Natural-hazard impacts on hazardous industry and critical infrastructure

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Unit Technology Innovation in Security
Natural hazard triggered technological accident

Flood
Earthquake
Lightning
Landslide
Wind
Tsunami
Etc.

Fire
Toxic Release
Environmental contamination
Explosion
JRC activities

Accident analysis and guidance
- Lessons learning and recommendations
- Natech accident database: eNatech
  http://enatech.jrc.ec.europa.eu

Risk analysis/mapping tools
- Framework for Natech risk assessment and mapping: RAPID-N
  http://rapidn.jrc.ec.europa.eu

Capacity building and exercising
- Training on RAPID-N
- Emergency response exercise support

Stakeholders
- DG ECHO, HOME, ENER, CLIMA etc.
- EU MS, CC and neighbour countries
- Third countries
- OECD
- UNISDR
- UN Environment
- WHO, IFRC
The Sendai FW for Disaster Risk Reduction

- Move from disaster management to disaster risk management
- All-hazards and multi-stakeholder approach
- 7 Global Targets
- 4 Priorities for Action
  1. Understanding disaster risk
  2. Strengthening disaster risk governance to manage disaster risk
  3. Investing in disaster risk reduction for resilience
  4. Enhancing disaster preparedness for effective response and to “build back better” in recovery, rehabilitation and reconstruction
Root causes and disaster risk data

- **Accident/forensic analysis** → **Lessons learning**
  Understand root and immediate causes of accident, accident dynamics and consequences, contributing/aggravating factors; identify accident patterns and trends; build back better

- **Lack of data** is one bottleneck in Natech risk reduction

**What is needed?**

- Promotion of data sharing (no blame, data can be anonymized)
- Collection of data in adequate and structured way (e.g. Natech accident database: eNATECH http://enatech.jrc.ec.europa.eu)
- Separate reporting criteria from consequence severity to capture low-impact accidents and near misses → important for learning what worked
- Public-private partnerships to link science, practice and policy
The quality of information in industrial accident databases is not uniform and exhibits different levels of detail and accuracy. The level of detail is particularly non-uniform for Natech accidents.
<table>
<thead>
<tr>
<th>No</th>
<th>Date</th>
<th>Country</th>
<th>Natural Hazard</th>
<th>Site</th>
<th>Natech ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1923</td>
<td>Japan</td>
<td>Tokyo Earthquake</td>
<td>Yokosuka Naval Base</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>1963/08/30</td>
<td>United Kingdom</td>
<td>High wind</td>
<td>Murco Milford Haven Refinery</td>
<td>37</td>
</tr>
<tr>
<td>3</td>
<td>1989/09/18</td>
<td>United States</td>
<td>Hurricane Hugo</td>
<td>Virgin Islands Water and Power Authority</td>
<td>54</td>
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<tr>
<td>4</td>
<td>1989/09/20</td>
<td>United States</td>
<td>Hurricane Hugo</td>
<td>Amerada Hess Oil Co.</td>
<td>55</td>
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<tr>
<td>5</td>
<td>1994/01/17</td>
<td>United States</td>
<td>Northridge Earthquake</td>
<td>ARCO-Four Corners Pipeline</td>
<td>44</td>
</tr>
<tr>
<td>6</td>
<td>1994/02/22</td>
<td>South Africa</td>
<td>Merriespruit rain</td>
<td>Harmony Gold Mine</td>
<td>56</td>
</tr>
<tr>
<td>7</td>
<td>1998/02/27</td>
<td>Ecuador</td>
<td>Landslide</td>
<td>Trans-Ecuadorian Oil Pipeline</td>
<td>38</td>
</tr>
<tr>
<td>8</td>
<td>1998/04/25</td>
<td>Spain</td>
<td>Dofná Disaster/The Los Frailes tailings dam failure/Aznalcollar Disaster/Guadamar Disaster</td>
<td>Los Frailes mine</td>
<td>27</td>
</tr>
<tr>
<td>9</td>
<td>1998/09/26</td>
<td>United States</td>
<td>Hurricane Georges</td>
<td>Chevron Pascagoula Refinery</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>1999/08/17</td>
<td>Turkey</td>
<td>Kocaeli Earthquake</td>
<td>TUPRAS Izmit Refinery</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>1999/08/17</td>
<td>Turkey</td>
<td>Kocaeli Earthquake</td>
<td>AKSA Acrylic Fiber Production Plant</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>2000/01/30</td>
<td>Romania</td>
<td>Heavy rainfall</td>
<td>Aurul Mine</td>
<td>28</td>
</tr>
<tr>
<td>13</td>
<td>2000/01/30</td>
<td>Romania</td>
<td>Bia Mare Rainfall</td>
<td>Aurul</td>
<td>53</td>
</tr>
<tr>
<td>14</td>
<td>2002/08/15</td>
<td>Czech Republic</td>
<td>Elbe Flood</td>
<td>Spolana Chemical Plant</td>
<td>6</td>
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<tr>
<td>15</td>
<td>2002/11/25</td>
<td>Morocco</td>
<td>Heavy rainfall</td>
<td>Samir Mohammedia Refinery</td>
<td>41</td>
</tr>
<tr>
<td>16</td>
<td>2002/12/17</td>
<td>France</td>
<td>Low temperature</td>
<td>Solvay Chalampe</td>
<td>25</td>
</tr>
<tr>
<td>17</td>
<td>2003/09/26</td>
<td>Japan</td>
<td>Tokachi-oki earthquake</td>
<td>Hokkaido Refinery</td>
<td>51</td>
</tr>
</tbody>
</table>
- Natural hazard
  - Type and date
  - Location
  - Occurrence
    - Triggering hazard, parameters
    - Consequences
- Industrial site
  - Type and industrial activity
  - Location
  - Site description
  - Operator
- Attachments
  - Documents
  - Reference materials
- Lessons learned
  - Equipment, human, organizational, mitigation measures, emergency response
- Emergency response
  - Response planning
  - Response to natural hazard
  - Response to Natech event
    - Insufficient personnel and equipment to respond to both emergencies: Please select

**Contributing Factors**

1. Event sequence: Event Sequence 1 [ES1 (Collapse of LPG storage tank)]
   - Factor: Testing / inspecting / recording
   - Description: It is good practice during LPG tank inspections to leave the water for not more than 2-3 days in the tank. At the time of the earthquake the tank that collapsed had been filled with water for 12 days.

2. Event sequence: Event Sequence 2 [ES2 (Fire and explosions)]
   - Factor: Emergency shut off / safety valves
   - Description: Due to the fires initiating the fires fighting teams were released sources were exhausted.

3. Event sequence: Event Sequence 2 [ES2 (Fire and explosions)]
   - Factor: Failure to carry out duties
   - Description: Prior to the earthquake an emergency valve on the LPG pipes had been manually locked "open" to prevent it from acting due to minor air leakages during repair work. Once LPG started to be released from the damaged pipe and the fire ignited, the valve could not be reached and...
Natech risk assessment

- Risk assessment is needed to **identify safety gaps and priorities** for risk reduction
- Big **gap in availability of methodologies** and tools (multi-hazard!)
- **Natech specifics**: Multiple and simultaneous releases; increased domino risk; loss of safety barriers and lifelines; hampering of response operations

**What is needed?**
- Methodologies and tools for Natech risk assessment (e.g. RAPID-N [http://rapidn.jrc.ec.europa.eu](http://rapidn.jrc.ec.europa.eu))
- Guidance for industry and authorities on Natech risk assessment and management
- Standardize (but don’t harmonize!) the risk-assessment process
RAPID-N

RAPID-N: Rapid Ntech Risk Assessment Tool

Risk Assessments | Fragility Curves | Damage Classifications | Risk States | Hazards | Hazard Maps | On-site Hazard Data | Natechs | Ntech Damages | Industrial Plants

Operators | Plant Units | Typical Plant Units | Substances | Property Estimators | Properties | References | Regions | Units

About RAPID-N

Natural-hazard triggered technological accidents (Natechs) involving the releases of hazardous substances, fires, and explosions at critical chemical infrastructures have been recognized as an emerging risk. Natech risks are expected to increase in the future due to the growing number of critical infrastructures, more natural hazards due to climate change, and the vulnerability of the society which is becoming more and more interconnected.

Read More

Resources

RAPID-N User’s Manual (Girgin, 2011)

This document aims to provide basic information about the implementation and usage of the RAPID-N. Following a short description of the technical details and components of the application, the user interface is described. Record types and tools that form the application are grouped into modules and detailed information is given for each record type in a separate subsection. Details of related calculation methods and algorithms are also provided. A short risk assessment tutorial is available at the end of the manual.

Users from >120 institutions globally

Government, industry, academia, practitioners

http://rapidn.jrc.ec.europa.eu
Modular Architecture

Scientific

- Update Property Estimator
  - Property: Peak Ground Acceleration
  - Type: Function
  - Function: \[ f(\text{PGA}) = 55 \times 0.09^\text{PGA} \]
  - Unit: cm/s²

- Conditions
  1. Property: Moment Magnitude
  2. Property: Epicentral Distance
  3. Property: Faulting Mechanism

- Regions
  1. Greece, Flinn-Engdahl Region
  2. Southern Greece, Flinn-Engdahl Region
  3. Dodecanese Islands, Greece, Flinn-Engdahl Region
  4. Crete, Greece, Flinn-Engdahl Region

- References

Notes

Plants

- Facility: Anatolu Tarfiyehanesi AŞ - Mersin
- Type: Storage Tank
- Coordinate: 36° 48′ 59.76″ N, 34° 41′ 53.976″ E

- Properties
  - Storage Condition: Atmospheric
  - Shape: Cylindrical Vertical
  - Roof Type: Floating Roof
  - Construction Material: Steel
  - Volume: 22284 m³
  - Height: 14.611 m
  - Diameter: 45 m
  - HVD Ratio: 0.3114 m/s
  - Fill Level: 85 %

- Substances
  1. Naphtha (CAS: 8035-30-6)

Hazards

- Hazard Information
  - Hazard: Kocaeli Earthquake, 1999/08/17
  - Hazard Map: ShakeMap (XML, Gzipppd), 2011

- Facility Information
  - Facility: Power Plant, Turkey

Damage Estimation

- Damage Classification: Auto
- Flexible fragility curve selection: Yes

Assessment

- Name: Kocaeli Earthquake Single Plant
- Data: 2012/08/28 13:11:13
- Type: Private

- Facilities
  1. Kocaeli Earthquake Single Plant, Turkey
Methodology

Natural Hazard
- Hazard Map
  - Probabilistic
  - Deterministic
- Manual Input
- Hazard Parameter Estimation Methods

Damage
- Site Data
- Natural Hazard Parameters
- Process Unit Data
- Damage Probability
- Fragility Curves
- Historical Data
  - Hazard Parameters
  - Damage states
  - Consequences

Consequence
- Risk States
- Consequence Analysis
- Natech Risk
- Risk Receptor Data
  - Land-use
  - Population
Damage Assessment

Damage:
- Process Unit Data
- Damage Probability

Fragility Curves:
- Historical Data
  - Hazard Parameters
  - Damage states
  - Consequences

Fragility Curve Information:
- Name: HAZUS, On-ground anchored steel tank
- Process Unit Type: Storage Tank
- Damage Classification: HAZUS (Water Storage Tanks)
- Hazard Parameter: Peak ground acceleration (PGA)
- Unit: %g
- Type: Pre-defined
- Functional Form: Log-normal (median)

Conditions:
- Base Type: On-ground
- Base Support Type: Anchored
- Construction Material: Steel

Data:

<table>
<thead>
<tr>
<th>No</th>
<th>Damage State</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>≥ DS2</td>
<td>0.3</td>
</tr>
<tr>
<td>2.</td>
<td>≥ DS3</td>
<td>0.7</td>
</tr>
<tr>
<td>3.</td>
<td>≥ DS4</td>
<td>1.25</td>
</tr>
<tr>
<td>4.</td>
<td>= DS5</td>
<td>1.6</td>
</tr>
</tbody>
</table>

References:

Fragility Curve
Risk Assessment

Consequence

- Risk States
- Consequence Analysis
- Natech Risk

Risk Receptor Data
- Land-use
- Population

Risk Assessment Information

Name: Kocaeli Earthquake Single Plant
Date: 2012/08/28 18:11:13
Type: Private

Hazard Information
- Hazard: Kocaeli Earthquake, 1999/08/17
- Hazard Map: ShakeMap (XML, Gzipped), 2008/11/09 03:19:14

Facility Information
- Facility: 🌍 Power Plant, Turkey

Damage Estimation
- Damage Classification: Auto
- Flexible fragility curve selection: Yes

Facilities

1. 🌍 Power Plant, Turkey

<table>
<thead>
<tr>
<th>No</th>
<th>Process Unit</th>
<th>Hazard Parameters</th>
<th>Fragility Curve</th>
<th>Damage Estimate</th>
<th>Damage Parameters</th>
<th>End-point Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Storage Tank (T-STR)</td>
<td>PGA: 18.277 %; EMS: Slightly damaging; MM: Strong; MK: Strong; MI: 6.0566; dL: 101.38 km; dR: 101.79 km; PGAmax: 74.415 cm/s; POV: 15.573 cm/s</td>
<td>OG60-F50-G</td>
<td>DS2: 4.0546%</td>
<td>Fire/Explosion Event: Vapor Cloud Explosion; Qinvolved: 4250 kg; fmin, past: 1; Pr: 100%; N: 3; V: 5.7432 m/s; P: 30% t: 0.13; RMP Scenario: Worst-case; T: 10 min; Release: 425 kg/min; Qmax: 4250 kg; Amax: 6146.1 kF; Vinvolved: 1; V: 425 kg/m; t: 0.4; qa: 5000 W/m²; t: 40 s; D: 342 TDU; dL: 270.38 m; dR: 4250 kg; P: 4.0546%; Prelease: 4.0546%</td>
<td>271 m: 4.0546%</td>
</tr>
<tr>
<td>2</td>
<td>Storage Tank (T-STR)</td>
<td>PGA: 18.277 %; EMS: Slightly damaging; MM: Strong; MK: Strong; MI: 6.0566; dL: 101.38 km; dR: 101.79 km; PGAmax: 74.415 cm/s; POV: 15.573 cm/s</td>
<td>OG60-F50-G</td>
<td>DS3: 0.004631%</td>
<td>Fire/Explosion Event: Vapor Cloud Explosion; Qinvolved: 8500 kg</td>
<td>341 m: 0.004631%</td>
</tr>
<tr>
<td>3</td>
<td>Storage Tank (T-STR)</td>
<td>PGA: 18.277 %; EMS: Slightly damaging; MM: Strong; MK: Strong; MI: 6.0566; dL: 101.38 km; dR: 101.79 km;PGAmax: 74.415 cm/s; POV: 15.573 cm/s</td>
<td>OG60-F50-G</td>
<td>DS4: Very low</td>
<td>Fire/Explosion Event: Vapor Cloud Explosion; Qinvolved: 4250 kg</td>
<td>-</td>
</tr>
</tbody>
</table>

Risk States

- Land-use
- Population
Scientific Tools Module

- Fuzzy arithmetic
- Automated unit conversion
- Statistics and curve-fitting
- Mapping
  - Google Maps
  - GIS analysis
- Reference management

Data Estimation Framework

- Minimize data requirements
- Increase flexibility
  - No hard-coded functions
## Data Estimation Framework

### Building Blocks

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Condition</td>
<td>Atmospheric</td>
</tr>
<tr>
<td>Shape</td>
<td>Cylindrical Vertical</td>
</tr>
<tr>
<td>Roof Type</td>
<td>Floating Roof</td>
</tr>
<tr>
<td>Construction Material</td>
<td>Steel</td>
</tr>
<tr>
<td>Volume</td>
<td>22285 m³*</td>
</tr>
<tr>
<td>Height</td>
<td>14.00 m*</td>
</tr>
<tr>
<td>Diameter</td>
<td>147.64 ft (45.00 m)</td>
</tr>
<tr>
<td>H/D Ratio</td>
<td>0.3114 m/m*</td>
</tr>
<tr>
<td>Fill Level</td>
<td>85 %v*</td>
</tr>
</tbody>
</table>

### Tool Kit

### Model
RAPID-N: Status and Application

- Global coverage
- Currently implemented for earthquakes and fixed installations and pipelines (floods: prototype)
- ~ 22,000 earthquakes (> M 5.5)
- ~ 13,000 shakemaps
- > 5,500 industrial facilities
  - Refineries
  - Power plants
- > 64,500 plant units
  - Storage tanks
- Complete implementation of U.S. EPA RMP Offsite Consequence Analysis methodology

**Application areas:**
- Land-use planning
- Emergency planning
- Preliminary Natech damage estimation
- Early warning
Cascading effect
JRC Alerting and Assessment Systems

- **Operational** natural hazard (early) alerting system
- **Operational** Natech risk assessment system
- Technical **means of data exchange**
Stage-wise approach (GDACS)

Stage 1
Identification of the hazardous installations located in various hazard zones

Stage 2
Estimation of physical or functional damage for process and storage equipment located in the affected installations

Stage 3
Assessment of accident scenarios based on the damage estimates and analysis of the hazardous consequences

Natural Hazard System
**Example: Exposure Analysis for GDACS (Stage 1)**

### Earthquake Event
- **Magnitude:** 7.3 M
- **Depth:** 29.6 km (intermediate)
- **Area affected by light damage (estimated radius):** 100 km (3396.19 ft)
- **Time:** 12 Nov 2017 18:16:17
- **Informing capacity:** 6.8 (24076)

### Event Timeline
For accessing reports of previous events, please click on the advisory number in the table below.

<table>
<thead>
<tr>
<th>Event</th>
<th>Date of Event</th>
<th>Date of Impact</th>
<th>Delay (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12 Nov 2017</td>
<td>18:16:17</td>
<td>00:20</td>
</tr>
<tr>
<td>2</td>
<td>12 Nov 2017</td>
<td>18:16:17</td>
<td>01:13</td>
</tr>
</tbody>
</table>

### Modified Mercalli Intensity Scale

### Earthquake Impact Details
- The earthquake happened on Friday at 6.34 pm (total population 224,246).

### Population
- **Preparation in major intensity:** 15,7 million people
- **Property damage:** 15,7 million people

### Affected Provinces
- **Kermanshah:** 15,7 million people
- **Khorasan:** 15,7 million people
- **East Azerbaijan:** 15,7 million people
- **West Azerbaijan:** 15,7 million people
- **Kurdistan:** 15,7 million people

### Affected Cities (Total 1000 apartments)
- **Kermanshah:** 1500 apartments
- **Khorasan:** 1500 apartments
- **East Azerbaijan:** 1500 apartments
- **West Azerbaijan:** 1500 apartments
- **Kurdistan:** 1500 apartments

### Industry

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Industry Type</th>
<th># Establishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>VII</td>
<td>Petrochemical / Oil Refineries</td>
<td>1</td>
</tr>
<tr>
<td>VII</td>
<td>LPG Storage</td>
<td>2</td>
</tr>
<tr>
<td>VI</td>
<td>Processing of metals</td>
<td>5</td>
</tr>
<tr>
<td>V</td>
<td>Power generation, supply and distribution</td>
<td>2</td>
</tr>
</tbody>
</table>

### Nearby and Affected Industrial Establishments

<table>
<thead>
<tr>
<th>Name</th>
<th>Region Province</th>
<th>Country</th>
<th>Industry Type</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility A</td>
<td>Kermanshah</td>
<td>Iran</td>
<td>Petrochemical / Oil Refineries</td>
<td>22 km</td>
</tr>
<tr>
<td>Facility B</td>
<td>Diyala</td>
<td>Iraq</td>
<td>Plastic manufacture</td>
<td>45 km</td>
</tr>
<tr>
<td>Facility C</td>
<td>Kordestan</td>
<td>Iran</td>
<td>Chemical installations</td>
<td>61 km</td>
</tr>
</tbody>
</table>
Example: Damage Assessment for GDACS (Stage 2)
Example: Consequence Analysis (Stage 3)
Power grid recovery after natural disaster

Color key:
Red: Generation
Blue: Transmission
Green: Distribution
Black: Customers

Source: T&D World Magazine (2014)
# Forensic analysis

<table>
<thead>
<tr>
<th>Damage types</th>
<th>Earthquake (16)</th>
<th>Space weather (15)</th>
<th>Flood (20)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Damage types</strong></td>
<td>Structural damage due to inertial loading</td>
<td>Damage to transmission and generation equipment from GICs</td>
<td>Damage to transmission tower foundations due to erosion and/or landslides</td>
</tr>
<tr>
<td></td>
<td>Foundation/ground failure</td>
<td>Potential for system-wide impact</td>
<td>Moisture and dirt</td>
</tr>
<tr>
<td>Contributing factors</td>
<td>Soil liquefaction</td>
<td>Early warning possible</td>
<td>Early warning possible</td>
</tr>
<tr>
<td></td>
<td>No warning time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most vulnerable equipment</td>
<td>Heavy equipment (e.g. generators, LPTs)</td>
<td>Equipment vulnerable to direct current (e.g. transformers)</td>
<td>Transmission towers</td>
</tr>
<tr>
<td></td>
<td>Ceramic parts (e.g. bushings, bus bars) or equipment (e.g. transformers)</td>
<td>Equipment protected from DC excitation (tripping)</td>
<td>Substation equipment</td>
</tr>
<tr>
<td>Recovery time is driven by</td>
<td>Number of items in need of repair or replacement</td>
<td>System-wide impact</td>
<td>Floodwaters recession (access)</td>
</tr>
<tr>
<td></td>
<td>Access to conduct repairs</td>
<td>Delayed effects</td>
<td>Number of items in need of repair or replacement</td>
</tr>
<tr>
<td>Recovery time range</td>
<td>A few hours to months; most commonly, 1 to 4 days</td>
<td>Power to areas serviced by equipment which has only tripped offline restored</td>
<td>Less than 24 hours to 3 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>within less than 24 hours after the end of the storm</td>
<td>Longer recovery times (up to 5 weeks) with hurricane and/or storm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Repairs of damaged equipment may take several months</td>
<td>damage</td>
</tr>
</tbody>
</table>
Disruption of other critical infrastructure

The disruption of **transportation** and **telecommunications** posed the most significant threat to the recovery of electric power systems.

<table>
<thead>
<tr>
<th></th>
<th>Earthquake</th>
<th>Space weather</th>
<th>Flood</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transportation</strong></td>
<td>Structural damage to ports, airports, bridges, roads and railroad tracks.</td>
<td>GNSS unavailability and/or positioning errors (navigation).</td>
<td>Flooding of roads and railway tracks.</td>
</tr>
<tr>
<td></td>
<td>Debris may block road and rail transportation.</td>
<td>Radiation risk to avionics.</td>
<td>Obstruction of roads due to debris left by floods.</td>
</tr>
<tr>
<td></td>
<td>Tsunamis may damage port infrastructure.</td>
<td>Minor disruption to road and railway transportation.</td>
<td>Traffic congestion associated with evacuation may delay preventive shut down.</td>
</tr>
<tr>
<td><strong>Communications</strong></td>
<td>Structural damage to cell towers and two-way radio repeaters.</td>
<td>HF radio communications blackout.</td>
<td>Inundation of telecommunications systems facilities and assets.</td>
</tr>
<tr>
<td></td>
<td>Cell phone network congestion.</td>
<td>Satellite communications affected.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cellular network base stations and two-way radio repeaters could experience increased static at dawn and dusk.</td>
<td></td>
</tr>
</tbody>
</table>
Space weather & CI

SW & Power grid

Space Weather and Power Grids: Findings and Outlook

SW & Financial systems

Space Weather and Financial Systems: Findings and Outlook

SW & Rail

Space Weather and Rail: Findings and Outlook
Summary data gaps

- **Industry data**
  - Closely held by industry and authorities (confidentiality, IP, security)

- **Accident data**
  - Reporting obligations: predefined severity threshold (loss of low-impact accidents and near miss data)
  - No reporting obligations: data held by industry (fear of repercussions on activity)
  - Loss of media interest
  - Collection of accident data during natural disasters may be secondary, late and not complete

→ Risk data are heterogeneous, incomplete or proprietary
→ Lack of knowledge on incident dynamics, scenarios, risk reduction
Data solutions

• **Systematic collection of Natech accident/risk data**
  • **Voluntary** based on available open information (bias!)
  • **Reporting obligation**: not only major events but also near misses/successes
  • **Supported by modern technology** (automatically follow conventional and social media; extract information using AI methods)
  • **Improve communication** between natural and technological risk communities (data collection needs)

• **Improve communication in industry and at all levels of government for free information flow**

• **Public-Private Partnerships - Trust**
Thank you for your attention!

RAPID-N tool for rapid Natech risk assessment and mapping: rapidn.jrc.ec.europa.eu

eNATECH database for Natech accidents enatech.jrc.ec.europa.eu

Contact: elisabeth.krausmann@ec.europa.eu
Expected increase in Natech risk:

→ more hazards
  (climate change, industrialization)
→ higher vulnerability
  (more people, urbanization)

... in a situation where Natech risk assessment methodologies & tools and guidelines for Natech risk management are scarce

Priority work areas*:

– Implement and enforce regulations for Natech risk reduction
– Develop methods, tools and guidance for Natech risk assessment
– Develop dedicated Natech emergency management plans
– Develop Natech risk maps
– Raise awareness and improve risk communication
– Train stakeholders on Natech risk reduction

*From a JRC survey on the status of Natech risk reduction in EU MS and OECD

Source: Kyodo AP
Natech risk governance / risk-sensitive investment

- **Multi-hazard risk**: distribution of knowledge and competences across many different actors (industry, civil protection, environment, labor, etc.)
- **Aggravating factors**: industrialization, climate change, population growth, cascading risk

**What is needed?**
- Awareness of industry’s vulnerability to natural hazards and limits of design basis
- Development and/or enforcement of legislative frameworks that address Natech risks & guidance on how to comply
- Free communication flow on Natech risks among all actors
- Promotion of an integrated risk-governance approach
- Public-private partnerships to link science, practice and policy
Disaster preparedness, response and recovery

- **Natech specifics**: Multiple and simultaneous releases; increased domino risk; loss of safety barriers and lifelines; hampering of response operations

- **Natech preparedness levels are low**, even in generally well-prepared countries

**What is needed?**

- Consideration of Natech characteristics in preparedness, response and recovery
- Assessment of ER resources to natural events and hazardous-materials releases
- Periodic review of emergency plans at plant and community level to ascertain that natural-hazard impacts are addressed (climate change, exceeding of design specifications – Plan B!)
Natech Flood Risk Assessment Tool
Development of a new prototype of the RAPID-N system
## Modelling Framework

### Update Property Estimator

**Property:** Peak Ground Acceleration

**Type:** Function

**Function:**
```plaintext
if (INERHP == 'B') SS = 0;
if (INERHP == 'C') SS = 1;
if (INERHP == 'D') SS = 2;
return exp(4.16 + 0.69 * [Mw] + 1.24 * log([dEkm]) + 6) + 0.12 * SS);
```

**Unit:** cm/s²

### Conditions

1. **Property:** Moment Magnitude, Value: 4.5 - 7.0
2. **Property:** Epicentral Distance, Value: 5 - 120 km
3. **Property:** Faulting Mechanism, Value: Normal

### Regions

1. Greece, Flinn-Engdahl Region
2. Southern Greece, Flinn-Engdahl Region
3. Dodecanese Islands, Greece, Flinn-Engdahl Region
4. Crete, Greece, Flinn-Engdahl Region

### Properties

<table>
<thead>
<tr>
<th>Storage Condition</th>
<th>Atmospheric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>Cylindrical Vertical</td>
</tr>
<tr>
<td>Roof Type</td>
<td>Floating Roof</td>
</tr>
<tr>
<td>Construction Material</td>
<td>Steel</td>
</tr>
<tr>
<td>Volume</td>
<td>22285 m³*</td>
</tr>
<tr>
<td>Height</td>
<td>14.00 m*</td>
</tr>
<tr>
<td>Diameter</td>
<td>147.64 ft (45.00 m)</td>
</tr>
<tr>
<td>H/D Ratio</td>
<td>0.3114 m/m*</td>
</tr>
<tr>
<td>Fill Level</td>
<td>85 %v*</td>
</tr>
</tbody>
</table>

### Chart

- < 8: Less than 10
- > 8: Greater than 8
- 7 – 9: Between 8 and 10
- ~ 8: About eight
- 8: Exactly eight

### References

1. Margaris, B.; Papazachos, C.; Papaioannou, C.; Theodulidis, N.; Kalogeras, I.; Skarlatoudi, attenuation relations for shallow earthquakes in Greece*, 2002
NATECH RISK ASSESSMENT AND MANAGEMENT
Reducing the Risk of Natural-Hazard Impact on Hazardous Installations
Elisabeth Krausmann, Ana Maria Cruz and Ernesto Salzano