

# Office of Cyber and Infrastructure Analysis

National Protection and Programs Directorate  
Department of Homeland Security

## Trends in Analytical Predictions

*Considering Systems-of-Systems in Planning and Executing Analyses*

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# Office of Cyber and Infrastructure Analysis

## VISION:

- Strengthen the security and resilience of the Nation's Critical Infrastructure through innovative cyber and physical analyses
- Inform the decisions that protect the Nation's Critical Infrastructure

## PRINCIPLES:

- Innovation, collaboration, boldness, excellence

## RISK ANALYTICS AND SERVICES BRANCH ROLE:

- Provide the relational, methodological, technical and data solutions that enable OCIA to be bolder, more innovative, collaborative and excellent



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# The Problem

- Complex systems fail in complex ways.
- Society is not structured to anticipate and address systemic risks.
- Managing infrastructure risk is complex.
  - ✓ Technically—it is difficult to sort out the interdependencies of infrastructure systems, to account for the ability of operators to innovate in an emergency, and to recognize and value cascading effects.
  - ✓ Politically—Federal agencies, State and local emergency responders, regional planning commissions, owners and operators, shareholders, customers. Everyone wants the best, but who will pay for it?



# The Problem (cont.)

- The complexity of the decision-making context leads to complex cost and schedule considerations.
- These issues have been a historic challenge to public and private decision making; considering the complexity and systems effects may help make them more manageable.



# Pre-Katrina Approaches

- 2003–2005 Homeland Security was sorting out the work of the new Department.
  - ✓ *Leadership, integration, coordination, prioritization* of the protection of critical infrastructure was assigned to the Office of Infrastructure Protection.
  - ✓ FEMA was responsible for the Federal Response Plan natural hazards and Weapons of Mass Destruction preparedness, response, and some forms of mitigation.
- Traditional owners/operators and state and local authorities were responsible for taking appropriate actions to manage risk.



# Pre-Katrina Approaches (cont.)

- Anecdotally, an infrastructure failure from a natural hazard would have been considered the owner/operator's concern, the state and local authorities' headache, and a FEMA planning challenge.
- If the same risk was attributed to sabotage, an entirely different group of government agencies would be involved.



# Post-Katrina Changes

- FEMA and IP began making efforts more holistic/all hazards.
  - ✓ Before, there were gaps that led to unmanaged risks.
  - ✓ Now, there are overlaps that lead to confusion over lanes.
- As government resources increased in growing organizations, it was difficult to apply lessons learned.
- Subtle, unaddressed issues percolated:
  - ✓ Different authorities and responsibilities creating alternate views that obscured problems.
  - ✓ Arguments over details preventing consensus over core issues.
  - ✓ Complexity of infrastructure.
  - ✓ Complexity of society and governance.
- Our organization began experimenting with changes to how we manage analytic work, to address these issues.



# 2010–Cascadia Earthquake and Tsunami Risk Baseline

- We offered to do the risk baseline analysis for FEMA Region's 8, 9, and 10
- Our analytic team at the National Infrastructure Simulation and Analysis Center was proficient at interdependency analysis and modeling complex response and recovery issues in post-disaster environments
  - ✓ Built capabilities from work on the New Madrid, Hayward Fault, and other earthquakes
  - ✓ No significant tsunami capabilities





# 2010–Cascadia Earthquake and Tsunami Risk Baseline (cont.)

- The purpose was to help decision-makers, planners, and first responders plan for and respond to a major earthquake in the Cascadia region off the coast of Oregon and Washington, analyzing the possible direct and cascading impacts from a large earthquake and ensuing tsunami on population and infrastructure.



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# Addressing Complexity Head On

Systems-of-Systems thinking in the research and analysis planning process:

- High level view:
  - ✓ Who would explain the event and help the U.S. manage it?
  - ✓ What would they likely say?
- Asked the 50–60 state and local authorities to help identify experts in earthquake and tsunami.
- Study team of 120+, including our own modeling team, academic and federal experts
  - ✓ Expected outcome was a useful risk baseline that planners could work from
  - ✓ Desired outcome was that a second line of experts would be there, know the plan and how to interpret it in case the first line was lost in the earthquake and tsunami.



# Results of the Work

- In 2011, we delivered a draft and then final product to the planners, thanked the team, and moved on to other work.  
<https://www.bluestonehockley.com/wp-content/uploads/2016/01/FEMA-earthquake-study.pdf>
- While the 120 or so researchers were asked to help interpret and apply their past work on questions of Cascadia subduction zone earthquake and tsunami for this specific purpose, they recognized:
  - ✓ Working together allowed them to all endorse a common analysis that reflected generally the findings of their research.
  - ✓ They observed how much easier it was for police, firefighters, infrastructure owners, and operators, etc., to make decisions and plans when the researchers provided a consistent message.



# Unexpected Outcomes of the Work

- In 2015, we were surprised to begin seeing news reports of proactive public actions to mitigate risk:
  - ✓ Oregon coastal schools, hospitals, and fire stations were publically identified as at-risk for tsunamis. Resources requested to begin moving them to safer locations.  
<http://www.npr.org/2015/02/26/389321604/many-of-oregons-coastal-schools-hospitals-and-fire-stations-at-tsunami-risk>
  - ✓ *The New Yorker* printed an article titled “The Really Big One,” talking about the earthquake and public and private efforts to prepare for and mitigate risks.  
<http://www.newyorker.com/magazine/2015/07/20/the-really-big-one>



# Unexpected Outcomes (cont.)

- ✓ *BBC* production of *MegaQuake*, documents efforts to prepare for this event in the Pacific Northwest  
<https://www.youtube.com/watch?v=zAjeke66q-k>
- ✓ *Weather Channel*, and *Seattle Times* all reported on the earthquake risks, related analyses, and efforts people are taking to prepare for it.
  - *Seattle Times* noted that emergency preparedness kits were “flying off the shelves.”  
<http://www.seattletimes.com/seattle-news/ready-or-not-earthquake-kits-flying-off-the-shelves/>



# 2011–Poe Lock Closure Study

- We were asked to analyze the potential impacts of the closure of the Poe Lock, one of the Soo Locks that allows vessel movement between Lakes Huron and Superior
- Initial 2 rounds of analysis were each doomed by erroneous assumptions
  - ✓ First error: unfounded belief that we could transport iron ore by rail to replace the Soo Locks shipments
  - ✓ Second error: Unfounded belief that all steel is interchangeable
- The project manager recognized the errors and became the lead analyst. He redid the work over 4 weeks of vacation, writing in the evenings and on weekends for another 6 weeks.



# Poe Lock Closure Study (cont.)

- With a coherent analytic draft with good assumptions, a broad and aggressive engagement with stakeholders/experts in industry began:
  - ✓ They recognized why this was important and identified more experts.
  - ✓ They realized that this was too complex a societal and infrastructure problem to fix without their participating and sharing information.
  - ✓ They explained subtle constraints that limited them from managing the loss of the key transportation node.
  - ✓ They understood that key North American industries were at risk for failure and a major economic down turn was possible.
  - ✓ After four years, the product “The Perils of Efficiency – An Analysis of the Unexpected Closure of the Poe Lock and Its Impact” was released



# Poe Lock Closure Study (cont.)

- Congressional Handout that preceded the publication  
<http://www.csgmidwest.org/GLLC/documents/DHSSooLocksCongressionalHandout.pdf>
- Detroit Free Press article about the study  
<http://www.freep.com/story/news/politics/2016/03/03/us-michigan-face-dire-consequences-if-soo-locks-fail/81261608/>





# Applying Lessons

- The complexity of government, public-private partnerships, and collaboration between researchers and decision makers seems difficult to overcome
- Scientists and experts working together can create clarity and make the case for action
  - ✓ Individually they are sometimes unaware.
  - ✓ At best, they may be “singing solos” that were individually defensible, but together, “singing in chorus,” gave them advantages.
  - ✓ Decision-makers don’t have time to sort out why past research does not “agree”. Assumptions, data, scenarios are too weedy.
  - ✓ Preparing a message that is consistent, that they all endorse, captures the attention of decision makers. Suddenly, science is more “settled.”



# Applying Lessons

- Our team looks back on the reverberating action from and attention for these studies as some of our greatest successes.
- We are beginning to see a pattern for extremely complex, system-of-systems problems benefiting from studies with broader scope, fewer assumptions, and iterative validation and clarification with experts.
- In some ways this may be the a systemic opportunity, i.e., the opposite of a systemic risk.
  - ✓ Accepting the project risk and social aspects of the extremely complex project had unanticipated amplifying benefits.
  - ✓ Our organization is focused on societal risks from incidents and conditions that affect infrastructure. We can be a key collaborator.



# Questions?



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For more information visit:  
[www.dhs.gov/office-cyber-infrastructure-analysis](http://www.dhs.gov/office-cyber-infrastructure-analysis)

Susan Stevens

Chief, Risk Analytics and Services

Office of Cyber and Infrastructure Analysis

[susan.stevens@hq.dhs.gov](mailto:susan.stevens@hq.dhs.gov)



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