# RAPID-N: Assessing and mapping the risk of natural-hazard impact at industrial installations

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*Supporting legislation*

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# Ecuadorean Amazon oil slick heads towards Peru

Crude discharged after pipeline was ruptured by landslide has entered Napo river w

ENERGY NEWS

# Hurricanes Destroyed 109 Oil Platforms: US Government

FOX NEWS .com

## Oil Spill Into Verdigris River Adds to Kansas Flooding Problems as E

## China quake hits chemical industry

16 May 2008

ROYAL SOCIETY OF CHEMISTRY

# Chemical leaks threaten Prague as floods hit Dresden

# Natural hazard triggered technological accidents

- A **natech** accident is a **chemical accident** caused by a natural hazard.

- Particular characteristics:
  - Simultaneous hazardous-materials releases from multiple sources
  - Damage to prevention and mitigation systems including lifelines (e.g. water, power)
  - Complicated response

# Natech Risk

- Natech risks are expected to **increase** due to:
  - **more hazards** (climate change, industrialization)
  - **higher vulnerability** (urbanization, interconnectedness)

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

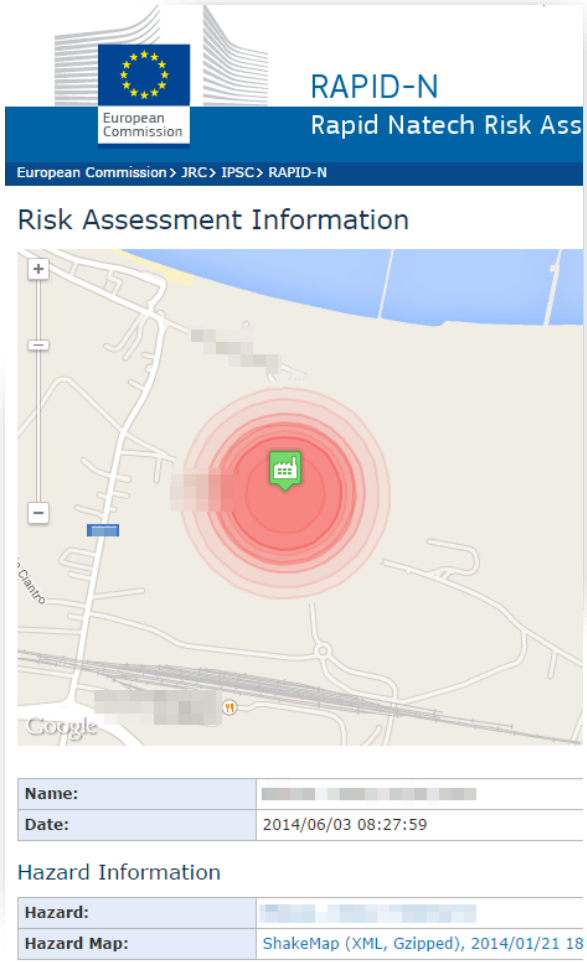
* E. Krausmann, D. Baranzini (2012) Natech risk reduction in the European Union, J Risk Research 15(8): 1027-1047

## Priority work areas*:

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

# JRC Activities

- Accident analysis and guidance
  - Site surveys for damage assessment (China, Japan)
  - Statistical analysis
  - Lessons learned and recommendations
  - Natech database: **eNatech** http://enatech.jrc.ec.europa.eu
- Risk analysis tools
  - Framework for natech risk assessment and mapping: **RAPID-N** http://rapidn.jrc.ec.europa.eu



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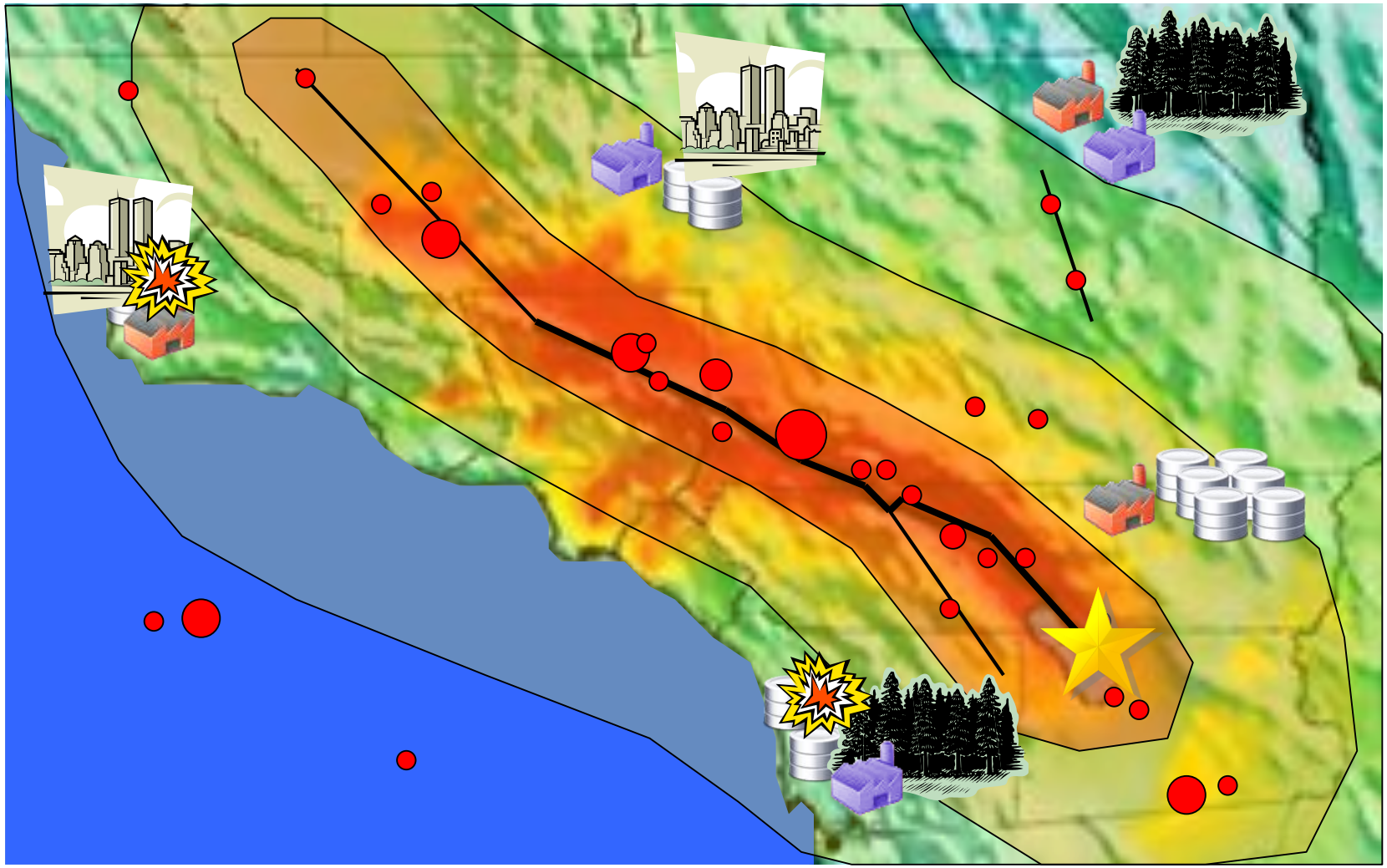

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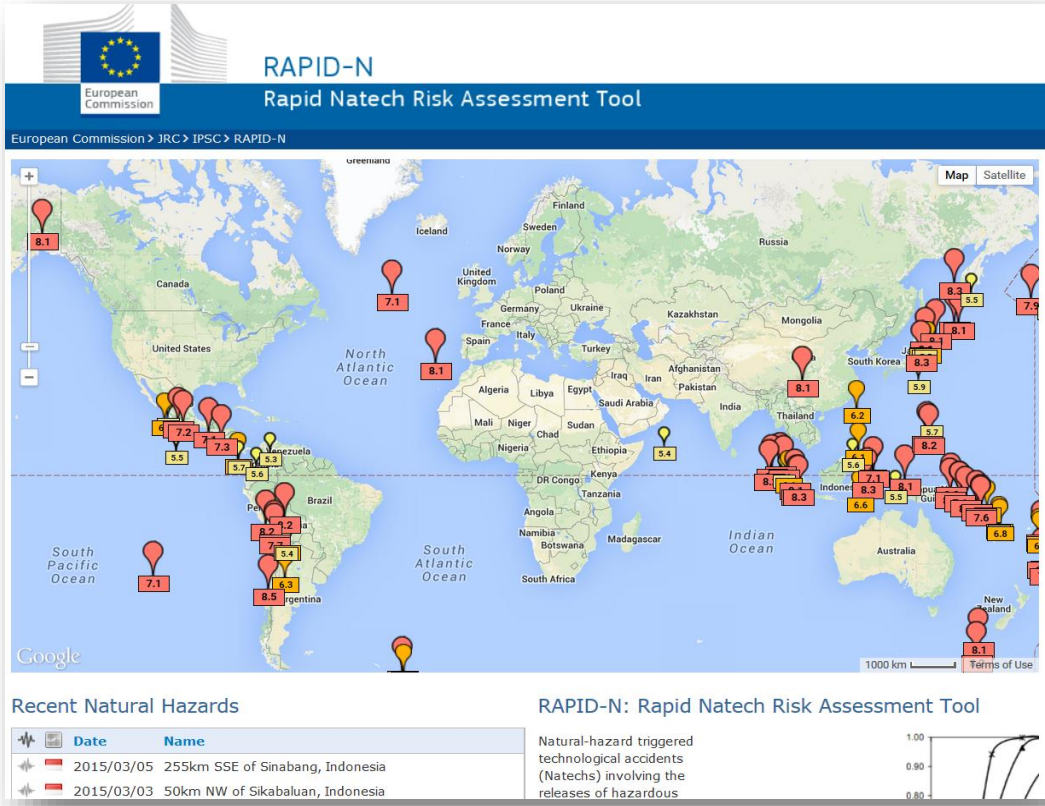
# RAPID-N: Rapid Natech Risk Mapping Framework

- Easy and quick data entry
- Rapid analysis
- Visualization
- Collaboration

- Cloud-based
- Modular architecture
  - Scientific Tools
  - Natural Hazards and Natechs
  - Facilities and Process Units
  - Risk Assessment

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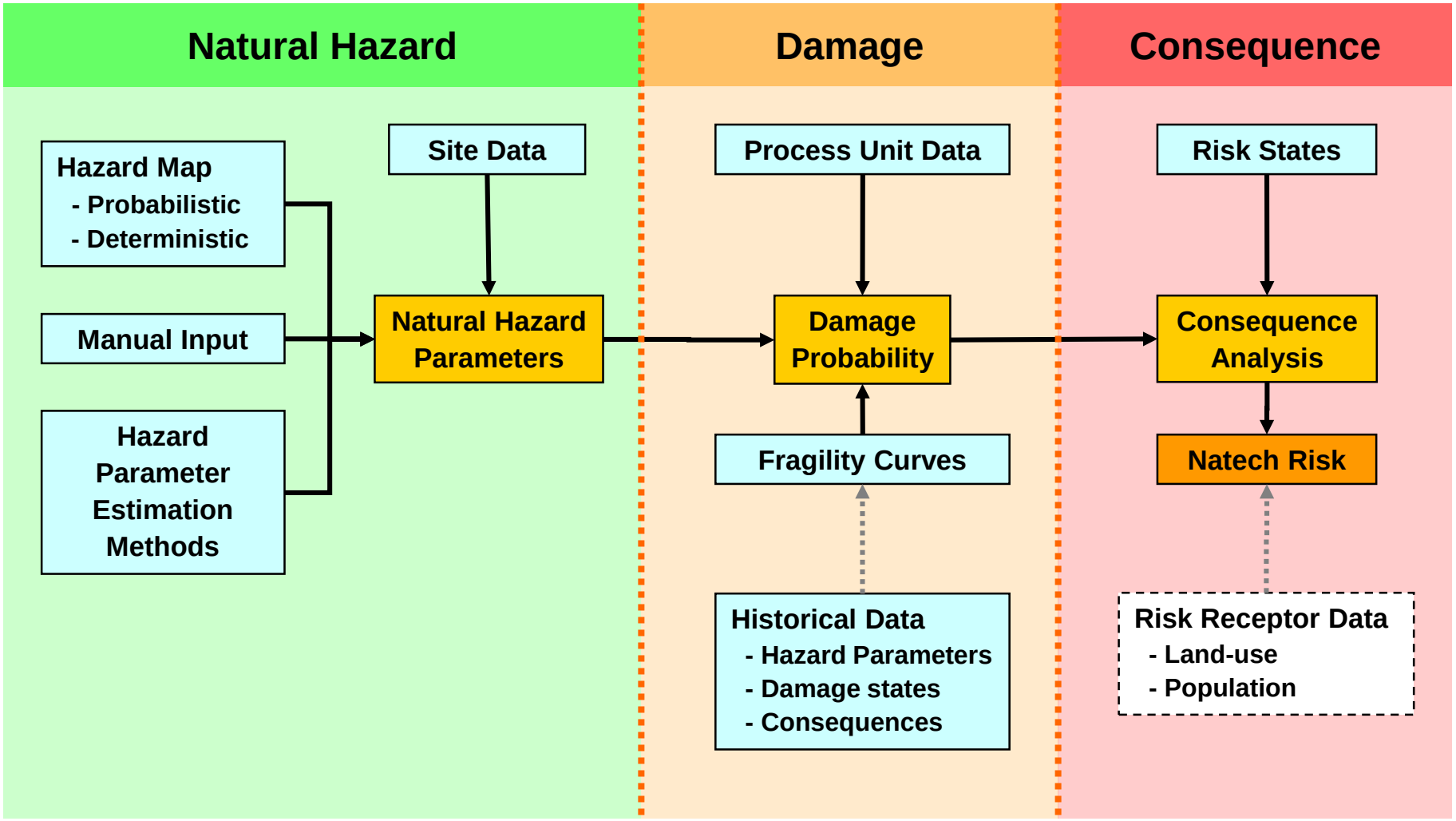
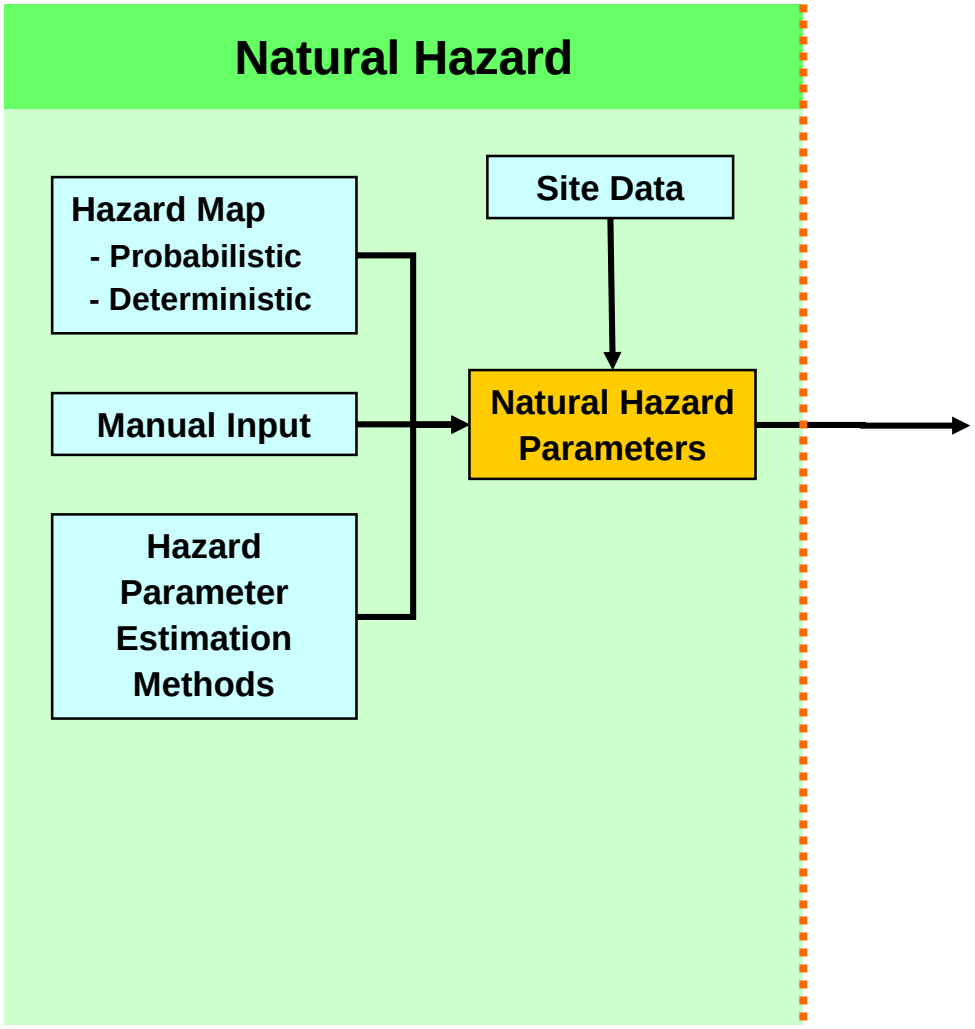

Natural Hazard
Damage
Consequence
Hazard Map
- Probabilistic
- Deterministic
Manual Input
Hazard Parameter Estimation Methods
Site Data
Natural Hazard Parameters
Process Unit Data
Damage Probability
Fragility Curves
Historical Data
- Hazard Parameters
- Damage states
- Consequences
Risk States
Consequence Analysis
Natech Risk
Risk Receptor Data
- Land-use
- Population




## Natech Information

| | |
|---|---|
| **Hazard:** | Kocaeli Earthquake, Turkey, 1999/08/17 |
| **Facility:** | Turkish Petroleum Refineries Corp. (TUPRAS) Izmit Refinery, Turkey |

### On-site Hazard Parameters

| | |
|---|---|
| **European Macroseismic:** | Destructive |
| **Horizontal peak ground acceleration:** | 0.25 g |
| **Vertical peak ground acceleration:** | 0.2 g |
| **Peak Ground Displacement:** | 40–60 cm |

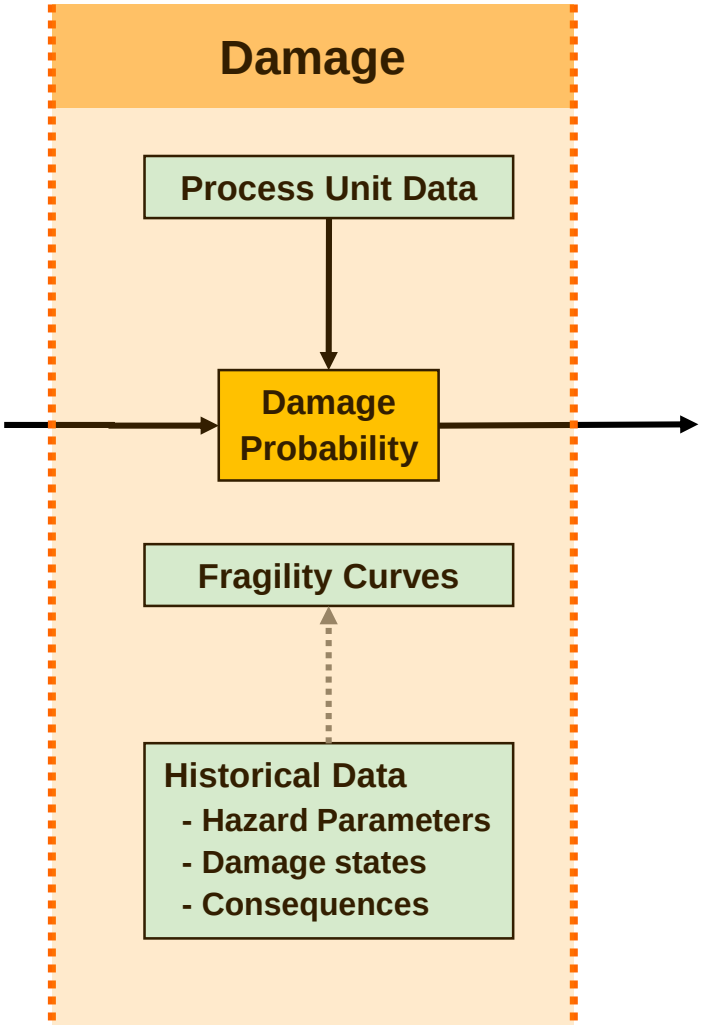
### References

| No | Reference |
|---|---|
| 1. | Girgin, S., "The natech events during the August 17, 1999 Kocaeli Earthquake: aftermath and less |
| 2. | Durukal, E.; Erdik, M., "Physical and economic losses sustained by the industry in the 1999 Koca |
| 3. | Steinberg, L. J. and Cruz, A. M., "When natural and technological disasters collide: lessons from |
| 4. | Danış, H.; Görgün, M., "Marmara earthquake and TÜPRAŞ fire", 2005 |
| 5. | Suzuki, K., "Report on damage to industrial facilities in the 1999 Kocaeli earthquake, Turkey", 200 |

Created: Serkan Girgin, 2011/10/18 15:48:13

## Natech Damages

| No | Process Unit Type | Process Unit Properties | Damage Classification |
|---|---|---|---|
| 1. | Storage Tank | Storage Condition: Atmospheric<br>Roof Type: Floating Roof<br>Construction Material: Steel<br>Base Support Type: Unanchored | Seligson et al. (1996) |




## 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 |

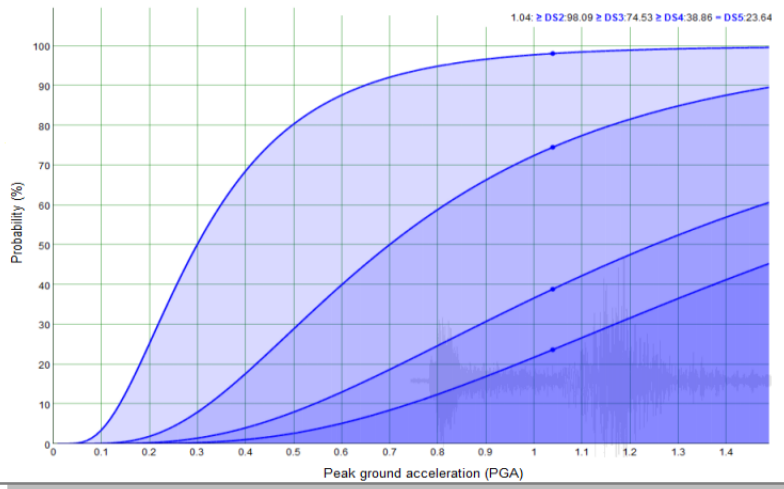
### Data

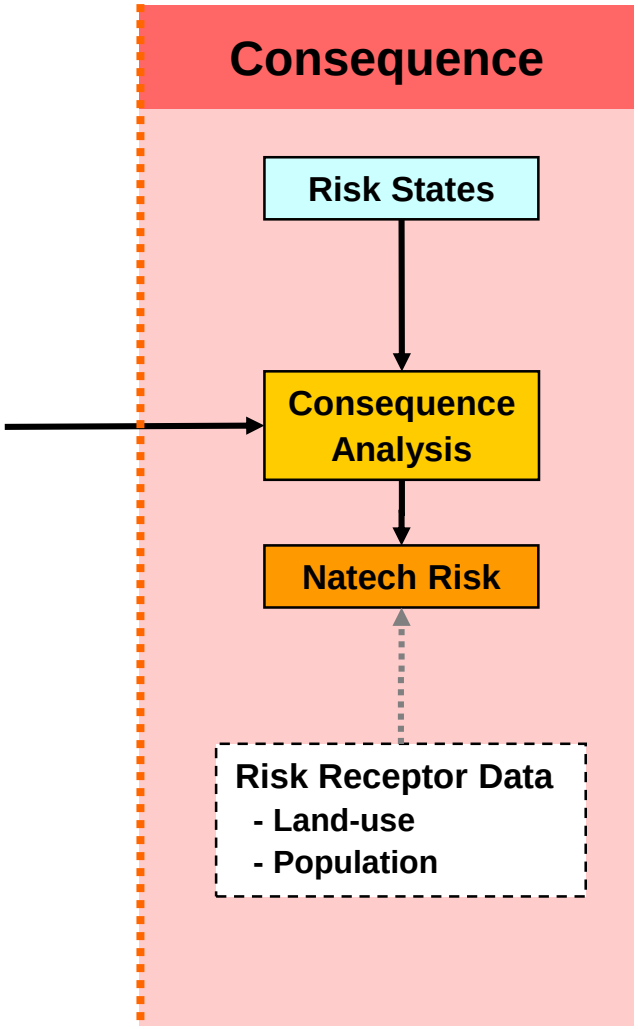
| No | Damage State | Median | Standard Deviation |
|---|---|---|---|
| 1. | ≥ DS2 | 0.3 | 0.6 |
| 2. | ≥ DS3 | 0.7 | 0.6 |
| 3. | ≥ DS4 | 1.25 | 0.65 |
| 4. | = DS5 | 1.6 | 0.6 |

### References

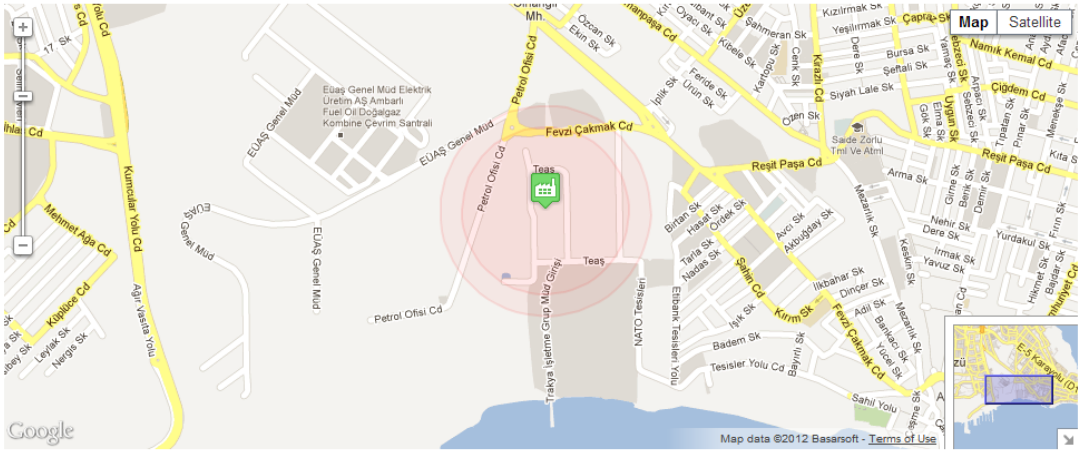
| No | Reference |
|---|---|
| 1. | U.S. EPA, "HAZUS-MH MR5 Technical Manual", 2010 |

### Fragility Curve






## Risk Assessment Information




| | |
|---|---|
| **Name:** | Kocaeli Earthquake Single Plant |
| **Date:** | 2012/08/28 13:11:13 |
| **Type:** | Private |

### Hazard Information

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

### Facility Information

| | |
|---|---|
| **Facility:** | [redacted] Power Plant, Turkey |

### Damage Estimation

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

### Facilities

1. [redacted] Power Plant, Turkey

| No | Process Unit | Hazard Parameters | Fragility Curve | Damage Estimate | Damage Parameters | End-point Distance |
|---|---|---|---|---|---|---|
| 1. | Storage Tank (T-STR)* [Gasoline] | PGA: 18.777 %g; EMS: Slightly damaging; MM: Strong; MSK: Strong; MMI: 6.4866; $d_e$: 101.38 km; $d_h$: 102.79 km; $PGA_h$: 74.415 cm/s2; PGV: 15.573 cm/s « | OS00-F50-G | ≥ DS2: 4.0546% | Fire/Explosion Event: Vapor Cloud Explosion; $Q_{involved}$: 4250 kg; $f_{m,\ passive}$: 1; $P_{c,\ fire}$: 100%; $f_{V,\ involved}$: 10 %v; $V_{involved}$: 5.7432 m3; $P_{c,\ release}$: 30%; $f_{yield}$: 0.1; RMP Scenario: Worst-case; $t_{release}$: 10 min; $q_{release}$: 425 kg/min; $Q_{released}$: 4250 kg; $A_{pool}$: 6146.1 ft2; $h_{pool}$: 1 cm; $q_{release,\ r}$: 425 kg/min; $\tau_a$: 1; R: 0.4; $q_R$: 5000 W/m2; $t_{exp}$: 40 s; $D_T$: 342 TDU; $d_e$: 270.58 m; $Q_{fuel}$: 4250 kg; $P_{damage}$: 4.0546%; $P_{natech}$: 4.0546% « | 271 m: 4.0546% |
| | | | | ≥ DS3: 0.004631% | Fire/Explosion Event: Vapor Cloud Explosion; $Q_{involved}$: 8500 kg » | 341 m: 0.004631% |
| | | | | ≥ DS4: Very low | - | - |

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# Property Estimation Framework

| Description | Estimator | Unit | Validity conditions |
|---|---|---|---|
| Default ambient temperature | 25 | °C | – |
| Wind speed | 1.5 | *m/s* | RMP Scenario = *Worst-case* |
| H/D ratio from diameter | | *m/m* | Shape = *Spherical* |
| Storage condition from roof type | | – | Roof Type = *Floating Roof*<br>Roof Type = *Internal Floating Roof*<br>Roof Type = *Open Roof* |
| Diameter from volume | | *m* | Shape = *Spherical* |
| Energy magnitude from radiated seismic ene | | – | |
| Peak ground acceleration | | %g | Region = *Western U.S.A.* |
| U.S. EPA RMP Liquid Factor Boiling | | | |
| Duration of fireball | | *s* | Fire/Explosion Event = *BLEVE* |

**Properties**

| | |
|---|---|
| **Storage Condition:** | Atmospheric |
| **Shape:** | Cylindrical Vertical |
| **Roof Type:** | Floating Roof |
| **Construction Material:** | Steel |
| **Volume:** | 22285 $m^3$* |
| **Height:** | 14.00 m* |
| **Diameter:** | 147.64 ft (45.00 m) |
| **H/D Ratio:** | 0.3114 m/m* |
| **Fill Level:** | 85 %v* |

```
} else {
return 2.6•pow([QFL:kg],1/6);
}
```

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# Status and Data Availability

- Currently implemented for earthquakes and fixed installations
- ~ 20,000 earthquakes (> M 5.5)
- > 52,500 earthquake catalog data
- ~ 10,000 shakemaps
- > 5,500 industrial facilities
  - Refineries
  - Power plants
- > 64,000 plant units
  - Storage tanks
- Complete implementation of U.S. EPA RMP Offsite Consequence Analysis methodology
- > 200 properties
- > 400 property estimators

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# Application Areas

- **Rapid local and regional natech risk assessment**
- **Land-use and emergency planning**
- **Identification of neighboring infrastructures at risk**
- **Early warning**
- **Preliminary damage assessment**

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# Example: Earthquake Case Study

- Istanbul Earthquake
- JICA (2002) Model A
- Mw 7.5
- Fault length 120 km
- Strike-slip


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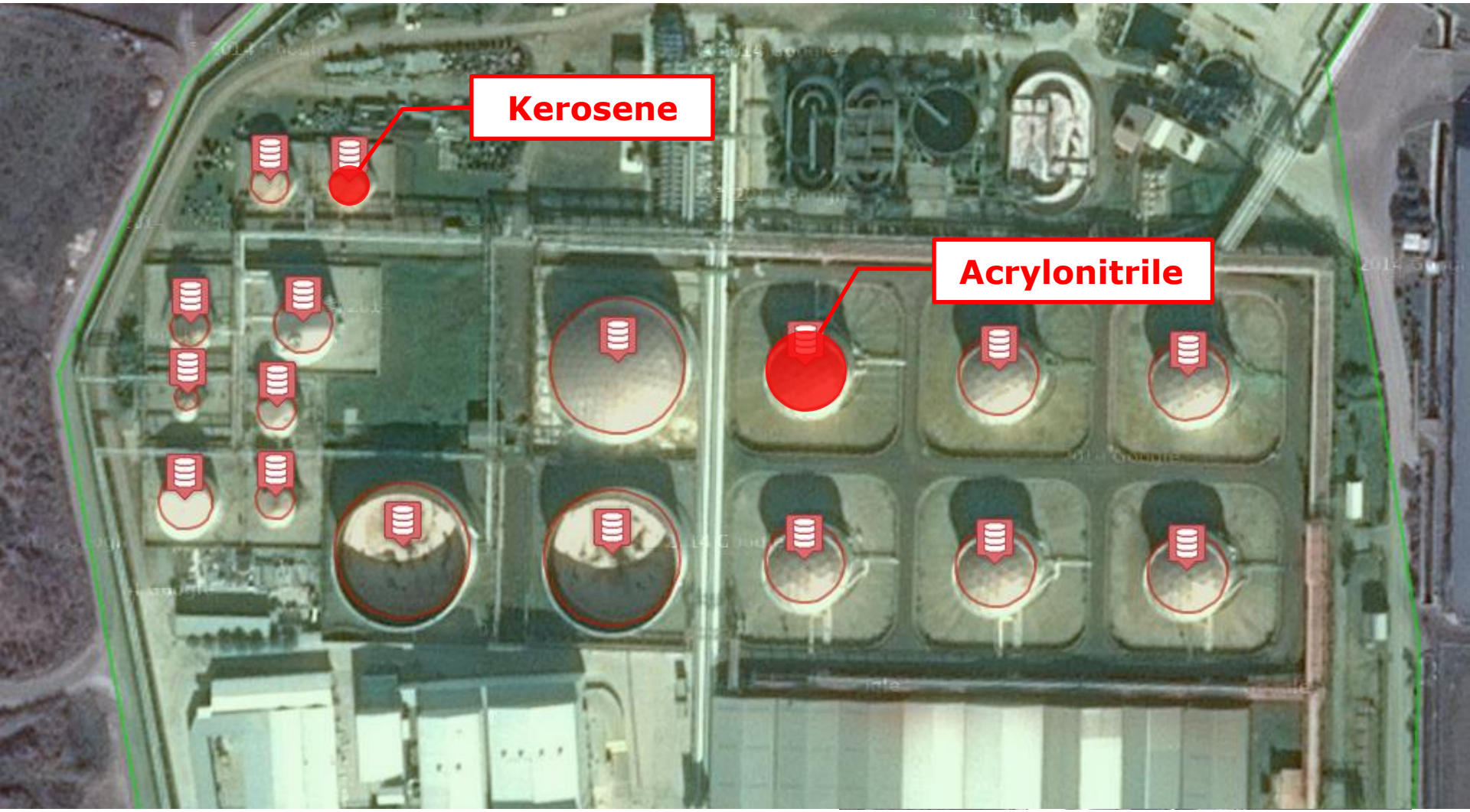
Kerosene
Acrylonitrile

## Release of toxic substance

*Impact area for 1-hr exposure without irreversible health effects*


≥ DS4: Very low - -

# Ongoing and Future Research

- Extension to other natural hazards and infrastructures
  - Pipelines (2014-2015), Floods (2015)
- Automated natech damage and consequence estimation (Alert)
  - Reporting to interested parties and authorities
- Cascading (domino) effects
- Consideration of risk receptors
- Fragility curve creation tool
  - Statistical analysis of natech damage data

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# Thank you
# for your attention!

## http://rapidn.jrc.ec.europa.eu

## Contact

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