolation of other chemicals and other pathways.

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### **AFLATOXIN AND POPULATION ATTRIBUTABLE LIVER CANCER RISK IN HIGH EXPOSURE PREVALENT AREAS- A SYSTEMATIC REVIEW**

Background: Aflatoxin is classified as Group 1 human carcinogen and can synergistically interact with chronic hepatitis B virus infection to increase individual's liver cancer risk. The population attributable liver cancer risks from aflatoxin in high exposure prevalent areas have not been well studied. We performed a systematic re-

view and calculated the population attributable risk (PAR) of liver cancer from dietary aflatoxin exposure in those areas. Methods: A literature search up to May 2011 in PubMed was conducted to identify eligible epidemiological studies for analysis. Summary odds ratios (ORs) or relative risks (RRs), and 95% confidence intervals of aflatoxin in related to liver cancer in 1) HBsAg positive and 2) HBsAg negative populations were calculated under a random-effects model. We also calculated PAR of liver cancer from aflatoxin by using the ORs/RRs for each study population. Results and Conclusions: 19 studies (11 case-control and 8 cohort) with a total 1330 liver cancer cases were identified from a study pool of 479. All the eligible studies are done in high prevalent areas of China mainland, Taiwan and sub-Saharan Africa areas. The pooled odds ratio of aflatoxin in relation to liver cancer by combining these studies adjusted by HBsAg+ is 4.30 (95% CI: 3.33-5.13). In HBsAg- individuals it is 5.11 (95% CI: 2.62-9.99) and in HBsAg+ individuals it is 2.40 (95% CI: 1.43-4.04). The PAR of AFB1 for liver cancer risk varies significantly by different populations and over the years, which reflect the heterogeneity between the studies and populations: the differences of biomarkers used for measurements, the changing of diets, the varied HBV prevalence and the aflatoxin exposure. This study highlights how the use of validated biomarkers to link exposure to aflatoxin and health effects can be applied to risk assessment.

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### **USE OF PHYSIOLOGICALLY-BASED PHARMACOKINETIC MODELS TO ASSESS WHETHER EPIDEMIOLOGIC ASSOCIATIONS ARE DUE TO REVERSE CAUSALITY**

Epidemiological studies have reported associations between increased blood concentrations of environmental chemicals and delayed onset of menarche or early onset of menopause, leading to concerns that the chemicals have endocrine-disrupting properties. However, the interactions between physiological changes during these life stages and chemical kinetics are complex and difficult to elucidate without the quantitative structure provided by a physiologically-based pharmacokinetic (PBPK) model. To address the question of whether associations between age of menarche/menopause and chemical concentration can be explained by pharmacokinetics, we have exercised human PBPK models that incorporate age-dependent physiological changes. We present two examples of how PBPK models can be used to evaluate associations in epidemiological studies between concentrations of a chemical in blood and physiological outcomes: polyfluoroalkyl acids (perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS)) and lead. The models indicate that the relationships between blood levels and menarche/menopause outcomes can be explained on the basis of pharmacokinetics rather than endocrine disruption. In both cases the internal chemical exposure is driven by physiological changes. Menstruation is a route



of excretion, and the increased chemical levels in blood are due to lack of monthly excretion of chemical in blood before menarche and during menopause. In the case of lead, bone is not a permanent storage site due to the changes in bone growth and resorption observed at different life stages and is thus a constant source of internal exposure. Many examples exist of epidemiologic associations between exposure biomarker concentrations and outcomes that, by using PBPK models, may be explained on the basis of chemical kinetics rather than causality.

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### **QUANTIFYING FACTORS & TRENDS IN CASUALTIES DUE TO HAZARDOUS MATERIALS TRANSPORTATION**

Hazardous materials regulated by the U.S. Department of Transportation (DOT) range from commodities as ubiquitous as gasoline, ammonia, and chlorine to threats as unexpected as carbon dioxide and sui generis articles like lithium batteries. The Pipeline and Hazardous Materials Safety Administration (PHMSA), the agency within DOT responsible for coordinating the U.S. Government's oversight of hazardous materials transportation and the documentation of accidents and incidents under its jurisdiction, has a fundamental interest in analyzing the historical human consequences of these incidents in order to identify persistent regulatory needs and past successes. Using 25 years of data collected by PHMSA and its predecessor agencies, this study attempts to answer two difficult questions. First, how can we best categorize and characterize hazmat-related safety risks, specifically enumerating the distribution of factors correlating with fatalities and major injuries? Second, in an environment prone to "black swan" events is it possible to identify and extrapolate trends that can be used to direct resources to effectively prevent future casualties? Particular attention is given to the challenges of making comparisons across multiple modes (e.g., road, rail, aircraft, and waterborne vessels) and determining the appropriate measures of exposure (whether the sheer nationwide volume of a commodity in transport or the distance traveled by the average shipment) to use for the normalization of risks.

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### **EUROPEAN SYNTHETIC BIOLOGY: PRESENT AND FUTURE REGULATORY TRENDS**

This paper provides an overview of present and future regulatory trends on synthetic biology based on interviews with policy makers, regulators and other policy observers in Sweden (Swedish Chemicals Agency), UK (various government departments) and Belgium (European Commission, European Parliament). The paper concludes with a number of recommendations regarding what is needed to ensure that the regulation of synthetic biology remains "risk" based in focus.

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### **UK HEALTH AND SAFETY AND THE "LOFSTEDT REVIEW"**

In March 2011, Ragnar Lofstedt of King's College London was asked by Minister Chris Grayling of the UK Department for Work and Pensions to carry out a review of all health and safety regulation in the UK. In this presentation, the author of that review summarises some of the key findings and policy implications.

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### **INTEGRAL PLAN OF MANAGEMENT FOR CHEMICAL EMERGENCIES IN LANÚS- ARGENTINA**

The goal of present work is to propose a plan to manage chemical risks in Lanús. The city of Lanús is under a great number of chemical risks. Under an hypothetical situation of crisis caused by a great disaster, they will develop innumerable activities, not only of local but regional and national and even international level. Lanús is one of the counties that integrate the Metropolitan Region of Buenos Aires (to a distance of the central area of 5 km by railroad and 6 km by route), can be identified, due to its geographic distribution and space, within the first crown or ring, according to historically urban growth. In the zone a multiunitary aquifer system exists, integrated by three units denominated Epipelche, Pelche and Hipopelche, supported on the impermeable plinth. In these hydrogeological units, permeable sedimentary complexes (water-bearing), little permeable complexes (acuclados) and impermeable complexes lodge (acuclados). Lanús limits the west in all the extension with Matanza Riachuelo system which is one of most polluted river in the earth, there is in course a Plan of Cleaning for its recovery. "The Integral Plan of Chemical Emergencies of Lanús" intends to orient the answer, in case of emergency or dehorns, of the municipal administration and the different institutions that are part of the municipal system of prevention and attention of disasters, contributing to preserve the life and to reduce the damages before the occurrence of natural events and human origin.

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### **FOODBORNE CONTAMINATION CONSEQUENCE MODELING**

Intentional foodborne contaminations have been attempted in the United States and abroad. Several online tools, software packages, and approaches have been developed and are available for evaluating potential vulnerabilities within the food supply chain. However, there remains a need for robust, risk-based consideration of various threats to the U.S. food supply (from 'farm-to-fork'). As part of the Chemical Terrorism Risk Assessment (CTRA), a DHS CSAC funded program, Battelle has developed a foodborne contamination consequence model that estimates the human



health consequences of an intentional food contamination scenario. Knowledge from published literature and subject matter expertise on agent stability, food processing technologies, and supply chain vulnerabilities are applied to evaluate the impact of chemical, biological, and radiological threats on public health. Foodborne contamination scenarios are mathematically simulated from the point of contamination (e.g., a storage silo), through food processing (e.g., pasteurization), packaging or bottling, distribution to retail or quick service restaurant (QSR) outlets, to points of sales of contaminated product, consumer and QSR preparation methods (e.g., cooking), and consumption patterns. A recall or public announcement component considers the time to the appearance of illnesses or injuries, and applies a rate of information diffusion to calculate the amount of contaminated product removed from retail outlets and consumer homes. Contaminant-specific data, such as that for dose-response, hydrolysis rate, temperature-dependent decay, and time to symptom onset, are utilized to provide estimates of potential consequences in terms of deaths and injuries of varying severity. These modeling capabilities can be applied to prioritize investments in mitigating a food contamination event and have other potential applications in establishing risk-based contaminant sampling programs for unintentional contamination events involving foods such as ground beef or lettuce.

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#### **ESTIMATING NONCANCER HUMAN HEALTH RISKS ASSOCIATED WITH ACROLEIN INHALATION USING THE STRAW MAN MODEL**

We estimated human health risks of nasal toxicity associated with acrolein inhalation using the Hattis et al. 2002 “Straw Man” noncancer risk assessment approach. The Straw Man is a probabilistic risk assessment model that assigns distributions in place of traditional point estimates for the point of departure and uncertainty factors. Specific uncertainty factor distributions are chosen from a preassembled database depending on the toxicological information available for a specific compound. For the first time, we evaluate how the Straw Man model might be applied to a highly reactive air toxic such as acrolein. The model outputs are (1) a distribution of concentrations corresponding to a specified risk level, and (2) uncertainty distributions of expected risks of harm at a specified level of severity as a function of chronic air concentrations. First we will present an overview of the available dose-response data for acrolein and a summary of the current approaches to regulating acrolein in the U.S. We will then describe our choice of input parameters for the Straw Man analysis, and will report the results of the Straw Man evaluation of acrolein implementing our newly created Regional Gas Distribution Ratio (RGDR) distribution, necessary for this class of air toxics. Our analysis is intended to showcase how the Straw Man method might be employed to calculate noncancer risks for acrolein and other highly reactive air toxics. The results of this analysis should not be taken as final risk estimates, because the

RGDR distribution, as well as all the distributions that inform the Straw Man analysis, could be expanded to include additional datasets and/or more sophisticated statistical techniques. These next steps will also be discussed.

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#### **RISK ASSESSMENT STRATEGIES FOR ADAPTATION AND SEA-LEVEL RISE**

Climate change adaptation planning requires that policymakers decide on whether to take action or follow a wait-and-see approach when confronted with a range of uncertain but significant local or regional climate impacts, such as sea-level rise, changes in the frequency and intensity of precipitation and extreme weather events, availability of water resources, and increased temperatures. The uncertain path of future climate change is compounded by uncertainties in making climate predictions at regional scales. Despite these uncertainties, many decisions with long-term consequences about land use, ecosystem protection, and long-lived infrastructure must be made today. The Council on Environmental Quality explicitly counsels the use of formal risk assessment methods in adaptation planning. But what methods ought to be used? This paper surveys risk assessment methods described in the evolving adaptation literature, describes how these methods have been applied in recent U.S. practice, and considers the applicability of other approaches used by the risk assessment community.

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#### **QUANTIFYING THE INTERDEPENDENT EFFECTS OF SUPPLY CHAIN DISRUPTIONS AND MITIGATION STRATEGIES**

Supply chain risk management has been a popular topic with both practitioners and researchers, and different models can help companies prepare and react to a disruption in their supply chain. Potential industry strategies for coping with these disruptions include maintaining inventory, buying from multiple suppliers, and substituting one input for another. However, less attention has been given to exploring the broader economic consequences that these strategies have on a region following a disruptive event. We deploy a risk-based interdependency model to analyze the broader impacts of supply chain disruptions. We find the equilibrium points as determined by the disruption and a company’s optimal strategy and explore the dynamics of moving between equilibria. A risk-based input-output model quantifies the impacts of this dynamic production model. The model is applied to a data-driven multiregional case study.

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### **OPTIMAL RESOURCE ALLOCATION FOR RECOVERY FROM MULTIMODAL TRANSPORTATION DISRUPTIONS**

The American economy relies on the ability of businesses to move commodities and products efficiently around the nation. Companies can choose among highway, rail, waterway, air, or a combination of these modes to deliver products to their customers, and each of these modes has distinct advantages and disadvantages compared to the other modes. However, if a disruptive event disables part of this network, companies may be forced to scramble to find alternate transportation modes or routes to continue to deliver their commodities efficiently. These disruptions can lead to increased transportation costs and late deliveries. We develop a decision model to determine the optimal resource allocation for a multimodal transportation network recovering from a disruption. Resources are distributed according to where the money can provide the greatest help in easing transportation difficulties in terms of costs and transportation delays for companies. Necessary and sufficient conditions are derived for both static and dynamic decision problems.

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### **DELPHI ANALYSIS OF ISSUES AFTER THE 2011 PACIFIC COAST OF TOHOKU EARTHQUAKE**

The Pacific Coast of Tohoku earthquake on March 11, 2011 has catastrophic impacts on Japan. Japan is currently on the way to recovery. However, as the damage on the country as well as society is so serious, Japanese society is urged to change some systems including hazard management, energy policy, information systems and city planning. These changes are accompanied with social group realignments, thus necessarily followed by various risks. In addition to these societal risks, Japan should be prepared for the coming disaster risks in near future. In 2004, Indonesia experienced magnitude 9.1 earthquake, named “2004 Indian Ocean earthquake”. After that event, Indonesian society has suffered magnitude 7-8 class earthquakes every year. This could be the case with Japan because of plate movement mechanism: i.e., Japan may have to brace for magnitude 8 class earthquakes again and again in the next several years. To cope with these risk issues, SRA-Japan established the special research committee for the 2011 Pacific Coast of Tohoku earthquake. The aim of the committee is, from viewpoints of risk analysts, to create and relate messages about risk issues in one year, in five years, in ten years and in thirty years from the earthquake. To do this, the committee garners SRA-Japan member’s opinions about possible risks in Japan by using Delphi method. In SRA-Japan, there are over 600 members in interdisciplinary fields from various backgrounds, thus the messages are expected to be helpful for Japanese society to lower its risks and to optimize the resource allocation. The research is now underway. An interim report will be presented.

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### **SUBSTANCE FLOW-BASED EXPOSURE ASSESSMENT FOR HBCD FROM A LIFE-CYCLE PERSPECTIVE IN JAPAN**

The present study aims to develop a risk reduction policy for chemicals, considering a product life-cycle. Environmental emissions from end-products containing brominated flame retardants (i.e., HBCD) for the period 1986-2030, which is currently undergoing a risk assessment has been estimated by substance flow analysis (SFA). Through the investigation of quantitative HBCD life cycle, estimated HBCD stock in&#12288;the use phase shows a continuous increase, indicating that emissions from the materials containing HBCD will be potentially long-term sources of pollutants leaching to the environment. In Japan, 571 kg/year and 41 kg/year of HBCD was calculated to emit to the atmospheric and aquatic environment in 2000, respectively. This corresponds to 0.03 % of the consumed HBCD quantity in Japan. These environmental emissions of HBCD were increasing rapidly until 2011. Using a multimedia fate model, where the estimated HBCD emission were used for the input parameter and a simple pharmacokinetic model, intakes of adults through life cycle of HBCD were converted to predicted body burdens and compared with the results observed from Japanese human milk. Predictions compared well with those observed for HBCDs for the period 1986-2005. SFA focuses on the emission from production to waste process (i.e., life cycle) of target chemicals and thus, this estimation may cover whole exposure pathways. The present study gives an insight to obtain basic information for long term measures toward strategic chemical management considering their life cycle.

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### **STATE OF THE SCIENCE AND INFORMATION GAPS REGARDING A COMPREHENSIVE ENVIRONMENTAL ASSESSMENT OF AN APPLICATION OF A CARBON-BASED NANOMATERIAL**

Part of EPA’s strategy for prioritizing research to inform future assessments of nanomaterials includes the development of case studies that describe what is known and what needs to be known to assess the ecological and health implications of specific nanomaterial applications and uses. This presentation describes the scoping process used to select a candidate carbon-based nanomaterial application for the next in a series of these EPA case studies and summarizes preliminary findings of the case study. The process for selecting appropriate nanomaterial applications for case study development considered multiple criteria, including adequacy of available information, relevance to EPA programs, evidence of general population and occupational exposure potential, applicability to ecological and human health risk assessment, and

feasibility of comparing nano-enabled to non-nano-enabled products. Implementation of this scoping process resulted in a list of five candidate carbon-based nanomaterial applications. The advantages and disadvantages of each candidate were evaluated by an EPA Work Group with respect to preparation of a case study structured around a comprehensive environmental assessment (CEA) framework, and one nanomaterial application was selected for the case study. The available published and unpublished data on this nanomaterial application were then reviewed and a draft case study developed. This draft case study synthesizes the available data on primary and secondary contaminants, analytical techniques, fate and transport processes, cumulative and aggregate exposure, and ecological and human health risks across the life cycle of the product. Data gaps based on this preliminary analysis are presented based on the available data identified to date. Prioritization of these information gaps will occur through a subsequent collective judgment process. Disclaimer: This abstract does not necessarily represent the views or policies of the U.S. EPA.

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### **A PROPOSED MODEL TO ANALYZE AUDIENCES' BEHAVIORAL BARRIERS TO ADOPTING CLIMATE CHANGE MITIGATION STRATEGIES**

While the American public has been exposed to an extensive amount of information as to the potential causes and effects of climate change, resulting carbon emitting behaviors have not shown a significant decline. In fact, many Americans are becoming increasingly skeptical of the existence of anthropogenic climate change; thus, they may be less likely to be motivated to make behavior changes. People's conflicting attitudes and subsequent behaviors toward pro-environmental actions represent a complex issue that warrants further examination in order for effective communication and intervention strategies to be implemented by those whose job is to communicate the associated risks or design the campaign. The purpose of this paper is to propose a procedural model, adapted from Stern's (2000) value-belief-norm theory, which researchers and practitioners could use to identify specific audiences' real and perceived barriers to engaging in climate change mitigation strategies. The ultimate goal of this work is to create a comprehensive information database that contains readily accessible and relevant academic research and campaign evaluation results for practitioners and researchers to leverage toward the identification of gaps in the extant literature. An example of how to use the model for identifying the barriers for a specific audience and a specific climate change mitigation behavior is detailed.

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### **QUANTIFYING AND VALUING CLIMATE CHANGE IMPACTS ON CORAL REEFS IN THE U.S.**

Coral reefs provide valuable services to the marine environment and humans, such as recreation, fish production, shoreline protection, and biodiversity. These ecosystems are highly vulnerable to the direct and indirect effects of increasing atmospheric and ocean CO<sub>2</sub> concentrations. Understanding how coral reefs will react under climate change scenarios is critical to evaluating policies to reduce the economic and environmental damages associated with declining coral reefs in the U.S. and worldwide. Here, we apply the COMBO simulation model ("CO<sub>2</sub> Mortality and Bleaching Output") to estimate future coral cover in three major U.S. locations for shallow water reefs: the Florida Keys, Puerto Rico, and Hawaii. Coral reefs in these three areas generate recreational and nonuse values worth several billion dollars annually. COMBO simulates the impacts of future climate change on coral reefs from both chronic stress from long-term changes in average sea surface temperature (SST) and ocean acidification as well as impacts from episodic high temperature mortality (bleaching) events. COMBO bases its modeling functions for chronic stress relationships on previous studies of corals in mesocosms; COMBO bases its modeling functions for bleaching events on records of heat-dose experienced by coral reefs and associated bleaching severity in different locations. Our results suggest severe impacts to shallow water reefs in the U.S. over the 21st century under all of our emission scenarios. However, these potential impacts are delayed under aggressive GHG reduction scenarios. We also monetized these changes in coral cover with a benefit transfer approach using published studies of consumers' recreational value for snorkeling and diving as well as non-use value for coral reefs. This modeling approach can also be used for risk management and communication. Specifically, we describe the risks to coral reefs using metrics that will resonate with decision-makers and the general public.

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### **ACCOUNTING FOR PROFESSIONAL JUDGMENT IN RISK MATURITY: A CASE STUDY FROM THE POWER UTILITY SECTOR**

Risk maturity models are used to benchmark and improve risk management performance. However, they rarely account for professional judgment. Professional judgment often appears to be an alternative to, rather than a component of, risk-based decision making (1-3). We conducted a case study to examine the role of professional judgment in risk decisions made by a power utility company, including: determining



risk appetite and optimal risk mitigation. Individual and collective professional judgment contributed to a nuanced and adaptable approach to the management of risk. The diverse, dynamic and unpredictable nature of the organization's environment precluded some processes, such as technical designs and operational procedures, from being universally applicable. In these situations, the organization was reliant on the judgment of its operatives to adapt processes to local conditions. Existing theory (4) typically distinguishes between general, codified knowledge and the contextual knowledge generated by sub-groups. Our findings show that effective organizational-wide risk management requires both general and contextual knowledge. Thus, the ability to develop and draw on contextual knowledge, through professional judgment, is a core competency contributing to risk maturity. We believe these findings provide important insights and guidance to risk managers seeking to build organizational risk maturity. References: 1.HM Treasury.The Orange Book:Management of risk-principles and concepts.London.Crown copyright,2004. 2.MacGillivray B,Sharp J,Strutt J,Hamilton P,Pollard S.Benchmarking Risk Management within the International Water Utility Sector.Part I:Design of a Capability Maturity Methodology,Journal of Risk Research,2007;10:85-104. 3.PricewaterhouseCoopers LLP.Enterprise Risk Management Integrated Framework:Executive Summary and Framework.AICPA,2004. 4.Taylor J, Van Every E.The Emergent Organization:Communication as Its Site and Surface.Lawrence Erlbaum Associates,NJ,2000.

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## **TOWARDS AN INTEGRATED APPROACH FOR MONITORING ENVIRONMENT, HEALTH AND SAFETY ASPECTS WITHIN AN ORGANIZATION**

Management of systems requires, amongst many other things, a thorough and continuous understanding of the actual system's state and its development trends. To do so, managers need to rely on both descriptive and explicative models of the system's strengths and weaknesses. In case of complex systems, those needs become much more difficult to achieve because of the:

- interconnections between different dimensions or layers of the system;
- holistic properties of the system making its final performances different from the sum of its elements' performances;
- External, and thus uncontrolled, factors affecting the system.

Environment, Health and Safety (EHS) management of technological systems threatening humans and environment fits totally this description. Therefore, as complex systems, industrial installations require the development of dedicated monitoring systems aiming to ensure that EHS management is correctly designed and implemented.

The development of indicators as monitoring tools has been widely documented in literature. Nevertheless, their use is still struggling with multiple challenges:

- How to find an adequate balance between the need for multiple indicators so to deal with the various factors affecting EHS in one hand, and minimize the number of indicators because of the reluctance of organizations to develop and implement numerous and too heavy indicators?
- How to coordinate the definition of indicators at various levels of the organization in order to help improving communication and common understanding of EHS issues?
- How to ensure that organizations take benefit of indicators without facing common side effects as misinterpretations, management by numbers...

This paper will suggest an approach aiming to help organizations to develop a coherent and well adapted set of indicators for EHS management. According to a systemic vision, the various dimensions impacting EHS can be systematically addressed in an integrated way allowing a global optimization of the organization resources.

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## **CONTAMINANT DISPERSION MODELING IN COMPLEX URBAN LANDSCAPES USING HYBRID COMPUTATIONAL FLUID DYNAMICS TECHNIQUES**

Substantial spatial variability exists in the concentrations of contaminants following the release of a contaminant in a complex urban landscape. This results in significant uncertainties in the estimates of contaminant levels, exposures, and potential risks following accidental or intentional releases of chemical or biological agents. Characterizing the uncertainties and variability in exposure estimates through measurements is expensive and prohibitive in most cases. Computational models can provide data with high spatial and temporal resolution to investigate and characterize localized exposures. Computational Fluid Dynamics (CFD) models have been widely used to simulate localized contaminant dispersion. However they have limitations with respect to providing real time or faster-than-real-time information on contaminant transport and hence are not an effective tool in rapid Emergency Event Response analysis. Fast computational models such as the Quick Urban & Industrial Complex Dispersion (QUIC) provide efficient alternatives for studying dispersion in complex landscapes. However, the accuracy of the QUIC model is limited because it uses empirical algorithms for estimating flow around buildings. An intermediate model called QUIC-CFD provides an alternative; while it computationally more demanding than QUIC, it is faster than most CFD models, as it uses a single-equation turbulence model. This study compares the estimates from these three computational models with measured tracer gas concentrations obtained from the Urban Disper-



sion Program studies in New York City, following releases of perfluorocarbon tracers from multiple locations. Computational models of the 1 km X 1 km domain were developed for CFD, QUIC, and hybrid model simulations. Results indicate that even though CFD is more accurate than the other models, QUIC-CFD also provides a reasonable estimate of tracer gas concentrations with significant time savings.

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### **MODELING RESPIRATORY MECHANICS IN ANIMALS: TULAREMIA IN THE RHESUS MONKEY**

Deposition And Response in the Respiratory Tract (DARRT) is an improved mathematical model for predicting the probability of infection or injury from exposure to aerosols of chemical and biological (CB) agents and to better describe the resulting medical impact. Many present models assume that only particles reaching the lung are of concern and therefore that accounting for the inhalation of 1-5 micron “respirable” particles is adequate. Further, most models of human response to CB agents ignore the mechanics of the inhalation process and simply correlate observed biological endpoints with exposure (that is, presented dose). However, research shows that accounting for larger particles and deposition location is important for determining the probability and severity of the biological response. Coarse particle deposition in the nose, mouth and throat can pose a substantial health risk, particularly for infectious agents, Furthermore, small particles can deposit in different parts of the respiratory tract and initiate correspondingly variable biological responses. Much of the data for understanding these risks is taken from exposure of laboratory animals. The DARRT model uses the Multiple Path Particle Dosimetry (MPPD) model to estimate regional respiratory doses of inhaled aerosols for humans as a function of the particle size. In particular, DARRT includes a particle size-dependent model for the risk of aerosol infection by *F. tularensis*, the causative agent for tularemia. An important source of data for modeling tularemia in humans is aerosol exposures conducted for tularemia in rhesus monkeys. To date, application of the monkey data to predictions for humans has assumed equivalence for the mechanics of respiration between humans and the rhesus monkeys. In current work, we are developing an MPPD model for the rhesus monkey to improve the extrapolation of to human exposures by accounting for respiratory tract differences.

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### **COMMUNICATING ABOUT ONE HEALTH: EXAMINING THE RISKS OF A “SHARED RISK” PARADIGM**

Recent years have witnessed increasing endorsement of the One Health concept, which emphasizes connections between human, animal, and environmental

health and advocates the collaboration between human and veterinary medicine and allied fields to promote the health of all species and the planet we share. The importance of a One Health approach is even more apparent given the accelerated impacts climate change and other human induced changes are predicted to have on reducing biodiversity and increasing the prevalence of zoonotic diseases over the next several decades. Using animals as sentinels for human health dates back at least to the time when canaries were used in coal mines to warn miners of dangerous levels of toxic gas. Humans have also served as sentinels for animals, such as when human disease is more readily diagnosed than wildlife deaths in rural areas. The One Health approach builds on these precedents by advocating a shift to a “shared risk” paradigm. Efforts to adopt the One Health approach have created a parallel urgency to understand how to communicate shared risk. Poorly crafted risk messages could, for instance, lead to less public support for species conservation or backlash against certain species that could be viewed as disease vectors rather than fellow victims. One has only to look at the recent unnecessary slaughter of pigs in response to the “swine flu” pandemic to see the consequences of poorly designed risk communication. This presentation will lay out a framework for theoretically informed research in consultation with the National Park Service that seeks to address the gap in social science research. Examples from recent research and the literature will augment the justification for a closer look at the risks of the “shared risk” paradigm.

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### **EVALUATION OF FORMALDEHYDE AIR EMISSIONS FROM A WASHING MACHINE AND POTENTIAL HUMAN EXPOSURE**

Consumers may be exposed to a formaldehyde preservative during the use of liquid laundry detergent. This study presented a refined approach to predict formaldehyde air emissions from a washing machine and the subsequent vapor concentrations in the laundry room air using the USEPA Simulation Tool Kit for Indoor Air Quality and Inhalation Exposure (IAQX). The model was used to refine an earlier USEPA study, which showed unacceptable consumer exposure. The formaldehyde evaporation from a washing machine was calculated using the Henry’s law constant and the overall gas-phase mass transfer coefficient. The mass transfer coefficients were calculated using data from washing machine experiments conducted for the USEPA. Human exposure was assessed using the time weighted average (15 minute, 24 hour, and lifetime) vapor concentrations in the room. The predicted formaldehyde exposures were less than the USEPA proposed toxicity benchmarks targets for noncancer effects and cancer risk. The mass balance estimated 99.7% of the initial formaldehyde mass in the washing machine was discharged down the drain with the wash water and only 0.3% was emitted into the room air. This paper thoroughly evaluated the USEPA IAQX model, provided new formaldehyde mass transport pa-

rameters, and enabled a more robust analysis for formaldehyde releasing detergents and fabric softeners.

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### **A TIERED APPROACH TO DERMAL EXPOSURE ASSESSMENT FOR ANTIMICROBIAL PESTICIDES**

The Threshold of Toxicological Concern (TTC) is a risk assessment tool for chemicals with limited toxicity data, providing health-protective intake limits (TTC values) for broad structure-based toxicity categories. The TTC concept evolved from FDA's Threshold of Regulation for food contact materials (1995) and has been used routinely by the Joint FAO/WHO Expert Committee on Food Additives and the European Food Safety Authority for the evaluation of flavoring substances. Many other applications have been explored in the past few years, and this paper presents an application of the TTC involving potential dermal exposures to antimicrobial pesticides (biocides). The basic TTC decision tree was constructed through analysis of a database of chronic oral toxicity studies, and the resultant TTC values assume oral exposure and systemic dose. Antimicrobial pesticides, however, have a number of common uses with potential skin exposure. Thus, a tiered screening level approach has been developed to estimate the internal dose from skin uptake of antimicrobials in typical exposure scenarios for comparison with appropriate TTC values. Examples include contact with workplace liquid formulations or with treated (or contaminated) clothing. Although skin uptake of the antimicrobials has not been extensively studied, the rate of skin penetration for a chemical can be correlated with its physicochemical characteristics and therefore it is possible to make approximate, conservative predictions of uptake. The tiered dermal approach described here uses progressively more realistic (and data intensive) assumptions in estimating the amount of antimicrobial penetration through skin to screen for level of concern. The approach can be used to identify antimicrobial chemicals for which the potential for harm from dermal exposure is negligible or where the collection of additional toxicity, exposure or physicochemical data will be necessary to make better estimates of risk. (This abstract does not necessarily represent EPA or FDA policy.)

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### **RADON IN THE PUBLIC EYE: A REVIEW OF THE EVIDENCE FOR RADON RISK PERCEPTION, RISK COMMUNICATION AND MITIGATION POTENTIAL**

Radon is a known human carcinogen and the second leading cause of lung cancer in Canada. Studies indicate 7% of Canadian homes and public buildings exceed 200 Becquerels per cubic metre (Bq/m<sup>3</sup>), the current regulatory level. Though research shows a 100 Bq/m<sup>3</sup> increase in radon results in an 11% increase in risk of lung cancer, studies indicate only 41% of Canadians are aware of the risks posed by radon in indoor environments. We examined the state of the literature on the public's knowledge, risk perception and willingness to act in relation to radon exposure. Relevant quantitative papers examining evaluations of radon risk communication programs and educational campaigns, experimental interventions, and risk perception surveys were identified (n=56). Data was collated and entered into a spreadsheet for analysis. More than twenty different tools were used to increase awareness about the hazards of radon in the home. Overall, improvement in knowledge about the risks associated with radon was only weakly correlated with undertaking mitigation strategies. Targeted messaging was more successful than broad messaging. The only variables associated with remediating were higher educational attainment and higher household income. A targeted, multistep approach to radon risk communication is proposed to increase willingness to remediate. For families, including risks to children or including children in campaigns may make risks more salient. Other suggestions include crafting programs that address education, testing and mitigation as separate entities. Risk communication strategies that take this approach will also allow for the issue of remediation cost to be addressed specifically for low-income households where necessary. Radon is a widely spread and insidious agent the Canadian public is poorly informed about. Appropriately designed educational campaigns will be a key tool in the promotion of awareness and the initiation of self-protective behaviour.

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### **ITRA SENSITIVITY STUDY: SUBWAY EVENT RESPONSE ANALYSIS**

Homeland Security Presidential Directive (HSPD) 18 (Medical Countermeasures against Weapons of Mass Destruction) requires a risk assessment of Chemical, Biological, Radiological, and Nuclear terrorism for the purpose of risk based decision support in the area of medical countermeasure acquisition and development. In support of HSPD-18, a sensitivity study on the effectiveness of medical and detection-based responses in reducing casualties and deaths in a set of chemical and radiological events was conducted. This analysis details the analytic models used to predict the

passenger impact of such events and the effectiveness of the public health system in mitigating these events. It analyzes the effectiveness on the various response strategies against the range of events, and documents which responses are most effective. Finally, it provides recommendations for implementation and further study.

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### **POPULATION RISKS IN A SMALL COASTAL TOWN OF THE RIO DE LA PLATA RIVER: A CASE OF STUDY**

Punta Lara is a small town localized on the south coast of the de la Plata River, in Buenos Aires province, Argentina. Environmental indicators of poor water quality, the lack of urban services such as sewages and the wrong management of resources generate a significant damage of environment that affects the population life quality. This town is exposed periodically to floods which increases the contact of inhabitants with polluted water. In fact, the urban and environmental conditions do not fulfill the indispensable urban services requirements to humans. This city presents a great inefficiency of management in hydraulic works and social-environmental prevention. The Rio de la Plata is a tidal regaled water body which receives all the effluents produced by the urban activities 15 km upstream the maximum sewage from Buenos Aires and downstream the petrol industry park and the port and the maximum sewage from La Plata and Gran La Plata (5 km). Punta Lara belongs to a region of coastal strip. Due to its natural particularity, it became the habitat of a great variety of aquatic and terrestrial species with high ecological value, which is rarely is appreciated and continuously degraded. It exists an area of three thousand ha protected by Provincial Natural Reserve declaration. This it is an important reason to decide actions. The goal of present work is propose five viable actions which will diminish significantly risk on health and structures.

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### **THE IMPORTANCE OF MODE OF ACTION**

The need for more efficient assessment as a basis to address the many unevaluated chemicals in the marketplace was identified by the NAS Science and Decisions Committee as one of the more significant challenges facing the toxicological and risk assessment communities. That this requires tiered approaches to testing and assessment was also recognized. However, the importance of mode of action in development of predictive methodologies relevant to early tiers and more accurate chemical specific approaches in latter tiers was not explicitly addressed. This presentation will address deliberations of the Alliance for Risk Assessment Panel related to increasing common understanding of the extent of incorporation of mode of action considerations and associated uncertainties in increasingly mode of action informed predictive and chemical specific approaches to dose-response analysis in various tiers

of assessment. The application of internationally agreed criteria in assessing weight of evidence for mode of action-related considerations in dose-response evaluation for various tiers is also considered.

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### **PUBLIC UNDERSTANDING OF SOLAR RADIATION MANAGEMENT AND ITS IMPLICATIONS ON FUTURE RESEARCH**

Geoengineering (or climate engineering) has recently become the subject of serious debate within scientific and political circles. A geoengineering technique called solar radiation management (SRM) is designed to reflect incoming sunlight, with the objective of slowing and partially offsetting greenhouse gas driven climate change. Intentionally manipulating the Earth's climate is very controversial, and to date there has not been a broad public dialog on the use of SRM. Experts assume that the public is unaware of its existence and cannot contribute to the debate. This research provides an international baseline assessment of the general public's awareness and opinions of geoengineering and SRM. An internet-based survey was administered to nationally representative samples in Canada, the United Kingdom, and the United States (n = 2,893). The results suggest that 8% and 45% of the population correctly understand the terms geoengineering and climate engineering respectively, with awareness levels similar across the three countries. On average there was slight support for the use of geoengineering as a solution to global warming, although a substantial share of the population does not yet have an opinion. Distinct supporter and detractor groups were identified. The results have important implications for the role of public engagement in future research programs on high-risk emerging climate technologies.

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### **STUDYING AND IMPROVING RESPONSE TO TROPICAL CYCLONE THREATS: LESSONS FROM THE VIRTUAL HURRICANE LAB**

This presentation reports the initial findings of a program of work that explores the use of realistic hurricane simulations to test how alternative approaches to warning communication affect risk perceptions and preparedness decisions. A prototype simulation is described in which participants experience the approach of a virtual hurricane, where they have the opportunity to invest in different kinds of action to protect their home from damage. As the hurricane approaches participants have access to an "information dashboard" in which they can gather information about the storm threat from a variety of natural sources, including mock television weather broadcasts, web sites, and conversations with neighbors. In response to this information they then have the opportunity to invest in different levels of protective actions. The key feature of the approach is that the simulation allows experimental control



over the nature and format of information that participants see when surfing the web or watching television broadcasts. Findings are reported from an application using 381 residents of central and southern Florida, who made decisions to prepare for a hypothetical 2012 hurricane. The study yielded several unexpected findings, including a tendency for forecast maps that do not have center track lines to induce lower average degrees of worry than those that do among all residents in the uncertainty cone, a “fatigue” effect where reading hypothetical news articles about a previous storm that caused damage also induced lower worry, and a “false survivor” effect in which participants who had experienced hurricanes but suffered no damage expressed the least degree of current during the simulation.

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### **THE CHANGING LANDSCAPE OF CHEMICAL TOXICITY VALUES AND POSSIBLE IMPACTS TO DOD LEGACY SITE CLEANUP**

The Department of Defense (DoD) has developed a three-tiered process called “scan-watch-action” for emerging contaminants. The process (1) identifies chemicals and materials with evolving science or regulatory climate, (2) conducts qualitative Phase I Impact Assessments and quantitative Phase II Impact Assessments, and (3) develops risk management options (RMOs) for chemicals with high risk to people or DoD business functions. This presentation will discuss some of the activities associated with the scanning process; participation by DoD in interagency review of Integrated Risk Information System (IRIS) Toxicological Reviews. Observations and insights from participation in several reviews will be discussed but the topic will be narrowed down to a single chemical class and to one area of impact to DoD. DoD recently participated in a review EPA’s proposed changes in polycyclic aromatic hydrocarbon (PAH) relative potency factors, this presentation will use a case study to show how these changes could affect investigation and cleanup of DoD sites, in this case a former skeet range, contaminated with PAHs.

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### **GAP ANALYSIS METHODOLOGY FOR THE DEPARTMENT OF HOMELAND SECURITY’S BIOTERRORISM RISK ASSESSMENT**

In addition to providing an assessment of the bioterrorism risk faced by the nation, the Bioterrorism Risk Assessment (BTRA) developed by the Science and Technology Directorate of the Department of Homeland Security (DHS) has been used to help identify critical knowledge gaps to inform biodefense research efforts. Gap analysis in the BTRA program uses a two part methodological approach. The first part of this approach is an assessment of the scientific data underlying the BTRA agent-specific data values and assignment of a confidence level to the data in qualita-

tive terms of high, medium, or low. This confidence level assignment is then reviewed by relevant Subject Matter Experts (SMEs) for finalization of the confidence value. Second, parameter impact on BTRA model results is assessed through a series of component model and overall model sensitivity studies. These studies identify those parameters whose value has the greatest impact on model outputs. Critical knowledge gaps are then defined as those parameters for which the confidence in the data is low, but its impact on model output is high. In a similar manner, knowledge gaps for other parameters can be further prioritized by the combination of these two efforts. This methodology is provided as an example of how gap analysis can be performed for set of computational models that serve as individual components of an overall assessment.

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### **THE IMPACT OF CLIMATE CHANGE ON MORTALITY RISK AND IMPACTS ATTRIBUTABLE TO EXTREME HEAT AND COLD IN MAJOR U.S. METROPOLITAN AREAS**

Global mean temperature increases from climate change are expected to result in more frequent and severe summer heat events while future winters are expected to become milder. This could increase the risk of mortality attributable to extreme heat while reducing the risk of mortality attributable to extreme cold in the United States. Here, we present an analysis of the risks and mortality impacts attributable to extreme heat and cold could change in 49 U.S. metropolitan areas as a result of future climate change. This work incorporates site-specific temperature thresholds and mortality response functions for extreme heat and cold developed in the epidemiological literature by Medina-Ramon and Schwartz (2007) into the BenMAP platform. We then estimate temperature-attributable mortality for a range of climate change scenarios from the Climate Change Division (CCD) at the US EPA as part of a larger analysis of climate impacts. First, we evaluate mortality events within a metropolitan area using its own threshold temperature and mortality response function. Second, we consider the implications of baseline conditions and acclimatization/adaptation on the present day relationships by estimating the mortality responses for each location assuming the thresholds and mortality responses for every other urban center. For example, the range of the hot temperature thresholds (21.1°C to 32.2°C) as well as the cold thresholds (9.4°C to -17.2°C) shows the potential for significantly different regional responses for temperature related mortality. As another sensitivity analysis, different “seed” years are used to reflect observed weather variability. In addition, we estimate other metrics to demonstrate the impact of climate change including: changes in temperature distributions (e.g. number of days above a threshold); changes in mortality over time for a location; and, the net effect of a warming climate increasing heat mortality risk while decreasing cold mortality risk.



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### **THE ECONOMICS OF ENVIRONMENTAL RECLAMATION FOR SHALE GAS DEVELOPMENT IN PENNSYLVANIA**

Improperly abandoned oil and gas wells threaten human health and safety as well as pollute the air and water. In the next twenty years, tens of thousands of new gas wells will be drilled into the Marcellus, Utica, and Upper Devonian shale formations of Pennsylvania. Pennsylvania currently requires production companies to post a bond of \$2,500 per well, but the size of the bond covers only a small fraction of the site reclamation costs, which may be in the vicinity of \$100,000. The economics of shale gas development favor transfer of assets. However, there is no mechanism to prevent the new owners from assuming reclamation liabilities beyond their means. Historical data are used to estimate existing liabilities and econometric models are employed to project future reclamation costs and gas production revenues under uncertainty. An operator's decision to transfer, plug, or produce from an existing well is evaluated by considering the internal and external factors impacting shale gas economics. The current regulatory requirements for financial assurance do not incentivize regulatory compliance and may leave future generations with a large environmental burden. Alternative policy remedies are evaluated.

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### **CHALLENGING EXPOSURE PRIORITIZATION APPROACHES**

New efforts to manage chemical risks call for high-throughput hazard information to be interpreted in the context of screening level exposure information. Unfortunately, the exposure scenarios associated with many chemical products are not well characterized by simple approaches to exposure assessment. Therefore, the task of prioritizing tens of thousands of chemicals calls for new and creative techniques in decision making under high uncertainty. While refined estimates of exposure are determined through linked models across the source to exposure continuum, a key challenge to developing new models and approaches exists in establishing which information sources, criteria and metrics to use in factoring exposure into prioritization schemes at a screening level. In April 2009, the USEPA issued an exposure based prioritization challenge to several exposure modelers. In this study a gap analysis of these efforts was conducted to elicit the expert judgment of the proprietary modeling efforts. The gap analysis evaluates the assumptions, defaults, relevant data sources, and decision criteria used to rank the given set of 'challenge' chemicals. Based on a set of benchmarking chemicals, an expected performance level is determined for each model, and then used as a basis for comparison. The overall gap analysis of the models addresses critical modeling components in the linked processes across the source

to exposure continuum: emissions, fate and transport, distribution (i.e. concentration in environmental media) and exposure due to human activities and usage patterns. A preliminary analysis leads to insights regarding the factors driving the ranking results despite uncertainty. This data is being used for (1) development of a multi-criteria decision model to combine disparate exposure metrics to establish rankings. Future work will involve a value of information analyses assess the importance of the various types of information as they relate to risk rankings within a priority setting decision framework.

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### **BAYESIAN DATA COMBINATION FOR BENEFIT TRANSFER**

In recent years a variety of Bayesian modeling approaches have been proposed for the efficient utilization of existing data sets and / or study results to inform and guide new policy designs. Let the term "study" be synonymous with a single original data set or aggregate estimate. Then the key question that prompted these Bayesian advances can be stated as: "Which study or set of studies should be used to inform the policy context?" Examples include hierarchical modeling, which considers all original sources to be connected via a pre-specified statistical umbrella framework (e.g. Smith et al. 1995, Moeltner et al., 2007). Related versions relax this explicit connectedness by allowing multiple underlying hierarchies (Mukhopadhyay & Gelfand, 1997), or separate hierarchies for subsets of coefficients (Dunson et al., 2008). A different strand proposes Bayesian model averaging algorithms that derive probabilities for each study as to its poolability with any other study, including the policy context (Leon-Gonzalez & Scarpa, 2008, Moeltner & Rosenberger, 2008). Final inference is based on a weighted distribution of results from all possible study combinations that are deemed compatible with the policy context. The aim of this paper is to provide a synthesis and critical comparison of these methods as to their suitability for policy guidance when the underlying source data flow from choice experiments (CEs), a common elicitation tool in marketing and - more recently - environmental valuation. To date, there exists little guidance as to which avenue of combining CE data is the most promising for information (or "benefit") transfer. We compare existing Bayesian methods based on accuracy, computational complexity, and their reliance on primary data for the policy context.

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### **ADVANCING PROBABILISTIC RISK ANALYSIS BY ENHANCED TREATMENT OF COMMON CAUSE FAILURES: A MECHANISTIC PERSPECTIVE**

This presentation focuses on modeling dependent failures, specifically Common Cause Failures (CCFs), one of the crucial topics in advancing Probabilistic Risk

Analysis (PRA). Existing parametric approaches for CCF modeling are reliant on the availability and quality of historical failure data and are inadequate in tracking CCFs to their root causes. Therefore, they are insufficient for (a) preventing CCFs in current operating plants and (b) risk-informed decision making in design stage. It is proposed that better treatment of CCFs requires: (1) Developing “theoretical” foundations for depicting the underlying failure mechanisms of the elements of risk scenarios (i.e. hardware failures, human errors, organizational failures, software faults, and external physical environmental events) in order to identify the root causes and phenomenology of dependencies, (2) Applying appropriate “modeling techniques” (e.g., Bayesian causal modeling) in order to explicitly and quantitatively relate the root causes in the failure mechanisms to the top events and, consequently, to the accident sequence models and (3) Applying more advanced data-driven approaches, consistent with the nature and availability of the data, in order to “empirically” deal with dependencies (in situations where it is difficult to model the root failure mechanisms any further). The focus of this research is to improve CCF modeling by incorporating the underlying physical failure mechanisms (and their interactions as vital sources of CCFs) or the Probabilistic Physics of Failure (PPOF) into PRA, covering both the required theoretical mechanistic perspective (referring to item #1) and modeling techniques (referring to item #2). In addition to contribution to PRA, this line of research will also make a scientific contribution to other engineering domains as it will build a foundation for modeling the interactions of multiple failure mechanisms, something lacking in design of energy-efficient systems.

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### **A UNIFIED SYSTEM BIOLOGY DATA INTEGRATION BY USING A MODIFIED JDL FRAMEWORK**

Faratian et al. (2010) in “System Biology in Drug Discovery and Development: Methods and Protocols,” *Methods in Molecular Biology*, volume 662, stated that “Cancer is a complex heterogeneous disease, not only at a genetic and biochemical level, but also at a tissue, organism, and population level. Multiple data streams, from reductionist biochemical in vitro to high throughput - omics from clinical material, have been generated with the hope that they encode useful information about phenotype and, ultimately, tumour behaviour in response to drugs.” From an environmental public health perspective, generation of large scale system biology datasets can have a significant functional role in the near future in protecting public health if and when those datasets are analyzed in an integrated fashion to further understand key events of chemicals leading to different health outcomes. Simply generating large voluminous datasets won't be useful for the purpose of public health genomics and risk assessments. In this regard, a modified Joint Director Laboratory (JDL) Data Fusion based Human Health Risk Assessment (HHRA) framework was developed. This

DF-HHRA framework was developed based on our review of specific short-term and long-term recommendations in the National Academy of Sciences (2009) Silver Book chapter five, “Towards a Unified Approach to Dose-Response Assessments”. We are further exploring issues surrounding spatial and temporal data and evaluating various DF extension techniques and how effectively those datasets can be integrated in the context of DF-HHRA framework. One of our project objectives is to develop a DF facilitated informatics platform as a tool to conduct these integrated cancer and non-cancer risk assessments. Such an approach of multiple model DF analysis and application of different DF extension techniques would be appropriate for multiple datasets representing complex relationships among different biological organizational levels.

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*RTI International*

### **AN INTEGRATED DECISION SUPPORT SYSTEM FOR FOOD SAFETY RISK MANAGEMENT**

In a society with limited resources, decisions about resource allocation need to be made in a consistent manner, with the goal of maximizing benefits and reducing risks while considering associated costs. Such a system must be data driven and public-health focused, but it must also consider other significant components beyond public health that inform the food safety decision-making process including economic considerations, societal factors, and public perception, among others. While acknowledging that such multi-dimensional comparisons are challenging, the lack of a systematic approach to such decision making can result in unwanted outcomes, from a decrease in public trust to unintended consequences in the marketplace, the environment, society, and the political realm. This project was undertaken to address the need for a systematic approach to risk-based decision making process. We developed a “proof-of-concept” Integrated Decision Support System (iDeSS) for food safety risk management that includes a central relational database that houses data on hazards, food commodities, and consumers and four individual modules for ranking hazard-commodity pairs based on risk factors related to public health, prioritizing high risk hazard-commodity pairs based on multiple decision criteria other than public health, evaluating mitigation options for high priority hazard-commodity pairs with respect to their costs and impacts on risk, and optimizing the process of resource allocation among available mitigation options. iDeSS enables decision makers to evaluate the food safety system in a comprehensive way and to follow a systematic process for evaluating food safety problems. iDeSS also offers a number of features that are critical in developing a decision support system including data-driven results, stakeholder involvement, transparency, flexibility, availability of multiple decision criteria, support for scenario evaluation, and optimized allocation of available resources.

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*Battelle Memorial Institute, DHS CSAC*

### **CHEMICAL SUPPLY CHAIN INCIDENT MODEL FOR HUMAN HEALTH CONSEQUENCE ESTIMATES**

Chemical incidents, such as the methyl isocyanate incident in Bhopal, India, the hydrogen sulfide incident in Chongqing, China, and the chlorine rail car accidents in Graniteville, South Carolina have demonstrated consequences of releases along the chemical supply chain (CSC). Additionally, media hype combined with exaggeration or misinterpretation of consequence assessments may increase the likelihood of a terrorist attack on chemical industry. In response, the Chemical Security Analysis Center of the Department of Homeland Security has developed the Chemical Infrastructure Risk Assessment to quantify the risks associated with terrorist attacks on the CSC. In order to quantify risk, human health consequences were estimated from releases and subsequent dispersion of toxic industrial chemicals from targets, such as chemical production facilities, bulk highway transport vehicles, rail cars, barges, and pipelines. To that end, an outdoor inhalation consequence model that incorporates key aspects of source terms, plume dispersion, meteorology, population modeling, and release location was developed. High resolution geographic information systems (GIS) population density and land usage data (e.g., roads, rail lines, and navigable waterways), combined with a predictive meteorological map capable of estimating the likelihood of meteorological conditions, allowed for accurate location of CSC releases and the overlaying of dispersion plumes on populations to calculate human exposures. Dispersion plumes were extracted from Hazard Prediction Assessment Capability software using an interpolative lookup table algorithm that dynamically created a library of exposure isopleths over a range of continuous and discrete dimensions. The general framework allows for many future applications, such as estimating the risk along an entire rail-line or reduction in risk caused by new policy restricting on tanker trucks carrying hazardous materials around specific urban areas.

M2-I.4 Morgan KM, Spire C, Golden N, Zablotsky-Kufel J, Cole D, Hoekstra M; kara.morgan@fda.hhs.gov

*US FDA*

### **INTRODUCTION TO THE INTERAGENCY FOOD SAFETY ANALYTICS COLLABORATION**

A combination of the great uncertainty surrounding information about attribution and the importance of this information to inform and evaluate risk-based decision making at the regulatory agencies has led to a shared interest among federal agencies in having defensible attribution information. In order to focus the work of the collaboration, each agency wrote a statement of needs for attribution. The areas of overlap among the three agencies were identified as the priority areas for IFSAC

to focus on. This session will provide background on the development of IFSACE, and review the Strategic Plan developed to describe the needs and the proposed path forward.

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*Environmental & Occupational Health Sciences Institute*

### **PHYSIOLOGICALLY BASED TOXICOKINETIC MODELING OF ZEARALENONE AND ZERANOL: ESTIMATING DIETARY EXPOSURE AND TOXICITY FOR INDIVIDUALS AT RISK**

Zearalenone (ZEA) and its metabolite zeranol (ZAL) are fungal contaminants present in food crops and are known to be estrogen agonists. A novel Physiologically Based Toxicokinetic (PBTk) model for zearalenone and zeranol and their primary metabolites zearalenol and zearalanone in urine has been developed for humans with the help of mechanistic data and parameter values from the literature. Zearalenone, a mycotoxin produced by *Fusarium* fungi is a widespread contaminant in grains, fruits, vegetables, and their products or by carryover to animal tissues, milk, and eggs after intake of contaminated feedstuff. Exposure to zearalenone has been estimated from daily intake values for different dietary habits in the population. Zeranol, which is a metabolite of zearalenone in mammals, and is 5-6 times more potent than estrogen, is also added as a growth additive in beef in the US and Canada. The combined exposure to both compounds from dietary intake has been estimated based on dietary data of USA across various population segments and their toxicokinetics has been modeled in humans. The PBTk model considers oral intake doses received through daily food intake and explicitly models the metabolism in the gastrointestinal and hepatic systems causing changes in the final cumulative toxic effects. Metabolic events like dehydrogenation and glucuronidation, which have direct effects on the accumulation and elimination of the toxic compounds, have been quantified. The model uses *in-vitro* metabolic data and applies them to the whole body model based on individual hepatic enzyme contents. The PBTk model considers urinary and fecal excretion and biliary recirculation and compares the predicted biomarkers of blood, urinary and fecal concentrations with published experimental results. The model developed here can be used for better understanding the health effects due to daily dietary exposure to *Fusarium* mycotoxins, especially in pre-pubertal females.

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### **PERCEIVED RISKINESS AND WTP OF FOUR TERRORIST THREATS**

A 2009 national telephone survey of 924 U.S. adults focused on perceptions of terrorism/homeland security issues. Respondents rated severity of effects, level of understanding, number affected, and likelihood of four terrorist threats: poisoned water supply; explosion of a small nuclear device; an airline attack similar to 9/11; and



explosion of a bomb in a building, train, subway, or highway. Respondents rated the Perceived Riskiness and WTP for dealing with each threat. Demographic, attitudinal, and party affiliation data were collected. Psychometric variables were far stronger predictors of both Perceived Riskiness and WTP than were demographic ones. For Perceived Riskiness, the adjusted R-squared for regression models using demographic variables as predictors ranged from .06 to .11. For each threat, White Male status was a significant negative predictor; Evangelical status was a significant positive predictor. The adjusted R-squared values for models with psychometric predictor variables - Severity, Understood, Number Affected, and Likelihood -ranged from .49 to .61. All four predictors were significant for each threat, with one exception. For WTP, the adjusted R-squared using demographic variables ranged from .02 to .07. White Male status was a significant negative predictor and Evangelical status was a significant positive predictor for each threat; Education Level was a significant negative predictor for three threats. The adjusted R-squared for models using psychometric predictors were higher, ranging from .29 to .41. All four psychometric variables were significant predictors for each threat. A model predicting WTP as a simple function of Perceived Riskiness was statistically significant, ranging from .22 to .34 across threats. A model that combined Perceived Riskiness and the four psychometric variables further improved the ability to predict WTP. Adding the demographic variables did not appreciably improve prediction.

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*US Food and Drug Administration (FDA)*

### **MULTI-ATTRIBUTE ASSESSMENT METHOD FOR PHARMACY COMPOUNDING**

Pharmacy Compounding (PC) is the combining, mixing or altering of a drug by a pharmacist, based on a prescription, to create a new drug that meets a medical need for a patient. PC serves patients by allowing those with allergies to drug ingredients or other medical needs to take medications that they would otherwise be unable to use. Producing a drug outside of a pharmaceutical manufacturing facility can introduce uncertainties in the quality of the product. A portion of the uncertainty is likely due to variability in both the level of training of pharmacists and the adequacy of the facilities used to produce compounded drugs. The variabilities among pharmacists and facilities can make compounded drugs susceptible to quality issues such as incorrect potency, lack of content uniformity, or contamination with bacteria or endotoxin. FDA's mission includes protection of the public by minimizing consumer exposure to unsafe, ineffective, and poor quality compounded drugs. To this end, FDA is developing risk management strategies for allocating program resources to compounding practices that entail the greatest risks to the patient. To provide a uniform framework for prioritizing compounding issues, a multi-attribute assessment method was

developed through the elicitation of PC experts within the U. S. Food and Drug Administration. The Pharmacy Compounding Assessment Model (PCAM) is a multi-attribute method that integrates expert judgment to prioritize incoming pharmacy compounding cases based upon the scoring of several attributes perceived by PC experts to be indicative of potential risk within a pharmacy compounding scenario. The utilization of PCAM will aid pharmacy compounding regulators by providing a consistent and objective methodology to better inform resource allocation, which will improve the ability to protect public health. Disclaimer: This paper reflects the views of the author and should not be construed to represent FDA's views or policies.

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*INERIS*

### **DECISION AID PROCESS IN RISK MANAGEMENT - FROM THE CONDUCT OF THE EXPERTISE PROCESS TO ITS GOVERNANCE**

The analysis and management of risks in the field of safety, security and environment are complex issues on which the conduct of public expertise is subject to strong stakes. This paper addresses the issues of the understanding, the support and the governance of public expertise process and public decision-making process through research done on risk prevention of major technological accidents. Our onboard research approach has allowed us to see what decision support tools could accompany the expertise process and, thus, the decision-making process. We have shown what it necessary, in areas with strong issues such as risks management, to dispose of methodological approaches to better understand the conditions of expertise and the emergence of recommendations. Opening expertise process to society also allowed us to explore the different modes of participatory governance and propose steps for the design of participatory structures. Different case study (e.g. Seveso high threshold plants, nanotechnologies,...) have enabled us to highlight the different tensions, constraints and biases to which the conduct of expertise is subject.

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*Johns Hopkins University*

### **COMPARABILITY OF TOXICOLOGICAL EVALUATION FRAMEWORKS FOR VETERINARY AND HUMAN PHARMACEUTICALS AND ENVIRONMENTAL CHEMICALS FOR FOUR FEDERAL PROGRAMS**

The US population is routinely exposed to numerous naturally-occurring and anthropogenic compounds, often as a result of their uses in industry and agriculture. These compounds, which include commercial chemicals, pesticides, veterinary drugs and other substances, are regulated by different offices of the Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) under different legal authorities. As a result, differing approaches for toxicity evaluation employed by the varying programs may lead to inconsistencies in levels of public health protection across types of chemicals. The purpose of this project is to characterize and contrast



methods used by FDA and EPA to evaluate drug and chemical toxicity in humans in order to foster rigor and transparency in regulatory decision making. We will briefly describe existing data on US population exposure to commercial chemicals, pesticides, human and veterinary drugs. We will compare toxicity assessment procedures for these chemical types through document review and interviews with Agency personnel. We will present project findings and recommendations for a unified set of principles for safety evaluation of substances.

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*Advanced Industrial Science and Technology (AIST)*

### **PROPOSAL FOR AN OCCUPATIONAL EXPOSURE LIMIT OF CARBON NANOTUBES BASED ON THEIR RISK EVALUATION**

The risk evaluation associated with carbon nanotubes (multi-, double- and single-walled) was carried out for the purpose of deriving the occupational exposure limit (OEL) and making a model framework to assess risks from emerging technology. The OEL is derived from rat toxicity studies including inhalation exposure tests and intratracheal instillation tests in which the inflammation is taken as a toxicity endpoint, and biokinetic study of retained carbon nanotubes (CNTs) in the rat lung. To obtain the general biological effects caused by CNTs, various simplified tests and estimation methods were applied. Among them, the most representative one is the biaxial approach. Using this approach, we revealed that the biological activity due to CNTs is strongly dependent on their BET specific surface area irrespective of multi-walled, double-walled or single-walled CNTs. In other words, the distinction of multi-walled CNTs from single-walled CNTs is not significant. Therefore, we proposed one value of OEL of 0.03 mg/m<sup>3</sup> irrespective of CNT classification, which should be applied according to the specific surface area of CNTs. In addition, we examined and discussed the possible causal relationship between cancer and CNT exposure. Although we cannot arrive at a distinct conclusion at present, the experimental results we have obtained to date are consistent with our working hypothesis that CNT exposure increases the incidence of cancer after prolonged severe inflammation due to massive exposure. Considering such situation, we proposed the OEL as a period-limited one for about ten years, which should be reviewed after about ten years, and wrote it in the notation of OEL(PL).

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### **TRUST IN ORGANIZATIONS RELEVANT TO THE TOHOKU EARTHQUAKE AND TO THE CRISIS AT THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT**

The Tohoku Earthquake caused over 15,000 deaths, and more than 8,000 are still missing. It also caused the ongoing crisis at the Fukushima Daiichi nuclear power

plant. The massive damage resulting from the earthquake and the chaos caused by the power plant crisis seemed to destroy the public's trust in the risk managers relevant to these issues. The purposes of this study are to clarify the levels of public trust in the organizations relevant to the issues and to examine the primary factors defining the levels of trust. One thousand and thirty adults in Japan participated in the survey. They were asked to evaluate their trust in, value similarity to, competency of, and motivation of six organizations using three items for each factor on five-point Likert scales. The results of the mean ratings showed that the least trusted organization was Tokyo Electric Power Company (TEPCO), which runs the Fukushima Daiichi nuclear power plant, followed by the Nuclear and Industrial Safety Agency (NISA), which is responsible for the administration of nuclear safety issues. The Meteorological Research Institute, which is the national agency studying the tsunami forecast was rated the highest of the six, followed by the East Japan Railway Company, which was forced to suspend operations, causing millions to have to walk long distances home. The Earthquake Research Institute of the University of Tokyo and the Food Safety Commission were in the middle. Intuitively, the expectation would be that TEPCO and NISA lost public trust due to the lack of competency in resolving the accident. The results of structural equation modeling revealed, however, that their path coefficients from value similarity to trust were the greatest of the six. The negative correlation between the mean trust and path coefficients in the organizations was extremely high. The implication of the findings is clear: The more trust is destroyed, the more value similarity matters.

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*Toxicology Excellence for Risk Assessment*

### **SHIPWRECKED: FINDING THE LIFE RAFT OF KNOWLEDGE FOR RISK ASSESSMENT**

Risk assessment is comprised of a diverse sea of experts. While certain areas of expertise may be emphasized for different issues or applications, the effective application of risk assessment to aid in problem solving and decision making is a multidisciplinary effort. While experts may be familiar with multiple aspects of the National Academy of Sciences risk assessment paradigm, no one person can be an expert in all relevant areas. Therefore, collaboration among people with complementary expertise can often provide added value in risk assessments. The NAS (2009) framework illustrates the diversity of knowledge needed for a purpose-focused risk assessment. In addition to hazard characterization, dose-response assessment, exposure assessment, and risk characterization, the framework highlights the importance of problem formulation, risk communication, and decision analysis. Consideration of the framework and underlying issues allows the identification of key knowledge areas for different aspects of the risk assessment paradigm. Using the NAS risk paradigm, an educational model was developed to allow risk assessors to assess their knowledge base and construct a curriculum to better fit their needs in risk assessment.

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*Gradient*

### **EVALUATING BIPHASIC DOSE-RESPONSES IN NANOTOXICOLOGY ASSAYS**

The term hormesis describes a dose-response relationship that is characterized by a response that is opposite above and below the toxicological or pharmacological threshold. Previous reports have shown that this relationship is ubiquitous in the response of pharmaceuticals, metals, organic chemicals, radiation, and physical stressor agents. Recent data suggest that various nanomaterials may also exhibit a hormetic dose-response. This analysis quantifies the parameters of the hormetic biphasic dose-responses (e.g., width and magnitude of stimulation) in various nanotoxicology studies. This methodology is useful in characterizing screening assays that attempt to parse the observed toxicological dose-response data into categories based on the magnitude of the response. For example, these methods may be used to quickly identify NP induced hormetic responses that are either desirably enhanced (e.g., neuronal cell viability) or undesirably stimulated (e.g., low dose stimulation of tumor cells).

W4-I.5 Neumann JE, Martinich J, Hudgens D, Emanuel K, Ravela S, Kirshen P, Bosma K, Ludwig L, Herter J; jneumann@indecon.com

*Industrial Economics, Incorporated, Climate Change Division, USEPA, WindRiskTech, Battelle Memorial Institute, Woods Hole Group, Independent Consultant*

### **ASSESSING THE ECONOMIC IMPACT OF CLIMATE CHANGE INDUCED SEA LEVEL RISE AND STORM SURGE IN THE U.S.**

Sea-level rise (SLR) from thermal expansion and melting of large ice sheets under business as usual greenhouse gas (GHG) emission scenarios increases the risk of permanent inundation of coastal lands and structures. In previous work, we developed the National Coastal Property Model, a spatially comprehensive model of the US coastline. We found economic impacts of permanent inundation of more than \$63 billion cumulative discounted cost (at 3%) for a 68 cm SLR by 2100, and \$230 billion undiscounted. The values from permanent inundation alone, however, may still under estimate the true risk as SLR also increases the risk of damage from surges from periodic storms. Presently, no comprehensive, dynamic estimates of the joint impact of SLR and storm surge exist for the US. In this work, we extend our National Coastal Property Model to incorporate storm surge, and apply it to the EPA stabilization scenarios developed for this symposium. Our approach first involves simulating storm generation activity over the 21st century and using the generated wind fields to drive NOAA's Sea, Lake, and Overland Surge from Hurricanes (SLOSH) model. We use SLOSH to generate cumulative density functions (CDFs) of storm surge height at selected locations along the U.S. coastline. Next, we calculate the expected value dollar damages associated with the simulated storm surge CDFs, translating the storm surge CDF to a damage CDF using the elevation, property value, and coastline

data in the existing coastal property model, along with US Army Corps of Engineers flood level-damage relationships. Finally, we evaluate the adaptation response (i.e., abandon, armor, nourish, elevate) to the joint risks presented by SLR and storm surge and estimate the cost of this response. Preliminary results suggest that incorporating storm surge risk increases estimates of the economic impacts of SLR by a factor of three to five.

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*Linnaeus University*

### **UNCERTAINTY IN MULTIMEDIA MASS-BALANCE MODELS: AN EVALUATION BY FUZZY ARITHMETIC AND PROBABILITY BOUNDS ANALYSIS**

Multimedia mass-balance models are instrumental in chemical risk and safety assessment. The key compound related properties in such models describe partitioning between media and persistence (environmental half-lives). Uncertainty in determining these properties can be separated into random and systematic components, requiring different types of representation. Here we evaluate two approaches that are suitable to treat also systematic errors; fuzzy arithmetic and probability bounds analysis. When a best estimate and a range can be computed for an input parameter, then it is possible to characterize the uncertainty with a triangular fuzzy number (possibility distribution) or an equivalent probability box bound by two uniform distributions. We have applied empirical and estimation data for a number of well-known environmental pollutants in a Level I and II equilibrium criterion model, as illustrative cases for this evaluation. Propagation of uncertainty by discrete probability calculus or interval arithmetic can be done at a low computational cost and gives maximum flexibility in applying different approaches. Our evaluation seems to suggest that the difference between fuzzy arithmetic and probability bounds analysis is small, at least for the specific cases investigated. The fuzzy arithmetic approach is, however, less conservative than probability bounds analysis if the assumption of independence is removed. Both approaches are sensitive to repeated parameters that may inflate the uncertainty estimate. Uncertainty described by probability boxes was therefore also propagated through the model by Monte Carlo-simulation to show how this problem can be avoided.

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*Department of Homeland Security, National Cyber Security Division*

### **IDENTIFYING AND MANAGING NATIONAL-LEVEL CYBERSECURITY RISK**

This presentation will introduce a top-down approach to cyber infrastructure risk assessment and management, describes the approach that DHS's NCSA leverages in its engagement with critical infrastructure and key resources (CIKR) sectors, and discusses why managing cybersecurity risks is an increasingly critical activity for

organizations, sectors, and the Nation. As the cybersecurity discipline has become a key focal point of national and homeland security discussions, CIKR sector entities and governments at all levels have increased their demand for understanding cyber risks. In response, the National Cyber Security Division has leveraged its unique public-private sector partnership role as a mechanism for establishing approaches to highlight national-level cybersecurity risks and concerns. The presentation will define cyber infrastructure, describe a top-down, functions-based approach to risk management, explain why this approach is best suited for the virtual and distributed nature of cyber infrastructure, and explain why organizational risk management approaches are needed to inform a national-level approach to cybersecurity risk management. The presentation will draw upon recent national-level risk management efforts including the National Infrastructure Protection Plan (NIPP) implementation and the Information Technology Sector Baseline Risk Assessment. It will also describe the Cybersecurity Assessment and Risk Management Approach (CARMA), which is a national-level approach to cyber risk management that can initiate sector, sub-sector, regional, or State and local strategic cyber risk management efforts. CARMA consists of five stages and can integrate into established cyber risk management frameworks or be used as a foundation for a broader risk management framework. The processes and outputs specific to each stage can be used to scope, identify, and address cyber risk at the national-, sector-, or enterprise-level.

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*Transport Canada*

### **RISK MANAGEMENT: THE HEART OF THE TRANSPORT DANGEROUS GOODS PROGRAM**

Each year, products identified as dangerous goods are transported across Canada by road, rail, water and air. Shipments of dangerous goods range from industrial chemicals to manufactured goods and, while indispensable to our modern way of life, can pose a threat to life, property and the environment if not handled safely. The Transport Dangerous Goods Directorate's legislated mandate is to promote public safety in the transportation of dangerous goods, and its activities reflect the requirements of the Transportation of Dangerous Goods Act, 1992. The Transportation of Dangerous Goods Regulations, adopted by all provinces and territories, establish the safety requirements for the transportation of dangerous goods. Federal and provincial legislation provide for the regulation of an extensive list of products, substances or organisms classified as dangerous. This presentation provides an overview of risk management at the Transport Dangerous Goods (TDG) Directorate of Transport Canada. The organization, its activities, its approach to risk and future challenges are discussed. The quantities of dangerous goods freight transported in Canada and the number of dangerous goods accidents to be reported under the TDG Regulations are presented to give an overall perspective. A few risk analyses are also mentioned.

Risk management and the underlying risk analyses bring the knowledge to develop policies, regulations and standards and leads to the continuous improvement of the Transportation of Dangerous Goods program and therefore public safety.

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*National Institute of Advanced Industrial Science and Technology*

### **EXPOSURE ASSESSMENT FOR AMBIENT HEXAVALENT CHROMIUM (CR(VI)) IN JAPANESE INDUSTRIAL AREA**

Airborne hexavalent chromium (Cr(VI)) is a known human respiratory carcinogen. Cr(VI) inhalation risk for the general population has been of great concern and its characterization is important. The goal of this study is to assess the risk of ambient Cr(VI) for general population and identify the mass of high risk sub-population(s). The authors improved and evaluated Cr(VI) sampling and analysis procedures, and measured ambient Cr(VI) in Japanese industrial area. A low-volume air sampler was used for sampling with an alkaline (potassium hydrogen carbonate)-treated hydrophobic polytetrafluoroethylene (PTFE) filter, that was designed to prevent Cr(VI) reduction. Field spike-recovery tests typically demonstrated over 80 % recovery of Cr(VI) and no inter-conversion of valence (reduction to trivalent chromium) occurred. The limit of detection (LOD) was 0.02 - 0.1 ng per cubic meter, which corresponds to 0.4- 2 ng per filter, by this method. This LOD is lower than U.S. EPA's  $10^{-5}$  risk level, which is corresponding to 0.83 ng per cubic meter. The ambient air sampling was conducted in the spring and autumn of 2009, at industrial area of Tokyo metropolitan where some dozen of small chromium plating factories in operation. Population density of the area was eleven thousand persons per square kilometer. The Cr(VI) concentration was up to 0.4 ng per cubic meter, which was less than  $10^{-5}$  risk level. Next, ambient Cr(VI) concentration in that area was estimated by an atmospheric dispersion model. Cr(VI) emission factors were characterized on electroplating (hard chromium and decorative chromium) factories and municipal solid waste incinerators. Estimated Cr(VI) concentration was less than 0.1 ng per cubic meter. The estimated results were consistent with measured concentration.

M2-D.2 Orosz MD, Southwell C, Chen J, Maya I, Chatterjee S, Salazar D, Southers E; mdorosz@isi.edu

*University of Southern California*

### **A PORT SECURITY RISK ANALYSIS AND RESOURCE ALLOCATION SYSTEM - FROM TACTICAL TO STRATEGIC**

Seaports, airports, and other transportation nodal points face many challenges - including maximizing operational efficiency, minimizing risk from terrorism or other man-made and natural disaster events and minimizing impacts to the environment. Often these challenges are at odds with one another - increasing one often comes at the expense of achieving others. For example, in a seaport environment, increasing port security by adding additional container inspection stations often causes a



corresponding slowdown in container movements throughout the port - negatively impacting both the economy and the environment. The challenge is finding the right balance between operational efficiency, security, safety, and the environment. The University of Southern California's National Center for Risk and Economic Analysis of Terrorism Events (CREATE) has responded to this need and is developing Port-Sec - Port Security Risk Analysis and Resource Allocation System. Under funding from DHS S&T and in collaboration with the Ports of Los Angeles and Long Beach (POLA/LB) and the USCG, a USC team is developing a system that provides port security personnel the tools and methods that will allow them both tactically and strategically address port security risk, needs and concerns. Tactically, there is a need to adjust in near real-time resource allocations to maximize security (i.e., reduce risk from an attack) while simultaneously minimizing impact on day-to-day operations and the environment. Strategically, there is a need to forecast the impact that future facility expansions and new technologies will have on operations, security, safety, and the environment. A demonstration prototype PortSec system capable of providing tactical analytical support is undergoing evaluations by POLA/LB security personnel. The system is currently being extended to support incident commanders during event responses.

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### **PRACTICAL TOOLS FOR PRIORITIZING FOOD SAFETY PROJECTS AND RESEARCH**

There is a need for risk-based approaches that integrate sound science with information technology to appropriately manage food safety risks and determine appropriate research priorities. However, these approaches must be practical in two important respects. First, they must recognize that data gaps are inevitable and that tools must be flexible enough to consider both expert judgment and readily available data. Second, they must be accessible to risk managers to ensure that the decision making process is intuitive and reproducible. Thus, the selection of qualitative, semi-quantitative, and quantitative approaches to risk ranking and risk prioritization may well depend on the risk manager's familiarity and experience with decision support tools, as well as the need to incorporate expert judgment to address specific data gaps. In addition, the practicality of the approach depends on specific risk management objectives. Whereas risk ranking methods typically compare threats to public health, risk prioritization methods often involve multi-factorial techniques that consider a broader array of decision attributes (in addition to public health risk) that might influence the prioritization including, but not limited to, cost burden of the outbreaks, public perception, feasibility of controls, impact on the industries, and trade impact. This presentation will summarize the landscape of practical approaches to determine food safety research priorities, discuss the strengths and weakness of various approaches,

and offer some thoughts as to how these types of approaches can be used effectively to establish research priorities that meet risk management goals.

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### **FROM SHEDS TO SHEDS-LITE: DEVELOPMENT OF AN EFFICIENT HUMAN EXPOSURE MODEL**

The performance of an EPA exposure modeling system was evaluated for its applicability to the prioritization of 52 "Challenge" chemicals on the basis of exposure. EPA is interested in expanding this and other tools to prioritize thousands of chemicals under a new multi-level targeted testing research program for managing chemical risk. The Stochastic Human Exposure and Dose Simulation (SHEDS) models represent a family of higher tiered models that simulate realistic distributions of human exposure to different chemicals through the daily activities of representative populations. In evaluating the list of chemicals it was determined that the SHEDS model would be applicable for several but not all of the chemicals. The probabilistic SHEDS model in its current form requires considerable input data and/or parameters. The availability of the required data can be especially problematic for new chemicals with new pathways of exposure not explicitly considered currently by SHEDS. SHEDS in its current form is structured around using human activity patterns from the general population; additional scenarios will be developed for industrial or special populations. A key advantage to the model is the ability to readily address both near and far field exposure considerations. Additionally, generalized exposure estimates are possible in SHEDS by grouping chemicals with similar properties and usage patterns. Feasible categories for this type of modeling configuration of SHEDS are industrial/occupational, plastics, commercial additives, pesticides/herbicides and natural risks. Specific chemicals by category will be mentioned during the presentation. We will briefly describe an on-going activity regarding the development of a more efficient and broadly applicable exposure-based screening and prioritization modeling tool "SHEDS-Lite" for future applications.

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### **REVIEW OF RISK ANALYSIS USE IN DEPARTMENT OF DEFENSE (DOD) ACQUISITION**

Risk analysis is involved in all stages of all DoD acquisition programs. These programs, intended to resolve specific gaps in joint military capabilities, require a comprehensive Analysis of Alternatives (AoA) prior to their approval. Risk analysis is used in AoA considerations to help identify the most cost-effective solution that meets capability requirements, and to establish parameter objectives in the Acquisition Program Baseline (APB), that will guide the acquisition approach. Following the



AoA, from project development to implementation and sustainment, risk analysis is used to help refine strategies to meet initial parameter objectives. Currently, acquisition programs experience frequent cost and schedule overruns due, in part, to shortcomings in cost, schedule, and technical performance risk analysis methods used to define and adhere to the APB. To address increased fiscal constraints, Congress and the Office of the Secretary of Defense are requiring more rigorous analytics prior to program approval to limit deviations from cost and schedule objectives. These requirements have forced the investigation of improved risk and trade space analysis methods to establish a better-informed APB and limit deviation from parameter objectives. This presentation will begin with a contextual overview of risk analysis in DoD acquisition programs, and will follow with an elaboration on current risk and trade space analysis methodologies. It will conclude with a discussion of shortcomings that have been identified in these methodologies, and the problems they pose in the context of the program lifecycle.

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### **TOO BIG OR NOT TOO BIG? THAT IS THE SYSTEMIC RISK QUESTION!**

This research examines the extent and implications of the systemic exposures of US financial institutions by determining their sensitivities to systemically important variables. These sensitivities are tracked over the 40 quarters to determine the differences and similarities between and among the largest and the rest of the financial institutions. It covers the largest 35 US BHCs as well as about 500 smaller US BHCs. In addition, it covers the possible exposures from about 250 hedge funds as well as a handful of large non-US financial institutions. This paper compares the extent of systemic risk exposures of the largest BHCs over the past decade, with specific reference to the observed financial upheavals during 2007-2009. The focus is then turned to the not too big financial institutions-including those at or below the SIFI threshold of \$50 billion in assets-to study such “smaller” financial institutions’ systemic risk exposure, in addition to similar exposures of non-financial institutions such as the shadow banks, hedge funds, etc. Results indicate an interesting pattern of convergence of systemic exposures in the case of the not too big financial and non-financial institutions towards those of the largest BHCs. This seems to indicate that regulators, institutions, markets, etc., should urgently focus their attention on not just the TBTF, SIFIs, but also on the smaller institutions that may hitherto have been flying under the radar of systemic regulators, possibly towards impending, potential and catastrophic financial crisis. The findings of this research should prove to be use for regulators as they craft the rules for determining and regulating SIFI in the near future. In addition, financial institutions as well as academics will also benefit from this research due to the insights provided for determining the inflection point for effectively consider-

ing the when an institution actually becomes too risky or important enough to cause catastrophic systemic failure.

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### **INDUSTRY AND STAKEHOLDER ENGAGEMENT: THE CASE OF CO-INCINERATION OF HAZARDOUS WASTE BY CEMENT INDUSTRY**

Stakeholder engagement is prone to several ambiguities. On such ambiguity centers around the different perception that actors have about their role (i.e., opinion versus decision) along with how to weight the diverse ideas that are put forward in the discussion process. In addition to those different attitudes about the process, we are required to deal with the different positions about the object of discussion (i.e., the project under discussion). In this presentation, I will illustrate the results of stakeholder engagement in a project where these several levels are taken in consideration. The case involves a set of cement kilns in Portugal owned by SECIL, where the use of alternative fuels (including one that uses hazardous waste) is currently in place. The type of waste, the emissions measurement, the studies undertaken, etc. where under close scrutiny of a Stakeholder commission that help to define the scope and depth of those studies (independently of the legal obligations) and that have the power and resources to contract independent third parties. Additionally, I will present strategies which were undertaken to empower stakeholders in the decision making process. Of particular relevance is how different stakeholder engagement processes were used (from qualitative to more semi-quantitative ones) that were put in place and were subsequently adapted to, both the needs of the stakeholders and of the company. Successful stakeholder engagement in this case resulted in: a) The implementation of a consistent science-based risk management strategy; b) The acceptance of the use of alternative fuels, resulting in significant economic and societal benefits, and c) A consistent reduction of negative perception of cement production and the use of alternative fuels over 10 years period when the stakeholder engagement program was put in place.

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### **CYBER-SECURITY RISK ASSESSMENT: CHALLENGES AND SOLUTIONS**

The Office of Management and Budget (OMB) no longer requires the preparation of formal cyber-security risk analysis [1]. According to the OMB [1], substantial resources have been expended in past doing complex risk analysis with limited tangible benefit in terms of improved security. Instead of trying to precisely measure risk, security efforts are better served by generally assessing risks and taking actions to manage them [1]. According to the 2011 Global State of Security survey [2] only 30% of respondents used risk reduction to justify cyber-security investment. Reduc-

ing the scope and usage of the cyber-security risk assessment has not improved the state of security either. The lack of improvement in cyber-security can be attributed to 1) the limitations of current cyber-security risk assessment methodology, 2) the failure to understand the characteristics of the cyber-security domain and 3) assuming that there are no “known unknowns” or “unknown unknowns” in cyber-security domain. Cyber-security domain is inherently dynamic, in which the system configuration changes frequently, and new attacks and vulnerabilities are discovered regularly. Cyber-security’s threat agent is intelligent and adapts to the situation and countermeasures. Attack actions are driven by attacker’s exploratory nature, thought process, motivation, strategy, and preferences. The authors developed a new framework for automatically generating the cyber-security risk scenarios by, 1) capturing diverse and dynamic cyber-security knowledge, 2) assuming that there are unknowns in the cyber-security domain, and new knowledge is available frequently, and 3) emulating the attacker’s exploratory nature, thought process, motivation, strategy and preferences. [1] The Office of Management and Budget, Circular A130. <http://www.whitehouse.gov/omb/circulars/a130/a130trans4.html>. [2] Respected-but still restrained, in Global State of Information Security Survey 2011, PricewaterhouseCoopers.

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#### **POST-DISASTER RESILIENCE FOR INTERDEPENDENT SYSTEMS: APPLICATION TO INLAND PORT DISASTERS**

Economic resilience is often thought of as an ability exhibited by a system that allows it to recover from a disruptive event in a desired time and with an acceptable cost, noting that resilience is planned for in advance of a disruptive event through preparedness investments and activities. Resilience is particularly important in interdependent systems, as disruptions can propagate, resulting in direct as well as wider-spread indirect impacts. To estimate resilience in interdependent industry and infrastructure sectors, we build a dynamic data assimilation approach to improve the predictive behavior of a risk-based interdependency model. In our dynamic data assimilation approach, the “data” represent the level of recovery of the industry and infrastructure sectors after a disruptive event (e.g., attack, natural disaster) has occurred, leading to some or all of them being inoperable. As is often the case in reality, we assume that our estimation for sector recovery has some noise leading to errors in forecasting recovery. We aim to minimize the error in prediction so that we can best achieve the desired level of post disaster recovery. We apply our approach to post-disaster recovery planning for the Port of Catoosa, an inland waterway port in Oklahoma. We simulate the daily flow of commodity import-exports through the port and assume that a disruption causes an initial loss of supply leading to inoperability in sectors. We suggest metrics of resilience, maximum possible daily output loss, and total sector loss and/or regional loss as indicators for preferred planning

options for industry and infrastructure sectors. Such metrics could help in improved preparedness decision-making.

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#### **USE OF QUANTITATIVE MICROBIAL RISK ASSESSMENT AND PROJECTIVE TRANSPORT MODELS TO INFORM BEACH CLOSURES**

Natural water recreation locations are a well known source of gastrointestinal infection outbreaks. Therefore a means of projecting not only potential microbial impacts to recreational beaches, but risk of gastrointestinal infection associated with these impacts would be a useful tool. This work is underway in an effort to develop a tool for beach managers to quickly identify the risk level associated with recreational exposure to waterborne pathogens in the environment, such as pathogenic E. coli and adenovirus. The tool uses predictive transport models for two Great Lakes beaches based on current, local metrological conditions and water quality data allowing for a projected risk estimate. Transport models were selected from the open literature for two test beaches; Silver Beach in Saint Joseph, MI and Washington Park Beach in Michigan City, IN. The first generation of the tool is an Excel macro and spreadsheet; the second generation required a more user friendly environment. Therefore Java was selected as the software platform for the latest tool generation. The software provides a graphic user interface, generates the pathogen concentrations from the transport model and estimates risk to children, adults and the combined population. A built-in aspect of this tool is the capability to automatically update from the internet, which greatly reduces the demand on the user to generate the values independently. The immediate next step in the evolution of this tool is to transport it onto an android smart phone. This would create a dynamic aspect that would provide any potential user with the ability to use it on location, without the need of a computer interface. The next step in tool development is to subject the transport models to bootstrap uncertainty analysis. This tool will provide beach managers with increased decision making potential with a portable means of assessing potential risk to beach users and informing their sampling strategy.

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#### **RISK MANAGEMENT METRICS IN DOMESTIC FOOD SAFETY AND INTERNATIONAL TRADE CONTEXTS: THE CHANGING ROLE OF QUANTIFIED VARIABILITY AND UNCERTAINTY IN DIFFERENT CONTEXTS**

The Sanitary and Phytosanitary Agreement contemplates the application of risk-informed sanitary measures through the application of a concept referred to as the Appropriate Level of Protection. In the area of microbiological food safety,

this concept has begun to be operationalized through linkages with concepts such as Performance Objectives and Microbiological Criteria. In parallel with considerations for international trade, individual countries conduct risk assessments to determine the current level of public health risk and to pursue improved public health outcomes by setting performance standards applicable to their domestic producers. The underlying constructs behind public health risk assessment of current production conditions, analysis to support standard-setting to improve public health, and measures of risk applicable in international trade have a number of subtle yet important differences that may not be widely understood. The role of quantified variability and uncertainty in these applications will be presented. In addition we will describe the application of the concept of a design load as one potential approach to finding common conceptual ground among these contexts. A design load is a quantitative and systematic description of assumed downstream food handling conditions to be used in evaluating the acceptability of upstream production in the food continuum. This concept is intended to be applicable to both domestic and international supplies, and for use in both descriptive and normative applications.

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#### **LINKING PROBLEM FORMULATION TO DOSE-RESPONSE ASSESSMENT**

The importance of problem formulation as an early activity in the risk assessment process is increasingly recognized. The widespread adoption of problem formulation activities as part of the 'design' of risk assessments was considered one of the keys to improving both the quality and the utility of risk assessment in the Science & Decisions (the "Silver Book") report of the National Research Council. This presentation describes some of the ways in which the risk assessment design can be influenced by early attention to problem formulation. The application of Value of Information (VOI) analysis, either formally or informally, provides a means to influence the design of risk assessment processes and products. As an example, the application of VOI analysis to understand the importance of the shape of the dose-response curve in specific decision contexts is described. In addition, various barriers to effective problem formulation will be discussed, including the inappropriate application of the Red Book's "conceptual separation" of risk assessment and risk management, with respect to the need for early identification of specific risk management options.

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#### **MICROWAVE POPCORN WORKERS: PULMONARY IMPAIRMENT AND PRELIMINARY RISK ASSESSMENT**

Background: The flavoring additive, diacetyl, is a potent toxic agent for the lung, causing bronchiolitis obliterans. An analysis and risk assessment were per-

formed using data from a microwave popcorn plant. Methods: Current employees' medical history and pulmonary function tests were obtained on 8 occasions over 2.7 yr with 80% participation. 583 air samples were mostly between 0.01 and 10.0 ppm. Percent predicted FEV1 and FEV1/FVC were analyzed by multiple regression controlling for age, gender, smoking history and ethnicity. Using an estimated date of onset, incidence of impairment (both FEV1 and FEV1/FVC < lower-limit-of-normal) was analyzed by Poisson regression. Several exposure metrics were investigated. Benchmark dose and excess lifetime risk were calculated. Results: Declines in percent predicted FEV1 (0.40 per ppm-yr,  $p < 10^{-6}$ ) and FEV1/FVC (0.0013 per ppm-yr,  $p = .0004$ ) were observed with cumulative exposure. Impairment incidence was predicted by cumulative exposure with a negative effect of duration. Better fitting models were obtained with square root of cumulative exposure. There was strong evidence of heterogeneity in pulmonary response: a cluster of incident cases at low cumulative exposure and short duration. Model fit was significant with terms to capture both a general effect and higher risk among a declining sub-population (LRT=13.5 (2 df),  $p=.0011$ ). Based on preliminary analyses, benchmark doses for 1% or 10% excess prevalence with lifetime exposure were about 0.05 and 0.5 ppm respectively; exposures with 1% excess lifetime incidence risk, ranged from 0.01-0.05 ppm. Conclusion: Despite limitations, data from multiple cross-sectional surveys proved useful for risk assessment. Sources of bias likely caused underestimation of effects. Heterogeneity of response, probably commonly present but not usually observable, poses analytical challenges.

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#### **A PROPOSED FRAMEWORK FOR EVALUATING ALTERNATIVE TEMPORAL PATTERNS OF EXPOSURE FOR RISK CHARACTERIZATION**

One practical hurdle faced by risk assessors is that the temporal pattern of human exposure frequently does not correspond to the pattern of exposure or dose administration of the studies used as the basis of health-protective exposure guideline values. In a practical context, temporal exposure scenarios are addressed using a variety of alternative techniques, including but not limited to integrating exposure over time, modifying guideline values, margin of exposure approach, using conservative guideline values, or a combination of these approaches. Thus, alternative approaches - varying in sophistication, are available to address the integration of complex temporal exposure patterns with the appropriate guideline value comparison. Examples of such techniques at three broadly defined levels of complexity (Tiers I, II, and III) are described here with emphasis on the Tier II approach. We developed a decision tree framework to guide the risk assessor in addressing repeated short-term exposures. Generic kinetic modeling was conducted using EXCEL<sup>®</sup> spreadsheets, with the elimination half-life being used to determine whether accumulation occurs before the next



dose for a variety of exposure scenarios. This information was coupled with information on the rate of repair to determine whether an acute exposure limit is adequately health protective, or whether one also needs to evaluate the exposure relative to the (more restrictive) chronic limit. It should be noted that these relatively simple examples cannot capture all of the complex considerations and issues that may be relevant to the risk characterization process for a particular chemical or exposure scenario, but represent the most common considerations within the proposed framework. The generic kinetic model is a work in progress, thus further review and enhancement of the method is needed.

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#### **COMPARISON OF CHEMICAL COMPOSITION OF COMPLEX DISINFECTION BYPRODUCT (DBP) MIXTURES PRODUCED BY DIFFERENT TREATMENT METHODS**

Analyses of the chemical composition of complex DBP mixtures, produced by different drinking water treatment processes, are essential to generate toxicity data required for assessing their risks to humans. For mixture risk assessments, whole mixture toxicology studies generally are preferred to component studies. A concern with whole mixture studies is the similarity of the tested mixture to the mixture of concern in the environment. We evaluated the chemical composition of three chlorinated DBP mixture concentrates (A, B, C) formed by different concentration methods. We compared their DBP composition to a reference chlorinated mixture (R) at 1x dilution of the disinfected source water. Tukey studentized tests and statistical power tests were performed (at  $\alpha = 0.2, 0.1, 0.05, 0.01$ ) to examine differences among 19 individual DBPs and 4 DBP classes. Preliminary results suggested concentrate C and R are similar except for levels of 3 individual DBPs. Concentrates A and B differed significantly from C and R based on concentrations of trihalomethanes, haloacetic acids, total organic halogens (TOX), and other individual DBPs. Statistical analyses at different  $\alpha$  levels yielded consistent results for most of the DBP fractions including TOX, suggesting that these results are robust. However, the percent TOX associated with measured individual DBPs (MTOX) and unknown (UTOX) fractions varied across the concentrates; MTOX and UTOX each comprised ~50% of TOX in R; in concentrates A, B, and C, the percentage of UTOX was 70%, 70%, and 64%, respectively. This suggested that among the three concentrates, concentrate C is quite similar to R for measured DBPs and MTOX, but the UTOX fractions of all concentrates differ. We conclude that the concentrate C has DBP concentrations that are most similar to that of R. [The views expressed in this abstract are those of the authors and do not necessarily reflect the views or policies of the U.S. EPA.]

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#### **RAT THERMOREGULATION: EXPLORATION OF ITS VALUE IN RISK ASSESSMENT OF MIXTURES OF TYPE I AND TYPE II PYRETHROID INSECTICIDES**

Pyrethroid insecticides produce changes in thermoregulatory response (TR) in small rodents. In rat, type I-pyrethroids permethrin (PM) and bifenthrin (BIF) produce hyperthermia, and type II cypermethrin (CPM) and deltamethrin (DLM) produce hypothermia. These structure-specific TR effects have been mostly demonstrated using moderately high-effective doses and rectal probe measurements after single oral dosing. In addition, CPM and DLM have been reported to produce biphasic dose-effect relationships: mild hyperthermic effects at low doses, and the expected hypothermia at greater dosages. At present, there is insufficient data to establish if the joint neurotoxicity of pyrethroids is influenced by the structure-specificity of the endpoint selected for study. In order to explore structure- and dose-related actions, we obtained time- and dose-effect relationships for above pyrethroids using mini-transponder technology (BMDS, USA). These telemetry-based chips collect and transmit real-time, subcutaneous body temperature (T). Adult Wistar rats (8-9 weeks old) were implanted ~96 h before testing and TR was monitored to determine individual physiological baselines. Temperature data were collected at 30 min intervals for 5 hr after a single oral dose (~1-20% LD50; 1 ml/kg) of each compound dissolved in corn oil (N = 6-8 per dose group). The expected type I- and II-like TR patterns were observed at highly effective doses (in mg/kg: PM 150, BIF 12, DLM 9,  $\alpha$ -CPM 15). However, a mild increase in T was observed for all pyrethroids at a much lower dose regardless of structure. These preliminary results suggest that the dual, type I/II classification only may be a high-dose effect. This testing protocol was capable of detecting pyrethroid time-, dose-, and structure-dependent effects, what may be useful in the context of examining pyrethroid mixtures in ongoing risk assessment efforts (work in progress).

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#### **RISK AND CRISIS COMMUNICATION REQUIREMENTS FOLLOWING AN ACUTE CHEMICAL INCIDENT**

A long-standing but rapidly growing literature indicates that effective public communication forms an essential part of any emergency response programme. However, a number of risk communication barriers around chemical incident emergencies have been identified. This poster presents the findings of the risk and crisis communication work package of a recently completed European Commission funded project, the Chemical Incident Emergencies Toolkit (CIE Toolkit). This study was designed to improve understanding regarding public health information needs and behavioural intentions in relation to a chemical incident. Focus groups were con-



ducted with emergency health responders in the UK and Poland to explore existing communication strategies and perceptions regarding public information needs and responses. Similarities in communication strategies and expected responses were found, although differences were identified in style of messaging and expected levels of public compliance with official instructions. An online survey issued to members of the public in the UK (N=600) and Poland (N=600) examined the impact and uptake of the health responders' procedures and messages. A number of key factors influencing intention to comply were identified, including coping appraisals, ease of compliance and family bonds. Consistent with practitioner expectations there were lower levels of intended compliance in Poland. Our findings suggest that successful crisis communications should aim to influence perceptions regarding the efficacy of recommended behaviours, the difficulties people may have in following advice and perceptions about the cost of following recommended behaviours. Furthermore, generic principles of crisis communication may need adaptation for national contexts. The findings from this project are being used to develop a training module which will form part of a CIE Toolkit and manual that will be used to raise competencies of public health professionals.

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#### **RISKS RELATED TO THE TRANSPORTATION OF HAZARDOUS MATERIALS: A DECISION-MAKING TOOL FOR SELECTING A CARRIER**

To comply with current storage regulations, facilities handling hazmat could make storage decisions that may increase deliveries which would consequently introduce transportation-related risks. It is therefore important to consider overall risk management throughout the entire hazmat supply chain. In a previous study, we showed that facilities handling hazmat are often concerned about risk management. What about hazmat carriers? We developed a survey and sent it to 1,450 hazmat carriers in the province of Quebec in order to get a portrait of the organizational safety practices they implemented to reduce their accident risk. Here we present the main results of this innovative survey, covering both technical and organizational elements (driver training, risk management, criteria used for selecting subcontractors, use of new technologies, level of emergency preparedness). The results show that most carriers have adopted adequate organizational safety practices (OSH committees, specific programs for preventing accidents) and are generally aware of the risks generated by the cargo. Some risky activities seem nevertheless to be underestimated (risks related to loading/unloading, temporary storage, multi-client shipments, etc.). The results of our survey have also allowed us to develop a decision-making tool to guide the choice of hazmat carriers based on risk. The survey highlighted that some practices are not used uniformly among carriers. Some are applied to varying degrees as a function of other specific characteristics: type of material, hazmat class or logistical characteristics

(multiple-client delivery, quantity carried, short-term storage requirements, etc.). After selecting the specific transport characteristics needed, the shipper will get a list of required organizational safety practices allowing him to select a hazmat carrier based on risk level. This risk level combined with the cost of transportation will allow the shipper to make a more enlightened decision.

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#### **A PROBABILISTIC DEPLETED URANIUM PERFORMANCE ASSESSMENT: METHODOLOGY AND RESULTS**

The nation's first Performance Assessment (PA) for disposal of depleted uranium (DU) waste has recently been completed for an above-ground facility in western Utah. The PA will be used by the State of Utah to inform an approval decision for the facility and by federal regulators to inform rulemaking in general for DU waste disposal facilities in the United States. The specific dose assessment performance objective of the PA is annual individual radiation dose within a 10,000-year performance period. Physical processes evaluated include radioactive decay and ingrowth, diffusion and advection in unsaturated and saturated zones, plant and animal bioturbation, cover evolution/erosion, and air dispersion. The PA differentiated the impact of variability in exposure parameters (values applicable over a few years or decades, such as individual physiological and behavioral parameters) and transport parameters (values applied over the full 10,000-year performance period, such as solubility and adsorption parameters). This presentation focuses on explaining the probabilistic methodology and radiation dose results of the PA. Although probabilistic methods have been used in PAs to evaluate uncertainties in radionuclide release and transport over time, to date these methods have not commonly extended to receptor exposure and dose models. Sensitivity analyses were performed to identify key input variable distributions for different waste disposal system configurations. The important exposure and transport assumptions contributing to radiation doses will be explored and discussed. The value of a two-dimensional probabilistic approach in a PA is assessed.

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#### **THE CURIOUSLY UNDERSTUDIED TOXICITY OF "NANOFIBERS": A RISK-BENEFIT APPROACH**

As nanoscale science and engineering moves from the laboratory to the marketplace, the goal of the "responsible development of nanotechnologies" espoused by the U.S. National Nanotechnology Initiative (NNI) is increasingly salient. "Responsible development" of technologies entails evaluating prospective benefits and potential risks, and implies a need for prioritization. To that end, this paper argues that the toxicity of one-dimensional (1-D) nanostructures other than nanotubes (i.e.

“nanofibers”) is relatively understudied, and merits increased attention. “Nanofibers” can exhibit properties such as enhanced surface area, improved electrical conductivity, and greater device resilience relative to bulk materials. These characteristics are particularly relevant to the area of energy storage, where technological advances are critical to the integration of renewable generation in electricity grids, the widespread adoption of alternatives and supplements to the internal combustion engine, and other important applications. Energy storage thus comprises a valuable case for exploration of the potential benefits of “nanofibers”, particularly since several innovations in this realm are approaching commercialization. At the same time, “responsible development” requires examination of possible hazards. While toxicity data regarding nanotubes, particularly carbon nanotubes, is beginning to accumulate, the literature concerning other kinds of 1-D nanostructures remains thin. More concretely, the number of toxicological studies of nanotubes exceeds those focused on “nanofibers” by an order of magnitude. Given the similar application potential of these two classes of materials, this dramatic dichotomy highlights a priority area for future research. The article reviews the limited relevant toxicological literature to date, and concludes by suggesting life cycle and market-driven strategies to help prioritize ongoing efforts to close this knowledge gap.

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### **PUBLIC HEALTH CO-BENEFITS FROM GHG MITIGATION OPTIONS AT A DEVELOPING COUNTRY**

Although developing countries are not subjected to Greenhouse Gas (GHG) emission targets, the Government of Chile committed itself in Copenhagen to a reduction of 20% from the baseline by 2020. Half of this goal (10%) is contingent on the availability of foreign sources. Still, 10% is a sizable reduction. Chile has a widespread air pollution problem. Most of its urban in the center and south of the country violate the current PM10 standard, and the newly established PM2.5 annual standard. We quantify the public health co-benefits associated to GHG mitigation measures in Chile. This study considers fossil-fuel combustion from the energy sector, transport, Industrial and public, residential and commercial sectors at the provincial level. The results shows that almost all mitigation options would produce co-benefits, with a mid value of 10 to 180 USD/tCO<sub>2</sub>e. The only mitigation option with negative co-benefit is biomass-based electricity generation, with a value -15 to -249 USD/tCO<sub>2</sub>e. Home insulation improvements produce the bigger co-benefits, between 38 and 627 USD/tCO<sub>2</sub>e. When the estimated co-benefits are included in the analyses, the relative merit of several mitigation options change, and 11/21 measures that had negative net benefit now became positive.

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### **USING BAYESIAN NETWORKS TO EVALUATE SEA-LEVEL RISE**

Projections of sea-level rise for the coming decades indicate that future impacts will include land loss from inundation and erosion, migration of coastal landforms and environments, increased elevation and duration of storm-surge flooding, wetland losses, changes in coastal aquifer hydrology, as well as impacts to human development, infrastructure, and social systems. Improving the ability to predict future sea-level rise effects on coasts is a challenge. There are uncertainties in how the coastal system will respond to changes in sea level, and there are also large uncertainties in the prediction of other variables associated with future climate conditions (e.g., storm frequency and intensity, air and ocean temperature, rainfall) that drive the relevant physical and biological processes. We have developed a probabilistic approach using a Bayesian statistical analysis framework that can be used to evaluate the potential for a range of sea-level rise impacts to coastal regions. Initial results from the U.S. mid-Atlantic coastal region identify relationships between the climate (and other) forcing factors and response scenarios, as well as identifying research needed to reduce uncertainty. The Bayesian network approach provides a means to support decision making and evaluate specific management questions about alternatives for adapting to sea-level rise and other forms of climate change.

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### **THE COLLABORATIVE ARA ADVENTURE: EXTENDING AND EXPANDING DISCUSSIONS OF PROBLEM FORMULATION AND DOSE-RESPONSE**

A series of workshops held over two years, was sponsored by the Alliance for Risk Assessment (ARA), an organization aimed at improving the process and efficiency of risk assessment. The series focused on extending the work begun by the 2009 NAS report ‘Science and Decisions’, by broadening and deepening scientific discussion on two key recommendations: improving problem formulation and selecting the appropriate dose-response assessment methodology. These public workshops were supported by 45 sponsors: government agencies, scientific societies & industry groups, consulting groups, and non-profit organization/consortia, with state and federal regulators actively involved throughout. Working with an Expert Panel experienced in toxicology and risk assessment, ~25 dose-response assessment methodologies were reviewed, each part of a case study illustrated with specific examples. Case studies were prepared & presented by workshop participants at two workshops, with Panel comments and recommendations providing insight on utility and practicality of the methods. Using a framework developed from expanding the concepts embodied in an NAS report figure, case studies were organized based on the underlying

complexity of the problem formulation. This open process encouraged interaction among all workshop participants, which was critical for information sharing among the participants and remarkably successful. It was clear that moving towards a more data-informed risk assessment process and early incorporation of mode of action (MOA) as a centrality for risk assessment were generally viewed as key improvements, when directed by the particular problem formulation. In addition, as MOA becomes more predictive, it will help drive appropriate data collection and identify key issues in problem formulations. A publicly available compendium of the acceptable dose-response assessment methodologies will represent a key work product of these workshops.

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### **LOTS OF BACTERIA - FEW CASES: REOPENING THE LISTERIA DOSE-RESPONSE MODEL BLACK-BOX**

Listeriosis is a rare disease with regard to its relatively high frequency of isolation in food. The two major dose-response models scaled on epidemiological data for *Listeria monocytogenes* were developed by FDA/FSIS/CDC in 2003 and by FAO/WHO in 2004. Since then, knowledge on the bacteria, the host and their interaction has increased, notably concerning the physiopathology of the infection, the virulence of the strains and/or the susceptibility of individuals. New data from experimental infections on animal models are also available. Before developing new dose-response models, it is necessary to better understand how the previous ones were developed: the FDA/FSIS/CDC model uses a dose-response shape from a mouse model. It then considers a very large variability in strain virulence and in host susceptibility. A scaling factor of ca.  $10 \log_{10}$  is eventually needed to reconcile the model with epidemiological data; the FAO/WHO model is a simpler exponential model scaled on epidemiological and exposure data. It does not consider other variability component than the one of a classical exponential model. With the current knowledge, the way to reconcile exposure and epidemiological data in risk assessment models is to consider that the average probability of illness for a random individual exposed to a given dose of uncharacterized *Listeria monocytogenes* is extremely low. The dose-response models issued from animal models cannot be used directly for risk assessment without largely overestimating the number of cases. Obviously, some combinations of high strain virulence, high individual susceptibilities and other factors in the interaction *Listeria*-host lead to some occurrences of higher probabilities of illness for a given dose. These factors should be better characterized to better evaluate these risks of illness.

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### **HOW DO YOU MODEL A “NEGLECTIBLE” PROBABILITY UNDER THE WTO SANITARY AND PHYTOSANITARY AGREEMENT?**

Since the 1997 EC - Hormones decision, World Trade Organization (WTO) Dispute Settlement Panels have wrestled with the slippery question of what constitutes a negligible risk under the Sanitary and Phytosanitary (SPS) Agreement. Recently, the 2010 Australia - Apples decision focused considerable attention on the appropriate quantitative model for a “negligible” probability statement in a risk assessment. Responding to previous criticism in the 2000 WTO Australia - Salmon case for using narrative terms such as “negligible,” “extremely low,” and “very low” to qualitatively describe likelihoods, the 2006 Australian Import Risk Analysis for Apples from New Zealand used quantitative ranges for such terms. The uncertainty about a negligible probability was characterized as a uniform distribution with a minimum value of zero and a maximum value of one in one million. Based on consideration of expert testimony, the 2010 WTO Panel in Australia - Apples found that the use of this uniform distribution would tend to overestimate the likelihood of “negligible” events and suggested that a triangular distribution with a most probable value of zero and a maximum value of one in one million would correct the bias. The Panel observed that the midpoint of the uniform distribution is 5 in 10 million, but it did not consider that the triangular distribution has an expected value of 3.3 in 10 million (with a midpoint of 2.9 in 10 million). Therefore, if using the triangular distribution is the appropriate correction, the magnitude of the purported bias appears modest. The Panel’s detailed critique of the Australia - Apples risk assessment, and the conclusions of the WTO Appellate Body (which hears appeals from reports issued by Panels) about the materiality of faults with the risk assessment found by the Panel, may have important implications for the standard of review for risk assessments under the WTO SPS Agreement.

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### **LIFE-CYCLE BASED APPROACHES FOR EVALUATING CARBON NANOMATERIALS**

Life-cycle based approaches for holistically evaluating the environmental implications of emerging nanotechnologies have become generally recognized as important. Although several life-cycle assessments (LCAs) of carbon-based nanomaterials in recent years have offered valuable insights for the sustainable development of carbon-based nanotechnologies, LCAs typically have limitations in design and implementation that can omit important factors from consideration. In this presentation we highlight various LCAs of carbon nanomaterials and compare them to an alternative life-cycle based approach known as Comprehensive Environmental Assess-



ment (CEA), which provides both a framework for systematically organizing complex qualitative/quantitative information and a process to evaluate such information using collective judgment. The CEA framework encompasses the inception of the material or product, environmental fate (transport/transformation) of releases during the product life cycle/value chain, exposure-dose of biotic and abiotic receptors, and impacts of both primary materials and secondary by-products. The CEA process builds on the information compiled in the framework and uses collective judgment methods incorporating diverse technical and stakeholder perspectives to evaluate the implications of complex and incomplete information. Although CEA can be applied for both research planning and risk management purposes, in this presentation we primarily focus on how CEA differs from LCA as an assessment approach for evaluating the environmental implications of carbon nanomaterials. Disclaimer: This abstract does not necessarily represent the views or policies of the U.S. EPA.

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#### **QUANTITATIVE RISK ASSESSMENT OF LISTERIOSIS DUE TO CONSUMPTION OF RAW MILK**

The objectives of this study were to estimate the risk of illness due to *L. monocytogenes* in raw milk sold by permitted dealers, and the risk for people on farms who consume raw milk. Three scenarios were evaluated for raw milk sold by dealers: raw milk purchased directly from bulk tanks, from on-farm stores, and from retail. To assess the effect of mandatory testing of raw milk by regulatory agencies, the number of listeriosis cases per year were compared where (i) no raw milk testing was done, (ii) only a screening test to issue a permit was conducted, and (iii) routine testing was conducted and milk was recalled if it was *L. monocytogenes* positive. A greater risk of listeriosis was associated with consumption of raw milk obtained from retail and farm stores as compared with milk obtained from bulk tanks. This was likely due to additional time-temperature combination steps in the retail and farm store models, which increased the chances for growth of *L. monocytogenes* in raw milk. A close relationship between prevalence of *L. monocytogenes* in raw milk and the values of disease incidence was observed. Hence, a reduction in the number of cases per year in all populations was observed when a raw milk-testing program was in place, especially when routine testing and recalling of milk was conducted.

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#### **APPLICATION OF A SOURCE-TO-OUTCOME MODEL TO QUANTITATIVELY ASSESS VARIABILITY IN DOSE AND SENSITIVITY IN HUMANS**

A source-to-outcome model was created for dietary exposures of chlorpyrifos by linking probabilistic dietary exposure models with a PBPK/PD model of an early key event in the toxicity pathway for the cholinergic effects of the compound. This modeling addresses several concerns raised in Chapter 5 of the NAS report "Science and Decisions". First, the modeling goes beyond the margin-of-exposure or hazard index approaches used in traditional non-cancer risk assessments and provides information on the fraction of the population affected by a given dose (i.e., exposure). Second, the model allows the quantitative investigation of inter-individual variations in both exposure and response (variation in sensitivity) for different age groups (adults, children, and infants). Third, by focusing the modeling on an obligatory change that occurs early in the toxicity pathway, the model avoids the complexities and uncertainties in modeling the occurrence of apical effects. One important finding from the project is that while there are background rates of some apical effects of chlorpyrifos, current dietary exposures to humans are not predicted to cause any change in the frequency of these apical effects in marginal populations. This suggests that a low-dose nonlinear individual and population dose-response model is most appropriate for this compound.

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#### **NAPHTHALENE DOSIMETER FOR ASSESSMENT OF EXPOSURE FOR FUEL HANDLERS: A CASE STUDY**

The identification of an emerging chemical is only the first step in a multi-step sequence used by the Department of Defense (DoD) to manage risks from emerging contaminants. Once a chemical is identified, the time and resources required to identify and implement solutions to address potential risks can be significant. The case of naphthalene demonstrates the long lead time required to identify and implement risk management actions (RMAs) to address those risks presented by the changing regulatory landscape. Naphthalene was one of the first emerging contaminants to be identified by the DoD's scan-watch-action process and it remains on the DoD's Action List of high priority emerging contaminants. The potential change in the regulatory categorization from a "possible" to a "likely" human carcinogen could have a substantial impact on how DoD manages occupational exposure to fuel. Jet fuel (JP8), which is a universal fuel for most military equipment, contains 1-3% naphthalene by weight. According to the National Academy of Sciences, fuel is the single largest source of chemical exposure to DoD personnel. At the same time that regulators are evaluat-



ing the potential carcinogenicity of naphthalene, DoD is developing technology to better inform leadership on the scope of the exposure issue. To increase confidence about the scope of exposure to naphthalene among fuel handlers, DoD is conducting research and development (R&D) on a personal dosimeter and will use this dosimeter to conduct an exposure assessment. The uncertainty surrounding the final regulatory decision on naphthalene's toxicity persists even as the R&D continues. The case of naphthalene provides an excellent example of how enterprise wide risk management is needed to balance this dual track. The case of naphthalene is informative for risk managers because it demonstrates management of the time gap between risk identification and the development of potential RMAs and the need to plan for and balance R&D efforts with regulatory developments.

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### **PESTICIDE RESIDUES ON FOOD: A MOUNTAIN OR A MOLE HILL**

Health effects from pesticide residues on food are often alleged in the media and from advocacy groups. Additionally, recent epidemiologic studies have associated decrements in intelligence quotient (IQ) and attention deficit hyperactivity disorder (ADHD) with pesticide exposures, though not specifically with pesticide residues. However, pesticide residues are usually less than one-millionth of the food mass, and fruit and vegetable consumption has well established benefits. This paper addresses the potential for pesticide residues to cause health effects using standard risk assessment methodologies and through an evaluation of the biological plausibility of some of the epidemiologic findings. An estimate of cancer risk from pesticides in fruits and vegetables is presented using the most extensive residue and food consumption databases available in the United States. These estimates are compared with estimates of cancer avoided through the consumption of fruits and vegetables based on epidemiology studies comparing cancer incidence with diet. Additionally, epidemiologic studies of health effects of pesticides are analyzed to consider the biological plausibility of the associations, possible confounding, and the relevance of pesticide residue exposure to other pesticide exposure pathways.

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### **USING THE CONCEPT OF SYSTEMIC RISKS TO APPROACH SOCIAL UNREST**

In this paper we develop a framework of social unrest based on a complex understanding of systemic risk. The term 'systemic' describes the extent to which any risk is embedded in the larger contexts of social and cultural aspects that shape our understanding of risk, influence our attention to causal relationships and trigger our activities for handling these risks. Social unrest can be grouped into this framework of systemic risks. It can be a cause of risk to others, it can be a consequence of

experiencing risk (for example a terrorist threat) or the manifestation of such a risk (the actual terrorist attack) or it can be a promoter of a risk chain that is located in other functional systems of society (for example financial crisis). Since social unrest is more a process of escalation than a finite state of the world we have conceptualized the term in from of a step-by-step escalation scheme. Each step makes social unrest more likely and also if it then occurs more severe. In the course of this process, activities may get more and more radical, in particular if these collective protest actions are ignored or even oppressed (examples may be wild strikes, regional boycotts or blockades).

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### **RISK CULTURE: LOCAL RESPONSES TO GLOBAL THREATS. TRANSFORMING VULNERABILITIES INTO CAPABILITIES**

This research pursues to analyze and explain how societies select which risks to face and which to ignore, based on the cultural theory of risk perception by which risk are socially selected. Therefore we make a distinction of two types of risk: natural and anthropic. Based on this distinction, we emphasized how community consensus perceives, selects and accepts each type of risk according to culture and the factors that influence on communities' vulnerability. As a result, the present research aims to generate awareness about risk, provide a guide for disaster risk reduction in vulnerable communities and develop an integrated approach for risk management and risk response, which includes culture as a key component to understand risk dynamics, face threats and reduce the propensity to vulnerability. The research was conducted on three levels: on the first level is developed a theoretical framework for understanding the concepts of risk, threat, vulnerability and culture as well as the connection between disasters and development. On the second level was selected the Colombian Caribbean Region as case study where were created synergies around risk culture with vulnerable communities and stakeholders, from which we found that academy, humanitarian community and policy-makers work independently, generating duplication of the information and a lack of coordination in research. Based on the results of the preceding levels, on the third level takes place the socialization of the research through the implementation of a training program on Vulnerability Prevention and Risk Culture Promotion and the publication of a Manual for an Integrated Disaster Risk Management.

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### **DEVELOPING AN INVENTORY-BASED PRIORITIZATION METHODOLOGY FOR ASSESSING INOPERABILITY AND ECONOMIC LOSS IN INTERDEPENDENT SECTORS**

Natural and man-caused disasters disrupt the production of commodities and services that are essential to the functions of infrastructure and economic sectors. The intrinsic interdependencies among these sectors trigger the propagation of disaster consequences that often result in a wider range of inoperability and amplified losses. This paper evaluates the impact of using inventory-enhanced policies on the recovery behavior among disrupted interdependent sectors. A dynamic inoperability input-output model (DIIM) is extended to identify the critical sectors based on two underlying minimization objectives, inoperability and economic loss. A dynamic cross prioritization plot (DCPP) is developed to integrate these objectives into a prioritization tool that allows variation in the importance associated with each objective. Implementing the methodology for the state of Virginia, a baseline inventory case revealed a high concentration of: (i) manufacturing sectors under the inoperability objective, and (ii) service sectors under the economic loss objective. Simulation of enhanced inventory policies to the manufacturing sectors reduced the recovery period by nearly a week and the total economic loss by \$47.58M. The variation of importance attributed to the two objectives is demonstrated for the inventory-enhanced case. While the study focuses on enhancing inventory levels in Virginia's manufacturing sectors, complementary analysis is recommended to manage the resilience of the service sectors. The flexibility and scalability of the proposed prioritization methodology and the resulting decision support system can also be extended to accommodate analysis in other regions as well as other disaster scenarios.

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### **COMPARISON OF STRATEGIES TO STRUCTURE WEIGHT-OF-EVIDENCE EVALUATIONS**

Environmental regulations seek a sound basis in science, yet the body of available information is seldom dispositive and entails synthesis across studies conducted under different disciplines, with different inherent strengths, shortcomings, and standards for well conducted studies. Conclusions must be based on uncertain inferences and extrapolations, with choices among apparently contradictory findings, yet inaction because of suspended judgment or action on imperfect information have their own negative impacts on public good. A weight-of-evidence approach is required that attends to both consistency within disciplines and synthesis across disparate types of studies. I review several approaches - rules-based systems, evidence-based toxicology, expert judgment elicitation, and structured hypothetico-deductive processes

- and gauge their comparative utility in supporting public-health regulatory decision-making. Rules-based approaches can be consistent and operational, but risk codification of conventional wisdom and succeed only to the degree that sound inference is built into the rules. Evidence-based toxicology promises rigor, but in underdetermined systems, it provides poor basis for sound choices. Expert judgment is good at synthesis of diverse lines of evidence, but it is nontransparent and invites criticism of choice of judges. Hypothetico-deductive systems are complex and require case-specific assembly of arguments, but promise a means to judge the relative credence to be accorded differing interpretations - with different regulatory consequences - in a way that encourages open discussion of how inferences relate to the evidence at hand. A key question is where in the regulatory decision-making process, and in whose hands, the evaluation of uncertainty of inference and the consideration of possibilities, plausibilities, and soundness of inferences should reside.

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### **LINKING THEORIES OF ATTRIBUTION, RISK PERCEPTION, AND COMMUNICATION TO INVESTIGATE RISK MANAGEMENT AND SAFETY IN AN APPLIED CONTEXT**

During the past fifty years, social scientists have amassed an impressive body of literature to explain how individuals attribute both the causes of and the responsibility for phenomena: whether to "internal" traits of individuals or to "external" characteristics of the environment. To date, psychological studies linking attributions of responsibility for accident causation, risk perception, and safety have largely considered occupational settings, such as factories, and everyday routines, such as driving. A second body of scholarship, however, situates attribution of responsibility in the larger context of risk management and seeks to explain how individuals attribute responsibility for preventing accidents (i.e., for ensuring safety) in cultural, moral, legal, and ethical terms. While these two literatures share an attention to perceptions of risk, risk management, and risk-related behavior, no apparent research has attempted their integration. This research links these two approaches to attribution theory with theories of risk perception and communication to explore risk management and safety promotion in an applied context. To do so, it combines social psychological concepts used to explain causal attribution of accidents with sociological concepts relevant to understanding the attribution of responsibility for accident prevention. Three U.S. national parks, Mount Rainier National Park, Olympic National Park, and Delaware Water Gap National Recreation Area, provide unique settings for this mixed-method study, which considers the perspectives of both park employees and visitors with respect to visitor accidents and unintentional injuries. The presentation will offer preliminary results from ongoing survey and in-depth interview analysis.

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### **A CRITICAL ANALYSIS OF ECOLOGICAL RISK ASSESSMENT ENDPOINTS FOR BIOFUEL FEEDSTOCKS**

The activities associated with cultivation of biofuel feedstocks and their conversion to fuel is expected to result in a complex set of inter-related environmental impacts. One approach that the US EPA has taken to focus this complex information is to construct conceptual models which schematically represent hypothesized links between activities undertaken throughout the biofuels production supply chain and the resulting environmental impacts. Six feedstock models (corn, corn stover, soybean, perennial grasses, short rotation woody crops and forest biomass) were developed to represent the range of current and future biomass sources for converting to biofuels. Initially, environmental and ecological endpoints were selected based on soft criteria, i.e. those that could be generally informative to environmental decision-makers. Subsequently, a more systematic analysis of assessment endpoints has been undertaken to understand the benefits and drawbacks of particular endpoints for various assessment approaches, (including ecological risk assessment and comprehensive environmental life cycle analysis), for different kinds of decision-makers, and for comparing among biofuels and between biofuels and other forms of transportation energy. The endpoints were evaluated by experts within and outside the agency. The criteria used for these evaluations include measurability, capacity for detecting changes attributable to biofuels activities, and utility for environmental decision makers. Additionally, we asked which endpoints might be used to compare the impacts of biofuel production to impacts of other forms of transportation energy (e.g., domestically produced petroleum). Where known, data sources were identified. We present the results of this evaluation as comparison tables. The outcome of this analysis will be used to frame the risk assessment of diverse feedstocks grown in spatially disperse regions throughout the United States.

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### **MODELING OPERATIONAL RISK USING A BAYESIAN APPROACH TO EVT**

Modeling of operational risk has emerged as important risk component for financial and insurance institutions due to the severe losses that it has produced in the last years. One of the main problems in the study of operational risk is the availability of data since many operational losses are not recorded or simply because of their low frequency. However, some data sets have become available and have allowed to analyze operational risk. In this study, an analysis of financial institutions internal loss data is performed using the Generalized Pareto Distribution by considering the uncertainty about the threshold. The proposed model considers the form of the dis-

tribution below and above the threshold, combining a parametric estimation with a Bayesian approximation to perform inference about the unknown parameters in both cases. The estimation is carried out using Markov Chain Monte Carlo (MCMC) methods, allowing posterior inference. After this, it is possible to determine the minimum capital requirements for operational risk.

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### **SOFTWARE FOR DISPLAYING TOXICOLOGICAL DATA AT NTP: THE EXPOSURE RESPONSE ARRAY AND FOREST PLOT VIEWER PROGRAMS**

The NTP Office of Health Assessment and Translation utilizes a variety of animal and human data to inform its conclusions on health risks from toxicants. Thoughtful and deliberative integration of health effects data is important both to data interpretation and a clear presentation of conclusions. Visualization of these data in a graphical format can expedite assessment of patterns across studies and make the data integration process more efficient. This requires flexible software that includes sufficient text detail with graphed results and has a user-friendly interface. We developed two Java-based programs that fulfill these requirements. Exposure Response Array Viewer was designed to create figures that summarize and display health effects data from experimental animal toxicology studies in a form that is useful to compare effect levels across variables of interest (e.g. exposure route or duration). The program graphically presents effect levels in the form of LOAELS and NO-AELS (or BMDLs) and the dose range tested along with text describing study details (e.g. species, strain, or sex). Forest Plot Viewer was designed to graphically display epidemiology study results such as OR or  $\beta$ s with confidence intervals alongside text describing study-population specifics and key study details. By displaying data in a graphical output as well as presenting columns of text describing key findings, the programs are designed to display data that cannot be graphed together. Clear presentation of these critical factors facilitates data interpretation and comparisons across studies. One of the main advantages of these programs is the capacity to display up to 15 columns of text as well as use data columns that are not displayed to format, group, or filter displayed effects by relevant study details. Forest Plot Viewer and Exposure Response Array are freely available on the NTP website.

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### **QUANTIFYING THE HURRICANE RISK TO OFFSHORE WIND TURBINES**

The US Department of Energy has estimated that if the US is to generate 20% of its electricity from wind, over 50 GW will be required from wind turbines in shallow waters off the East coast and Gulf Coast. Many of these will be at risk of damage from hurricanes. Turbine tower buckling has been observed in typhoons, but no off-



shore wind turbines have yet been built in the U.S. We derive two analytical probability models to estimate the number of turbines that would be destroyed by hurricanes in a single offshore wind farm. A novel modification of a Phase-Type distribution models the case that turbines are not replaced if they are destroyed, and a compound Poisson distribution models the case with replacement after each hurricane. We apply these models to estimate the risk to offshore wind farms in four representative locations in the Atlantic and Gulf Coastal waters of the U.S. In the most vulnerable areas now being actively considered by developers, nearly half the turbines in a farm are likely to be destroyed in a 20-year period. We show that adding backup power so a turbine's nacelle can yaw to follow the wind direction changes in a hurricane significantly reduces the risk the turbine will be destroyed. Reasonable mitigation measures - increasing the design reference wind load, ensuring that the nacelle can be turned into the wind, and building most wind plants in the areas with lower risk - can greatly enhance the probability that offshore wind can help to meet the United States' electricity needs.

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### **INCORPORATING A VALUE-FOCUSED DECISION MODEL OF PUBLIC RESPONSE INTO SETTING RECOVERY POLICY FOLLOWING A LARGE-SCALE BIOLOGICAL DISASTER**

The 2001 Anthrax incidents in the U.S. caused widespread anxiety and required lengthy and costly remediation for just small areas. A large-scale anthrax attack would result in mass casualties and have major economic consequences for the affected area, and potentially for the nation as a whole. The extent to which an impacted area recovers from such losses depends in large part on the decision making of local residents. In this study, we explored the behavioral decision-making of local residents and business owners in the Seattle, Washington area in response to a large-scale terrorist attack using weaponized anthrax. The focus was on structuring a decision model around the objectives and motivations that drive local residents' and business owners' decision making during disaster recovery. This understanding produces insight critical to the development and implementation of recovery policies. To build the decision model, we utilize scenario simulation, a methodology that uses video simulation of a news report, to immerse respondents in the grim details of the anthrax attack. From live group scenario simulations with key stakeholders in Seattle, we developed an underlying risk model as a means for structuring Seattleites decision-making during the scenario (influence diagram). The attributes, scales, tradeoffs and uncertainties that characterize the decisions about responding to and recovering from the anthrax attack were also elicited. Subsequently, we conducted individual web-based scenario simulations to determine how prevalent certain attitudes, perceptions and behavioral intentions were among Seattleites regarding the anthrax attack. From residents we obtained estimates of those who would leave Seattle temporarily, or permanently.

From business owners we collected similar estimates on whether they would relocate their business temporarily, or permanently. We also cataloged the reasons motivating these decisions and evaluated the responses to various proposed stakeholder-specific mitigation policies.

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### **THE IMPORTANCE OF RISK TYPE IN SELECTING APPROPRIATE ANALYTIC APPROACHES AND MANAGEMENT STRATEGIES**

Based on an historical examination of the development of risk management and various approaches to risk analysis/assessment, this paper will present a four-tiered risk typology based, not on the substance of a given risk issue (e.g., industrial hygiene, food safety, financial risk, transportation safety), but rather on fundamental characteristics related to the identification, assessment/analysis and management of risk. Central to the development of the proposed typology is the argument that most of the currently used analytical approaches and managerial responses to risk were developed for risks with very different characteristics than those exhibited by many emergent 21st Century risks such as terrorism, market bubbles in highly interconnected and poorly understood global financial networks, and increasingly complex industrial and critical infrastructure activities (e.g., Deepwater Horizon, civil aviation). Traditional methods are well suited for two of the four risk types identified here (Stable Easy to Discern and Stable Difficult to Discern risks) but are of only limited utility, and may well be dangerously misleading, for the other two types (Dynamic Natural and Dynamic Adversarial risks). Two overarching lessons arise from the typology. The first is that it is essential to properly characterize a given risk with respect to those characteristics that determine which analytic approaches and management strategies will be appropriate. The second is that new ways of thinking about, analyzing and responding to risk are necessary if we are to be successful in addressing emerging 21st Century risks.

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### **USING DOSE-RESPONSE CURVES TO CREATE WIN-WIN ENVIRONMENTAL LEGAL POLICIES**

This project identifies legal strategies for concentrating and for spreading risk from environmental pollutants. Real and important gains in health, safety, and environmental quality can result from redistributing pollutants. Where dose-response curves are hormetic, redistribution can lead to win-win outcomes, where some people are helped and no one is hurt. And where dose-response curves are curvilinear, there are opportunities to decrease aggregate harm by using either risk spreading strategies for concave functions or concentrating strategies for convex ones.



### **AEROSOL DISEASE MODELS: LIMITATIONS OF CURRENT DATA AND PROMISE OF MODEL-DIRECTED RESEARCH**

Nonhuman primates (NHP) represent our closest animal relatives, and it is widely held that host response from experimental infection will mimic those observed clinically in humans more so than any other animal species. As such, aerosol exposures to highly infectious agents using NHPs represent a highly complex model system to derive health effects data about pathogens that are either infectious or communicable when airborne. Delivery of the bacterial aerosol in such a system, and the subsequent quantitation of the delivered 'dose' to the animal are fraught with inherent variability both in the physical and microbiological components comprising the system. Once delivered into the respiratory system of the animal, virulence is at least partially determined by a delicate balance of the effects of the deposited bacteria on target tissues, immunologic responses (both protective and deleterious) and secondary responses such as triggering the complement and coagulation cascade. While critical bacterial/cell interactions can be isolated in cell culture, there is no substitute for measuring these pathophysiological processes in the intact animal to elucidate the nature of bacterial infection. With this in mind, one is obligated to derive estimates of delivered dose and the subsequent predicted outcome from such whole animal systems. Derivations of dose using this source of data are not without uncertainty; high levels of variability introduced by the animal experimental designs and the methods employed in many such systems. Further, outcome in the nonhuman primate may mimic, but may not necessarily copy, outcome in the clinical disease presented in a human. This is a poignant fact for *F. tularensis* because of the exceedingly low ID<sub>50</sub> (<10 cells) presently considered the benchmark for the minimal number of cells required for infection. The constellation of factors associated with aerosol delivery, and the host response will be discussed in the context of input variables for use within quantitative dose response assessments.

### **WATER POLLUTION RISK ASSOCIATED WITH NATURAL GAS EXTRACTION FROM THE MARCELLUS SHALE**

In recent years, shale gas formations have become economically viable through the use of horizontal drilling and hydraulic fracturing. These techniques carry environmental risk due to their high water use and substantial risk for water pollution. The potential for an average well in the Marcellus Shale to cause surface and ground water contamination was assessed using probability bounds analysis, a method useful when data is sparse and parameters highly uncertain. The study model identified five modes of water contamination: transportation spills, well casing leaks, leaks through

fractured rock, on-site discharge, and wastewater disposal. Probability boxes were generated for each pathway. The epistemic uncertainty is largest for the wastewater disposal which accounts for over 97% of the potential water contamination risk at the 99th percentile and below. At the 99.9th percentile, a rare, but serious retention pond breach could cause on-site discharge accounting for half of all the contamination risk. Even in a best-case scenario, there is a 50% chance that an individual well will release 30 cubic meters of contaminated fluids. Considering that the total number of wells in the Marcellus Shale region could range into the tens of thousands, this substantial risk suggests that additional steps be taken to reduce the potential for contaminated fluid leaks from hydraulic fracturing shale gas. Likewise, more data should be collected to reduce the considerable epistemic uncertainty.

### **TECHNIQUES FOR LINKING PUBLIC HEALTH GOALS AND MICROBIOLOGICAL CRITERIA ACROSS MULTIPLE HAZARDS: APPLICATION TO POULTRY, SALMONELLA AND CAMPYLOBACTER**

While the conceptual linkages between public health goals, performance standards and microbiological criteria have been developed and explored mathematically for single hazards in food, the potential of establishing product-level goals and criteria that consider risks from multiple hazards has not been previously discussed or demonstrated. This presentation describes the application of public health goals expressed as Disability-Adjusted Life Years (DALYs) lost from cases of salmonellosis and campylobacteriosis from consumption of poultry, using a previously established microbiological risk assessment model. In addition to allowing for multiple hazards, the approach explores two alternate methods for generating microbiological criteria from public health goals. One method follows the logic from public health goals to performance objectives, and then establishes microbiological criteria based on these performance objectives. Consider a health goal of 3.1 DALYs per million servings; an associated performance objective includes a combination of concentration and prevalence across both hazards. The microbiological criterion in this hypothetical case is 51 samples of 30 mL each, allowing up to five acceptable positives. The second method establishes microbiological criteria based on the desired public health goal, without reference to an intermediate performance objective. The resulting DALYs for each combination of concentration and prevalence which satisfy the criterion obtained in the first method range from 0.4 to 3.8 DALYs per million servings. The microbiological criterion produces DALYs that fail the public health goal, thereby calling into question the robustness of the first approach. The overall approach, while introducing some complexity, provides additional flexibility in finding improvements to overall public health, and may offer appropriate tools to address current and future standard-setting situations where multiple hazards are of simultaneous concern.

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## **NATIONAL CLIMATE ASSESSMENT & US ADAPTATION STRATEGIES**

Climate adaptation planning is emerging as a critical mechanism by which human and natural systems can better adjust to a changing climate. Adaptation efforts in the United States are being conducted at multiple Governmental levels and by both public and private organizations. Because of the inherent uncertainty in long-range projections, including regional-scale climate projects, risk analysis will play an important and growing role in developing climate adaptation strategies at all levels. This presentation will summarize current Federal activities in climate impacts analysis and adaptation, focusing, including adaptation policies for Federal agencies, environmental analysis, and, in particular, on the National Climate Assessment (NCA). At the national level, the National Climate Assessment acts as a status report on climate change science and impacts. It is based on observations made across the country and compares these observations to predictions from climate system models. The NCA aims to incorporate advances in the understanding of climate science into larger social, ecological, and policy systems, and with this provide integrated analyses of impacts and vulnerability. The NCA will help evaluate the effectiveness of our mitigation and adaptation activities and identify economic opportunities that arise as the climate changes. The current Assessment is being developed under the auspices of the Global Change Research Program, working through a Federal Advisory Committee and an interagency task force, with an expected completion date in 2013. The presentation will identify how risk and decision analysis professionals can contribute to the NCA and other emerging climate adaptation efforts

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## **CLIMATE CHANGE IN THE INDIAN COUNTRY: CULTURE, BELIEFS, RISK PERCEPTION AND BEHAVIOR**

Research on Native Americans' beliefs, perceptions and preferences regarding climate change is lacking, mostly because of the difficulty involved in working with Native Americans as a research group. This research focuses on exploring the Nevada Native Americans beliefs regarding the reality of climate change, its causes, and risk perceptions of its impacts. The research also investigates Nevada Native American's willingness to engage to climate change mitigation voluntarily actions, and climate change policy preferences. As part of the activities of a Nevada EPSCoR NSF funded project, Nevada tribes' environmental managers and tribal members inhabiting the Pyramid Lake Paiute Tribe reservation were surveyed using different techniques and approaches. The survey results show that Nevada Native Americans tend to believe in the reality of climate change and its anthropogenic causes. They are also noticing climate change related impacts in their environments, most notably decrease in snow

packs, decline in surface water, and decrease in water from springs. The most important climate change impacts they fear are those impacts that may impose change on their cultural practices and traditional lifestyles such as medicinal plants, pine nuts and willow gathering, hunting, and fishing. Nonetheless, they think that climate change will hurt the future generation, ecosystems and less wealthy countries more than the U.S., themselves and their families. Most of Nevada Native Americans support taking mitigation actions such as increasing the house insulations, fixing low-energy light bulbs and planting more trees, but only a minority support actions such as using more fuel efficient vehicles and using public transportation. When it comes to policy preferences, the vast majority of Native Americans support developing renewable energy resources and educating the public regarding climate change and its causes, but they don't support policies that might increase the cost of goods and gasoline or increase citizens' taxes.

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*ANSES*

## **RISK BASED MICROBIOLOGICAL CRITERIA FOR SHIGA TOXIN-PRODUCING E. COLI (STEC) IN GROUND BEEF**

Shiga toxin-producing *E. coli* (STEC) is a group of pathogenic *Escherichia coli* strains with the potential to cause severe enteric and systemic disease in humans. While the serotype O157:H7 is considered as clinically the most significant, in Europe it is estimated that up to 64% of STEC infections are caused by non-O157 serogroups. Undercooking of ground beef or hamburger patties is a common cause of reported STEC outbreaks. There is a growing demand for food safety targets to support the control of STEC particularly in ground beef. We evaluate the public health impact of risk-based microbiological criteria (MCs) for STEC at the end of the processing line. These MCs define the sampling protocol and acceptance criteria of food batches can serve as a readily food safety management tool in addition to GHP and HACCP systems. By developing a quantitative microbiological risk assessment populated with new collected data on ground beef preparation, STEC heat resistance and dose response model we obtain a relation between the within lot distribution of STEC concentrations on a portion of ground beef and the associated probability of illness for the consumer. This relation is combined with a set of possible types of within and between lots variability of STEC concentrations (considering different contamination patterns) and a set of potential specification of MCs. By analyzing the QMRA outputs, we assess the proportion of lots not complying with the possible criteria, and the relative residual risks following complete control of these lots. For different contamination patterns, this results in different risk estimates and different impacts of MCs on test compliance. Our results provide a tool for food safety managers to select the MC that is expected to provide the best balance between the cost of batches not complying with the MC and human health risk reduction that may be achieved.

### **NATURAL RESOURCES DEFENSE COUNCIL (NRDC) PERSPECTIVE ON TRANSPARENCY, SPEED AND STAKEHOLDERS' INVOLVEMENT IN EPA'S CHEMICAL RISK ASSESSMENT**

The EPA has a program for assessing the hazards of industrial chemicals in our air, water, and soil. These scientific assessments are not regulations themselves, but they are frequently used by regulators, at EPA, in the states, and around the world, to set the allowable levels of exposure to chemicals from different sources. Under TSCA - chemicals are considered safe until they are proven to be harmful by regulatory agencies. In most cases, the agency can't prove that a chemical is harmful without completing an assessment. And, unfortunately, under the current law there is no enforceable deadline for EPA to complete its chemical assessment, no 'harmful until proven safe' interim standards to limit chemical exposures, and no consequences for the industry if EPA fails to (or is prevented from) completing an assessment. Combined with the "innocent until proven guilty" approach of the current law, industry has every incentive to delay the completion of those assessments it thinks may lead to regulatory restrictions or liabilities. The recurring failure to complete risk assessments and set new legal limits on chemicals is so severe, that it became the focus of an investigation and report by the Government Accountability Office (GAO) in 2008. This presentation presents three high-profile chemical assessments - formaldehyde, styrene, and TCE - to support regulatory reforms. Reforms should include: enforceable deadlines for completing chemical assessments, meaningful consequences for the failure to complete a safety assessment, default interim health-protective standards (such as some protective fraction of the LD50) until the EPA can complete its assessment, restrictions on the expansion or new use of a chemical pending completion of the safety assessment, and shifting the burden of proof from the EPA to the chemical industry to show that chemicals are safe. EPA needs the authority to take action and protect the public from unsafe chemicals without waiting for additional years of study or surmounting endless hurdles thrown up by the regulated industry.

### **CLOSING THE LOOP: AN ASSESSMENT OF THE LIFE CYCLE OF BERYLLIUM-CONTAINING MATERIALS IN THE DEPARTMENT OF DEFENSE**

The Department of Defense classifies beryllium as a strategic, critical material. It is used in a vast array of defense-related products, such as bearings for landing gear, electronic connectors, mast-mounted sights, hatch springs, and mirrors. Beryllium's physicochemical characteristics make it a valued metal for military aerospace applications. Despite these characteristics and its numerous uses beryllium compounds pose

significant human health hazards when the beryllium or the beryllium-containing component is abraded, ground, or otherwise made respirable. Workplace activities and processes that generate aerosols are of particular concern. Exposure to aerosols (particulates, fumes, and dusts) of beryllium compounds (metal, alloys, oxide) is associated with beryllium sensitization and chronic beryllium disease. The U.S. Environmental Protection Agency (USEPA), the National Toxicology Program, and the International Agency for Research on Cancer (IARC) support the conclusion that beryllium is likely a human carcinogen. Because beryllium is a potential occupational exposure hazard and a strategic, critical material, it is important to know where beryllium is used, how it is used, and how it is managed at end-of life. The main goal of this presentation is to provide the results of a life cycle study that tracked specific beryllium-containing materials used in the DoD through production, component fabrication, manufacture, storage, use, maintenance, and end-of-life management. The presentation will highlight existing policies, procedures, and practices concerning the safe use and handling of beryllium, gaps in the life cycle of beryllium-containing materials, and risk management options to address these gaps.

### **LESSONS LEARNED FROM A PRELIMINARY QUANTITATIVE MICROBIAL RISK ASSESSMENT FOR LEAFY GREENS**

This presentation will present findings from a project that was undertaken to relate what is known about the behavior of *E. coli* O157:H7 under laboratory conditions, and integrate this information to what is known regarding the 2006 *E. coli* O157:H7 spinach outbreak in the context of a Quantitative Microbial Risk Assessment (QMRA). The QMRA explicitly assumes that all contamination arises from exposure in the field, but the mechanism is unspecified. What can be specified are the prevalence per serving and the pathogen concentration per gram on product coming out of the field. Extracted data, models and user inputs were entered into an Excel spreadsheet and the modeling software @RISK was used to perform Monte Carlo simulations. The model predicts that cut leafy greens that are temperature abused will support the growth of *E. coli* O157:H7, where concentrations of the organism may increase by as much as a 1 log CFU per day under optimal temperature conditions. When the risk model used a starting concentration of -1 log CFU/g, with 0.1% of incoming servings contaminated, the predicted cells per serving were within the range of best available estimates of pathogen concentrations during the outbreak. The model predicts that levels in the field of -1 log CFU/g and 0.1% prevalence could have resulted in an outbreak approximately the size of the 2006 *E. coli* O157:H7 outbreak. This QMRA model represents a preliminary framework that identifies available data and provides initial risk estimates for pathogenic *E. coli* in leafy greens. Important data gaps that were identified include retail storage times, correlations between storage



time and temperature, determining the importance of *E. coli* O157:H7 in leafy greens lag time models, and validation of the importance of cross-contamination during the washing process.

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### **CUMULATIVE RISK ASSESSMENT AND MULTIDIMENSIONAL INDICATORS**

Many community groups have asked for a cumulative risk assessment (CRA) or cumulative impact assessment for their communities; they believe that some traditional risk assessments have overlooked major issues facing their communities. In response to this call, US EPA published its Framework for Cumulative Risk Assessment in 2003 and has undertaken a number of other efforts; the US National Research Council published *Science and Decisions*; and many other activities have been and are being undertaken by governmental and non-governmental organizations. Progress, however, continues to be slow on this challenging problem and several different approaches have been taken. This presentation briefly breaks down these CRA approaches into several categories and describes an approach of multidimensional indicators for accelerating scientific advances and application to multiple real-world communities. These multidimensional indicators allow for core advances which can be used for a variety of CRA approaches and rely heavily on improved exposure estimation approaches at community scales. It also holds promise for incorporating non-chemical stressors into community-based cumulative risk assessments more widely.

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### **EXTENDING YOUR COMMUNITY-BASED RESEARCH TO OTHER COMMUNITIES: US EPA'S C-FERST (COMMUNITY-FOCUSED EXPOSURE AND RISK SCREENING TOOL)**

Community-based research on environmental exposures and risks has empowered many communities, reduced environmental injustices, and otherwise improved many communities. Gaps remain, however, in the development of readily-available data and tools critical to informing community activities. In order to provide tools and information to more communities, EPA is developing the Community-Focused Exposure and Risk Screening Tool (C-FERST) to assist with community assessments and lead toward actions to improve the health and well-being of communities. For researchers, C-FERST can provide a venue for extending their research beyond individual communities and expand the impact of scientific research. C-FERST focuses on research which can be used in any community in the U.S., such as ambient concentration, human exposure, and health effects, from spatially-explicit modeling results covering large geographic areas; also included are measurement methods and

risk reduction approaches which have broad geographic applicability. The intent of C-FERST is to foster meaningful community-based cumulative risk assessments and cumulative impact assessments. Collaborative research opportunities and needs exist for exposure modeling efforts, model evaluation, measurement methods, source apportionment approaches, risk reduction efforts, community sustainability best practices, the effects of ecosystem services on human health and well-being, and other activities widely applicable across the U.S. and, sometimes, other countries. The presentation will discuss how research activities in these areas could be part of EPA's web-based GIS decision support tool for conducting cumulative human exposure and risk screening assessments, to help build sustainable and healthy communities. This presentation will describe how previous research is being delivered to communities and a description of how future research could be delivered, including your current or future research.

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### **VAPOR INTRUSION: RISKS AND BENEFITS OF AN ALTERNATIVE APPROACH**

A growing body of evidence indicates that recalcitrant chemical vapor intrusion (VI) is highly variable (spatially heterogeneous and temporally episodic). VI risks cannot be reliably estimated (e.g., +/- 25%) without samples of the indoor air, and continuous or numerous indoor air samples over a long duration (e.g., 1 yr) are needed, from each building. Given the number of samples needed and disruptive and time-consuming nature of chemical indoor air sampling, including 'background' source removal/assessment and sampling, and the high analytical costs, the reliable assessment of current and future chemical VI risk is often impractical. The cost for reliably assessing chemical vapor intrusion approximates the cost of implementing vapor controls. Also, a fraction of the buildings where costs were expended for a reliable assessment of VI will find unacceptable exposures, and also incur costs for vapor controls to be installed, operated, and monitored for an extended period of time. Finally, it is globally recognized that the risks of VI are dominated by the risks from Radon which can be easily measured in indoor air and can be found to present >100x the generically-estimated source-based risk for chemical VI. An approach is proposed where buildings overlying chemical VI sources are assessed by assisting public volunteers to continuously measure the naturally-occurring general tracer of soilgas VI, Radon, in their indoor air for a period of one year (unless risks are excessive). Where radon levels are found to present risks >100x the potential generic chemical VI risk, Responsible Parties will be recommended to offer building occupants a pre-emptive '>100:1 Radon Zone 2+' vapor control system, as a more beneficial alternative to continued attempts at VI assessment for chemicals alone. Continuous post-mitigation monitoring of indoor Radon levels can ensure the effectiveness of VI controls and



significant risk reduction (with documentable improvements to public health).

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### **BEST PRACTICES FOR RISK AND TRADE SPACE ANALYSIS FOR ACQUISITION MANAGEMENT: OVERVIEW OF THE MILITARY OPERATIONS RESEARCH SOCIETY WORKSHOP**

In September 2011, the Military Operations Research Society held a Working session on Risk, Trade Space and Analytics for Acquisition. During this session, the Department of Defense, individual military services, industry representatives and university representatives from across the country joined in professional dialogue on the topics. These professionals were able to share and compare their terminology, methods and application of risk and decision analysis as it applies to materiel acquisition process. They identified appropriate analysis categories, priorities, and metrics to be used by the decision makers. They explained best practices on how to use these metrics throughout the decision architecture. They identified shortfalls in the application of these processes and metrics throughout DoD. They provided recommendations on the way ahead for development and execution of decision processes along the acquisition life cycle. This presentation will be the results of the MORS Special Session which is a synthesized version of two specific focus areas. One on Risk Analysis and one on Trade Space Analysis. Each directly related to the acquisition process.

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### **THE INSTRUCTIONAL DYNAMIC IN RISK MESSAGES: A COMPARATIVE ANALYSIS OF MESSAGES INTENDED TO ENHANCE PERCEPTIONS OF SELF-PROTECTION**

Our paper is based on a two-step analysis. First, we collected all stories broadcast on national television related to a serious food recall. We then coded the messages for the degree to which they provided adequate instruction (based on recommendations from subject matter experts) for how to identify and avoid consuming the harmful product. Next, we created an experimental design that allowed us to measure perceptions of participants' perceived capacity for avoiding the contaminated product. Participants in condition one were shown a typical story with little instructional information. Participants in condition two were shown a story that included more detailed instructions for self-protection. The experiment confirmed that the stories including clear instructional messages increased the subjects' perceived ability to protect themselves. The messages without instructional content did not. The clear majority of the stories we collected and coded did not include detailed instructional information.

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### **MODELING AND RISK ASSESSMENT OF TERRORIST-COUNTER-TERRORIST INTERACTIONS WITH MULTI-AGENT INFLUENCE DIAGRAMS**

The unique sophistication of an intelligent adaptive agent in terrorist risk assessment requires a novel methodology to model adversarial decision-making in response to offensive, defensive, and mitigative measures. The Multi-Agent Influence Diagram (MAID) [Koller, Milch (2003)] furnishes a promising approach by synthesizing multi-agent modeling, game theory, and probabilistic decision networks. We augment the MAID with an architecture that incorporates agent beliefs, values, and goals into the model structure. The multi-agent scenario and their respective strategies are intuitively represented by a decision graph where the agents' strategies and expected utilities can be evaluated from the perspective of a game in terms of the Nash equilibrium or quantal response equilibrium. In this presentation, we discuss the value of modeling the terrorist-counterterrorist problem using the MAID approach, the natural risk metrics that the methodology affords, and the future extensions of this work.

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### **THE EMPIRICAL TEST OF SEVERAL VULNERABILITY HYPOTHESES IN TERMS OF RISK PERCEPTION AND EXPERIENCE**

Our study aims to empirically test the 'Vulnerability Hypothesis'. Vulnerability is usually defined as a degree of hazard from biophysical risks as well as social risk. Vulnerability may be an internal risk factors of the subject or system that is exposed to a hazard and corresponds to its intrinsic predisposition to the affected or to be susceptible to damage. We elaborate this hypothesis both by building the more comprehensive theoretical model and by testing it through empirical analyze of the survey data. In data analysis, we will do, first, systemically analyze the hypothesis whether the vulnerable groups really have the higher risk perception than other competent groups do. Second, we will analyze whether or not those vulnerable groups really face risky experience more than the strong groups do. Third, we examine the relationships between risk experience and the risk judgment.

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### **RISK ASSESSMENT ON ANIMAL WELFARE PERFORMED AT THE EUROPEAN FOOD SAFETY AUTHORITY IN THE EU**

EFSA is the keystone of the EU risk assessment regarding food and feed safety, including animal health and animal welfare. EFSA provides independent scientific advice and communication on existing and emerging risks. Since EFSA's scientific advice serves to inform risk managers, a large part of EFSA's work is undertaken in

response to requests from the EC, the European Parliament (EP) and EU Member States (MS). EFSA also undertakes scientific work on its own initiative, so-called self-tasking. Current EU legislation on animal welfare covers calves, pigs, laying hens and broilers as well as experimental animals. Decisions on welfare requirements must be based on a sound science and appropriate risk assessment. Since 2003, EFSA has provided scientific opinions and advice as well as technical support to risk managers in the area of animal welfare. The EFSA Animal Health and Welfare Panel has delivered 36 scientific opinions on a variety of welfare issues. Although EFSA does not make scientific research, it has played an important role on assessing the risk on animal welfare and has provided important reviews of the current scientific knowledge on animal welfare. The concept of animal welfare is not only related to the protection and well-being of the animals but also to its relationship with animal and public health. Animal welfare indicators for the control and monitoring of animal welfare should allow ranking of the welfare standards applied (from minimum to higher standards) in order to assist the development of improved animal welfare production and husbandry methods and to facilitate their application at EU and international levels. EFSA scientific opinions have been and are used for international standard purposes considering the general reluctance to accept and enforce standards not supported by science. The paper summarises the used Risk assessment methodologies by EFSA future possible trends.

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#### **DO MAPS PROMOTE WATER TESTING AMONG RESIDENTS WITH PRIVATE WELLS? THE INFLUENCE OF MAP FEATURES AND PERCEIVED PROXIMITY TO MAPPED HAZARDS ON RISK BELIEFS, UNCERTAINTY, AND TESTING INTENTIONS.**

The purpose of this study was to assess the influence of three map features and perceived proximity to mapped hazards on risk beliefs, perceived uncertainty and protective behavior. Maps depicted private well water test results for arsenic. Features were map color (symbolic “stoplight” risk colors or non-risk colors), a hatching symbol to display map areas with no data (with or without hatching), and a table to supplement map information (with or without table). This full factorial 2 x 2 x 2 randomized trial resulted in 8 map interventions plus a 9th table only control. The sample was homeowners with private wells from a county with some arsenic water test results over the drinking water standard. Participants were spatially and randomly selected from 8 townships that had different spatial distributions and amounts of arsenic and no data. Of 1224 mailed surveys, 830 (67.8%) were returned. Structural equation modeling will be used to examine the influence of map variables on behavioral intentions to test water for arsenic and how risk beliefs and uncertainty mediate those relationships. These influences will be examined within a context of partici-

pants’ characteristics that include prior risk beliefs, satisfaction with water aesthetics, skepticism about well water-related health risks, numeracy, gender, years in home, age, and education. Data collection is completed. Study results will be shared in this presentation.

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#### **MAPPING MODELED HEALTH RISK FOR ENVIRONMENTAL HAZARDS: THE INFLUENCE OF THREE MAP FEATURES ON RISK BELIEFS AND PERCEIVED UNCERTAINTY FOR MAPS OF MODELED CANCER RISK FROM AIR POLLUTION**

Often, models are used to estimate health risks from environmental hazards and maps are used to display this information. The concrete nature of images, such as maps, may convey more certainty than warranted for information estimated from models. Furthermore, maps using conventional stoplight colors to symbolize the safety of these estimates may generate stronger risk beliefs than warranted for modeled information. In Wisconsin, natural resources and public health professionals developed a model to estimate cancer risk based on estimated air emissions and want to display this information using maps. We selected two map features to convey the certainty of modeled cancer risk (less vs. more certain): data classing (unclassified vs. classified) and how risk is expressed in the legend (relative risk vs. defined risk). Color (non-risk vs. stoplight risk colors) was a third feature. The purpose of this study was to assess how these features influenced risk beliefs and uncertainty about risk beliefs at four map locations that varied by risk level. This full factorial 2 x 2 x 2 x 4 randomized trial used 32 maps that varied by study features and 4 risk levels. Maps were arranged into 8 blocks of 4 maps. Dependent variables included risk beliefs and perceived uncertainty at personal and neighborhood levels. 776 university students, randomly assigned to one block of four maps, participated in this online survey for extra credit. Structural equation modeling is used to assess the influence of map features on risk beliefs and perceived uncertainty in the presence of participants’ characteristics (prior beliefs about air pollution, family cancer experience, academic major, numeracy, and gender). Data analysis is in progress. Results and implications will be included in this poster presentation.

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#### **COST OF EQUITY IN DEFENSIVE RESOURCE ALLOCATIONS IN THE FACE OF A POSSIBLY NON-STRATEGIC ATTACKER**

Hundreds of billions of dollars have been spent in homeland security since September 11, 2001. Many models have been developed to study games between governments (defender) and terrorists (attacker), however, few studies consider the tradeoff between equity and efficiency in homeland security resource allocation. In

this paper, we develop a novel model in which a government allocates defensive resources among multiple potential targets, while reserving a portion of defensive resources (represented by the equity coefficient) for equal distribution (according to geographical areas, population, density, etc.). We consider that the defender is uncertain whether the terrorist is strategic (adaptive) or non-strategic. The attack probabilities of a strategic terrorist are endogenously determined in the model, while the attack probabilities of a non-strategic terrorist are exogenously provided. By varying the equity coefficient, we compare the optimal defensive resource allocations among multiple targets, and the associated expected losses. We show that expected property loss increases in equity coefficient. We also conduct sensitivity analysis with regard to four system parameters (i.e., equity type, total defense budget, cost-effectiveness of defense, and the probability that the terrorist is non-strategic). Extensive numerical examples illustrate that the cost of equity (in terms of additional expected property loss) increases convexly in the equity coefficient. Furthermore, such cost would be lower in: (a) type of equity (if the government would consider per-target equity); (b) the cost-effectiveness of defense; (c) the total defense budget; and (d) the probability that the terrorist is non-strategic.

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#### **SUBSIDIZING TO DISRUPT A TERRORISM SUPPLY CHAIN - A FOUR-PLAYER GAME**

Terrorism with weapons of mass destruction (WMDs) is an urgent threat to homeland security. The process of counter-WMD terrorism often involves multiple government and terrorist group players, which is under-studied in the literature. In this paper, first we consider two subgames: a proliferation game between two terrorist groups or cells (where one handling the black market for profits proliferates to the other one to attack, and this is modeled as a terrorism supply chain) and a subsidization game between two governments (where one potential WMD victim government subsidizes the other host government, who can interfere with terrorist activities). Then we integrate these two subgames to study how the victim government can use the strategy of subsidy to induce the host government to disrupt the terrorism supply chain. To our knowledge, this is the first game-theoretic study for modeling and optimally disrupting a terrorism supply chain in a complex 4-player scenario. We find that in the integrated game, when proliferation payment is high or low, the victim government will not subsidize the host government to destroy the black market regardless of its cost. In contrast, in the subsidization subgame between the two governments, the decision of subsidization depends on its cost. When proliferation payment is medium, the decision of subsidization depends on not only its cost but also the preparation cost and the attacking cost. We study three extensions: (a) a subsidization subgame of incomplete information, (b) a simultaneous-move inte-

grated game, and (c) an integrated game with a different sequence of moves. Findings from our results would assist in government policy making.

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#### **BAYESIAN MODEL AVERAGING FOR BENCHMARK DOSE ESTIMATION FROM CONTINUOUS DATA**

The use of Benchmark dose (BMD) with its lower limit, the BMDL, has been accepted by both government agencies and scientific communities since its introduction by Crump in 1984. Recently, Bayesian model averaging (BMA) has been proposed by a number of researchers as a method to take into account between-model uncertainty for BMD estimation (Bailer et al. 2005, Morales et al. 2006, Shao and Small 2011). However, the BMA method was mainly applied to estimate BMD from dichotomous data (or quantal data) in the previous studies. In the present study, a Bayesian framework is presented to calculate the BMD from continuous data based on the concepts and methods introduced by Crump in 1995. The Bayesian methods are used to fit alternative dose-response models for continuous data using Markov Chain Monte Carlo (MCMC) simulation for parameter estimation, and BMA (including both approximation and exact estimation) is used to compare and combine the alternative models. Additionally, BMA estimates for the BMD are developed, with the uncertainty in these estimates used to derive the lower bound BMDL. We believe that the BMA method may help risk assessors enhance the precision of BMD estimates. For the purpose of method demonstration and comparison, multiple dose-response models for continuous data embedded in U.S. Environmental Protection Agency (EPA)'s Benchmark Dose Software (BMDs) are selected as examples to illustrate this methodology.

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#### **WHAT AFFECTS THE SHARING OF RISK KNOWLEDGE IN GOVERNMENT NETWORKS - A SOCIAL NETWORK ANALYSIS.**

Risk management is reliant on the availability and sharing of knowledge. Whilst the exchange of codified knowledge informs practice and reduces organisational 'forgetting', it is the sharing of tacit knowledge or advice with colleagues that offers support, aids decisions and fosters innovation. Interaction in social networks is particularly important in knowledge intensive organisations or dynamic or uncertain contexts. One such environment is a government policy group dealing with critical risk-based knowledge. We employ both quantitative and qualitative methods to assess the effectiveness of knowledge sharing (KS) in a government policy group, and identify the factors, conditions and mechanisms that affect KS in risk. A social network approach is employed to analyse a network of 23 officials (85.2% of the population) involved in risk-based decision making; including risk analysts, scientists, policy mak-



ers and inspectors. Analysis examines the connectivity of actors - considering both formal relations (e.g. risk reporting responsibilities) and informal relations. Network data collected from questionnaires was analysed in UCINET. Semi-structured interviews with all 23 officials provided rich data about the context, and the factors and conditions that effect KS. Results indicate that KS is influenced by length of service, awareness, accessibility, and perceived value of relationships. Factors that support risk management via KS include physical proximity, bespoke evidence and policy databases, shared goals and trust between functions. The research provides evidence to the claim that KS through social networks contributes to risk management. Continuing research will help define why and how risk management draws value from effective KS, and investigate the roles individual actors play in brokering risk knowledge. Findings will help inform government departments and other organisations seeking to improve risk management by leveraging knowledge from social networks.

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#### **AVOIDANCE AND ADAPTIVE BEHAVIORS FOLLOWING THE FUKUSHIMA NUCLEAR DISASTER: LESSONS IN PREPARING FOR RADIOLOGICAL TERRORISM**

The 2011 Fukushima nuclear disaster in Japan following the Tsunami and earthquake provides valuable insights into how the public responds to radiation contamination. The session will first identify the avoidance and adaptive behaviors exhibited by the Japanese in the days, weeks and months following the nuclear disaster, and second, what lessons can be applied to preparing and responding to a radiological attack. The examination of the avoidance and adaptive behaviors will include: 1) How the perceived risks were influenced by the preexisting narrative surrounding the government and nuclear reactor firm's ability to handle such disasters based on their handling of previous events; 2) The efficacy of the risk communication messages and how these might have amplified or reduced the perceived risks and subsequent behaviors; 3) How the populace responded to safety concerns from food supply chain contamination to fleeing neighboring cities for areas regarded as safer; 4) The longer term ripple effects for the Fukushima prefecture and neighboring regions including the willingness of residents and businesses to return and stay in the area. The second part of the presentation will examine how the lessons from Fukushima can inform the preparedness and response to a radiological dispersal device (RDD) attack, and the risk communication challenges to mitigate adverse avoidance behavior in the short and long term. Understanding such challenges is critical to augment the resiliency of a society to prepare and recover from an RDD. Evidence will be drawn from survey data and qualitative research in the six months after the disaster.

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#### **A NEW NANOCRYSTALLINE CELLULOSE PILOT PLANT IN ALBERTA: ENVIRONMENTAL HEALTH AND SAFETY CONSIDERATIONS**

The Canadian forest sector has been hit hard by the recent global recession. As a result, new ways to transform through innovation are being considered. One such approach is to create high value materials and products from biomass. One naturally occurring nanoscale material, Nanocrystalline Cellulose (NCC), is being touted as a potential boon for the forest sector. NCC, liberated from trees and plants using chemical a relatively simple chemical process has been described as "nature's carbon nanotubes". Depending on the source material, liberated NCC has a high aspect ratio (~ 200 x 10 x 5 nms). Key properties of NCC that are of particular interest for industrial application include its high surface area, tensile strength, concentration-related physical characteristics, optical and magnetic properties and biodegradability. It is anticipated that NCC will be used to improve the functional features of a variety of consumer products including composite materials for the automotive industry, pharmaceutical and food product fillers among others. The Alberta Government, through Alberta Innovates - Technology Futures is installing a pilot plant in its Edmonton facility. The implications of installation and scale-up of an NCC manufacturing facility, including occupational health and safety and risk management issues will be explored in this presentation. A planned interaction with NIOSH will inform this work.

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#### **RISK ASSESSMENT OF NANOMATERIALS -FULLERENE C60-**

Fullerene C60 has tremendous potential for use in many industrial and medical nanotechnology applications. However, there has been a worldwide concern about its safety owing to the lack of information available regarding its potential hazardous effects and their risks. Thus, we conducted exposure, hazard, and risk assessments. In the exposure assessment, we estimated the exposure levels in the workplace of a C60 manufacturing facility and a secondary production facility and in the general environment surround the C60 manufacturing facility. In the hazard assessment, we aimed to provide a period-limited acceptable exposure level for humans, which should be modified within the next 10 years as new knowledge becomes available. We have presented a hazard assessment, including a review of the available toxicity information on the effects of C60 on the lungs. We then estimated the no-observed-adverse-effect level (NOAEL) of C60 on rat lung toxicity to be 3.1 mg/m<sup>3</sup>, on the basis of the lung retention of C60 in an inhalation exposure test and an intratracheal instillation test. The NOAEL for human was calculated to be 3.1 and 1.3 mg/m<sup>3</sup> for healthy workers and the general population, respectively. The uncertainty factors were considered to be 9 and 90 for healthy workers and the general popula-



tion, respectively. Therefore, the period-limited acceptable exposure levels were estimated to be  $(0.39 \times \frac{f[\text{work},n=x, \text{GSD}=y]}{0.0913})$  mg/m<sup>3</sup> for healthy workers and  $(0.014 \times \frac{f[\text{work},n=x, \text{GSD}=y]}{0.107})$  mg/m<sup>3</sup> for the general population. From the results of risk assessment, it is considered that the risk of C60 is low in the workplace and general environment.

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### **ALIGNING RISK WITH REALITY - A CASE STUDY FROM THE UK FINANCIAL SERVICES INDUSTRY**

This paper uses a case study methodology to examine how a large UK Financial Services organisation has successfully integrated two diverse risk cultures to align risk appetite and decision making across the wider organisation. It provides insights into how risk assessment methodologies, and bodies of evidence from decision science can be successfully combined with models from social science areas to drive changes in perception of risk and risk taking behaviour.

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### **HOW THE ACCIDENT AT FUKUSHIMA AFFECTED THE PUBLIC'S PERCEPTION OF NUCLEAR POWER: RESULTS OF A LONGITUDINAL SURVEY**

Major nuclear accidents, such as the recent accident at Fukushima, Japan, have been shown to decrease the public's acceptance of nuclear power. Only a few studies have compared perceptions of nuclear power before and after a catastrophe. Little is known, therefore, of how acceptance of nuclear power is influenced by a serious accident. We conducted a longitudinal mail survey among a representative sample of the Swiss population (N = 786). The first wave was in autumn 2010 (before the accident in Fukushima), and the second started at the end of March 2011 (two weeks after the accident in Fukushima). Trust, acceptance, perceived risks, and perceived benefits related to nuclear power stations were measured. In our model, we assumed that benefit and risk perceptions determine acceptance of nuclear power. We further hypothesized that trust influences benefit and risk perceptions, and that trust is correlated across the two waves. The proposed model explains the data very well (CFI = .96). The results suggest that perceived benefits and risks in 2010 determined people's acceptance of nuclear power stations in 2010. After the accident in Japan, perceived benefits and risks still explained a large amount of the variance in the acceptance of nuclear power stations. Trust had a strong impact on perceived risks and benefits in 2010, the impact was a bit lower in 2011. Trust in 2011 was strongly influenced by the level of trust in 2010. Trust, acceptance and benefit perceptions were significantly lower and risk perceptions were significantly higher in 2011 compared with 2010. Our survey results suggest that even after a severe accident trust remains important for

people's risk and benefit perception. Results are discussed in the framework of the trust and confidence model.

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### **PROBABILITY PARADOXES EXPLAINED BY THE SECOND UNCERTAINTY PROCESSOR**

Neuroimaging evidence suggest that we have at least two uncertainty processors in the multicameral human brain. One of these processors is devoted to risk calculations while the other handles detection and processing of epistemic uncertainty. The processors are localized in different parts of the brain and use different chemical systems that are separately activated by the format of sensory input. When both processors fire, they can give conflicting resolutions, but the brain appears to often give priority to considerations of incertitude over variability. We explore how these competing processors effect perception and cognition of uncertainty and suggest that several famous paradoxes in probability and decision making arise because of the interplay between these mental processors. These phenomena include the Ellsberg Paradox and ambiguity aversion, loss aversion, the two-envelopes paradox, hyperbolic discounting, the two-dimensionality of risk perception, and others. Although these phenomena are usually presumed to be biases or cognitive illusions, we describe the adaptive significance of these phenomena in humans and other species and place them in an evolutionary context where they do not appear to be failings of the irrational human brain but rather adaptations. The psychological and neurological evidence suggests that epistemic and aleatory uncertainty should not be rolled up into one mathematical concept in risk assessment, but require a two-dimensional view that respects biological realities within the decision-maker.

W3-E.3 Simon-Cornu M, Beaufort A, Gonze MA, Metivier JM, Mourlon C, Parache V; marie.simon-cornu@irsn.fr  
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### **COLLECTING DATA TO ASSESS FOOD EXPOSURE: COMPARISON OF A 4-YEAR PROJECT (L. MONOCYTOGENES IN SMOKED SALMON) VERSUS A REAL-TIME ASSESSMENT AFTER FUKUSHIMA ACCIDENT (RADIOLOGICAL HAZARDS)**

Assessing human exposure to a food hazard requires an intensive data collection, relative to the emission of the hazard, the fate of the hazard from emission to the food "as it is consumed", and the consumption of the food. When collecting these data for risk assessment, the time frame and the availability of resources may lead to different situations, as illustrated here by two extreme cases. The first case is a 4-year research project led and self-funded by the French Food Safety Agency, assessing the fate of *L. monocytogenes* from production to consumption of cold-

smoked salmon, and associated exposures and risks. Intensive data acquisition was focused on filling the needs of the exposure model. Data specifically obtained in this context and then directly used as inputs of the risk assessment included for example: 626 detection analyses, 384 enumeration analyses with a specific sensitive protocol (LOQ=0.2 cfu/g), 61 challenge tests, 15 storage trials, 132 time-temperature profiles. The second case is a feasibility study performed by IRSN (Institute of radioprotection and nuclear safety) to simulate with the modeling platform SYMBIOSE the fate of radiological releases (particularly <sup>131</sup>I, <sup>134</sup>Cs and <sup>137</sup>Cs) in the terrestrial environment of the Fukushima Dai-ichi nuclear power station (Japan). The context, i.e. the distance between France and Japan and the wish to perform calculations quickly, led IRSN to rely only on publically available sources. Collected data used as inputs for the simulations included for example: the land use (derived from remote-sensing processing of a Landsat scene), or the contamination of soil and surface water. Many crude assumptions were made when no trustworthy information was found (e.g. concerning animals' feed). The Japanese ministries also made available measures for thousands of samples (edible and non edible plants, other foods), that were used for model-data comparison.

P.37 Simon-Cornu M, Beaugelin-Seiller K, Calmon P, Mourlon C, Nicoulaud V, Garcia-Sanchez L, Gonze MA; marie.simon-cornu@free.fr  
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### **CONDUCTING UNCERTAINTY AND SENSITIVITY ANALYSES IN RADIOLOGICAL RISK ASSESSMENT WITH THE PROBABILISTIC DATABASE OF SYMBIOSE**

Symbiose is a simulation platform assessing the fate of radioactive hazards in environmental systems, and their impact on humans. The main concern is to promote a scientific and software approach that is flexible enough to deal with a wide range of situations, from simplified generic studies to more realistic spatially-distributed and site-specific assessments, for assessing risks induced by radioactive releases from nuclear facilities under accidental, decommissioning or normal operating conditions. Environmental models in Symbiose address media such as atmospheric, terrestrial, freshwater and marine systems, as well as major transfer processes at their interfaces. Equations and default parameters (modifiable by the user) are proposed on the basis of multiple sources (refereed literature, grey literature, own datasets) to account for hundreds of components and interactions, most of which are modeled using a mechanistic approach (i.e. with physically-based parameterisation). A calculation engine offers various numerical solvers dealing with possibly complex system dynamics, and functioning in either a deterministic or probabilistic mode (Monte Carlo). On the basis of an International Atomic Energy Agency report, log-normal and log-uniform probability distribution functions (PDF) were added to account for uncertainty on key inputs when modelling transfer of radioactive substances in continental environ-

ments: liquid-solid interactions in rivers and soils, root uptake by plants, transfer to animals, storage of foods... Rules to transform available data into log-normal and log-uniform PDF were applied as a function of the scarcity of data and taking into account (spatial, temporal,...) variability issues. When performing uncertainty and/or sensitivity analyses, this probabilistic database can be used either as such or as a default basis to be completed. This offers promising perspectives in a field where such analyses are claimed to be necessary but still rarely applied.

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### **IDENTIFYING UNCERTAINTIES WITHIN ENVIRONMENTAL RISK ASSESSMENTS**

Uncertainties in environmental risk assessments (ERAs) must be addressed if the results are to be communicated with a high level of confidence. Current typologies of uncertainties are difficult to implement<sup>1</sup>. This research introduces an evidence-based system to help identify uncertainties in ERAs in order to resolve this problem. Previously, the different types of uncertainties present in ERAs were identified and the relationships between them and other aspects of the assessments were analysed. The resulting uncertainty typology and statistical analyses are applied to case studies consisting of peer-reviewed articles from the fields of genetically modified higher plants, air quality, and chemicals. These research areas have large evidence bases from which observations can be drawn, involve an array of assessment processes, and contain well-documented uncertainties. The collated articles were reviewed for instances of uncertainty, and the strengths of the previously highlighted relationships were investigated further. An analysis of the collected data enabled the development of three field-specific identification systems, centred on the strong relationships between the uncertainties and the different types of evidence employed in the ERA. These distinct systems were then adapted into a transferrable generic tool. Testing of this tool is ongoing, and focuses on the emerging risk area of engineered nanomaterials and preliminary results are presented. It is intended that this research will be of use in the formative stages of ERAs and uncertainty assessments, and that it will promote an understanding of the potential failings. Furthermore, it will help practitioners design and perform assessments with these uncertainties in mind. This work is funded by Cranfield University/Defra/EPSRC/ESRC/NERC under grant EP/G022682/1. 1 Klinker et al, 1999, European Science and Technology Observatory: Sevilla, 19056/EN/2.

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### **LOCAL RISKS, STRATEGIC CONSEQUENCES; IMPROVING RISK MANAGEMENT IN UK LOCAL GOVERNMENT**

Organisations cannot prevent every risk from occurring, and must instead prioritise their responses on hazards by either prevention, managing them to an accepted level or by tolerating them. Such decisions are based on the skills and knowledge of individual decision makers and also past experiences, and these are gained through learning processes. Local authorities in the UK have difficulty defining their risk appetite because of the diverse range of hazards they are responsible for managing, everything from preventing child abuse to responding to severe weather events (1). Subsequently, while some risks can be accepted others cannot, and this can make it difficult to establish lessons. These challenges are further complicated by shifting institutional architecture which looks to decentralise power to communities, while budgets are reduced (2). These circumstances present an opportunity to review past practices and to develop more effective solutions. This research demonstrates the commonalities between the tensions and range of challenges within one sector in the UK, and the potential methods by which they can be addressed. A series of targeted interviews (n=16) with a range of individuals who are employed to deal with risk have been coded and used to identify a series of common themes, including learning, process, and trusted judgement. The identified themes were then investigated, using published and grey literature, expert input and practitioner interviews to develop an understanding of the tensions and methods for addressing them within this sector, and the potential application within a wider range of sectors. 1) Byrne, T. (2000) *Local Government in Britain: Everyone's Guide to how it all Works*, 7th edition, Penguin, London 2) HM Government, (2010) *Decentralisation and the Localism Bill: an essential guide*, Communities and Local Government, London

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### **GAME THEORETICAL RISK MANAGEMENT**

Risk management within information security (e.g. ISO 27005) usually mandates that experts identify threats, vulnerabilities, consequences and likelihood. In the domain of information security, one usually assumes an active and potentially adaptive adversary. However, these methods very rarely mandates that the risk analyst clarifies his underlying assumptions relative to factors that are critical when predicting the likelihood of future incidents. In practice, it appears to be the case that likelihood estimates are based on traces of historic events such as incident logs. As highlighted by Taleb in his book *The Black Swan*, history is not always a good teacher when it comes to identifying catastrophic events. We suggest that we need to re-think what kind of data to use when predicting the likelihood of incidents. Rather than asking

experts about the likelihood of various events, one should instead ask (potentially different experts) questions such as- Who are the stakeholders, What incentives do the stakeholders have? How do the stakeholders value the various outcomes/potential incidents? What kind of information is available to the various stakeholders? What decision strategies do the various stakeholders employ? We claim that if one is focusing on these issues rather than the direct elicitation of likelihood guesses, one will be better equipped for identifying, preparing for and handling disastrous events - that for other stakeholders might be highly desirable. To address this, we present a framework for integrating game theoretic concepts into a classical risk management approach. We suggest that this approach provides benefits even if no equilibria are computed and that the benefits come from the fact that the game theoretic perspective forces the risk analyst to identify and consider factors that are essential when predicting the actions of an intelligent and adaptive adversary.

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### **INCREASING THE TEMPERATURE OF HIGH TEMPERATURE, SHORT TIME PASTEURIZATION MAY INCREASE THE RISK OF LISTERIOSIS FROM CONSUMPTION OF PASTEURIZED FLUID MILK**

While adequate pasteurization is critical to the safety and quality of fluid milk, previous research has suggested that modest increases above the minimum high-temperature short-time pasteurization temperature (72°C for 15 s) can increase the subsequent outgrowth of bacteria during refrigerated storage of milk. This study evaluated how an increase in pasteurization temperature from 72°C to 82°C affected growth of *Listeria monocytogenes*, a foodborne pathogen eliminated with proper pasteurization but of concern when milk is contaminated post-pasteurization. 12 8-gallon samples of raw milk were collected from the same dairy farm over 24 months, split and pasteurized for 25 s at 72°C or 82°C; after cooling milk was inoculated with *L. monocytogenes* and stored at 6°C for 24 d for enumeration. Overall, milk pasteurized at 82°C showed greater *L. monocytogenes* growth, specifically (i) lag phase decreased by 2.5 d (from 4.4 to 1.9 d,  $p < 0.001$ ), (ii) maximum growth rate increased by 0.064 log(CFU/ml)/d (from 0.50 to 0.57 log(CFU/ml)/d,  $p = 0.026$ ), and (iii) maximum cell density increased in a temporally dependent manner ( $p < 0.001$ ) where the first 6 lots showed a 1.9 log(CFU/ml) increase (from 10.0 to 11.9 log(CFU/ml)) and the second 6 lots only a 0.44 log(CFU/ml) increase (from 8.1 to 8.6 log(CFU/ml)). To evaluate the magnitude of the risk to human health posed by the increased pasteurization temperature, the 2003 U.S. government quantitative microbial risk assessment for *L. monocytogenes* in ready-to-eat-foods was modified to predict relative cases of listeriosis per annum based on differences in growth parameters between the two treatments. Predictions for pasteurizing all fluid milk at 82°C rather than 72°C showed a 3.1-fold increase in the median cases of listeriosis (4.3 and 2.8-fold increase in the 5th



and 95th percentiles). Increasing the pasteurization temperature of milk may modestly increase the incidence of listeriosis caused by fluid milk consumption.

P.89 Steinhardt JS, Scherer CW, Buckingham JL, Kermis AD, Klopp AL, Kubli KA, Ross E; jss399@cornell.edu

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### **IN GOOGLE WE TRUST: PRESENTATION AND INFORMATION SEEKING OF UNCERTAIN INFORMATION ABOUT THE 2011 JAPAN NUCLEAR CRISIS**

Using the 2011 Japanese earthquake-tsunami as a focal point, this two part exploratory study examines 1) how individuals seek risk information and assess credibility in sources online, and 2) how uncertain risk information is presented in news stories and blogs on the internet. Through observation followed by qualitative interviews with students at a large university the research explores the process of seeking information about the Fukushima 1 nuclear accidents and their impact on local food safety as well as about the risks of building new domestic nuclear power plants. Participants were asked to evaluate these risks using any online sources available. We conclude that students place a significant amount of trust in search engines as gatekeepers and believe that if a source comes up early in search results it is credible. Students believe that large corporations such as The New York Times and CNN have more at stake if they report inaccurate information and place trust in their stories. Websites that students have not previously encountered and ones that they believe are poorly designed are also viewed as less credible. To better understand how uncertain risk information is presented, and what sources information seekers could be accessing, a sample of news stories from CNN, NPR, New York Times, and selected blogs were analyzed. Stories were selected which discussed how nuclear contamination in Japan was impacting food safety there and the United States. In general, we conclude that there is uncertainty in almost all of the content; however, many of the articles make their claims with certainty. Very few articles actually contain scientific sources, however, almost all of the articles make scientific claims. Mainly these are through political sources. Other times, articles just make use of the words “officials, experts, and authorities.” Most articles represent two viewpoints (often: safe vs. unsafe), but stress one side or the other.

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### **CORRECTIVE LENSES FOR IRIS**

Over the last six years, the Center for Progressive Reform (CPR) has published a series of white papers about EPA's Integrated Risk Information System. While supportive of the program's high quality of work, CPR's papers are critical of the speed with which new IRIS profiles are completed and old profiles are updated, the gaps in the database from the perspective of the public health advocacy community, and

the review processes employed by the agency. We have proposed several reforms to the IRIS program that could eliminate data gaps and speed the assessment process. They include aligning the IRIS agenda with regulatory agendas in EPA's air toxics and drinking water programs, developing environmental-justice-based criteria for selecting chemicals to review, and streamlining all outside review of draft IRIS profiles into a single stage. This presentation will cover CPR's proposed reforms, as well as new research about differences in the degree of participation in the IRIS process by potentially regulated parties versus the potential beneficiaries of health-protective regulation. CPR's research generally, and our work on IRIS in particular, present a cross-disciplinary perspective on risk-based regulation.

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### **ASSESSMENT OF METHODS FOR ESTIMATING EXISTENTIAL RISKS: PART II**

This presentation focuses on four ‘model’-based methods that one could use to estimate existential risks. The term ‘model’ is being used emphasize that the approach contains a method for structuring how multiple factors interact with each other in a causal fashion that ultimately could lead to human extinction. The most established method to be discussed is known as Bayesian networks. Three other innovative methods are also considered: influence modeling based on environmental scans; simple elicitation using human extinction scenarios as anchors; and computationally intensive possible worlds modeling. The four methods are also assessed about how well the approach describes causal relationships between events that could lead to human extinction; level of elicitation efforts required of experts; ease of approach implementation; transparency of inputs into risk estimates; and acceptability of the approach.

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### **ENSURING CONSISTENCY IN RISK ANALYSIS EVENT TREES AND CONSEQUENCES**

Risk is often evaluated by constructing event trees and estimating consequences for the scenarios built by the trees. This process is intended to construct a spanning set of scenarios that captures the risk for the scope of the assessment. In practice, it is easy to overlook important sub-events that significantly impact the relative likelihood and/or the relative risk of the scenarios. It is also common to estimate consequences for different types of scenarios using disparate models that may not be equivalently conservative and, thus, may skew the risk results, sometimes by multiple orders of magnitude - especially for rare and highly consequential events like terrorist attacks. The impact of inconsistency in event trees and consequence assessments tends to grow in severity and importance as the scope of the risk assessment broadens. In this talk we will present notional examples of terrorism risk assessments where relative



risks are severely miscalculated by failing to model important aspects of the event tree and where consequence assessments which are not equivalently conservative result in reversal of relative risk estimates. The talk will conclude with suggestions for best practices and rules of thumb for ensuring that event trees and consequence estimates are consistent. These best practices will be useful in designing event trees and consequence calculations as well as validating terrorism risk models.

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### **FROM CALCULATIONS TO RESULTS TO DECISIONS: HOW A RISK ARCHITECTURE APPROACH SUPPORTS DECISION MAKING AT THE DOMESTIC NUCLEAR DETECTION OFFICE (DNDO)**

One of the important challenges for risk analysis is ensuring that the results can be effectively used to provide risk information for management decisions. The process to gain acceptance of risk information relies on two key components: sufficient maturity, credibility, and specificity of the risk results and an understanding among decision makers of the necessity and usefulness of the risk information. These two components are synergistic. A risk analysis that is not yet mature, credible, or sufficiently detailed to support decisions will not be viewed as valuable no matter how much it is needed. Similarly, well characterized risk information may still not be used if the need for risk information in decision making is not recognized. With its recent risk assessment approach, DNDO has crossed the threshold in both areas and is beginning to actively use risk information to inform its decisions and analyses for prioritizing its efforts. This talk will discuss the approach being used and the new risk assessment elements that have allowed risk information to become useful to decision makers - functional decomposition of the analysis into a 'risk architecture', adversary modeling, and portfolio analysis. Specific examples of the types of decisions being informed and the type and quality of the risk information being developed will be provided. Lastly, we will show how elements of the risk analysis can be used independent of formal risk calculations to inform various decision making processes and add rigor and consistency to organizational decisions.

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*University of Mississippi*

### **SCARY NEWS: HOW JOURNALISTS VIEW MEDIA FRAMING OF PUBLIC RESPONSE TO TERRORIST ATTACKS**

When terrorists provoke a high level of public outrage, the expected payoff is greater. The news framing of risk can strongly influence public responses to terror attacks. This national U.S. survey explores journalists' responses to news coverage of terrorism, to inform preparedness efforts, as well as explanatory content in news stories may mitigate potential public outrage. The self-administered survey of 147 media professionals, journalism students and journalism educators examined attitudes,

experiences and risk perceptions about terrorism events, priorities for news coverage of preparedness and counter-terrorism measures, reactions to hypothetical stories about biological attacks, news routines in terrorism coverage, and terrorism reporting strategies. A new framework proposes a mitigating relationship between explanations in media coverage of crises and public outrage. In the current study, stories containing speculation, off-record sourcing, conflicting reports, vague advice for avoiding exposure or false alarms were seen as more frightening, uncertain, vague and confusing, as well as less authoritative, reassuring, explanatory, ethical, credible and trustworthy. Stories containing mitigating content, such as risk comparisons, explanation of relative risk, risk assessments and other testing processes, specific/practical advice or translation of unfamiliar language were seen as more reassuring and just as engaging as those without it. However, mitigating content did not improve story perceptions when it contained conflicting reports. The most credible, least confusing stories were those containing mitigating content but no outrage rhetoric. The findings suggest that journalistic routines in terrorism coverage could mitigate public responses to attacks and help disempower terrorists.

W3-D.2 Swanson WL, Ryti RT; rryti@neptuneinc.org  
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### **CAN SOIL BIOASSAYS BE USED TO ESTABLISH OR MODIFY SITE-SPECIFIC CLEANUP GOALS?**

Among the lines of evidence evaluated in ecological risk assessments, bioassays performed with site-specific soils can be one of the most relevant and diagnostic of the potential for adverse effects on specific receptors. However, the results of the bioassays vary as a result of laboratory conditions (moisture, light, test organism, etc) as well as various confounding factors related to soil properties and characteristics. This paper reviews how soil bioassays performed to support ecological risk assessments have been used to supplement literature-based toxicity information. Statistical methods were used to evaluate overall bioassay trends, the impact of confounding factors, and draw conclusions regarding adverse effect levels of contaminants. Results for seedling germination tests are presented to illustrate these statistical methods and the challenges related to interpreting results from this type of test.

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### **DOSE-RESPONSE RESEARCH TO SUPPORT RISK-BASED SITE-SPECIFIC DECISIONS FOLLOWING AN ANTHRAX ATTACK**

A great challenge in biothreat agent response and decontamination is the assessment of residual risks from low levels of contamination. This is especially true for *Bacillus anthracis*, the causative agent of anthrax. Though more than ten years have passed since the anthrax letter attacks of 2001, the lack of an acceptable dose-

response relationship for *B. anthracis* continues to impede the development of effective risk-based approaches for decision making. *Bacillus anthracis* is the most highly studied of the biothreat agents, yet there are significant data gaps in the dose-response assessment of low dose exposures and the necessary data for the extrapolation from animal to human dose-response relationships. Collectively, these data gaps limit the development of a dose-response relationship suitable to support site-specific cleanup, detection limit, and decontamination technology decisions. Because of the lack of credible studies, *in vivo* animal studies were conducted to determine survivability and physiological responses following multiple daily low dose exposures of *B. anthracis* Ames strain spores. New Zealand White rabbits were exposed to aerosolized spores once a day for five straight working days each week for three weeks (up to 15 times each). The targeted inhaled doses ranged from 100 to 10,000 colony forming units. The rabbits were monitored during the three exposure weeks and for three weeks after the last exposure for clinical signs of disease, mortality, changes in body temperature, cardiovascular function, hematology, C-reactive protein, bacteremia, toxemia, and seroconversion. The data obtained from this preliminary study are promising; however, additional larger studies are currently being designed to generate data with greater statistical power to identify doses associated with low response levels. The measured physiological parameter data and dose-response benchmark dose modeling from the preliminary exposure studies will be presented.

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### **OBJECTIVE-BASED RISK ASSESSMENT METHODS FOR ADVANCED NUCLEAR POWER PLANT DEPLOYMENT**

The nuclear power industry has been historically plagued with considerable power plant deployment risks, with project cost and schedule overruns presenting a significant risk to investors. In light of the recent events at the Fukushima Daiichi nuclear plant, the regulatory landscape is even more uncertain for nuclear power deployment. The industry has responded by employing risk management practices to reduce the uncertainty associated with nuclear power plant deployment. Although these risk management practices have been put in place, there are still considerable cost and schedule excursions that have occurred in the construction of recent nuclear power plant projects. This study does the following:

- Evaluates current risk management practices in the nuclear industry
- Empirically identifies specific issues that limit effective risk management
- Proposes a novel objective-driven approach to nuclear power plant deployment risk management
- Evaluates the benefits of the objective-driven method by developing a steam generator replacement risk register with the objective-drive method and comparing it against risk registers built without the model. The objective-based risk management method is based on the Value Focused Thinking (VFT) concept. The method improves identification, assessment,

mitigation and organizational learning associated with nuclear power deployment risk. The study demonstrates the benefit of the method by comparing risk management efficacy on prior nuclear power plant steam generator replacement projects which were performed without the method, to risk management efficacy performed with the method. Efficacy of risk management without the method is assessed by comparing the risk assessments performed at the commencement of the various projects to the documented lessons learned at the end of the projects. The measures of risk identification and assessment are compared for both sets of risk assessments.

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### **EXPERIMENTAL DESIGN FOR THE ASSESSMENT OF THE ANIMAL WELFARE DURING CATTLE SLAUGHTERING WITH AND WITHOUT PREVIOUS STUNNING**

The European Union (EU) is promoting the animal welfare of farmed animals, including their transport and killing. A relevant number of European consumers declare that they would be prone to pay more for products of animal origin obtained by procedures that are respectful of their welfare. The most frequent method used for killing cattle in the EU includes a previous stunning by a penetrative captive bolt. Nevertheless, other two methods without stunning (Halal and Shechita) are in place. The aim of this work is to propose a risk assessment methodology to compare the animal welfare risks associated to each one of these three methods considering two different periods: from the entrance to the stun/killing box until the intervention (stun or sacrifice); and from the intervention to the loss of consciousness and death. Three different experimental groups are proposed: cattle slaughtered with previous stunning; halal, and shechita slaughtering (170 animals per group). Data of variables linked to animal welfare will be collected just before the killing (i.e. vocalizations, time from immobilization to the intervention, use of coercive methods) and during the killing (mainly the time from the intervention to collapse, and to the loss of consciousness) for the three slaughtering methods. The main factors that may modify these variables (i.e. standing up after having collapsed, number of carotid veins partly cut, repeated cut, presence of false aneurysms) would also be taken into account. The analysis of the data, should allow to draw up conclusions about which of the methods is associated to a higher level of animal welfare. This would allow the labelling of the meat on a sound basis and would contribute to the informed choice of the consumers.

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### **EXTENDING METHODS OF VULNERABILITY ANALYSIS TO ADDRESS RESILIENCE AND ROBUSTNESS**

After September 11, 2001, numerous methods of vulnerability analysis have been developed to help owners and operators of infrastructure systems protect such

systems against possible terrorist attacks. However, hardening a significant fraction of a large, complex infrastructure network is typically not cost-effective. There is therefore an urgent need for methods of vulnerability analysis that take robustness and resilience explicitly into account, by highlighting those few sources of vulnerability that are most likely to result in cascading failures (i.e., poor robustness to withstand disruptions) and/or long restoration times (i.e., poor system resilience). Cascading failures have been historically a major unsolved problem for complex networks such as electricity systems, but recent developments in probabilistic analysis of cascading failure have made it possible to take cascading failures into account in methods of vulnerability assessment. Moreover, methods of vulnerability analysis can also be designed to highlight those vulnerabilities that are likely to lead to disproportionately long restoration times. In this research, we extend an existing method for identifying near-optimal interdiction strategies in electricity networks. Specifically, we analyze the impact of cascading failures on system vulnerability in a probabilistic manner; take restoration time into account, making it possible for decision makers to maximize resilience; and use the resulting method to examine the effectiveness and cost-effectiveness of possible defensive investments. In particular, the use of methods that account for restoration time and cascading failure makes it possible to evaluate the effectiveness not only of target hardening, but also of alternative mitigating strategies, such as improving resilience by decreasing restoration times (e.g., through stockpiling of spares), or increasing the capacity in crucial parts of the network (to reduce the potential for cascading failure).

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### **ENVIRONMENTAL RISK MANAGEMENT AND ECONOMIC PERFORMANCE OF POLICY INSTRUMENTS: A STRATEGIC ANALYSIS OF UK EXPERIENCE SINCE 1997**

This research provides a strategic analysis of a sample of UK environmental policies, providing new evidence of what works when and why, to inform the delivery of better policy and regulation. Since the 1997 General Election innovative policy instruments have been implemented in the UK moving beyond “command and control” regulation to utilise economic, information based and voluntary approaches. Such approaches manage environmental risks whilst enabling businesses to compete and innovate\*. However, they may not be appropriate for all sectors of the economy, or for high impact risks with high levels of social concern\*\*. Since 2010 the UK Coalition Government has renewed the drive for regulatory reform whilst aiming to be the “greenest government ever”. This research takes stock of recent experience to help achieve these objectives. Environmental policies targeted at a range of environmental risks were selected to provide 30 case studies illustrating direct regulation, economic instruments, education and advice, co-regulation, self-regulation, and tech-

nology/investment programmes. Each policy was characterised according to targeted actor, policy instruments used, economic impact and impact on targeted environmental risk. Evidence was drawn from expert interviews and academic and gray literature. Correlations between instrument type and other characteristics were analysed. The research tests existing theories of what works when and why, and suggests where innovative approaches may be used in future. A programme of research will develop these insights into a policy development framework to be utilised by the UK Department for Environment Food and Rural Affairs during forthcoming regulatory reform initiatives. \*Gunningham & Sinclair (2002). Leaders and laggards. Next generation environmental regulation; \*\* Pollard et al (2004). Characterizing environmental harm: Developments in an approach to strategic risk assessment and risk management. *Risk Analysis*, 24(6).

P.111 Teuschler LK, Aume LS, Rice GE, Simmons JE, Pressman JG, Narotsky MG, Speth TF, Miltner RJ, Hunter ES, Richardson SD; teuschler.linda@epa.gov  
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### **A STATISTICAL APPROACH FOR JUDGING STABILITY OF WHOLE MIXTURE CHEMICAL COMPOSITION OVER TIME FOR HIGHLY COMPLEX DISINFECTION BY-PRODUCT MIXTURES FROM EPA'S FOUR LAB STUDY**

Chemical characterization of complex mixtures and assessment of stability over time of the characterized chemicals is crucial both to characterize exposure and to use data from one mixture as a surrogate for other similar mixtures. The chemical composition of test mixtures can vary due to natural variations of the collected environmental mixture, concentration procedures, preparation of the mixture for testing, and chemical reactions during storage; these variations can affect toxicity. This presentation describes a statistical approach for evaluating chemical stability of highly complex disinfection by-product (DBP) mixtures resulting from disinfection of water concentrates used in EPA's Four Lab multigenerational rodent bioassay. Complex DBP mixtures were produced by concentrating natural source water with reverse osmosis membranes, storing the concentrate in 16 drums, and chlorinating the concentrate prior to placement on animal cages. At time intervals dictated by water demand, concentrate was chlorinated. Chemical analyses were conducted for each chlorination event; concentrate was sampled prior to use (day 0), at various time periods from arbitrarily selected cages, and upon removal from cages. Mixed linear models were used to evaluate stability of 44 individual DBPs, total organic halide (TOX), and 18 DBP mixture subgroups across and within drums, and over time. Three hypothesis tests evaluated whether: average chemical concentrations were stable across drums over time; concentrations were stable within drums over time; and chlorination events were reproducible across drums on day 0. A judgment of instability required a >20% change in chemical concentrations from Day 0 to Day 14 or a >20% coefficient of



variation on Day 0. Results showed a high degree of stability and reproducibility for 32 single DBPs, TOX, and 11 DBP mixture subgroups, including the halomethane, haloacid, and haloaldehyde chemical classes. (The views expressed in this abstract do not necessarily reflect the views or policies of the US EPA.)

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### **RISK MODELS AND NEGOTIATION ANALYSIS FOR LAND DEVELOPMENT ADJACENT TO INFRASTRUCTURE SYSTEMS**

Risk-informed decision making for the protection of transportation, energy, communications, water, emergency services, and other infrastructures from adjacent land development is an essential need. The issues include diverse technology and administrative remedies; large-scale and distributed assets; multiple owners and stakeholders; diverse nature of stakeholders, constraints and competing objectives; uncertainties in forecasts, time horizon, schedule, and cost; and needs for agency transparency and accountability in the prioritization and programming of investments. The problem calls for knowledge across several domains including risk analysis, lifecycle analysis, scenario analysis, impact analysis, reliability modeling, multi-criteria analysis, and negotiation analysis. This presentation will develop risk and decision models that address risk of land development adjacent to infrastructure systems, testing the models with agencies responsible for a 6000-mile multimodal transportation network. The models will address a time horizon of about ten years, which is longer than annual or biannual budget cycles and shorter than long-range investment planning. The first part of this effort develops predictive models to estimate time-to-develop for mile-long sections of corridor. The second part of this effort refines a scenario analysis to describe the impact of various scenarios on the time to develop. The third part of this effort performs negotiation analysis to support regulators/planners, localities, infrastructure owner/operators, and developers in coordinated risk management of land development. This research has led the National Research Council to evaluate best practices, methods, and tools that support transportation agencies to manage the risk of land development.

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### **ADVANCEMENTS IN INTEGRATED WILDFIRE RISK ASSESSMENT**

Federal wildfire management within the United States continues to increase in complexity, as the converging drivers of increased development, past management practices, and a changing climate magnify threats to human and ecological values and place additional stress on limited fiscal resources. Further amplifying wildfire management complexities are manifold sources of uncertainty, including variability surrounding fire occurrence and behavior, limited understanding of the spatiotemporal dynamics of ecological responses to fire, and limited resource value measures to guide

prioritization across resources threatened by fire. In this presentation we will review progress towards identification and characterization of uncertainties and the incorporation of this information into integrated wildfire risk assessment frameworks to support decision-making. First, we will review a recently developed typology of uncertainties common to wildfire decision-making and highlight the most salient sources of uncertainty. Second, we will describe the expanding role of spatially explicit burn probability modeling as state-of-the-art exposure analysis, and illustrate the application of burn probability modeling to support strategic fuel reduction treatments as well as active wildfire incident management. Third, we will discuss how our limited understanding of fire effects poses challenges to quantifying risk, especially for non-market resources, and how we have relied on systematic elicitation of expert judgment to advance wildfire effects analysis. We will provide examples from recent and ongoing integrated risk assessments ranging from local to national planning scales and describe their use for informing on-the-ground management and strategic policy development. Lastly we will discuss remaining barriers to broader adoption of risk management principles within federal wildfire management.

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### **NEED DRIVES DEVELOPMENT - ARMY BIOLOGICAL MILITARY EXPOSURE GUIDELINES (BMEGS)**

The U.S. Army Public Health Command (USAPHC) published risk assessment guidance in 2009 for assessing exposures to aerosolized microbial pathogens from environmental, occupational (i.e., laboratory accident), or intentional (e.g., terrorist) releases. The development of guidance supplements for specific areas continues and they provide military public health relevant technical information in the emerging area of microbial risk assessment from non-traditional exposures. A critical procedural gap is the ability to integrate mechanistic knowledge dose-response relationships into the military risk assessment matrix used to categorize population-level health and operational risks. A team of risk analysts at the USAPHC have developed procedures to derive Biological Military Exposure Guidelines (BMEGs) for pathogens in air or water that represent health-protective or safe-sided estimates for certain health effects. Standardized data review and analysis should facilitate efficient derivation of BMEGs. An additional outcome of the BMEG derivation process is the identification of data gaps that can be used to fuel model-directed research. Directed research will begin to close current data gaps, reduce uncertainty about the nature and magnitude of microbial risks, and improve confidence of future BMEGs. A phased approach to BMEG development is being implemented due in large part because the concept of microbial exposure guidelines is so new. Preliminary BMEGs based on available scientific evidence and models can be useful decision criteria, if needed today and there is adequate confidence in their level of protection/prediction. Interim and Final



BMEGs may take years to achieve, but will represent values with greater community acceptance.

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#### **WHICH PICTORIAL WARNING LABELS ON CIGARETTE PACKAGING WORK BEST? EXPERIMENTAL EVIDENCE FROM SMOKERS AND YOUTH IN MEXICO AND THE US**

Background: By 2010, 31 countries had implemented pictorial health warning labels (HWLs), and the US will implement this policy in 2012. Research is needed to determine which pictorial HWLs content is most effective. The primary objective of the current study was to evaluate pictorial HWLs with different executional styles (graphic depiction of smoking consequences; human suffering; symbolic representation of risk) and that included testimonial text or not. The secondary aim was to determine whether population subgroups (i.e., smokers vs. nonsmokers; youth vs. adult; low vs high SES; Mexican vs. US populations) responded differently to pictorial HWLs. Methods: The sample comprised adult smokers (19 or older) and older adolescents (16 to 8 year old smokers and nonsmokers) in Mexico (n=535 and n=527, respectively) and the US (n=722 and 677, respectively). The Mexican sample was recruited from public settings in Mexico City and the US samples were drawn from an online panel. For each of 15 different health effects, 5 to 7 HWLs were developed to capture executional elements. Participants rated all HWLs for 2 randomly selected health effects, rating them for attention, relevance, credibility, negative emotional arousal, and perceived effectiveness. Linear mixed effects models were estimated to determine HWL characteristics associated with higher ratings, and we tested interactions between HWL characteristics and individual-level characteristics. Results: HWLs with graphic depictions, elements of human suffering, and that included testimonial text were rated as most effective. Negative emotional arousal appears to mediate much of the perceived effectiveness. Similar patterns were observed across population subgroups within and across countries. Conclusions: These results suggest that pictorial HWLs have similar effects across populations and there may be little need to target messages to particular subgroups with this innovative public health communication intervention.

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#### **CRITICAL ANALYSIS OF RADIATION PROTECTION REGULATIONS**

Most approaches to radiation risks evaluation are based on linear nonthreshold concept. Both small and large doses might result in cancer disease. A risk is generally determined as probability of disease that is supposed to be linearly dependent on dose. For small doses, frequencies of radiation associated cancer can't be effectively

separated from general cancer statistics. For large doses, there is not enough statistics. Therefore coefficient of linear dose-response dependency is estimated from statistics of average doses (200-500 mSv). Then these dose-response effects are extrapolated on small doses. Although the linear extrapolation results in risk overestimation, radiation protection regulations are based on these estimations. Consequently norms of radiation protection are excessively restrictive and costly. Let's show excessiveness of radiation protection regulations in comparison with other risks that are estimated as death probability from different events (disease, accidents etc.). We usually consider risks that are estimated in the range from 10<sup>-5</sup> to 10<sup>-2</sup>. Generally upper bound of acceptable risk is 10<sup>-4</sup>. According to ICRP, radiation risk for effective annual dose 20mSv is 0,00114, 50 mSv - 0,00285, 100mSv - 5,7 mSv. But these values characterize probability of disease, and moreover sometimes in the future. In order to compare radiation risks with other risks, we adjust radiation risks taking into account probabilities of death from cancer, disease duration etc. Adjusted radiation risks are in the range from 10<sup>-5</sup> to 10<sup>-3</sup>. Such comparative study of radiation risks show that such costly measures as evacuation of the population and rehabilitation of the areas might not be necessary for annual doses below 50mSv (adjusted risk ~10<sup>-4</sup>).

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#### **ANALYSIS OF CHANGES IN DENSITY OF DISTRIBUTION OF AIR TEMPERATURE OVER LAST DECADES USING QUANTILE REGRESSION METHOD AND RADIOSONDE MEASUREMENTS**

Temperature is one the most important physical parameter of the Earth atmosphere, which affects virtually any process, including extreme events, like, for example, the formation of storm clouds. Modeling risks caused by extreme weather events is an important part of modern climatology. And many researches are being done to investigate climate changes and particularly global air temperature changes (Global warming). But most of those studies are based on tracking changes in mean values of the temperature. However, in many cases, extreme events are caused by temporary extreme values of physical parameters of the atmosphere, not by smooth change of means. Sometimes, the number of extremely high or low values may increase significantly without visible change of widely used monthly means. So it is crucial to not only track changes of the mean temperature, but also address changes in the density of distribution. As I've shown at my previous report, quantile regression method allows assessing distribution changes effectively, by calculation full range of trends for measured distributions of the climatic parameter, which gives it significant advantages over traditional methods. In this paper, new methodology was applied to the actual air temperature measurements made on selected weather stations over recent 30 to 40 years using weather balloons. Different issues, we've faced to when using real-life data, such as erroneous values, missing values, large gaps in time series, e.t.c. were con-

sidered. The most significant results will be discussed. Different ways of visualizing the actual results will be presented.

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### **UTILITY-BASED ADVERSARY MODELS IN RISK ANALYSIS FOR TERRORIST DECISION MAKING**

Homeland Security Presidential Directive (HSPD) 18 (Medical Countermeasures against Weapons of Mass Destruction) requires a risk assessment of Chemical, Biological, Radiological, and Nuclear terrorism for the purpose of risk based decision support in the area of medical countermeasure acquisition and development. In any probabilistic risk analysis associated with terrorist attacks, a particular difficulty is modeling the decision process that a terrorist will implement and how the adversary will respond to changes in the Homeland's defensive architecture. To be implementable in risk assessment, the decision process must be easily populated using expert input, must be validated to meet expert expectations, and must support the assignment of probabilities and their associated uncertainties across thousands to millions of scenarios in a time- and calculation-efficient method. This paper describes a utility-based approach based upon terrorist attributes that has been successfully implemented in the HSPD 18 risk analyses to model terrorist decision processes. The mathematical models used to calculate the utility function and to translate the utility model to probabilities and distributions across risk scenarios is described. In addition, the approach to both elicit and to validate the model based upon expert input is explained. Examples are used to illustrate the implementation and the ability of the model to adjust terrorist decisions in response to modifications in the Homeland's defense.

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### **ASSESSMENT OF METHODS FOR ESTIMATING EXISTENTIAL RISKS: PART I**

In recent years, many researchers and commissions have pronounced that the risk of human extinction is quite high but none of these estimates have been based upon a rigorous methodology suitable for estimating existential risks. This presentation assesses three methods that could be used to estimate the probability of human extinction. Methods assessed include: simple holistic elicitation; whole evidence Bayesian; and evidential reasoning using imprecise probabilities. Assessment criteria include: how well the approach describes causal relationships between events that could lead to human extinction; level of elicitation efforts required of experts; ease of approach implementation; transparency of inputs into risk estimates; and acceptability of the approach.

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### **SOCIAL AND PSYCHOLOGICAL ELEMENTS OF HURRICANE RISK PERCEPTION**

Despite a considerable amount of research on the social dynamics surrounding hurricanes there have been few examinations of the manner in which individuals perceive hurricane risk or how that may affect evacuation. This study is designed to contribute through the development of a quantitative measure of hurricane risk perception and an examination of how hurricane risk perception acts on behavioral intention for evacuation. This project is anchored by a set of three mail surveys that includes a panel of individuals living on the U.S. Gulf and Atlantic Coasts. To draw the sample, all census tracts falling within a 10-mile buffer of the coastal areas of study were identified. Census tracts were arrayed and quota samples were taken to establish a uniform spread of 1,200 sample points along the coast from Brownsville, TX to Wilmington, NC. The first wave of data collection was conducted in July 2010. A total of 653 completed questionnaires were returned (56% adjusted rate). The questionnaire ran eight pages. The second panel data collection was completed in July 2011 (pending at abstract submission). This presentation will provide an initial look at the results from the first and second panels of data collection. We will specifically present work in progress on the analysis of an evacuation intent model using the Theory of Reasoned Action conditioned on social and psychological elements of risk perception. Early results from the first survey show that risk perception can be seen as both an affective and cognitive orientation of the individual and that optimistic bias for hurricane evacuation is a related but independent factor. A range of demographic and social-level factors are also found to be important (e.g. disabilities, evacuation barriers). The overall model predicts about 25% of variance in stated intention to evacuate from a major storm.

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### **THE ROLE OF RISK PERCEPTION IN POTENTIAL VACCINATION UPTAKE FOR WEST NILE VIRUS**

West Nile Virus (WNV) was detected in New York in 1999 and spread rapidly across North America. While total reported cases have been lower since 2003, WNV activity has continued and now represents a significant public health burden. Some effort is underway to develop a vaccine for West Nile Virus (WNV). While typical progress in vaccine development suggests an agent could be available within about five years, other factors suggest progress will be slower: safety and potency issues associated with high-risk populations (elderly and immunosuppressed), easing of the North

American epidemic since 2003, and the low rate of symptomatic infection may challenge commercial viability. It has also been argued that renewed epidemics in North America or Western Europe, or the designation of WNV as a potential bioterrorism agent, could boost efforts toward a vaccine. It is also worth noting that the spread of WNV in North America may be seen as a proxy for future emerging vector-borne infectious diseases. Taken together, these points argue for an investigation to examine orientation toward a hypothetical WNV vaccine. To do so, data was collected using a self-administered mail survey administered in Greeley, Colorado. A four-page questionnaire (English and Spanish) was mailed to 777 residents proportionally sampled for ethnicity (Hispanic-Latino/Anglo). 385 completed questionnaires were returned (50%). The study models likelihood of vaccination uptake at no cost and at a cost of \$25 contingent on demographics, understanding of mosquito ecology, WNV disease proximity, and the Health Belief Model (HBM), which includes a risk perception element consisting of perceived susceptibility and severity. Regression analysis (adj R-square of .29) shows that likelihood of vaccination uptake is predicted significantly by all elements of the HBM (severity, susceptibility, benefits, barriers) as well as the individuals understanding of WNV's ecology and the proximity of WNV to the individual.

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#### **SRA SPECIALTY GROUPS: WHAT IS MISSING?**

The Society for Risk Analysis encompasses a variety of fields and professions in the promotion and increased understanding of risk analysis. However, certain areas were not explicitly included within the Society or its specialty groups, yet remain potential boons for membership. To discover what are underrepresented within SRA and what activities occur within these areas that warrant their inclusion into the society, we engaged in several interviews with senior SRA staff members and engaged in a thorough literature review. The fruits of these efforts were used within a multi-criteria decision analysis with the ultimate goal of generating a ranked list of currently underrepresented subject areas according to their overall utility-added to SRA. This session will start with presentation summarizing these areas and their potential impacts within the Society, and will offer specific recommendations with respect to subject areas that the society should target for membership in the near future. A panel discussion featuring representatives from SRA-Japan, SRA-Europe and SRA-USA will follow.

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#### **AIR POLLUTION, ABNORMAL BIRTH WEIGHT AND OBESITY MAY INCREASE THE RISK OF DEVELOPING ASTHMA DURING ADOLESCENCE**

Asthma is an important public health task. Air pollution may increase the risk of inducing asthma. Abnormal birth weight has also been associated with developing asthma during childhood and adolescence; in addition, adolescents who are obese have a proposed higher risk of asthma. The objective of this study is to assess whether air pollution interacts the effects of abnormal birth weight and obesity during adolescence for inducing asthma. The air pollution database was based on Taiwan Environmental Protection Administration (Taiwan EPA) air quality monitoring station network. The birth cohort was based on two major databases including the following: 1) the birth registry database of the Ministry of Interior and 2) a six-month mass screening survey of adolescent asthma and lung function testing conducted by the Taiwan EPA and National Taiwan University (NTU) in Taiwan from October 1995 to March 1996. The study population included junior high school students countrywide. We analyzed a 10% random sampling of nationwide junior high school students (n=85,791), who completed two questionnaires (ISAAC and New England) and lung function testing. Air pollution may play a role of interacting with abnormal birth weight and obese during adolescence in inducing asthma.

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*TMU*

#### **MOUTHING FREQUENCY OF CHILDREN UNDER 2 YEARS OLD IN TAIWAN**

Children are often more vulnerable than adults to higher exposures to environmental contaminants due to their unique behaviors. In order to estimate the nature and magnitude of their exposures and potential health risks, it is necessary to obtain detailed information on children's activity patterns, especially in Taiwan, where there is lack of this information. The environment, such as the house type and the primary caregiver to the children, also is an important factor influencing contaminant exposures. In this study, 32 participating children were recruited. They were then matched by sex (two groups: male and female) and age (four groups: 6, 12, 18 and 24 months) groups. Children were videotaped about 2 hours, and then we recorded mouthing frequency (hand-to-mouth and object-to-mouth) from the videotapes using pen-to-paper method. The average age of children was 17.15( $\pm$  7.78) months. The median hand-to-mouth frequency was 10.50 contacts/h. The median object-to-mouth frequency was 9.50 contacts/h. The median hand-to-mouth frequency of children who



lived in a apartment (not including the first floor) was significantly higher than children who lived on the first floor or a single-family house ( $p = 0.038$ ). The number of parents was greater than the number of babysitters and elder caregivers was 19, 5 and 8, respectively. The median object-to-mouth frequency was significantly different in the primary caregiver group ( $p = 0.04$ , the median object-to-mouth frequencies of parents, babysitters and elder care givers groups were 13.50, 61.00 and 3.75, respectively). We conclude that the differences in house type and primary caregiver status need to be considered as part of conducting an appropriate exposure assessment. It is noteworthy to mention that the 95th percentile of the hand-to-mouth and object-to-mouth frequency in this study (87.50 and 90.50 contacts/h) was found to be higher than the almost other studies conducted in the U.S.

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### **CALM PANIC OF THE JAPANESE AGAINST THE COMPLEX DISASTER 3-11**

On March 11th in 2011, huge earthquakes ( $M=9.0$ ) attacked the northern part of Honshu (the main island of Japan). They caused the complex disaster with not only the quakes but also tsunami and Fukushima nuclear accidents. Immediately after the shocks most of the Japanese showed “calm panic”, i.e. they seemed to accept the tragedy. I had three hypotheses why the Japanese were in the calm panic. Hypothesis 1: the Japanese have equality oriented culture, and in the situation that everyone was suffering they would have thought it should be accepted. Hypothesis 2: the victims would have not yet come to the phase of reality perception. Hypothesis 3: the Japanese have strong sense of unity with nature, and they would have thought they had to accept what nature did because they were part of nature. A social survey was conducted to confirm the hypotheses in the connection of the effects of mass media.

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### **UPDATE TO THE U.S. EPA'S GUIDELINES FOR (HUMAN) EXPOSURE ASSESSMENT AND MONITORING**

The goal of the U.S. EPA is to protect human health and the environment by understanding, characterizing, and reducing risks to environmental agents. Exposure science evaluates and predicts exposures and provides information for developing exposure and risk assessments as well as the most effective strategies for reducing risks. When conducting a risk assessment, the assessor needs to understand whether an agent may cause an adverse health effect and how exposure to that agent may be reduced. The increasing number and complexity of risk assessments conducted by the Agency presents new challenges. Advances in the field of exposure science require updated resources for conducting exposure and risk assessments. The Guidelines for (Human) Exposure Assessment and Monitoring has been prepared to pro-

vide an updated resource for exposure and risk assessors both within and outside the Agency. This document builds on the solid foundation of the 1992 Guidelines, incorporating advances in the field that have occurred since the Guidelines were originally published. It reflects the best science currently conducted across the Agency. This updated document describes the principles of exposure assessment, provides guidance on approaches to conduct an exposure assessment, presents references for more detailed information, and supplies hyperlinks to exposure assessment tools and technical documents. The Guidelines are arranged into chapters, each of which explores a component of the exposure assessment process, including: basic concepts and principles in exposure science; planning and scoping; collecting and using data; using models; planning an observational exposure measurement study; incorporating lifestyles, vulnerable groups, and populations of concern into an assessment; evaluating uncertainty and variability; and presenting and communicating results. This presentation will highlight and showcase many of the updates in the document.

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### **INTRODUCTION TO CHEMICAL SAFETY FOR SUSTAINABILITY: EXPOSURE-BASED PRIORITIZATION**

The U.S. EPA's Chemical Safety for Sustainability (CSS) research program is being designed to assessments of impact of chemicals on human health, wildlife and the environment. These approaches are intended to increase the pace at which relevant information can be obtained and integrated into decision making and to inform sustainable approaches to chemical design, production, and use across chemical, material, and product life cycles. Tools will use systems approaches to understand the links between exposure and toxicity pathways involved in disease, to allow EPA to evaluate with respect to life stages and other susceptibility factors such as genetics and co-existing diseases. This hazard information must be complemented by reliable exposure factors to improve assessments of chemicals currently in and about to enter the marketplace. The strategy includes four types of chemical evaluation approaches of increasing complexity: Level I: Inherent properties; Level II: Screening and Prioritization; Level III Target Testing; and Level IV: Systems Models. This presentation will address the exposure aspects of Level II, i.e. exposure-based prioritization. Recent EPA workshops suggested that current approaches have significant limitations in their applicability to EPA's need to prioritize thousands of chemicals on the basis of human exposure necessitating the development, refinement and evaluation of new methods. In response to the EPA's need for novel approaches and tools for rapidly prioritizing chemicals, a “challenge” was issued to several exposure model developers to aid understanding of current systems in a broader sense and to assist EPA's effort to develop a new approach comparable to other international efforts. Preliminary results will be presented from a gap analysis between the present prioritization ap-



proaches and those needed for a reliable exposure-based approach. The exposure complement to the update to EPA's Endocrine Disruptor Screening Program (EDSP-21) will also be discussed.

W1-F.4 Valverde LJ, Convertino M, Dokukin D, Keisler J, Linkov I; igor.linkov@usace.army.mil

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### **PORTFOLIO OPTIMIZATION FOR ASSET MANAGEMENT: A USACE CASE STUDY**

The U.S. Army Corps of Engineers manages a diverse range of national assets through different business lines, including navigation, flood response, hydropower, and others. An optimal allocation of asset management resources is difficult, given the breadth of the national asset portfolio, and the diversity of projects, goals and needs between and within the organization's business lines. This presentation introduces an asset management model that improves the traditional asset management approach considering the non-monetizable impacts, high-risk factors, and cognitive biases that can hamper the decision-making process for resource allocation across multiple business lines. The risk-based model evaluates the exogenous and endogenous factors that can adversely impact — directly or indirectly — aspects or components of the asset types. The characterization and evaluation of critical events and processes (climatological and anthropological), of construction materials, of asset monitoring, and inter- and intra-correlation of assets among business lines have been considered as criteria of each business line-specific MCDA model. The criteria for the overall portfolio MCDA-based model are the value to the nation, the economic value, the safety and security, the environment impact, and the sustainability of each asset that are broad fundamental objectives. The portfolio optimization that selects the most important asset-types among business lines is performed by linear optimization constrained to the available resources. The model is flexible to consider different life cycle stages of asset-types, thus also the construction of new assets may be potentially modeled. A case-study is presented for three business lines: bridges, dams, and recreational facilities. It is envisioned that this type of formal asset management tool can greatly enhance USACE's ability to innovate and explore strategic options that represent potential value-enhancing alternatives to the status quo.

M4-E.4 Van Doren JM, Kleinmeier D, Ma Y, Blodgett R, Westerman A, Ziobro GC, Muckenfuss M, Gill V, Hammack T, Parish M, Neil KP, Mettee S, Nsofor O, Gieraltowski L; jane.vandoren@fda.hhs.gov

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### **SURVEILLANCE SAMPLING AT IMPORT: CHARACTERIZING RISK**

Consumption of Salmonella-contaminated food is one of the leading causes of foodborne illness in the United States. The 2008-2009 Salmonella Rissen outbreak attributed to contaminated white pepper and the 2009-2010 Salmonella Montevideo

and Senftenberg outbreaks attributed to contaminated black and red pepper highlighted the potential for spices to contribute to foodborne illnesses. Since spices are primarily supplied by way of imports to the United States, regulatory guidance such as import alerts and FDA surveillance sampling are tools used by the Food and Drug Administration to prevent contaminated spices from reaching the consumer. This talk will focus on surveillance sampling of FDA regulated imported products as a means of characterizing the prevalence and level of contamination in imported spices. Data presented will explore the prevalence of Salmonella in spices as a function of spice type, form and country of origin. Enumeration data reveal typical levels and distribution of Salmonella in spices. The impact of different sampling strategies on the efficacy of Salmonella detection in spices will also be explored.

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### **PRELIMINARY ASSESSMENT OF THE CARBON FOOTPRINT IN THE CHEMICAL INDUSTRY IN THE FIELD OF BASIC CHEMISTRY**

GHG emissions are part of the environmental risks that affect the Earth today. The emission of these gases produces adverse effects on living organisms and the environment. Among the most notable effects is the alteration of the hydrological cycle, as having a higher temperature in the Earth's surface increases the evaporation of water, causing as latitude, increased rainfall or drought periods. The first step to reduce GHG emissions is to quantify it. To measure the amount emitted, organizations use the carbon registry protocols, such as the GHG Protocol. I performed the study and quantification of GHG emissions in a Colombian chemical industry leader in salt and chlorine production. For quantification of GHG emissions, environmental input and output analysis method was used, including emissions from stationary point sources (boilers, reactor and energy consumption) and mobile sources (lifts, transport of raw materials and products) which resulted a carbon footprint of 341175 tons of CO<sub>2</sub> eq. Quantifying the carbon footprint for the organization can establish practices to mitigate GHG emissions, reducing environmental impact and atmospheric effects associated with them. Emissions reduction is focused on identifying the main sources of emissions, because from this industries can define best practices in a production process, such as the reduction in product delivery times, programs for the maintenance or renewal of equipment, among others. The first possibility of reducing the carbon footprint comes from chemical industry, increasing productivity, ie, emits the same amount with more manufacturing. Thus, reducing the carbon footprint is an initiative to encourage programs to increase production and efficiency of available resources in the organization. Also, is important to quantify the carbon footprint from developing countries, because the majority of emissions come from energy consumption, land use and industrial processes.

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### **WEIGHT OF EVIDENCE EVALUATION FOR ADVERSE HEALTH EFFECTS OF SEVERAL PESTICIDES AT ENVIRONMENTALLY-RELEVANT CONCENTRATIONS**

There are many examples of epidemiological studies showing an association between exposure to a compound and one or more adverse health outcomes that are only weakly, if at all, supported by the available toxicological data. For example, epidemiological studies have shown an association between exposure to chlorophenoxy pesticides such as 2,4-D and MCPA and adverse health outcomes including Non-Hodgkins lymphoma, Hodgkins disease, and soft tissue sarcoma, while the toxicological data, however, suggest that these compounds are not carcinogenic. Moreover, there is the question of biological plausibility. Given what we know about the etiology of particular health outcomes, what is the evidence for the required steps in terms of pathways for these diseases to occur, and are those reasonable pathways with respect to mode of action of exposure to the constituents of interest (e.g., what is the hypothesized mode of action and how does that compare to what is known about disease etiology). There is also the question of exposure, and what exposures would be necessary or sufficient to lead to the particular health outcome. We develop a framework for evaluating the weight of evidence for adverse health effects following exposure to 2,4-D, MCPA, and several other pesticides based on the epidemiological and toxicological data together with criteria related to biological plausibility. Finally, we integrate information on exposures, including a discussion of biomonitoring data, where available, to develop an integrated assessment of the weight of evidence for potential health effects.

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### **QUANTITATIVE MODEL EVALUATION: LESSONS LEARNED FROM SYMPOSIA ON GETTING THE NUMBERS RIGHT**

Models are often used to support environmental decision making, and the predictive power of these models is typically based on or can be evaluated using a variety of calibration metrics. At the 2008 Annual SRA Meeting, we chaired two symposia on quantitative metrics for model evaluation in environmental and occupational health settings. In this presentation, we will synthesize and further explore the key themes that emerged from these symposia discussions. In particular, we will discuss the use and limitations of different metrics, such as biomarker specificity with respect to validating exposure estimates, population biomarker and biomonitoring datasets to support exposure model development, and model to model comparisons to evaluate individual model performance. We will also discuss the difficulty of using Monte Carlo and related probabilistic simulation techniques for exploring uncertainty

in complex, integrated models and recommended strategies for incorporating and developing uncertainty analyses in this context. This information will be useful for analysts, modelers, and decision makers to consider during model development and life cycle model evaluation.

W2-G.1 Vorhees D, Strauss H, Heiger-Bernays W, Gopinathan B, Oruchin E, Stirrett-Wood G, Igbara J, Cowell W, Chien J, Dong Z; dvorhees@post.harvard.edu

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### **HEALTH RISK ASSESSMENT OF EXPOSURES ASSOCIATED WITH NIGERIAN OIL FIELDS**

People living in the Ogoniland region of Nigeria attribute a range of adverse health effects to petroleum releases to the environment. In 2010 at the request of the Nigerian government, the United Nations Environment Programme (UNEP) assessed conditions at over 300 sites affected by the release of petroleum from oil field operations in Ogoniland. As part of this study, we designed and conducted a pilot health study in collaboration with UNEP staff and scientists from the Rivers State University of Science and Technology in Port Harcourt, Nigeria. The study focused on some of the most highly contaminated communities where people work primarily as farmers and fishermen and was designed to determine (1) how people are exposed to petroleum, (2) whether these exposures might have adversely affected the health of people, (3) what records are available to investigate health effects and whether they suggest that adverse health effects have occurred, (4) whether immediate action is warranted to protect public health, and (5) how exposure monitoring and medical record-keeping protocols can be improved to facilitate more detailed study. Data collection included measurement of petroleum hydrocarbons in outdoor air, drinking water, rain water, and other environmental media, a survey of local community members administered in person to ascertain patterns of exposure and self-reported symptoms and health conditions, and collection and analysis of primary health care center records. Some significant exposures were measured, notably benzene concentrations in drinking water that were 8000 to 9000 times higher than the USEPA drinking water standard, but medical records and self-reported health information were not sufficient to reach conclusions about effects on human health. Therefore, the presentation concludes with recommendations for a prospective epidemiological study in selected communities that is designed to include essential information unavailable during UNEP's pilot study.

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### **UPDATED SAFETY ASSESSMENT OF ALUMINUM EXPOSURES FROM VACCINATION IN INFANTS USING PHARMACOKINETIC MODELING**

Aluminum salts (hydroxide or phosphate) are important adjuvants for specific vaccines. These specific, adjuvanted vaccines are more effective in eliciting an immune response when the antigens are complexed with aluminum particles, which activate specific cellular responses in antigen presenting cells. During the first year of life, infants receive vaccinations according to a set schedule recommended by the Advisory Committee on Immunization Practices (ACIP). Despite the therapeutic benefit of aluminum in specific vaccines, some of the public remain concerned about the safety of aluminum. We evaluated the relative contribution to aluminum levels in infants from vaccines and from diet, by updating both the pharmacokinetic model and the parameters used by the Agency for Toxic Substances and Disease Registry, which evaluated the safety of aluminum in 2002. We revised the analysis by using a 2010 vaccination schedule, a more recent aluminum retention function from human volunteers, an adjustment for the kinetics of aluminum efflux from the site of injection, the latest minimal risk levels (MRLs), baseline aluminum levels at birth, and the most recent infant body weight data available for children from the National Health and Nutrition Examination Survey (NHANES). The results show that despite more stringent exposure standards, infant aluminum exposure levels from vaccinations and diet remain safe.

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### **AN ANALYSIS OF THE GROWTH CURVES OF CONTROL SPRAGUE-DAWLEY RATS FED AD-LIBITUM FROM WEANING TO 90 DAYS OF AGE**

Sprague-Dawley (SD) rats have been extensively used in 90-day toxicity studies for the purpose of understanding the effects of drugs, environmental chemicals, and other agents on growth. Currently, however, no suitable mathematical models exist that can describe the growth of these animals. In an attempt to solve this problem, we fitted the growth data of these animals, utilizing a Diphasic-Logistic Growth (DPLG) model. The model assumes that the total body weight, during the period from weaning to 90 days of age, is due primarily to the combined effects of a pubertal and post-pubertal growth process. The model's biological parameters were estimated by applying a Levenberg-Marquardt nonlinear least squares fitting technique. Our results demonstrated that the DPLG model was very effective and efficient in describing the growth of these animals. The fits resulted in high R<sup>2</sup> and adjusted R<sup>2</sup>

values, large F values, low residual means, Durbin-Watson statistics that were very close to 2, and small standard error estimates for the model parameters. Furthermore, the graphs of the residuals essentially showed no model bias. Male Sprague-Dawley rats were found to have large pubertal and post-pubertal growth rates compared to females. The timing of the pubertal and post-pubertal growth spurts in males was also found to be larger. We conclude that the model is an excellent tool for describing the growth of Sprague-Dawley rats in a 90-day study period and can be used for studying the growth of other rodents. We also discuss how the model can be applied in risk assessment. Disclaimer: The views expressed in this presentation are those of the author and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency

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### **A MATHEMATICAL DESCRIPTION OF NATIONAL TOXICOLOGY PROGRAM (NTP) 2-YEAR GROWTH CURVES OF MALE AND FEMALE F344/N RATS**

It is well known that the NTP routinely presents rodent growth data and curves in 2-year bioassay studies. These serve as useful and comprehensive sources of growth data that can be used for age-specific PBPK modeling and other risk assessment efforts. Currently, however, suitable mathematical models are not available to the risk assessment community that can properly describe these curves. In this study, we used the Triphasic-Logistic Growth (TPLG) Model to describe NTP growth curves of control male and female F344/N rats taken from 2-year bioassay studies. The model was fitted to average weight growth data of F344/N rats obtained from five NTP bioassay studies, utilizing a Levenberg-Marquardt nonlinear least squares fitting technique to estimate the model parameters. Our results demonstrated that the TPLG model was very effective and efficient in describing the growth of these animals. The fits from each of the five studies resulted in high R<sup>2</sup> and adjusted R<sup>2</sup> values, large F values, low residual means, Durbin-Watson statistics that were very close to 2, and small standard error estimates for the model parameters. In addition to an aging component, we identified three major growth components or processes in both male and female growth curves according to the period when they reached their peak weight velocity: pubertal, young adult, and adult. The model parameters were used to characterize the growth of these animals from weaning to old age. Our results are significant, because the new model is able to accurately describe the age specific weight, weight velocities, and specific growth rates of NTP male and female F344/N rats for the entire period from weaning to 2 years of age. The impact of these results on risk assessment will be discussed. Disclaimer: The views expressed in this presentation are those of the author and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency



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### **INTERNATIONAL SYMPOSIUM ON CULTURAL PROPERTY RISK ANALYSIS: REPORT ON AN SRA SPONSORED EVENT**

An International Symposium on Cultural Property Risk Analysis, sponsored by SRA, was held in Lisbon, 2011 September 14-16. The Symposium offered 34 papers from 14 countries dealing with all aspects of risk assessment and management to better preserve cultural heritage, whether sites, monuments, architecture or collections. Presentations included case studies, methodological developments, advances in balancing energy demands for preservation with pressure for energy conservation, and perspectives of management and educators. Case studies ranged from applications to large (ten million object) collections to simple guidance on general priorities in small museums. Methodological developments included examples detailed risk modeling, modeling from different perspectives, and integration of risk descriptions and vulnerability assessments. The issue of balancing sustainability issues with energy requirements for preservation was addressed as a planning and communication issue and as a standards issue, critical knowledge gaps were identified, and risks were evaluated in controlled, uncontrolled, and intentionally intermittently controlled situations. Management and education issues were addressed from institutional, national and international perspectives. Abstracts of all papers will be available at: <http://protectheritage.com/Lisbon2011/> Application of risk analysis to the protection of cultural property provides a helpful, simple model for more general risk analysis. The goal of preservation of material heritage is persistent over long times and consistent across diverse (though not all) cultures. The relative simplicity of cultural property risk analysis, its widely recognized societal importance, and its relatively undeveloped state combine to create opportunities for risk analysis professionals to make important contributions. Your help is sought, will be appreciated, and could lead to better understanding of risk analysis in more complex settings.

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### **FUTURE ADVANCEMENTS: RECOMMENDATIONS FROM THE IRAC-JIFSAN LISTERIA DOSE-RESPONSE WORKSHOP**

A workshop was held March 17 & 18, 2011 in Arlington VA, to facilitate an open dialogue among participating experts to identify key factors and data to be considered when updating *L. monocytogenes* dose-response models. The two major dose-response models for *L. monocytogenes* were developed by FDA/FSIS/CDC in 2003 and by FAO/WHO in 2004. Since then, knowledge about the bacteria, the host, and their interaction has increased, notably concerning the physiopathology of the infection, the virulence of the strains, and/or the susceptibility of individuals. In addition, new data from experimental infections in animal models are available. The workshop sought inputs from the participants about the latest science on *L.*

*monocytogenes* epidemiology, pathology, interaction with the host, virulence, and dose response, to help answer to the following questions: • What new knowledge about *L. monocytogenes* and listeriosis could be applied to update the 2003 FDA/FSIS/CDC and/or 2004 FAO/WHO dose-response models? • What approach or modeling methodology could be used to update these dose-response models now? • What additional data could help to improve the *L. monocytogenes* dose-response function in the future? A variety of recommendations were suggested as approaches to updating current dose response models. Among the ideas discussed, participants identified short, medium and long term approaches. In the short term, some participants suggested that relevant data developed since the existing models were prepared be used to update the models. In the medium term, it was suggested that researchers start collecting data in animal models more closely reflective of humans, e.g., gerbils. In the long term, it was suggested that a mechanistic model be developed, based on key events that occur in humans during *L. monocytogenes* infection.

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### **ENCODING THE MEANINGS OF PROBABILITY TERMS**

There are domains in which the information base available to forecasters is so imprecise that they prefer to use imprecise linguistic expressions of uncertainty (e.g., likely, very small chance) rather than numerical probabilities to communicate degrees of belief that future events will occur or be true. Examples include intelligence analysis and IPCC reports and forecasts on global climate change. Although many decision analysts consider this form of communication to be problematic, it has the potential advantage of communicating both the magnitude and the precision of one's opinion. This potential cannot be realized by legislating or assigning numerical values or intervals to terms, as has often been suggested in the literature, because people revert to their natural understandings of terms despite instructions to do otherwise. However, the meanings can be made explicit to decision or policy makers by representing them as second-order probability distributions, which we call probability signatures, uniquely derived for each forecaster. This is true despite the fact that meanings of linguistic expressions of uncertainty vary enormously across individuals and are influenced by context. This talk first describes some well established context effects on the meanings of linguistic probability expressions and then illustrates how the probability signatures are derived empirically for individual forecasters using their own lexicons of uncertainty. We will present at least two studies. One demonstrates that individual forecasters' probability signatures are meaningful in a measurement-theoretic sense by using the signatures to predict the forecasters' binary choice probabilities on a distinct task. The second study is simply a demonstration that the meanings of probability expressions, represented as probability signatures, vary as much across intelligence analysts, who use these terms regularly in their work, as they do across unselected individuals.



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### **HIGH-THROUGHPUT EXPOSURE POTENTIAL PRIORITIZATION FOR TOXCAST CHEMICALS**

The U.S. EPA must consider lists of hundreds to thousands of chemicals when prioritizing research resources in order to identify risk to human populations and the environment. High-throughput assays to identify biological activity in vitro have allowed the ToxCast™ program to identify potential chemical hazard, but without similar assessment of potential for exposure, high-throughput risk assessment for chemicals with no other available information cannot be completed. Using models (USEtox and RAIDAR) identified by the EPA Exposure-Based Prioritization Challenge nearly 1000 ToxCast chemicals have been prioritized with respect to far-field exposure potential (e.g. partitioning into environmental media). The ToxCast (Phase I and II) chemicals include industrial compounds, pesticides, and pharmaceuticals that failed in human trials, all of which have been tested in over 500 dose-response assays for potential bioactivity. For most of these chemicals, the descriptors necessary for fate and transport modeling (i.e. model parameters) were not available and had to be predicted based upon structure using EpiSuite and QikProp (accessed through the Aggregated Computational Toxicology Resource - <https://actor.epa.gov>). The prioritizations (i.e. rank order) of the two models will be compared with each other as well as ground-truthed with respect to exposures inferred from the Centers for Disease Control National Health and Nutrition Examination Survey (NHANES), pesticide residues, and other similar data sources. This abstract does not necessarily reflect U.S. EPA policy.

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### **SEARCHING FOR DETERMINANT AND CHANGE IN ATTITUDE TOWARD NANOTECHNOLOGY**

Our study empirically analyzes the determinant and change in risk perception and acceptance toward nanotechnology which is one of emerging new technologies. First, in risk perception studies about nanotechnology, lot of existing researches have focused on role of sociodemographic variables such as age (older people tend to agree with nanotechnology, Bainbridge, 2002) and gender (women did less support nanotech, Scheufele & Lewenstein, 2005; Brossard et al., 2009) or social constructed variables such as trust (Cobb & Macoubrie, 2004; Seigrist et al., 2007a), knowledge (Scheufele & Lewenstein, 2005), religiosity (Scheufele et al., 2008) and affect's role in nanotechnology (Seigrist et al., 2007b) in judging the acceptance or the risk/benefit from nanotechnology. However, those studies have focused partially only on any ones or other factors among lot of determinants. Hence it needs more balanced approaches that include all of related variables. Second, although there are lot of studies search-

ing for static determinants of attitude for nanotechnology, there are very few studies to discover how such attitude can be changed by external stimuli and conditions. To know the possibility of attitude change rated with nanotechnology, by adopting the survey experiment, we provide, to the respondents, the two persuasive stimuli - mitigating the perceived risk and increasing the benefit about nanotechnology. Then we compare the original risk/benefit structures with them which are measured after giving those stimuli (change structure). By them, we could know the possibility of attitude change. Then, we find out the determinants for such change structure by setting change structure as a dependent variables and the social demographic or constructed variables as predictors. To examine two research topics, we analyze the data (number of sample=1,000) collected by social survey. We believe that our research will find out the variant determinants and change structures about acceptance or risk perception toward nanotechnology.

M4-I.4 Wang C, Jamshidi T, Bier VM; bier@engr.wisc.edu

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### **EXPERT ELICITATION OF ADVERSARY PREFERENCES USING ORDINAL JUDGMENTS: METHODOLOGY AND APPLICATIONS**

In this presentation, we first outline our methodology for using ordinal judgments from intelligence experts (e.g., partial rank orderings of potential terrorist attack strategies) as a basis for inferring probability distributions for uncertain adversary preferences using probabilistic inversion. We model the defender's uncertainty about the attacker's preferences by probability distributions over both the weights assigned by the attacker to various attributes in a multiple-attribute utility function, and also the possibility of unobserved attributes that may be important to the attacker, but are unknown or unobserved by the defender. We then apply this methodology to a set of attack scenarios using a realistic set of attacker attributes (rather than simplistic attacker objective functions, such as "maximize fatalities"). We compare our results to those of other available elicitation methodologies. Compared to other methodologies, the use of probabilistic inversion is found to reduce the time and difficulty involved in the elicitation process, by making it possible to infer estimates of adversary attribute weights from a limited number of ordinal judgments of scenario attractiveness. This approach may also contribute to greater acceptance of quantitative methods within the intelligence community.

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### **USING MULTICRITERIA DECISION ANALYSIS (MCDA) TO PRIORITIZE THE EXPOSURE POTENTIAL OF EXISTING AND EMERGING CHEMICALS**

In the United States (U.S.) and the European Union (EU), manufacturing processes consume tens of thousands of different chemical substances. Not only is the exposure potential for the majority of these substances unknown, but there is also little data to make exposure predictions. Regulatory agencies in the U.S. and EU are interested in developing high-throughput screening level tools which would be able to predict exposure potential for multiple chemical compounds and perform under conditions of high information uncertainty. Different exposure models (e.g., LIST) are currently available to assess and prioritize the exposure potential of chemicals, yet these models require a substantial volume of information. Specifically, parameterization is required for a number of linked process model components to characterize source, fate-and-transport, distribution in environmental media and finally exposure as a result of human activity and usage. Moreover, the former processes are often driven by predictive models used to ascertain chemical properties (i.e. QSAR). Inherent uncertainty in the structure of these model could result in variability in predictions of these driving factors. This presentation introduces a Multi-Criteria Decision Analysis (MCDA) framework to prioritize the exposure potential of chemicals, which integrates expert judgment with available data on chemical properties. MCDA is a class of systematic methods used to evaluate alternatives that must be compared on multiple criteria or factors. To develop this framework, the most important parameters of the various models utilized in the EPA Exposure Challenge were made to create a generalized, adaptive, and parsimonious model.

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### **STAKEHOLDER ENGAGEMENT IN PRACTICE - THE EXPERIENCE OF THE NATIONAL TREE SAFETY GROUP IN THE DEVELOPMENT OF A NATIONALLY RECOGNISED APPROACH TO TREE SAFETY MANAGEMENT IN THE UK**

Research has demonstrated that the overall risk to the public from falling trees was extremely low, representing about a 1 in 10 million chance of an individual being killed in any given year, which means that the risk falls well into the broadly acceptable zone of the Health and Safety Executives (HSEs) Tolerability of Risk (TOR) Framework (2001). The research also showed that there is limited societal concern

about risks of this type (although there may be adverse publicity in the immediate aftermath of an individual incident). The analysis indicated that trying to further reduce such a small risk is exceptionally difficult given that there may be as many as 4 billion trees in the UK and that it would be unlikely that adjustments to the current management regime would reduce the risk the health and safety in any significant way. Nonetheless, there was concern that some individuals may continue to be risk averse and defensive in their management of tree safety due in large part to a fear of prosecution. A stakeholder forum, the National Tree Safety Group (NTSG), therefore emerged to develop a nationally recognised approach to tree safety management. This paper looks at the formation and progress of the NTSG and reveals the emergence of a number of conflicting viewpoints and the way in which they were accommodated. The NTSG drew on parallel developments in relation to public safety in non-work environments and advocated that the evaluation of what is reasonable should be based upon a balance between benefit and risk. This calculation can only be undertaken in a local context, since trees provide many different types of benefit in a range of different circumstances. Thus the NTSG sought to move forward on two fronts - firstly an engagement with the Health and Safety Executive (HSE) and secondly to provide guidance towards management that is proportionate to the actual risks posed by trees.

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### **USE OF WORKER EPIDEMIOLOGICAL DATA TO ASSESS INHALATION RISK FROM 2-MERCAPTOBENZOTHAZOLE**

2-Mercaptobenzothiazole (MBT) is used in the production of rubber products and as a microbiocide preservative. The only inhalation exposure guidance are the American Industrial Hygiene Association (AIHA) Workplace Environmental Exposure Level (WEEL) 8-hour time-weighted average (TWA) of 5 mg/m<sup>3</sup>, derived from oral toxicity data, and the German Maximum Concentration Value in the Workplace (MAK) TWA of 4 mg/m<sup>3</sup>, based on a conclusion that MBT inhalation was without detectable health effects. Both exposure guidelines note MBT is a skin sensitizer, while the AIHA WEEL also indicates systemic risks from skin absorption. Oral exposure data indicate evidence of liver tumors in mice, and hematopoietic, pituitary, adrenal, pancreatic, preputial, and subcutaneous tissue neoplasms in rats. Serial epidemiological studies in worker populations from West Virginia (USA) and north Wales (United Kingdom) have suggested exposure to MBT might increase the risk of several cancers. However, coexposure to other workplace carcinogens has impeded evaluation of cancer risks from MBT. In 2009, Sorahan reevaluated data from the worker population in Wales and identified a subset of 363 workers for whom risks of lung and colon cancer and multiple myeloma could be adjusted to account only for MBT exposure. The lung cancer data did not exhibit a dose-response trend and only

four cases of multiple myeloma were identified among this subset. However, the colon cancer data suffer from neither of these limitations. Based on a well-documented retrospective exposure assessment, linear regression of the categorical data is used here to estimate an upper bound worker risk of over 0.1 per mg/m<sup>3</sup> exposure. These data suggest inhalation of MBT may pose a risk for colon cancer, but further studies are needed to corroborate this and to determine if MBT exposure increases the risk of developing other cancers. “The views expressed are those of the authors and do not reflect the views or policies of the USEPA.”

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#### **STOCHASTIC MODELING OF WATER RECLAMATION TREATMENT REDESIGN SUGGESTIONS ADDRESSING CRYPTOSPORIDIOSIS RISK AT A RECREATIONAL SPRAY PARK**

This study is aimed at modeling a water reclamation treatment system for a recreational spray park that experienced a significant cryptosporidiosis outbreak, using microbial risk assessment. In this case the spray park’s water reclamation treatment system was modeled using a Markov chain model to develop a distribution of the oocyst concentration exiting the water reclamation system and being sprayed onto the recreation surface. Probability distributions were then fitted to the output from the Markov chain model and used for the Monte Carlo method to model the risk of cryptosporidiosis infection to spraypad users. The water reclamation treatment system used during the time period of the outbreak (filtration and chlorination) was modeled, then the estimated risk level for this configuration was compared to two engineering design retrofits that have efficacy potential for *Cryptosporidium* (ultraviolet and ozone treatment). In addition to the supplemental treatment steps, the removal of a design flaw that allows for a portion of the water from the spraypad to bypass the treatment system was modeled alone and in tandem with the additional treatment options. An epidemiological study of the outbreak demonstrated that the likeliest cause of the outbreak was a bolus fecal release from a person recreating on the spraypad. Therefore this is the scenario that has been modeled. The results show that the removal of the bypass pipe, reduced the risk of infection appreciably, however, larger risk reductions were experienced with the additional treatment steps. While there is remaining risk due to the scenario (fecal release in the recreating area), removal of the bypass pipe is the minimum recommendation. We will present a stochastic modeling framework of water treatment systems via a mass balance approach, which is then included in a stochastic risk modeling framework to inform potential design changes improving human health protection.

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#### **QUANTITATIVE MICROBIAL RISK ASSESSMENT OF FOMITES ACCOUNTING FOR SURFACE SAMPLING EFFICIENCY FOR VIRUSES AND NON-SPORE FORMING BACTERIA**

Quantitative microbial risk assessment (QMRA) has demonstrated itself as a vital tool in assessing response and optimal mitigation actions from a release of pathogens in the indoor environment. There exist however significant data gaps preventing a greater understanding of the interaction between potential host and the indoor environment. One of the major gaps is a greater understanding of the interaction between; fomite (inanimate surface capable of harboring pathogens), humans and pathogens. This study was initiated to investigate the recovery efficiencies from various non-porous fomites for a virus surrogate, bacteriophage P22 and a non-spore forming bacteria, non-pathogenic *Staphylococcus aureus* (*S. aureus*) and to model the effect of this recovery efficiency on the associated risk estimates. The scenario used is a shared office where the first user contaminates the fomites in the office (non-porous common office fomite surfaces) with a virus and bacteria, hypothetically similar to influenza and pathogenic *S. aureus* for this hypothetical scenario, then two subsequent people use the office for 4 hour intervals separately. Two forms of the nested Markov chain models are developed, one where the transfer efficiency is included directly in the loss rates and the second where the transfer efficiency is neglected from the loss rates, such as is performed in current risk estimates. The results of the Markov chain models are used to fit probability distributions for the Monte Carlo method invoked for the risk estimation. Preliminary results show a significant difference in the risk estimate given the inclusion of transfer efficiency. Sensitivity analyses signify that while initial concentration to the fomites still remains the most significant effect on the estimated risk, inclusion of the transfer efficiency greatly reduces the risk model’s sensitivity to the initial concentration.

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#### **ENHANCING THE AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY’S (ATSDR) SITE ASSESMENTS WITH PHARMACOKINETIC MODELS AND BIOMONITORING DATA**

One of the key missions of the ATSDR is to assess the human health impact of contamination at waste sites, industrial sites, and even from toxicants resulting from natural processes. Assessment of the human health impact of toxic substances requires high quality toxicity information and exposure data. In several instances environmental exposure data may not exist but biomonitoring data (e.g. blood lead levels) are available. In the case of blood lead levels a direct comparison can be made to a



biomonitoring “equivalent” level; the CDC guidance value of 10 µg/dl blood lead. However, for most other substances comparison values are expressed in external exposure metrics. If health assessors are provided with biomonitoring data they must turn to the scientific literature to find a study that reports health effects at a similar level or must estimate the exposure that occurred in order to have a comparable metric. ATSDR has begun to enhance the health assessor’s understanding of adverse health risks in the community by employing computational methods to improve toxicity and exposure data. One of the more promising computational methods is the use of PBPK modeling for estimation of internal dose. Recently PBPK modeling has been used in a reverse dosimetry manner to estimate exposure given a biological level measured in the community. In addition, biomarkers of exposure and effect are being used to compare to national averages as identified in the NHANES data set. While such a comparison does not assure that the national average is at a no-effect level, such comparisons provide insight into the magnitude of the exposure. Neither technique is being used by ATSDR to exclusively provide conclusions about public health; however such analyses stand as a strong adjunct to assessments performed in traditional manners. This presentation presents two sites where ATSDR has used a combination of PBPK modeling and biomonitoring to help assess health risks from exposure.

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#### **AN OVERVIEW OF CARBON NANOMATERIAL TOXICITY RESEARCH**

Efforts to assess the risks of carbon nanomaterials has resulted in an expanding though still limited body of scientific data on the toxicity of these emerging materials. To date, published toxicity studies have utilized whole animals and cells, with no human data currently available. This presentation will provide an overview of selected carbon nanomaterial toxicity data and provide an introduction to the challenges in assessing the human health risks of carbon nanomaterials.

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#### **VALUE ORIENTATIONS, RISK PERCEPTION, AND INSTITUTIONAL TRUST-DRIVEN POLICY DILEMMAS IN THE NUCLEAR WASTE ARENA: TOWARD A PROCESS FOR FORECASTING AND AVOIDING POLICY GRIDLOCK**

The history of the institutional processes for developing a geologic repository for high-level nuclear waste has been a poster child for expensive and time-consuming policy gridlock. A large body of empirical data suggests this gridlock has been heavily influenced by differences in risk perceptions, values, and trust in the decision-making process. Whitfield et al developed and tested a model of value orientations, risk per-

ception, and institutional trust suggesting that support for nuclear waste management (NWM) was predictable based on underlying value orientations. This paper builds on these prior findings by showing how attempts to satisfy all relevant values inevitably lead to a plethora of policy dilemmas, each threatening to discredit the institutional process charged with NWM. Anthony has shown that most policy dilemmas can be anticipated and that once recognized suggest options for avoiding those dilemmas and cultivating trust in the institutional process. Perhaps the most fundamental policy dilemma among the many facing NWM has been the “not to fail” mandate to isolate existing nuclear waste from the environment. This mandate dictates that if any deficiency comes to light due to a real problem or controversy among stakeholder views, NWM attracts negative attention and credibility suffers. If however there are extended periods without visible problems, real risks are liable to be eclipsed by the pressures of cost, schedule, and general complacency until a real deficiency is induced. A possible option for transforming this lose-lose game into win-win effort is to focus the design of the institutional process on identifying and tracking indicators expressing the day-to-day balance of the risks of taking versus not taking action. We illustrate how identifying policy dilemmas in advance can be usefully applied to one possible future aspect of NWM, the implementation of interim storage for spent nuclear fuel away from commercial nuclear reactors.

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#### **RISK-RISK TRADEOFFS IN CLIMATE ENGINEERING**

The risk of potentially catastrophic climate change, and the cost of greenhouse gas (GHG) emissions abatement, have spurred interest in techniques for engineering the climate through solar radiation management (SRM), such as injecting reflective particles into the upper atmosphere. Such geoengineering projects may pose risk-risk tradeoffs, which might include, for example, excessive global cooling; moral hazard undercutting GHG abatement; pollutant deposition; adverse regional and distributional impacts; and abrupt warming if SRM were discontinued while GHG concentrations remain high. Sound decisions will depend on evaluation of these risk-risk tradeoffs and a search for risk-superior options. Recognizing these risks, some have advocated international governance strategies to restrain hasty deployment of SRM, because there may be incentives to be the first mover in deploying SRM (the converse of incentives to free ride in emissions abatement). And some have advocated research on SRM in order to understand it better, reduce the risks of hasty deployment in a crisis, and assist in the selection of the best (lowest overall risk, highest net benefits) option. But such research may pose its own risk-risk tradeoffs, because research on SRM might lower its costs and/or clarify its regional distributional impacts, either of which may exacerbate the race to deploy first. Lower cost, typically viewed as an advantage of SRM over GHG abatement, may encourage unaccountable states or



non-state actors to race to deploy SRM. Clearer understanding of regional distributional impacts may encourage actors to deploy SRM first, selecting the SRM project that most favors the deployer, and preempting (detering) the deployment of other SRM projects which might have superior regional distributional impacts but would yield excessive aggregate global cooling if deployed second or third. These tradeoffs suggest the need for careful attention to the strategic incentives, governance regimes, research programs, information sharing, accountability and reversibility of SRM.

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### **UTILITY OF REGULATIONS AND INSPECTION: FOOD SAFETY EXAMPLE**

The U.S. has been attempting to solve economic and social problems through regulation and inspection for over 140 years and now has approximately 165,000 pages of rules governing American life. This paper examines the possibility that, where risk regulations may be effective relatively early in the life of an agency, over time it is theoretically likely to be less effective as the agency tackles smaller, less certain risks with fewer obvious solutions, larger more complex industries and become emeshed in more politically driven webs. FDA's management of food safety will be discussed as an example of how new kinds of models may be needed to solve social problems.

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### **PROPOSITION 65 DERMAL EXPOSURE ASSESSMENT FOR DEHP IN CLOTHING WITH PLASTICIZED IMAGES**

A growing number of notices have been issued to apparel manufacturers and distributors claiming levels of di(2-ethylhexyl)phthalate (DEHP) in their products would lead to an exceedance of the Maximum Allowable Dose Levels (MADLs) for male reproductive toxicity and the No Significant Risk Level (NSRL) for theoretical cancer risk according to Proposition 65, formally known as California's Safe Drinking Water and Toxic Enforcement Act of 1986. Referred to as Safe Harbor Levels (SHLs), these values for DEHP were derived assuming exposure occurred orally, however, a few animal studies have suggested that DEHP can migrate through the skin. Therefore, the purpose of our study was to determine whether or not it is likely that DEHP SHLs would be exceeded based on dermal exposure through normal product use. We performed an exposure assessment to quantify the likely dermal exposure of DEHP from clothing. Our analysis assumed that DEHP was located within a plasticized image on shirts worn by various age groups: birth to 1 month, 1 to 2 years, and adults. Based on the Consumer Product Safety and Information Act of 2008 (CPSIA) and various state regulations for maximum allowable levels of DEHP in child care articles, such as pajamas, we assumed these images contained up to 1000 ppm DEHP. Ranges of different exposure scenarios were analyzed, including 3 to

24-hour length-of-wear durations and direct skin contact area ranging between 10 and 85% of the surface area of the shirt minus the sleeves. Our results indicate that dermal absorption of DEHP from normal clothing use would not approach the MADLs in neonatal infants (20 µg/day), children (58 µg/day), or adults (410 µg/day), nor the NSRL (310 µg/day). Results suggest that it is unlikely that plasticized images on clothing that conform to CPSIA DEHP limits would result in exceedance of Proposition 65 SHLs through dermal exposure under normal use situations.

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### **ADAPTING TO FUTURE HURRICANE RISK IN NEW ORLEANS UNDER CLIMATE CHANGE UNCERTAINTY**

As the city of New Orleans recovers from the devastating hurricanes in 2005, government officials and individuals will continue to seek ways to reduce their risk to future hurricane storm surge beyond advocating for more storm-surge barriers. Climate change and other uncertain factors make it difficult (1) to predict future storm surge risk to New Orleans, (2) assess the benefits of locally-managed risk mitigation programs, and (3) effectively communicate the benefits and tradeoffs of different mitigation programs to the businesses and individuals that may choose to participate in them. This presentation describes an effort to develop and apply new approaches for incorporating state-of-the-art physical and social science information into city risk-mitigation planning. Supported by the National Oceanographic and Atmospheric Administration, we worked with the New Orleans Office of Homeland Security (OHS) to implement hurricane risk reduction programs and communicate hurricane risk information and mitigation options to New Orleans' businesses and residents. This project is comprised of three interrelated activities: (1) Modeling storm surge risk to New Orleans at the neighborhood level under a wide array of state- and city-supported locally-managed risk mitigation programs; (2) Developing the decision-support information and tools needed by the New Orleans OHS to ensure that their risk mitigation programs achieve the desired goals; (3) Improving ways to communicate hurricane risk information to the public to support individual choices regarding the participation in government-supported risk mitigation measures. These efforts increased understanding of how to inform decision making under climate change uncertainty.

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### **ASSESSING THE BENEFITS OF THE PUBLIC HEALTH RESPONSE IN THE EVENT OF A CHEMICAL TERRORISM ATTACK**

The Chemical Terrorism Risk Assessment (CTRA) and Chemical Infrastructure Risk Assessment (CIRA) are DHS CSAC funded programs that estimate the risk of chemical terrorism attacks and assist in prioritizing mitigation strategies. One aspect of these programs is to model the public health response employed following a chemical terrorism attack against the general public. Referred to as the CTRA/CIRA Medical Mitigation Model, the objective is to estimate the number of victims that would be saved by or benefit from the response. At the foundation of the model is the concept of stock-and-flow modeling; “stocks” are states that individuals progress through during an event (e.g., “Exposed” or “Symptomatic”), while “flows” govern movement from one stock to another. This approach allows victims to be created at different times, progress at different rates, and impede each others’ movement when appropriate. The model simulates and tracks each victim as they progress from exposure to an end state (e.g., “Dead”, “Saved”, or “Benefited”). Some of the considerations used in determining the appropriate end state for each victim include chemical used in the attack, type of attack, route and severity of exposure, detailed treatment regimens with efficacy defined as a function of time, and medical system capacity. Key features of the Medical Mitigation Model include the quantification of all model parameters by subject matter experts from medical toxicology and emergency medicine, improved linkage between victim types and their corresponding toxicities, and more clearly defined stockpile sources. By estimating the number of lives saved or benefited, the model makes it possible to assess the effectiveness of the existing public health response system and to examine improvement strategies. Such a capability permits policy makers to make informed decisions on resource allocation and helps responders to better understand their ability to respond and areas of potential improvement.

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### **EXPERT PERSPECTIVES FOR IMPROVING USACE FLOOD RISK MANAGEMENT AND STAKEHOLDER ENGAGEMENT**

The U.S. Army Corps of Engineers (USACE) is the de facto leader in flood risk management (FRM) because of the many natural and manmade waterways for which it is responsible, and its associated expertise. Hurricanes Katrina & Rita caused many flood risk mitigation systems to fail in the Gulf Coast region, encouraging USACE to improve its flood risk management (FRM) framework. To better understand current beliefs about FRM within USACE, as well as differences between per-

ceptions of planners (responsible for managing & financing projects) and engineers (responsible for implementing projects), an Influence Diagram-based Mental Model approach was employed (Morgan, Fischhoff, Bostrom, & Atman, 2002). An Expert Model workshop was conducted with USACE researchers, planners, and senior leadership to identify key factors and develop an expert mental model of USACE FRM. This framework was then used as the analytical basis for follow-up Mental Models interviews with USACE planners and engineers. Several influences on FRM were identified, including those affecting the flood risk levels; socio-economic, political, and internal drivers that; and the quality of collaboration, coordination and communication both internally and with external partners and stakeholders. Increased intra- and interagency coordination and communication, as well as inclusion of local stakeholders, were seen as key areas to focus for FRM improvement, although differences of opinion exist as to the best way to accomplish these goals. Other results and considerations will be discussed.

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### **EXPOSURE RESPONSE ARRAY PROJECT AND SUMMARY OF AN OCTOBER WORKSHOP**

Exposure-response arrays are increasingly being incorporated into assessments across the U.S. EPA, based on the Risk Assessment Forum report “Recommendations for Improvements to the RfD/RfC Process,” and proposed changes in both the Integrated Science Assessments (ISAs) for the “priority” pollutants covered by the National Ambient Air Quality Standards, and for the assessments in the Integrated Risk Information System (IRIS). There are similar data presentations in the Acute Exposure Guideline Level (AEGGL) Technical Support Documents, and in the Toxicological Profiles developed by ATSDR. A template for exposure-response arrays was developed based on experience in all of these programs. The current project seeks to capture the lessons learned from the efforts across the EPA, and the broader group both inside and external to the Agency, to craft helpful advice and instructional materials for creating effective exposure-response arrays. To meet this goal, a one-day, web-based workshop is to be held in October 2011. Prior to the workshop, a draft set of recommendations is being developed by an inter-agency work group to serve as a focal point for the workshop. In the workshop, we anticipate guided discussions ranging across a number of topics, including (but not limited to): (1) the various types of arrays developed to-date; (2) formatting options - what works and what doesn’t; (3) how arrays can help in determining and communicating risk; (4) seeking consistency without sacrificing flexibility for effective presentation; and (5) consideration of the target audience (e.g., public vs. risk managers vs. scientists). This presentation will provide an overview of the progress on the overall project, including the workshop, and the future of the project.

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### **MODELING SKIP-ROW CORN RISK USING EXPERIMENTAL TRIAL DATA: PRODUCTION, INSURANCE, AND ECONOMIC IMPLICATIONS**

Skip-row planting practices—which may more efficiently ration soil moisture to crops throughout the growing season—are sometimes employed in the production of dryland crops in drought-prone areas, and have the potential to reduce risk and enhance yields relative to conventional fully planted practices when moisture conditions are suboptimal. The United States Department of Agriculture-Risk Management Agency (USDA-RMA)—the agency which administers the Federal Crop Insurance Program—began offering insurance for skip-row corn in selected areas in 2008, however, several concerns arose about how insurance for this practice should be appropriately treated. The purpose of this study is to assess the risk and production characteristics of skip-row corn relative to conventional practices in the Central Great Plains region, focusing on both yield distribution impacts and economic implications for insurance programs and technology adoption. Since skip-row practices are new to the region, experience data are limited. To alleviate this problem, side-by-side skip-row corn agronomic trial data (N=270) are augmented with a large producer level dataset consisting 130,080 conventional yield observations from 1996-2008 by employing a multivariate nonparametric simulation technique to derive skip-row yield distributions and insurance rates. Adoption of skip-row practices is found to increase mean yields and limit the severity of yield losses in areas prone to drought, and also result in reductions in expected insurance indemnities in excess of 50% in typical cases. The insurance rules currently in use by the USDA-RMA are also evaluated and found to have market-distorting impacts which crowd-out skip-row technology adoption, which results in increased risk exposure to the government, producers, and private insurers. From an economic and actuarial standpoint, this is troubling since it opens the door adverse selection and other market distortions and inefficiencies.

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### **GLOBAL BURDEN OF DISEASE CAUSED BY FOODBORNE TOXINS: USE OF BIOMARKERS VS. DIETARY RECALL AND MARKET SAMPLES**

Foodborne toxins, including metals and metalloids as well as toxins of fungal, bacterial, and algal origin, can cause acute and chronic diseases in humans worldwide. Until recently, human exposure to foodborne toxins was measured almost exclusively in one of two ways: by questionnaires relying on recall of what and how much had

been eaten, or by measurement of food samples that ideally were representative of true exposures. Both of these ways pose potential problems. Dietary recall is often inaccurate, and it can be difficult in many cultures worldwide to take food samples that accurately represent exposure. In recent years, however, biomarkers to assess foodborne toxin exposure and effect have been developed, and are increasingly used to estimate human exposures. A case study is described in attempting to estimate global burden of human disease caused by aflatoxin, a carcinogenic mycotoxin common in maize and peanuts worldwide. Obtaining accurate exposure estimates in different countries is the most difficult part of the risk assessment. In the future, if biomarker samples can be gathered more easily from populations worldwide, the quality of human health risk assessment from dietary toxins will be much improved. However, collection and interpretation of biomarkers pose new challenges to risk assessment. These will be discussed in light of physical, cultural, and technological issues.

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### **AGGREGATE RISK ASSESSMENT OF INHALABLE PARTICLE MATTER**

Aggregate risk of inhalable particle matters is an important consideration in urban area because of the potential for harm and serious disadvantages. The destruction of ecosystems and environmental disasters can occur when the pollutant is hidden and allowed to aggregate in living creature's body to high levels. As the sink and source of atmospheric particle matter pollutants in urban environment, the urban dust can be used as a useful indicator of local air pollutants' transport, deposition and aggregation. The present paper measures concentration of PAHs of 13 dust samples, which are collected to represent different conditions of three basic aspects of human's daily life: travelling, living and dining. The toxic equivalency factors (TEFs) were used to calculate benzo[a]pyrene equivalents (E<sub>BaP</sub>) for dust samples to assess the aggregate human health risk of atmospheric particle in daily life. The result of risk assessment indicated that the highest potential health risk of PAHs is found in dust sample of the room under decoration, and the lowest in elevator.

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### **WHAT, ME WORRY? THE ROLE OF AFFECT IN INFORMATION SEEKING**

Based on an augmented version of the Risk Information Seeking and Processing (RISP) Model, this study compares four path models to examine how RISP components account for individuals' intention to seek or avoid risk information related to climate change. To further theory development, we examine both positive and negative affect in their influence on information seeking and avoiding. Overall, infor-



mation insufficiency, risk perception, and favorable attitude lead to more seeking and less avoiding. Informational subjective norms are positively related to seeking and avoiding consistently, which suggests that one's social environment has the potential to strongly influence the way they handle climate change information. When negative affect is controlled for, people with stronger perceived behavioral control are more likely to seek information and less likely to avoid information. However, when positive affect is controlled for, the impact of perceived behavioral control becomes more complicated. The highlight of this study shows that even though people who feel negative about climate change are more likely to seek information and less likely to avoid information about climate change, those who feel positive about climate change are much more likely to avoid this information. This result contradicts the approaching tendency that positive affect usually generates in a risk context. Together, these findings present several means to improve the communication of risk information related to climate change. That is, it seems important to communicate about climate change by highlighting the gap between one's general awareness and actual knowledge, emphasizing potential negative consequences related to climate change, and fostering favorable attitude toward learning about climate change. Nonetheless, it is also critical to monitor potential audiences' social environment, perceived ability for information seeking, and emotional responses related to climate change.

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### **RISK ASSESSMENT OF POTENTIAL TRANSMISSION OF VARIANT CREUTZFELDT-JAKOB DISEASE (vCJD) VIA TRANSFUSION IN THE UNITED STATES**

As of March 2011, 221 primary vCJD cases (the human counterpart of 'mad cow' disease acquired through dietary exposure), have been reported worldwide. Most were likely acquired in the United Kingdom, France and other countries in Europe since 1980. Four probable secondary vCJD infections via red blood cell transfusion have also been reported in the UK since 2003. Of concern for the US blood supply is that some donors may have been exposed to the infectious agent and acquired vCJD during extensive travel or residence in regions where bovine spongiform encephalopathy epidemics occurred. However, to date, no case of transfusion-transmitted vCJD (TTvCJD) in the US has been identified. FDA has developed risk assessment models to estimate the potential TTvCJD infection in the US and used them to assess the effectiveness of current donor deferral policies in reducing risk. Due to limited knowledge and information on vCJD prevalence, susceptibility of different human genotype populations, and the probability of disease transmission through an infected donor; the results of the risk assessment are highly uncertain. FDA model results reveal the probability of TTvCJD infection using both a Lower vCJD Case Prevalence Estimate and a Higher Infection Prevalence Estimate. Preliminary results indicate

that the US TTvCJD risk is low. Current donor deferral policies likely reduced TTvCJD risk by approximately 90%, with approximately 80% of the remaining residual risk associated with travel to the UK. The risk assessment model identifies major data gaps and uncertainties associated with TTvCJD risk in the US, informs FDA risk management decisions, and is an effective tool for facilitating risk communication.

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### **AFTER THE ANALYSIS: RISK MANAGEMENT ACTIONS FOR EMERGING CONTAMINANTS**

The Department of Defense (DoD) has developed a three-tiered process called "scan-watch-action" for emerging contaminants. The process (1) identifies chemicals and materials with evolving science or regulatory climate, (2) conducts qualitative Phase I Impact Assessments and quantitative Phase II Impact Assessments, and (3) develops risk management options (RMOs) for chemicals with high risk to people or DoD business functions. An Impact Assessment has some components of a risk analysis modified for DoD use. Upon approval of the RMOs by an executive level governance council, they become risk management actions (RMAs) as they are implemented. The RMAs span the spectrum from policy changes to investments in research and testing of substitutes. This presentation will describe the status of a number of key RMAs for specific chemicals such as perchlorate, beryllium, naphthalene, lead, and RDX (an explosive compound).

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### **COMPUTER BASED CLASSIFICATION OF PERFORMANCE SHAPING FACTORS FOR SAFETY ANALYSIS**

One of the most important characteristics of the existing models and classification schemes for Human Error Analysis (HEA) is how they use different influencing or contributing factors (such as training, working conditions, task load, fatigue, etc.) to determine the operator's ability to successfully perform the required action. In Human Reliability Analysis (HRA) these factors are represented by Performance Shaping Factors (PSFs) that are used to calculate human error probabilities. The paper describes the model for erroneous action, which is specifically formulated to present and classify different interactions of the observed event that is related to the active error. In the model the selected set of six PSFs is integrated with the operator's performance parameters and, together with the suggested classification scheme, works efficiently for the causal analysis of operator errors, as well as for determination of the operator's abilities to prevent errors. The special types of classification algorithms that analyze the different stages of the erroneous action, with the use of the corresponding influencing factors, are demonstrated. These algorithms use the risk-as-feeling approach for modeling positive and negative effects in operator behavior, and



verbal decision analysis to classify different combinations of influencing factors into different levels of the operator's abilities to successfully perform the required action. The specific feature of the suggested approach is that it presents the opportunity of using the decision support system to logically analyze errors and their underlying factors in the process of data collection, instead of following the traditional approach of drawing conclusions from the investigation reports. The results allow to further improve the model of SAFE (System for Analyzing and Forecasting Errors) for accident/incident investigation in aviation.

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### **ASSESSING RISK OF INVASIVE SPECIES UNDER SEVERE UNCERTAINTY: A DOMINANCE-BASED APPROACH**

A critical issue for modern risk assessment of invasive species is severe uncertainty. The uncertainty associated with spread and establishment of invasive organisms influences how regulatory decision-makers respond to expanding incursions. The omission of uncertainty in estimating long-distance spread leads to very low establishment rates (as is typical for rare events) and may communicate overconfidence when used to support decisions regarding managing the expansion of pest population. In this paper, we present a model-based approach to invasive species risk assessment that combines two potentially conflicting analytical tasks: (1) estimating the likelihood of a new organism being established at a given locale and (2) quantifying the uncertainty of that prediction. Our methodology focuses on the long-distance spread of invasive pest species. We use the stochastic simulation model to generate distributions of plausible invasion outcomes for a species of interest over a particular spatial domain. We then apply second-degree stochastic dominance (SSD) criteria to order all geographic locations within that domain by their distributions of plausible outcomes to an ordinal risk rank. The SSD rule implies that decision-makers are risk averse and would choose a course of action based on the minimum tolerable distribution of invasion risks. We apply the modeling approach to evaluate the pathways of spread of the emerald ash borer, a major pest of ash trees in North America. Results show the tradeoffs between the pest's estimated establishment rates at remote locations and the amount of uncertainty in those model-based forecasts. The integrated risk ranks delineate major "crossroads" where the movement of the pest with commercial transportation is most likely to occur. Overall, the new approach generates more realistic predictions of long-distance spread than models that do not account for uncertainty and can help design more effective pest surveillance and regulatory programs.

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### **DEVELOPMENT OF A HUMAN PBPK MODEL FOR CARBARYL USING AN IN VITRO TO IN VIVO EXTRAPOLATION APPROACH AND ITS APPLICATION IN REVERSE DOSIMETRY**

There is increasing interest in applying in vitro data and pharmacokinetic (PK) modeling to predict in vivo kinetics in order to improve risk assessments of chemicals in humans. Physiologically based pharmacokinetic (PBPK) modeling provides an effective integration tool to quantitatively extrapolate in vitro data to in vivo. The goal of this study was to demonstrate an in vitro to in vivo extrapolation (IVIVE) approach for developing a PBPK/PD model for carbaryl. A parallelogram approach was used in which successful application of the IVIVE approach in rats served as the basis for application in the human. Carbaryl is a widely used pesticide with acute toxic effects due to its interaction with cholinesterase (ChE) in the brain. Carbaryl metabolism was determined using human hepatocytes. Interactions between carbaryl and ChE were determined in red blood cells in human blood, as a surrogate for brain ChE, the actual target for carbaryl toxicity. These in vitro PK and PD data were extrapolated to in vivo using biologically relevant scaling factors to describe the disposition and ChE inhibition dynamics of carbaryl in humans. The Markov Chain Monte Carlo technique was used to integrate the in vitro data and known information on human interindividual variability of enzyme expression instead of simply extrapolating the average values from the experiments. The variability in model predicted carbaryl exposure in the target tissue thus reflected the impact of human variability in metabolism, information that is not readily available from individual studies. Reverse dosimetry was conducted using the PBPK model to estimate carbaryl exposures consistent with human biomonitoring data by integrating carbaryl exposure patterns simulated with the CARES software and Monte Carlo analysis. This modeling approach can serve as a template for developing models for other environmental chemicals using in vitro data to support risk assessments.

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### **THE SOUTHERN STATES OUTBREAK SEQUENCE: SURVEYING SURVIVORS AND INFORMING RISK MANAGEMENT**

Risk management depends on fully understanding constraints—for instance, communication problems and social elements such as perception (e.g., Covello, 1991; Trumbo, 2000)—and is incomplete when it does not address these issues. Post-disaster questionnaires are a critical means of helping the profession better understand constraints by examining how people prepare for risks, what resources they had available during a real situation, how they actually reacted, and why they made those

choices. This work examines these surveys and their results in the context of the April 27, 2011, tornado outbreak that killed 238 people in Alabama (part of the 3-day outbreak the National Weather Service calls the Southern States Outbreak Sequence, which killed 339 people). The research team administered a survey to 125 people in Rainsville, Alabama, one of the affected areas. The survey examined responses to tornado warnings, preparedness and awareness, perspective (e.g., locus of control), and demographics, and this poster reports a selection of initial findings. Some results may apply to other post-disaster situations as well. The survey instrument, adapted from earlier research (e.g., Schmidlin, King, Hammer, & Ono, 1998; Mitchem, 2003), went through a number of iterations based on heuristic evaluation, field-testing following two disasters (Chaney & Weaver, 2007, 2010), external expert evaluations, and diagnostic usability testing based in part on Morgan, Fischhoff, Bostrom, & Atman (2002). The poster includes both preliminary analysis and highlights of complicating factors in such research that will guide future inquiry (e.g., problematic wording, variations in comments from respondents, and complex disaster conditions such as such as multiple tornados and multiple tornado warnings at a single location).

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#### **UNDERSTANDING THE TEMPORAL PATTERNS OF AEROSOLS AT HSIN-CHUANG IN TAIPEI BY DYNAMIC FACTOR ANALYSIS**

Studies investigating the particulate matter (PM) compositions are rapidly emerging recently to reveal direct evidence of the impact to human health rather than only using PM measures. Among them, the knowledge of the underlying mechanisms of the genesis and interactions of the ambient pollutants plays an important role of the understanding of particulate compositions as well as the associated air quality control strategies to reduce their risks to human and ecological health. Due to economic and operational reasons, in Taipei metropolitan area, the PM-speciate and criteria pollutants were only both available at Hsin-Chuang observed by two separate stations situated within 200 m. This study investigates the temporal patterns of the observations of ambient pollutants at Hsin-Chuang to obtain the most significant common trends during 2004-2009, which are the trends of a group of ambient pollutants. The common trends are uncorrelated to each other and may represent an important contributing mechanism to the local spatiotemporal distribution of air quality. We applied dynamic factor analysis (DFA) to investigating the nonstationary time series of the observations of aerosols in this study which is based upon the state space model which can account for the uncertainty from both the dynamic factor model and observations. In addition, loess regression method is used to differentiate the underlying driving forces to the temporal variations of ambient pollutants at different temporal scales. Results showed the meteorological conditions play the most important role in the temporal variations of pollutants. The time-varying magnitude of photochemical

reactions contributes significantly to the interactions among the aerosols and ambient pollutant. In addition, the transboundary transport is also important to the temporal changes of aerosols.

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#### **CARNIVORES AS A HAZARD: THE ROLE OF RISK PERCEPTION IN PREDICTING PUBLIC ACCEPTANCE**

The reappearance and recovery of large carnivores across various landscapes creates a need to understand how people will respond to the presence of these animals. To address this need, a psychological model of “acceptance” was tested to determine what variables most influence acceptance of black bears (*Ursus americanus*) in an area with an emerging black bear population (Ohio, USA). We hypothesized that people’s perceptions of risk and benefit would mediate the effect of trust and control on acceptance. We used a mail-back survey of Ohio residents (N = 9,400; adjusted response rate = 35%) to assess the variables of interest and test the hypothesized model. The model explained approximately 62% of the variance in acceptance, and perceived risk had the largest impact on the level of acceptance. The results also indicate that carnivores, unlike many other ecological or environmental risks, are psychometrically similar to classic technological hazards, perhaps due to the potential direct threat to human health and safety. We suggest that risk communication efforts that focus on raising social trust in the managing agency and perceived individual control can indirectly raise stakeholders’ acceptance by lowering risk perception and raising the perceived benefits of emerging carnivore populations. Results from an ongoing experimental test of such communication strategies will also be discussed.

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#### **EUROPEAN SOLVENTS INDUSTRY GROUP CONSUMER GENERIC EXPOSURE SCENARIO TOOL**

The European Solvents Industry Group (ESIG) has developed a novel tool to undertake an evaluation of the safety of consumer uses of solvents, as required by the Registration, Evaluation and Authorization of Chemicals (REACH) Regulation. This tool builds upon the consumer portion of the European Center for Ecotoxicology and Toxicology of Chemicals Targeted Risk Assessment tool (ECETOC - TRA, a recommended lower tier tool under REACH) by implementing refinements described in Appendix F of ECETOC technical report 107, while accounting for the application hierarchy described in Chapter R15 of the REACH Technical Guidance. Technical enhancements include utilization of additional data to refine scenario defaults and the ability to include the impact of indoor ventilation rates. When appropriate, additional exposure scenarios were developed to cover all consumer uses included in ESIG’s

Generic Exposure Scenario library. The TRA tool structure was also modified to automatically determine conditions necessary for safe use (Risk Characterization Ratio <1). Using specific standard phrases, this information is then automatically reported for relevant exposure scenarios, in order that the outputs can be readily assimilated within Material Safety Data Sheet and other similar information technology systems. Transparency within the tool is maintained by including all original defaults and associated exposure predictions, as well as the refined defaults and exposure predictions. For scenarios evaluated to date, the ESIG GES tool provided reasonable but still conservative exposure estimates.

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### **APPLICATION OF SYSTEMS BIOLOGY APPROACH TO IDENTIFY THE CONTROLLING MECHANISMS FOR J-SHAPED DOSE RESPONSE CURVE**

The hormesis phenomena or J-shaped dose response has been accepted as a common phenomenon regardless of the involved biological model, endpoint measured and chemical class/physical stressor (Calabrese, 2010). However, previous and current hormesis research is more at the level of intuitive data analysis. In our previous work, we developed a mathematical model based on systems biology approach linking molecular-level cell cycle checkpoint control information to clonal growth cancer model to predict the possible shapes of the dose response curves of Ionizing Radiation (IR) induced tumor transformation frequency. A monotonically increasing to J-shaped dose response curve has been captured. The fundamental factors influencing the shapes of the dose response curve relate to the behavior of the saddle-node points of the model in the bifurcation diagram. In this project, mathematical, statistical and dynamical analyses are further applied to our first generation of cell cycle-tumor transformation model to gain deeper insights of the controlling mechanisms of the J-shaped dose response with respect to various functional formats and parameter values. When the model is simplified only containing the essential components of the system, it is found that the J-shaped dose response curve is inevitable under certain format of the toxicological perturbation signal as well as certain range of the parameter values. The dose at the turning point of the J-shaped dose response is not sensitive to most of the parameter values of the model. More insights on biological/toxicological mechanisms leading to the J-shaped dose response for ionizing radiation with respect to cell cycle control are obtained

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### **CARCINOGENIC RISK ASSESSMENT FOR THE USE OF METHYLENE BLUE IN DAIRY COWS**

Methylene blue (MB), though not approved as an animal drug by FDA, is used as a food-animal antidote for nitrate poisoning because there is no viable alternative. CVM recommended in 1990s a 180-day preslaughter withdrawal period in ruminants. Since then, new information has emerged including total residue data and a 2008 NTP study report. Therefore, the purpose of this evaluation was to determine if the previously recommended 180-day withdrawal time for both edible tissue and milk could be reduced. To achieve such a goal, we followed a step-by-step approach. First, the NTP report (NTP TR 540) was evaluated and we concurred with the finding that MB is genotoxic and carcinogenic. Second, we calculated  $S_o$ , the concentration of total residue of carcinogenic concern of the test compound in the total diet of test animals that corresponds to a maximum lifetime risk of cancer in the test animals of 1 in 1 million. We allocated 70% and 30% of the  $S_o$  to tissue and milk, respectively. Third, we used the allocated  $S_o$  to derive  $S_m$ , the permitted concentration of residues of carcinogenic concern in a specific edible product. Fourth, we reviewed the available residue data for MB in tissues and milk, and found that neither the depletion rate of MB in tissues down to  $S_m$  concentration nor the depletion rate of MB in milk could be established. Based on the above assessment of the carcinogenic concern of MB and residue information, we conclude that (1) the available residue data are not sufficient to allow a shorter than 180-day withdrawal time for both tissue and milk, (2) a depletion study for total residues (typically  $^{14}C$ -radiolabel) with adequate sampling times and number of animals is needed in order to determine the depletion profile of MB in tissues and milk, and (3) the Food Animal Residue Avoidance & Depletion Program (FARAD) recommended 14-day withdrawal period for edible tissues and 4-day milk discard time for MB is not supported by the information available to CVM.

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### **MISCONCEPTIONS IN COMMUNITY MEMBERS' MENTAL MODELS OF DIOXIN-LIKE COMPOUNDS FOLLOWING AN EXPOSURE ASSESSMENT STUDY**

A community exposure assessment study is typically one step in a larger process of assessing and managing health risk from environmental contamination. Due to scope limitations and/or scientific uncertainty, post-study communications are usually limited to background facts about the contaminant and data regarding exposure levels, with limited or no discussion of the magnitude of the health risk. Literature about how participants and community members process such exposure study re-



sults and possible intended or unintended behavioral consequences of such studies is scarce. To explore such questions, the Community Perceptions of Dioxins (CPOD) study is surveying participants (both exposed and control groups) as well as non-participants from one such study assessing exposure to dioxin-like compounds (DLCs) in Michigan's Midland and Saginaw counties. We are using a mental models approach in three phases: In Phase I, we developed an expert model of dioxin exposure and health effects through 5 interviews of academic, government, and community experts. Phase II involved 50 in-depth interviews of community members to document their mental models, which were then compared to the expert model to identify misconceptions and gaps in lay knowledge. Phase III (underway) will use a mailed survey to assess the prevalence of lay misconceptions in a larger sample of the population in the affected communities. Phase II interviews have already documented several potentially important misconceptions about DLCs, including beliefs about water contamination (versus soil contamination) and the magnitude of dermal exposures. If confirmed as prevalent via the mailed survey, such misconceptions will provide strong evidence for targeted risk communication messages to improve understanding and related health behaviors both in this affected community and in the context of other exposure assessment studies.

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### **YOU DON'T TEST FOR NOTHING: BELIEFS ABOUT EXPOSURE FROM LIVING ON DIOXIN-CONTAMINATED SOIL**

In the 1990s, dioxin-like compounds (DLCs) were discovered in the soil of areas of Michigan's Midland and Saginaw counties. In 2004-2005 the University of Michigan Dioxin Exposure Study (UMDES) analyzed samples to determine whether levels in soil were related to levels in residents' blood. UMDES found that the largest contributor to residents' body burdens was food but living on contaminated soil was unrelated to body burden. These findings were shared with study participants and the community. Five years later, the Community Perceptions of Dioxins (CPOD) study has returned to these communities to assess residents' mental models of dioxins and dioxin exposure risks. CPOD used open-ended interviews (discussed in a separate abstract) to identify the structure of both expert and community members' mental models of dioxins. CPOD is now conducting a population-based mailed survey of residents to assess population prevalence of key misconceptions and omissions identified in the qualitative interviews. Preliminary data from this survey indicates that even among prior UMDES participants (N=367), 83% believe that living on contaminated soil is a significant source of exposure, and 64% consider it the largest current source of exposure. This pattern was consistent across age, gender, and education. For contrast, 60% considered food to be a significant source of exposure

and only 11% rated food as the largest current source. These findings suggest that respondents have not received, understood, or accepted the UMDES's findings. Data from residents who were not participants in UMDES is forthcoming. We conclude that soil-to-body connections are both inherently plausible and likely were reinforced in community members' mental models by UMDES's focus on assessing that pathway of exposure. This inaccurate but prevalent misconception that elevated soil levels necessarily imply elevated human body burden is an important target for future communications in this community.

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### **RISK PERCEPTIONS AND ACTIONS OF WORLD TRADE CENTER ATTACK SURVIVORS COMPARED INSIDE AND OUTSIDE THE WTC TOWERS**

The continuum of managing the risks of disaster from the time people are in buildings to when they leave an area involves a complex set of perceptions. These perceptions translate into actions that can alter disaster consequences. Data from the evacuation of WTC Towers 1 and 2 was used to analyze factors associated with differences in survivor behavior inside and outside the towers. This paper complements, extends, and compares earlier studies (Gershon et al. 2010; Zimmerman & Sherman 2011). It is based on a Columbia University convenience survey of 1,444 evacuee survivors. One analysis compares initial willingness (hesitation) and time for tower evacuation with the immediacy of leaving the area once evacuees left the towers. Differences in tower and area evacuation timing are explained in terms of survivor characteristics, e.g. health/injury, fire/emergency training, residence, perceptions of conditions encountered, and the importance of seeking or helping other people ("people seeking"). Another analysis involves the importance of survivor characteristics in terms of people seeking behavior. Initial findings show differences in behavior and perceptions of risk in the two environments: although some people may have evacuated the towers rapidly, they delayed leaving the area. Over half of those who lingered outside indicated they were people seeking, but only a third who delayed tower evacuation indicated people seeking. Also, while a third indicated being injured during the evacuation of the towers, injury was not a significant reason for lingering outside, although it was an important factor in tower evacuation. Congestion and debris apparently contributed to delays in leaving both the towers themselves and the area. New York City is coastal with more transportation options than most cities, thus providing more options for evacuation. However, as these analyses indicate, strategies are needed to adequately prepare the public for full evacuation when indicated.



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### **GENDER DIFFERENCES IN LAY PEOPLE AND EXPERTS CONCERNING THEIR DECISIONS ABOUT DIFFERENT STRATEGIES TO FIGHT EPIDEMICS**

There is an ongoing debate about the difference between men and women concerning their risk perception and their decision behavior in risky situations. We asked a randomly selected sample of the Swiss population and a group of experts about their decisions to accept different strategies to fight epidemics. Past research suggests that experts tend to rate risks within their own domain as lower compared to ratings by the public and we wanted to know whether gender differences can be found in lay people samples and in expert samples concerning their decisions about strategies to fight animal epidemics. Data was gathered conducting a mail survey in the German- and French-speaking parts of Switzerland. The response rate was 41% (N = 1123) for the population and 67% (N = 504) for the experts. Congruent with most antecedent studies, we found experts to differ significantly in their risk ratings from the lay people. Experts would decide to implement a certain strategy more often than lay people. We found gender differences in the lay people and in the expert samples. Therefore, we can clearly rule out the knowledge hypothesis for gender differences, as more knowledge does not override the difference between men and women in the expert sample. Gender differences remain even in areas where men and women have the very same knowledge, competencies and involvement. We included moral value questions in our analyses and we found gender differences for lay people and for experts. We see the differences between men and women in their different thinking about the world and we consider female experts' values to play a significant role in the decision-making process on societal risk policies. Implications for decision making and epidemic situations will be discussed.

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### **THE ROLE OF CONSTRUAL LEVEL THEORY IN RISK COMMUNICATION**

The construal level theory of psychological distance states that individuals construe objects that are farther removed from their direct experience more abstractly, whereas objects that are less psychologically distant are construed more concretely. Psychological distance is egocentric, measured from the self in the here and now and one's construal level changes when any one of the four dimensions of psychological distance (temporal, spatial, social, and hypothetically) are traversed. Of particular importance to risk communication, construal levels, whether abstract or concrete, affect perceptions and preferences towards subsequent objects, messages, or risks. Individuals will both prefer and be more persuaded by information and arguments

that are presented on a congruent construal level. Some risks can be thought of strictly abstract or concrete, but most risks are comprised of a more nuanced set of both abstract and concrete elements, often concrete costs and abstract benefits (i.e., saving for retirement, testing for radon, and climate change mitigation). Humans, by nature, discount costs or benefits that are to be realized at a distance. However, when in a high level construal, individuals put more, not less, weight on abstract costs and benefits compared to individuals in a low level construal. Our current research focuses on using construal level theory to communicate risk and increase the amount of weight message recipients give to its abstract costs and benefits, thus putting greater weight on the long term consequences of their decision. We hypothesize that using lessons learned from construal level theory to compose risk messages will result in greater message comprehension, retention, and, ultimately, greater behavioral change. We present preliminary data in support of this hypothesis and discuss the future direction and implications of our research.

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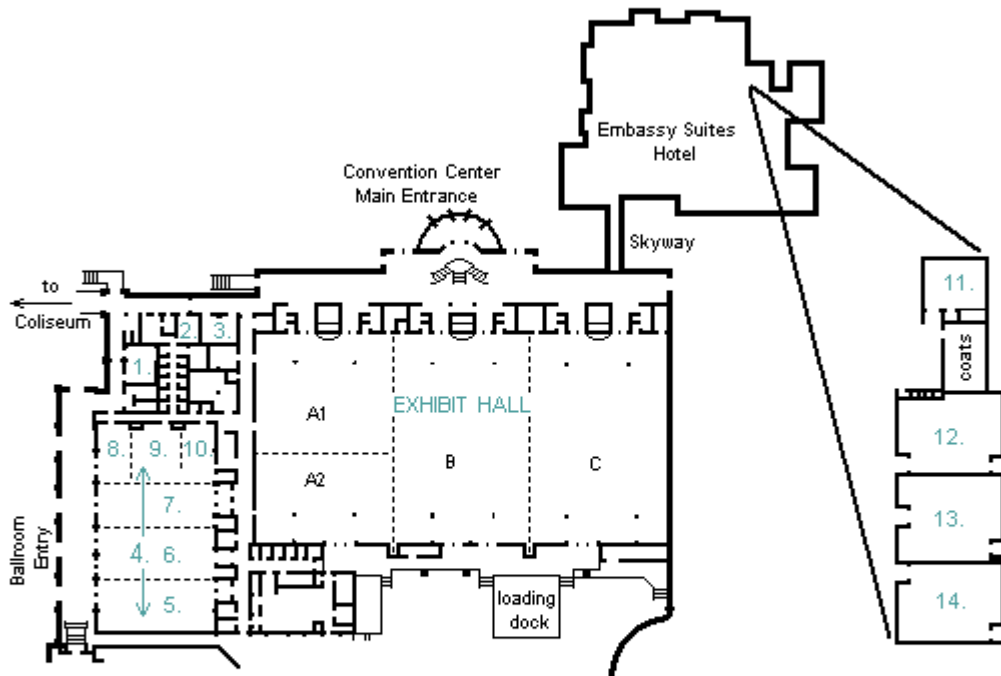
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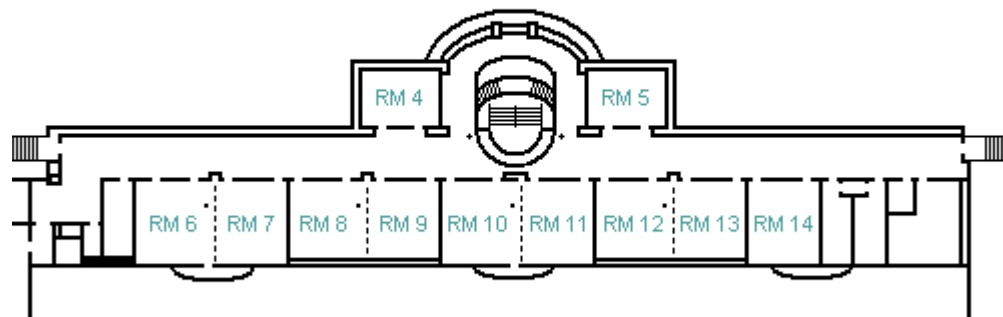
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**Charleston Convention Center  
Main Floor**

<b>Convention Center Floorplan Key</b>	
1.	Room 1
2.	Room 2
3.	Room 3
4.	Ballroom
5.	Ballroom A
6.	Ballroom B
7.	Ballroom C Hall
8.	Ballroom C1
9.	Ballroom C2
10.	Ballroom C3
11.	Executive Board Rm
12.	Ashley
13.	Cooper
14.	Wando



**Charleston Convention Center  
Second Floor**





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