Infrastructure Consequence Analysis of Destructive Events

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Sandia National Laboratories
exceptional service in the national interest.
Sandia’s Technical Diversity

Based in Albuquerque, New Mexico, Sandia National Laboratories’ expertise in modeling derives from our mission to support the Department of Energy’s National Nuclear Security Complex.
NISAC History & Mission

- Patriot Act identified NISAC as the center for Critical Infrastructure Interdependency Modeling, Simulation, and Analysis.

- Provide a common, comprehensive view of U.S. infrastructure and its response to disruptions.

- Operationally-tested DHS rapid-response capability.
  - 24/7 crisis action analysis
  - Jointly executed by Sandia and Los Alamos National Laboratories
Consequence Analysis

- A meteor impact in or near a major urban area would have significant impact on the residents and infrastructure in the surrounding region
- Here we present infrastructure analysis techniques as applied to a different but analogous scenario: a major earthquake
• The Cascadia Subduction Zone extends north and south more than 800 miles on the eastern edge of the Pacific Plate
• The Tohuku event off the coast of Japan resulted from an earthquake on the subduction zone on the western edge of the Pacific Plate
• In 1700 the Pacific Northwest experienced an earthquake and tsunami that rivals the recent incident off of the coast of Japan
• A catastrophic earthquake of this magnitude along the coast of Oregon and Washington is estimated to occur every 500 years and would impact the US from Northern California to Alaska
• In 2011, NISAC performed a study of the potential impacts of such an event on population, infrastructure, and the economy on behalf of DHS
Overview of the Analytic Approach

- A US Geological Survey 9.0 Magnitude ShakeMap (2009) was used to drive the earthquake impacts
- The NOAA Pacifex 11 Tsunami exercise run were employed to provide a basis for the offshore wave heights
- Both the direct earthquake impacts and the surge zones were used to assess the impacts:
  - Impacts on population
  - Direct impacts on infrastructure
  - Cascading impacts on infrastructure
  - Economic effects
The Earthquake Scenario

- **ShakeMap** is a USGS rapid response tool to portray the extent, intensity, and variation of ground shaking in an affected region.
- Scenario affects Oregon, Washington, Northern California, and British Columbia.
- Resulting tsunami affects the entire Pacific shoreline, including Alaska.
- Assume single major tremor 9.0M
  - No significant aftershocks
  - No additional earthquakes triggered along secondary faults.
Results: Impacts on Population

- **Ground Shaking Population Impacts**

<table>
<thead>
<tr>
<th>State</th>
<th>Fatalities</th>
<th>Injuries</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>751</td>
<td>774</td>
<td>primarily in Crescent City</td>
</tr>
<tr>
<td>OR</td>
<td>52</td>
<td>190</td>
<td>most in Cannon Beach</td>
</tr>
<tr>
<td>WA</td>
<td>540</td>
<td>1,151</td>
<td>most in Westport</td>
</tr>
</tbody>
</table>

- **Tsunami Population Impacts (for modeled sites only)**

<table>
<thead>
<tr>
<th>State</th>
<th>Fatalities</th>
<th>Injuries</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>47</td>
<td>1,045</td>
<td>Coos County hardest hit in OR</td>
</tr>
<tr>
<td>OR</td>
<td>674</td>
<td>14,109</td>
<td>Coos County hardest hit in OR</td>
</tr>
<tr>
<td>WA</td>
<td>411</td>
<td>9,508</td>
<td>King County hardest hit overall</td>
</tr>
</tbody>
</table>
Results: Tsunami Damage

- Damage state described via
  - Building Stability map
  - Flood inundation map

- Building Stability
  - 5 zones described: Poorly Constructed, Well Built Timber, Well Built Masonry, Concrete, Large Concrete

- Max inundation depth
- Deaths and injuries
Electrical Power

- Electric power asset damage can create outages in the power grid
- On average the electric system loses 6 GW of generating capacity and 11 GW of demand (out of 170 GW)
- Seattle, Tacoma, Portland, Vancouver Island and all other cities within 100 miles of the Pacific coastline will experience blackout
- Services restored in 1-7+ days

<table>
<thead>
<tr>
<th>Damage State</th>
<th>Electric Generation</th>
<th>Substations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Damage</td>
<td>Lost gigawatts</td>
</tr>
<tr>
<td>None/Slight/Outaged</td>
<td>38</td>
<td>2.5</td>
</tr>
<tr>
<td>Moderate</td>
<td>106</td>
<td>2.7</td>
</tr>
<tr>
<td>Extensive</td>
<td>12</td>
<td>0.3</td>
</tr>
<tr>
<td>Complete</td>
<td>3</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Natural Gas

- May impact backbone transmission line serving western WA and OR
- Only about 1/3 of households heat with natural gas (NG) in WA and OR
- Most homes use electricity for heating
- NG is used for power generation in the area, but most power generation in the region is hydroelectric
- NG issues unlikely to cause any power generation shortages for the grid
Ports & Maritime Infrastructure

- Major port facilities slight damage
- Tsunami closes navigation from Columbia to Pacific
  - Sedimentation
  - Channel Debris
  - Loss of navigation aides
  - Major path for export grains

Locations of navigation infrastructure at the mouth of the Columbia River.
No expected tsunami impacts
No facilities are expected to receive complete or extensive damage
3 facilities expected to receive moderate damage, including Rohm and Haas in Elma, WA, potential national supply chain impacts
- Only domestic producer of potassium borohydride
- One of two domestic producers of sodium borohydride
50 facilities expected to receive slight damage with no national or regional supply chain impacts
## Restoration of Key Infrastructure Sectors

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>Activity</th>
</tr>
</thead>
</table>
| **Immediate Aftermath** | **Search and rescue in damage zone, focused on damaged facilities with susceptible populations (e.g., hospitals, nursing homes)**  
|                 | Transport of emergency response surge capacity through major airports (SeaTac, Portland International) as staging areas for reaching more affected zones (by open roads, helicopter, seaplane), including fire suppression equipment to replace that destroyed by structural failure  
|                 | Identification and clearance of paths from areas with functional public health and infrastructure to damage zone  
|                 | Evacuation of injured from damage zone to working medical facilities  
|                 | Movement (to outpatient facilities) or discharge of ambulatory patients at hospitals in areas with functional public health facilities and infrastructure to clear bed space and shorten transportation times  
|                 | Repair of transportation routes (truck, rail) to minimally damaged port facilities near damage zone  
|                 | Coordination of truck and rail transport of POL (especially diesel fuel for emergency services vehicles and backup generators) from functional terminals/refineries to damage area and its perimeter  
| **Second Stage** | Identification of shelter/housing for key transportation workers and housing/evacuation for their families, to support operational flow of port facilities supporting recovery effort  
|                 | Evacuation of those lacking structurally sound housing or infrastructure resources from the damage area, especially those lacking means of home heating  
|                 | Repair of POL pipeline and terminal facilities to restore flows beyond the damage area. Rerouting of refined product from other western refineries as capacity allows by rail to undamaged areas  
| **Long-term**   | Community-centric restoration of infrastructure:  
|                 | • Basic Infrastructure (water, power, fuels, commodity supplies)  
|                 | • Public Services (fire, police, schools)  

### Restoration of Key Infrastructure Sectors

- **Immediate Aftermath**
  - Search and rescue in damage zone, focused on damaged facilities with susceptible populations (e.g., hospitals, nursing homes)
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- **Long-term**
  - Community-centric restoration of infrastructure:
    - Basic Infrastructure (water, power, fuels, commodity supplies)
    - Public Services (fire, police, schools)
Economic Impacts

- Total impact of $49 Billion
  - CA: $1 Billion
  - OR: $19 Billion
  - WA: $29 Billion
- Sectors with greatest economic impact:
  - Telecommunications
  - Waterborne Transportation
  - Transportation Fuels
  - Electric Power is a strong driver of impacts in other sectors
Coupling NISAC Expertise for NEO Impact Analysis
16 Critical Infrastructure Sectors

1. Energy
2. Communications
3. Chemical
4. Dams
5. Defense Industrial Base
6. Emergency Services
7. Food and Agriculture
8. Transportation Systems
9. Water and Wastewater Systems
10. Commercial Facilities
11. Financial Services
12. Critical Manufacturing
13. Government Facilities
15. Information Technology
16. Nuclear Reactors, Materials, and Waste
Sandia Community Works Together to Solve Non-Traditional Problem Sets

- **National Infrastructure Simulation & Analysis Center** – in support of Department of Homeland Security
  - Simulation/Modeling and Analysis of critical infrastructure
  - Assists decision makers with infrastructure protection, mitigation and response

- **Mark Boslough Physicist in Discrete Math and Complex Systems**
  - Using nuclear weapons airburst data and scaling laws
  - Model collisional airburst and compare to nuclear airbursts

- **Model of Area impacted by Asteroid**
  - Calculating risk to infrastructure due to impact
With Advanced Warning
Damage Could be Immense

- **Impact:** Crater diameter 2.1 km (1.31 miles)
- **Impact Depth:** 595 meters (1470 feet)
- **Seismic effects:** 5.9 Richter magnitude scale
- **The most extreme damage from an airburst occurs at 42000 ft**
- **If the impact is offshore can expect tsunamis of 40 feet locally and 10 feet over hundreds of miles of coastline**

Worst-case land impact (200-Mt crater-forming)

Richter Scale Magnitude: 5.9

- Wood frame buildings will almost completely collapse, 90% of trees blown down
- Multistory wall-bearing buildings will collapse, highway truss bridges will collapse.
- Glass windows will shatter
- 1” rocks will rain down

Yellow = 1 psi (35 mi radius)
Orange = 4 psi (13 mi radius)
Red = 15 psi (6 mi radius)
Dashed = 1” ejecta (50 mi radius)
Worst-case airburst (200-Mt optimal burst height)

- Multistory wall-bearing buildings will collapse, highway truss bridges will collapse.
- Wood frame buildings will almost completely collapse, 90% of trees blown down.
- Yellow = 1 psi (100 mi radius)
- Orange = 4 psi (38 mi radius)
- Red = 15 psi (7.5 mi radius)
- Glass windows will shatter.
Zone of potential total destruction (crater and/or firestorm)

- Glass windows will shatter
- Multistory wall-bearing buildings will collapse, highway truss bridges will collapse.
- 1” rocks will rain down
- Yellow = 1 psi (100 mi west, 35 mi east)
- Red = 15 psi (7.5 mi west, 6 mi east)
- Dashed = 1” ejecta (50 mi west & east)
FASTMap Situational Awareness
Internet Infrastructure
## FASTMap Reporting Capability

### Statistics Report

**Table of Contents**
- Internet Exchanges
- Colocation Facilities
- Central Offices
- Cable Landings
- Data Sources

### Internet Exchanges

#### Summary of Internet Exchanges

<table>
<thead>
<tr>
<th>Internet Exchanges</th>
<th>Total (Exchanges)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 PSI (13 mile radius) Damage Zone</td>
<td>4</td>
</tr>
<tr>
<td>1 PSI (35 mile radius) Damage Zone</td>
<td>4</td>
</tr>
<tr>
<td>All Zones</td>
<td>8</td>
</tr>
</tbody>
</table>

#### Internet Exchanges List

**Damage Zone: 4 PSI (13 mile radius)**

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>City</th>
<th>State</th>
<th>Lat</th>
<th>Lon</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE East</td>
<td>1945 Gallows Rd</td>
<td>Vienna</td>
<td>VA</td>
<td>38.909308</td>
<td>-77.223076</td>
<td><a href="http://www.mae.net/fac/mae-east.htm">http://www.mae.net/fac/mae-east.htm</a></td>
</tr>
<tr>
<td>MAE East</td>
<td>8100 Boone Blvd</td>
<td>Vienna</td>
<td>VA</td>
<td>38.913223</td>
<td>-77.225877</td>
<td><a href="http://www.mae.net/fac/mae-east.htm">http://www.mae.net/fac/mae-east.htm</a></td>
</tr>
<tr>
<td>Switch and Data/PAIX</td>
<td>8100 Boone Blvd</td>
<td>Vienna</td>
<td>VA</td>
<td>38.913223</td>
<td>-77.225877</td>
<td><a href="http://www.switchanddata.com">http://www.switchanddata.com</a></td>
</tr>
</tbody>
</table>
Chemical Facility Infrastructure
Topographical View Dams
What are the Expected Effects of the Impact

FastMAP
Contact Information

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