



RAPID-N: A Natech risk assessment and mapping tool

S. Girgin, E. Krausmann

European Commission, Joint Research Centre
Institute for the Protection and Security of the Citizen
Ispra, Italy

*Serving society
Stimulating innovation
Supporting legislation*



A “Natech” accident is a “chemical accident” caused by a natural hazard or a natural disaster.

Chemical accidents include accidental **oil and chemical spills, gas releases, and fires or explosions** involving hazardous substances from **fixed establishments** (e.g. petrochemical, pharmaceutical, pesticide, storage depot), and **oil and gas pipelines**



Natural-Event Impact on Chemical Infrastructures

At least 40% of surveyed EU MS and OECD Member Countries have experienced one or more Natech accident, sometimes with fatalities and injuries, environmental or economic damage, or supply disruption

- + Tohoku earthquake and tsunami (Japan, 2011): multiple Natech accidents, 6 refineries halted shutting in 30% of refining capacity, major fires and explosions in 2 refineries;
- + Hurricanes Katrina & Rita (USA, 2005): 113 off-shore platforms destroyed, 163 severely damaged; hike in global oil price; release of 30 million litres oil onshore;
- + Kocaeli earthquake (Turkey, 1999): multiple fires in a refinery producing 1/3 of Turkey's total oil-related output; international assistance required to cope with the accident.

Expected increase of Natech risk due to more hazards (climate change, industrialisation) and higher vulnerability of society (urbanisation, interconnectedness)

Natech Risk-Reduction Situation

- Legislation, codes and standards for chemical-accident prevention rarely address Natech risk explicitly
- There is little knowledge on the dynamics of Natech accidents
- There are hardly any methodologies and tools for Natech risk assessment and no guidance for industry on how to assess Natech risk
- Emergency-response plans do not consider the characteristics of Natech accidents (loss of utilities)
- There are no Natech risk maps to identify areas at risk

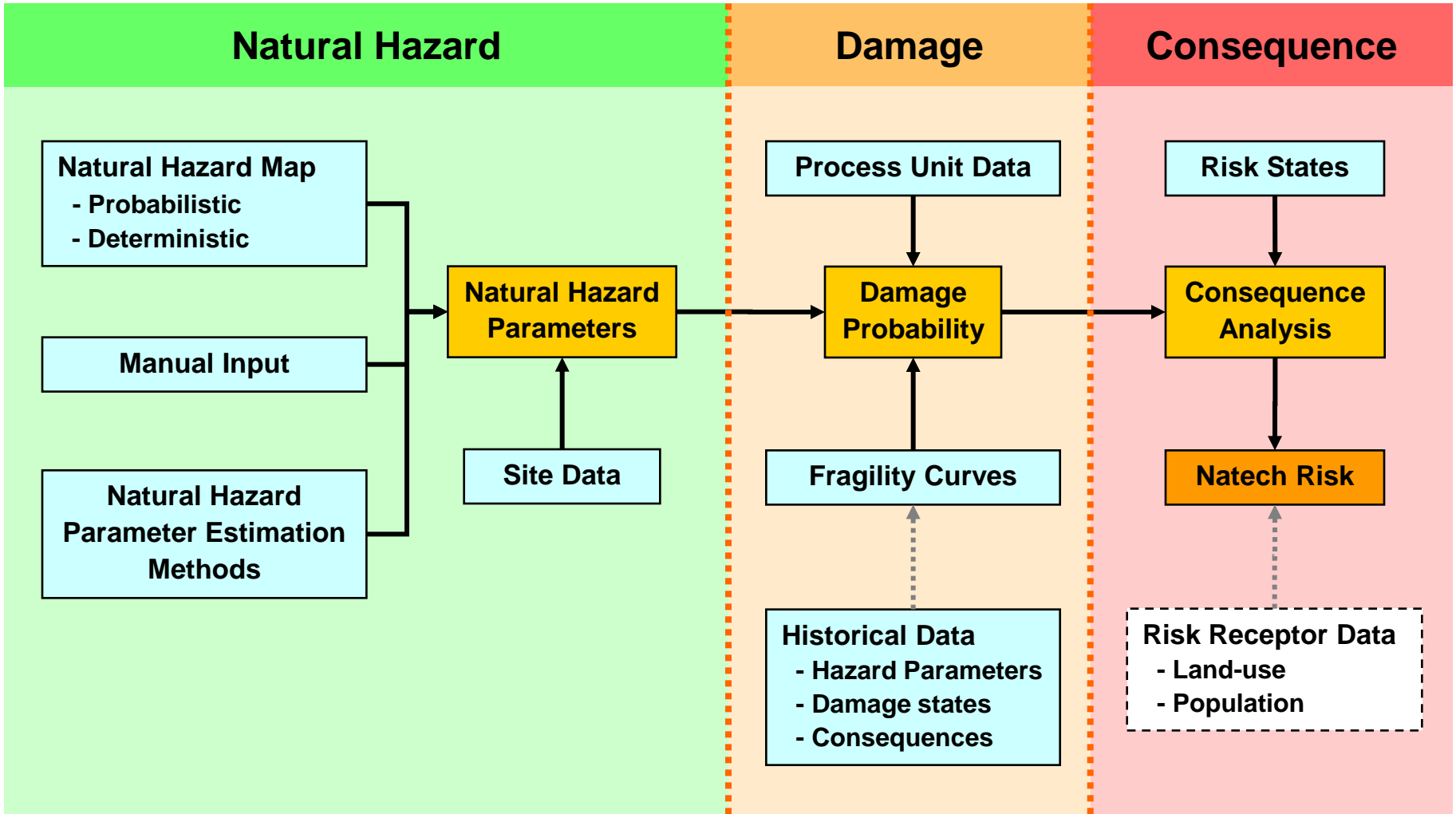
.... from a JRC survey on the status of Natech risk reduction in the OECD and in EU MS

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

Natech Risk Mapping

- **Natech risk maps are considered a high priority need for:**
 - Identification of Natech prone areas (land-use planning)
 - Emergency-response planning
 - **Hardly any Natech risk maps exist in the EU/OECD**
 - **Simple overlay of natural hazards and industrial facilities**
 - **Do not consider site-specific features**
 - Expected release scenarios
 - Existing safety measures
- **Development of a unified Natech risk assessment and mapping methodology and implementation as a software tool**

Methodology



Rapid Natech Risk Mapping Tool: RAPID-N

- Web-based application
 - Multilingual
- Easy and quick data entry
- Rapid analysis and visualization
- No commercial packages
- Modular architecture
 - Scientific Tools
 - Natural Hazards and Natechs
 - Facilities and Process Units
 - Risk Assessment
- Current focus on earthquakes



Home Risk Assessments Legal Notice Links Contact Help

Personal Logout English

Personal

Risk Assessment

- Damage Classifications
- Risk States
- Fragility Curves
- Risk Assessments

Facilities and Process Units

- Activities
- Facilities
- Substances
- Process Unit Types
- Process Units
- Mapping Tool

Natural Hazards and Natechs Module

- Hazards
 - Source parameters
- Earthquake Catalog Data
 - Online monitoring (USGS, EMSC)
 - Automated update of hazard data
- On-site Hazard Data
- Hazard Maps
 - USGS Shakemaps
- Natechs
 - On-site hazard parameters

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 Kocaeli Earthquake"
3.	Steinberg, L. J. and Cruz, A. M., "When natural and technological disasters collide: lessons from the 1999 Kocaeli Earthquake"
4.	Daniş, H.; Görgün, M., "Marmara earthquake and TÜPRAŞ fire", 2005
5.	Suzuki, K., "Report on damage to industrial facilities in the 1999 Kocaeli earthquake, Turkey", 2000

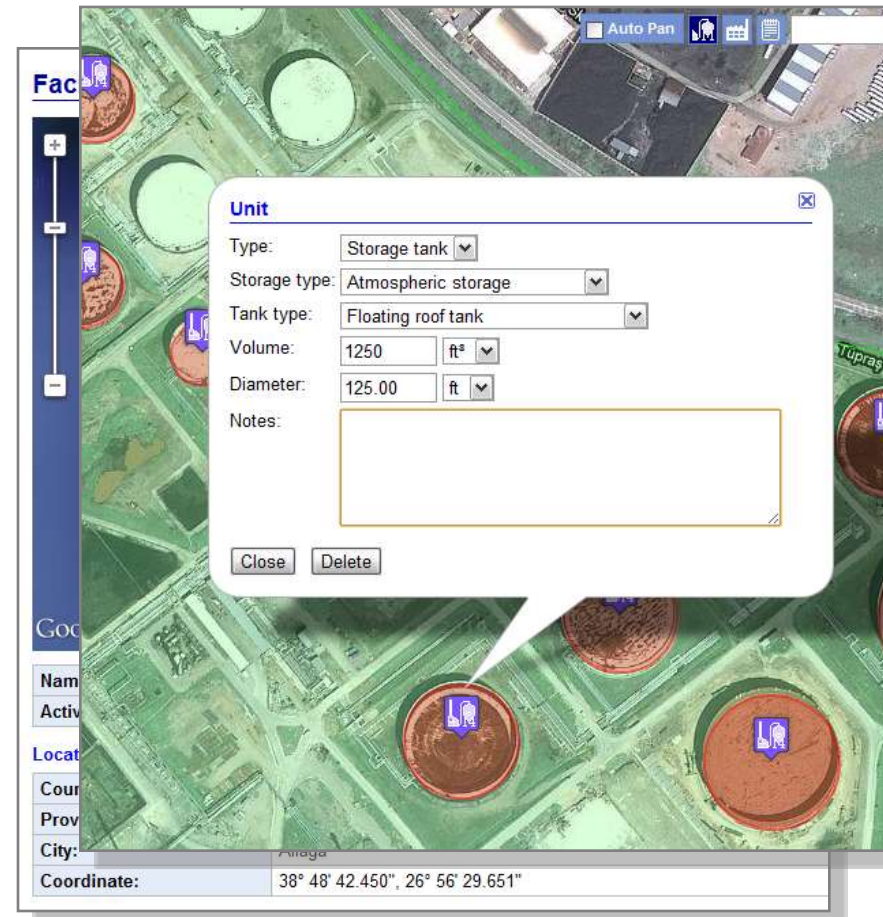
Created: Serkan Girgin, 2011/10/18 15:48:13

Natech Damages

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

Facilities and Process Units Module

- Facilities
 - Activity, location, operator
 - Site properties
- Substances
 - Identifiers
 - Physico-chemical properties
- Process Units/Groups
 - Process unit characteristics
 - Stored substances
 - Lumped process unit data
- Typical Process Units
 - Process unit data substitute



Risk Assessment Module

- Damage Classifications
 - Set of damage states
- Fragility Curves
 - Damage probability vs. PGA
- Risk States
 - Damage state
 - Damage parameters, e.g.:
 - Natech event (e.g. BLEVE)
 - Conditional probability (e.g. 50%)
 - Volume involved (e.g. 10 %v)
 - Validity conditions
- Consequence modeling

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

Risk State Information

Damage Classification:	Seligson et al. (1996)
Damage State:	DS3 (Moderate)

Risk Assessment Settings

Volume Involved:	10 %v
Event:	60-minute Release

Conditions

Storage Condition:	Atmospheric
Roof Type:	Fixed Roof
Construction Material:	Steel

Risk States

No	Damage State	Event	Probability	Volume Involved	Conditions
1.	DS3	60-minute Release	100%	10 %v	-
2.	DS3	Vapor Cloud Fire	100%	10 %v	Type of Chemical: Flam
3.	DS4	60-minute Release	100%	Auto	-
4.	DS4	Vapor Cloud Fire	100%	Auto	Type of Chemical: Flam
5.	DS5	Worst-case Release	100%	100 %v	-
6.	DS5	Worst-case Fire	100%	100 %v	Type of Chemical: Flam

Risk Assessment

- Natech damage assessment
 - Calculation of hazard parameters
 - Estimation of damage probability fragility curves
- Natech consequence analysis
 - Estimation of (worst-case) consequence scenarios
 - Calculation of end-point distances using RMP methodology (US EPA)
 - Toxic
 - Flammable
- Output
 - Risk map
 - Summary report

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:	Power Plant, Turkey
-----------	---------------------

Damage Estimation

Damage Classification:	Auto
Flexible fragility curve selection:	Yes

Facilities

1. Power Plant, Turkey

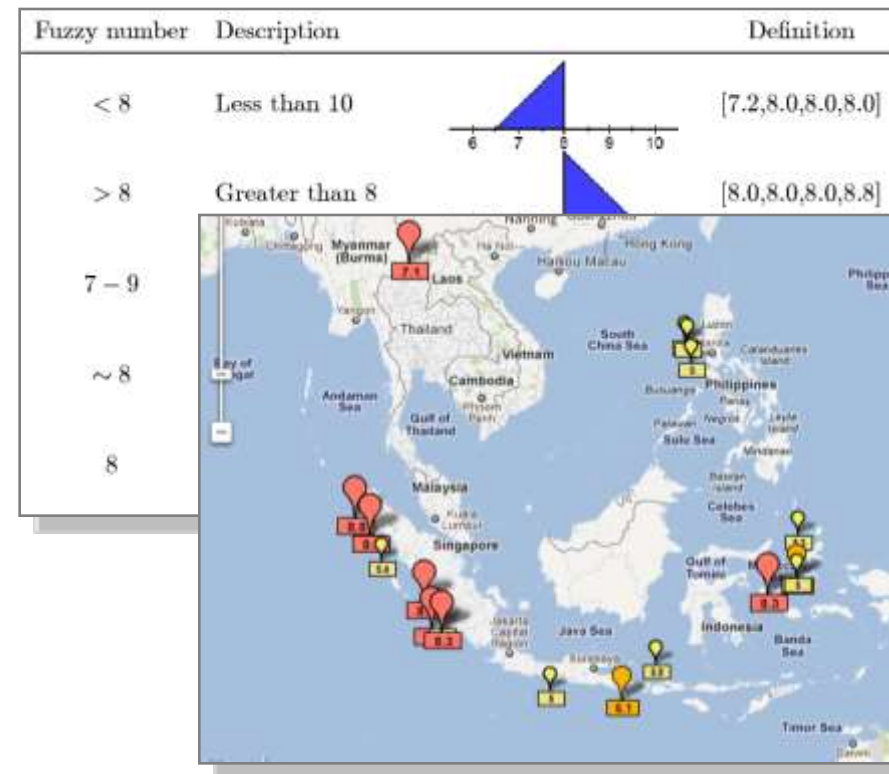
No	Process Unit	Hazard Parameters	Fragility Curve	Damage Estimate	Damage Parameters	End-point Distance
1.	Storage Tank (T-5TR) (Gasoline)	PGA: 18.777 %g; EMS: Slightly damaging; MM: Strong; MSK: Strong; MMI: 6.4866; d _g : 101.38 km; d _h : 102.29 km; PGA _h : 74.413 cm/s ² ; PGV: 15.373 cm/s ☹	0500-F50-G	≥ D52: 4.0546%	Fire/Explosion Event: Vapor Cloud Explosion; Q _{involved} : 4250 kg; f _{m, postfire} : 1; P _{c, fire} : 100%; f _{v, involved} : 30 %; V _{involved} : 5.7432 m ³ ; P _{c, release} : 30%; f _{v, release} : 0.1; RMP Scenario: Worst-case; t _{release} : 10 min; Q _{release} : 425 kg/min; Q _{released} : 4250 kg; A _{pool} : 6146.1 ft ² ; h _{pool} : 1 cm; Q _{release, r} : 425 kg/min; T _a : 1; R: 0.4; Q _h : 5000 W/m ² ; t _{temp} : 48 s; D _r : 342 TDU; d _g : 270.58 m; Q _{fuel} : 4250 kg; P _{damage} : 4.0546%; P _{natech} : 4.0546% ☹	271 m: 4.0546%
				≥ D53: 0.004631%	Fire/Explosion Event: Vapor Cloud Explosion; Q _{involved} : 8500 kg ☹	341 m: 0.004631%
				≥ D54: Very low	-	-

Scientific Tools Module

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

Property Estimation Framework

- Minimize data requirement
- Increase flexibility
 - No hard-coded functions



Property Estimation Framework

- Generic framework
 - Natural hazard properties (e.g. PGA)
 - Site properties (e.g. Soil class)
 - Process unit properties (e.g. Volume)
 - Substance properties (e.g. Density)
 - Facility properties
- Fixed value or complex function
- Location-aware
- Automatic selection of “most suitable”
 - Recursive
 - Exhaustive

Update Property Estimator

Property: Peak Ground Acceleration *

Type: Function *

Exact Estimate

Function: [...]

Properties

Storage Condition:	Atmospheric
Shape:	Cylindrical Vertical
Roof Type:	Floating Roof
Construction Material:	Steel
Volume:	22285 m ³ *
Height:	14.011 m *
Diameter:	147.64 ft (45.001 m)
H/D Ratio:	0.3114 m/m *
Fill Level:	85 %v *

Unit: [...]

Condition: [...]

1. Prop [...]

2. Prop [...]

3. Prop [...]

Region: [...]

1. Gre [...]

2. Sou [...]

3. Dod [...]

4. Crete, Greece, Flinn-Engdahl Region [...] * [-] [+]

References

1. Margaris, B.; Papazachos, C.; Papaioannou, C.; Theodulidis, N.; Kalogeras, I.; Skellern, P. "Attenuation relations for shallow earthquakes in Greece", 2002 [...] *

Summary

- RAPID-N features a web-based, integrated framework for Natech risk assessment and mapping (for earthquakes)
- **RAPID-N allows rapid assessment of natech risks with minimum data input**
- Application areas:
 - **Land-use planning**
 - **Emergency planning**
 - **Preliminary Natech damage estimation**
- Current status:
 - **Release phase (expert validation)**
 - **Included data (from open sources)**
 - > 18,500 earthquakes
 - > 7,300 earthquake maps
 - > 5,500 industrial facilities (only for internal use)

Future Work

- Automated Natech damage and consequence estimation (Alert)
 - E.g. Automatic warning of authorities by the JRC
- Consideration of risk receptors (population)
- Extension to other natural hazards
 - Floods
- Extension to other industrial facilities
 - Pipelines