European Commission

RAPID-N

Rapid Natech Risk Assessment and Mapping Framework

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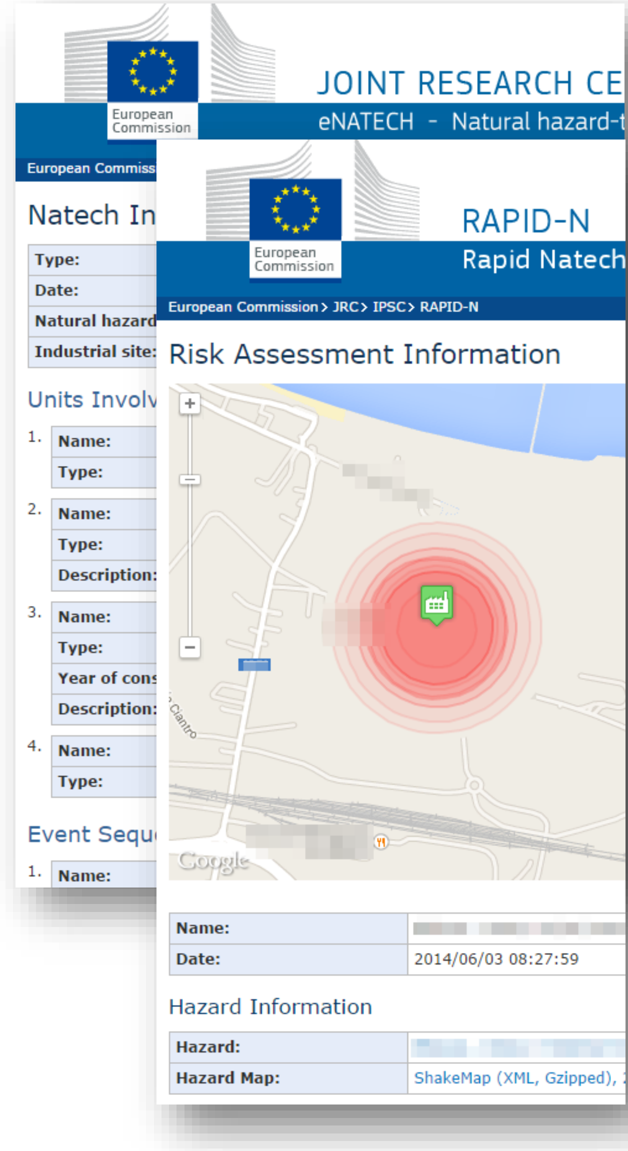
Joint Research Centre
the European Commission's
in-house science service

JRC Science Hub: ***ec.europa.eu/jrc***

Joint Research Centre

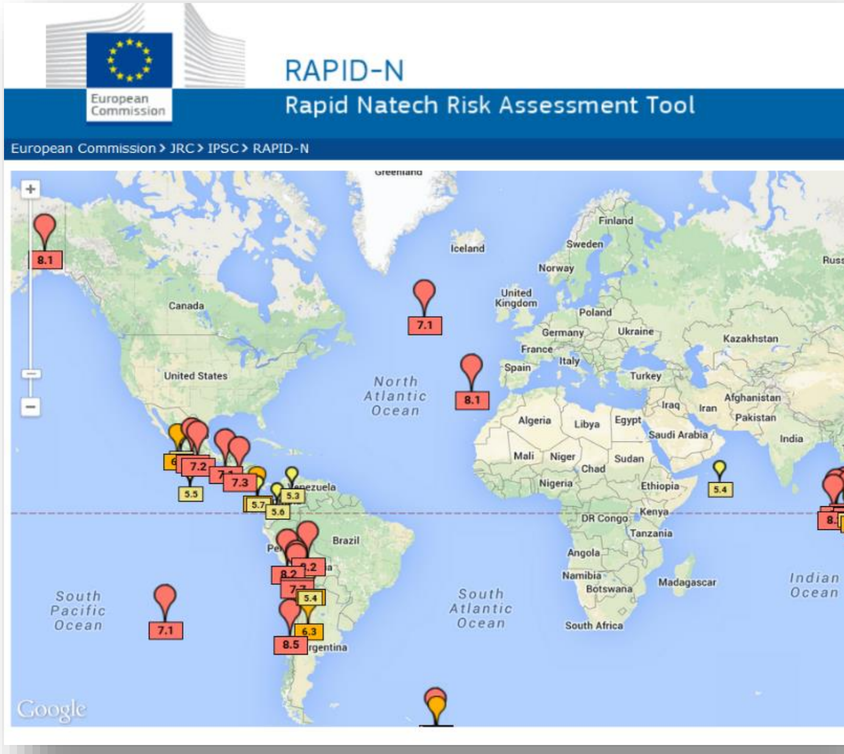
JRC Natech Activities

- **Identification** of <u>vulnerable equipment</u>, <u>scenarios</u> and <u>consequences</u>
- Site **surveys** for Natech damage assessment (e.g. Japan, China)
- Statistical **analysis** of accident data
- **Lessons learned** and **recommendations**
- Natech **trainings** (e.g. Natech Workshops)
- **Natech database: eNatech**
- **Natech risk assessment and mapping framework: RAPID-N**

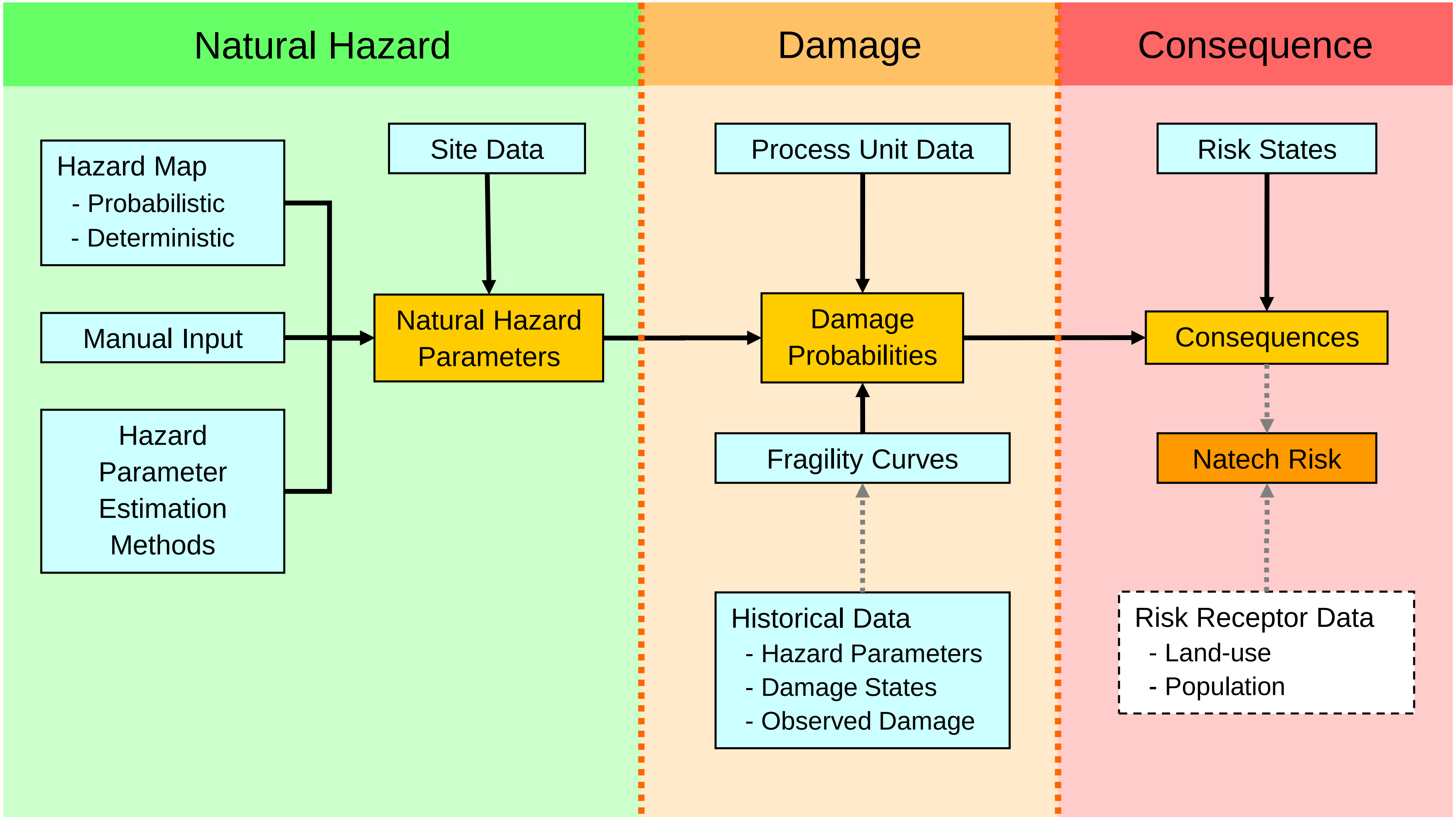


RAPID-N

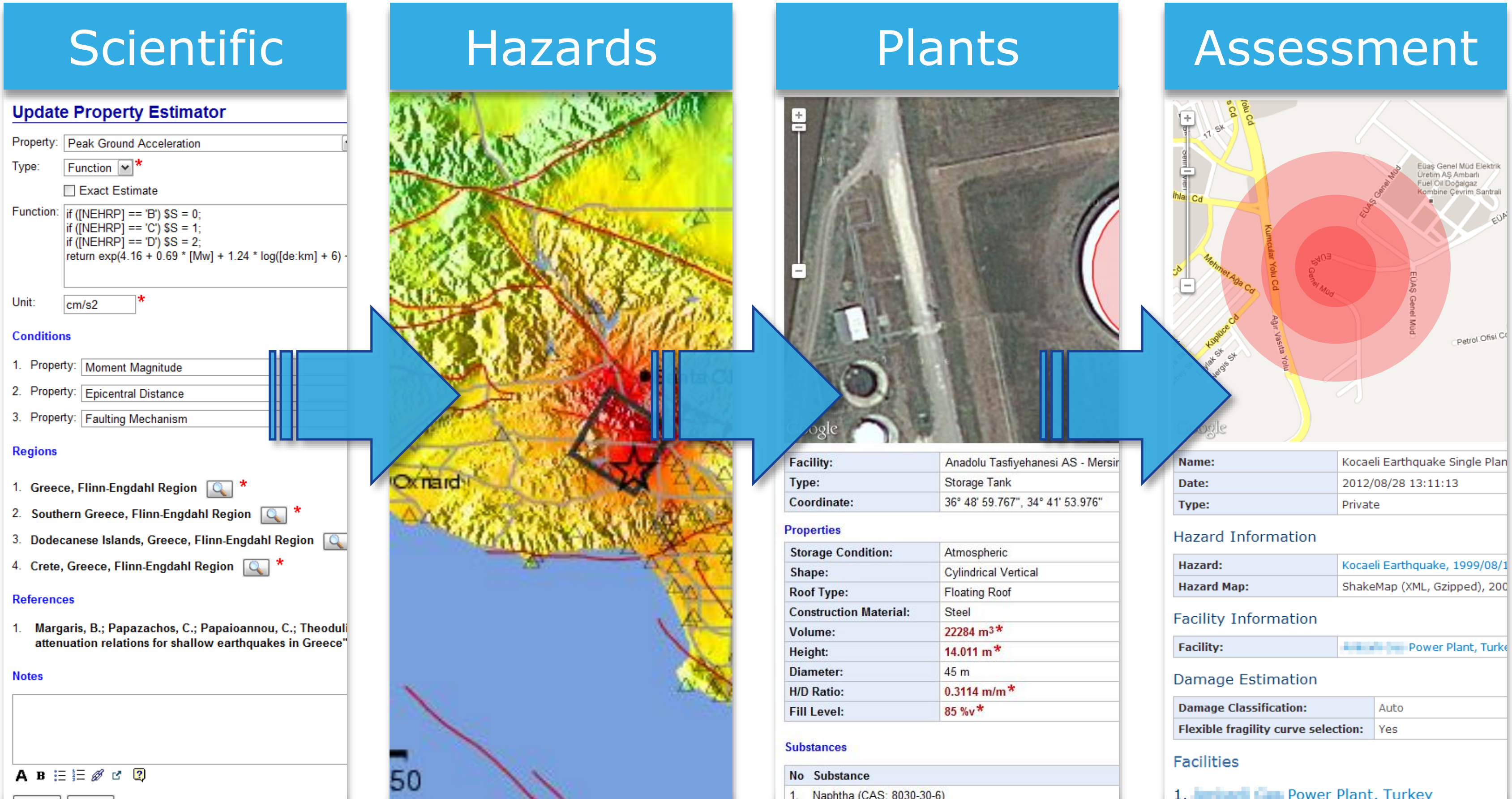
- Web-based, publicly available **decision-support** tool for Natech risk assessment and mapping
  http://rapidn.jrc.ec.europa.eu
- **Unites** natural-hazard damage estimation and consequence analysis **in one tool!**
- Features
  - **Easy** and **quick** data entry
  - Automated **data estimation**
  - **Rapid** and **scalable** analysis
  - **Visualization**



Methodology



Modular Structure



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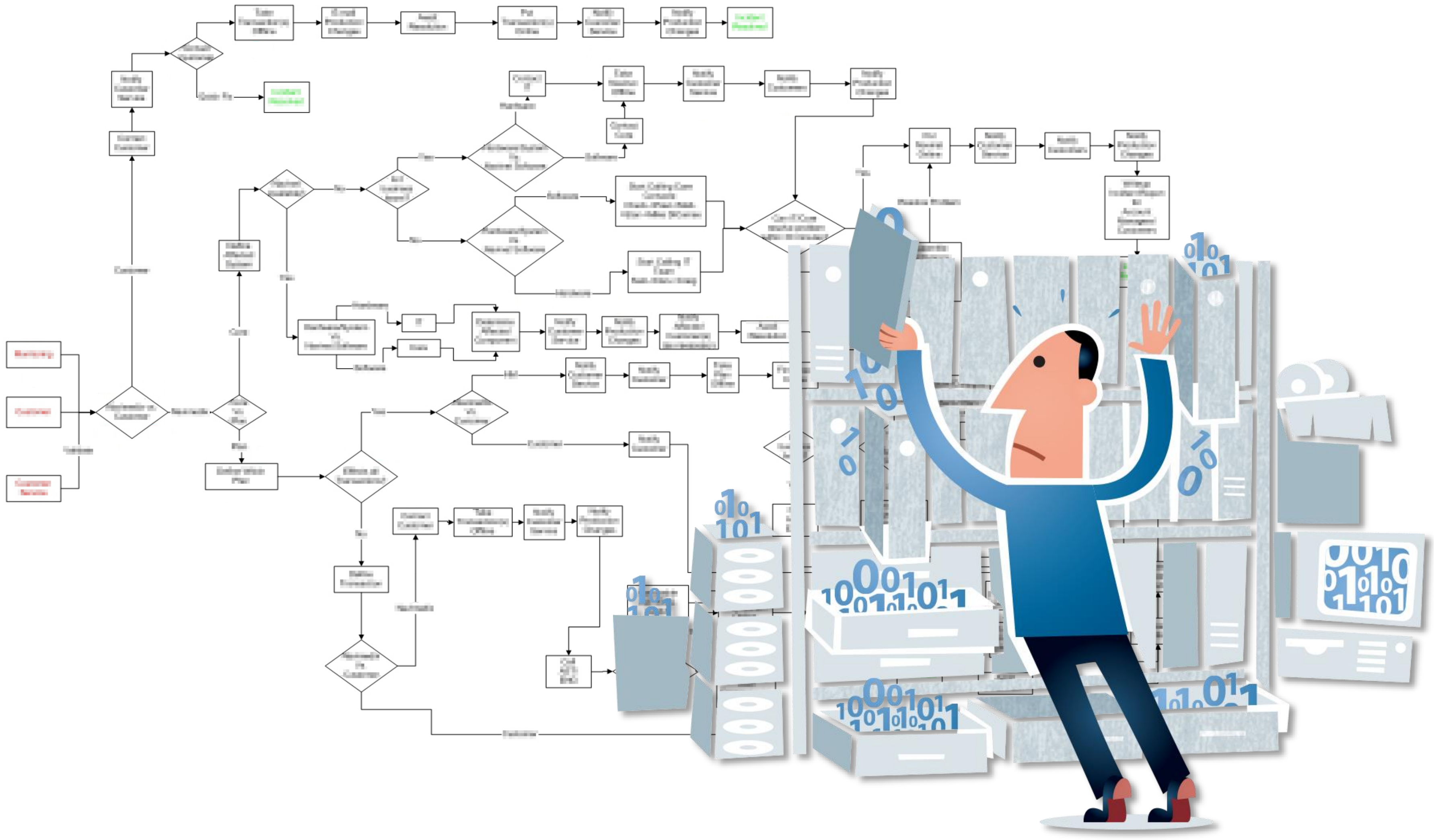
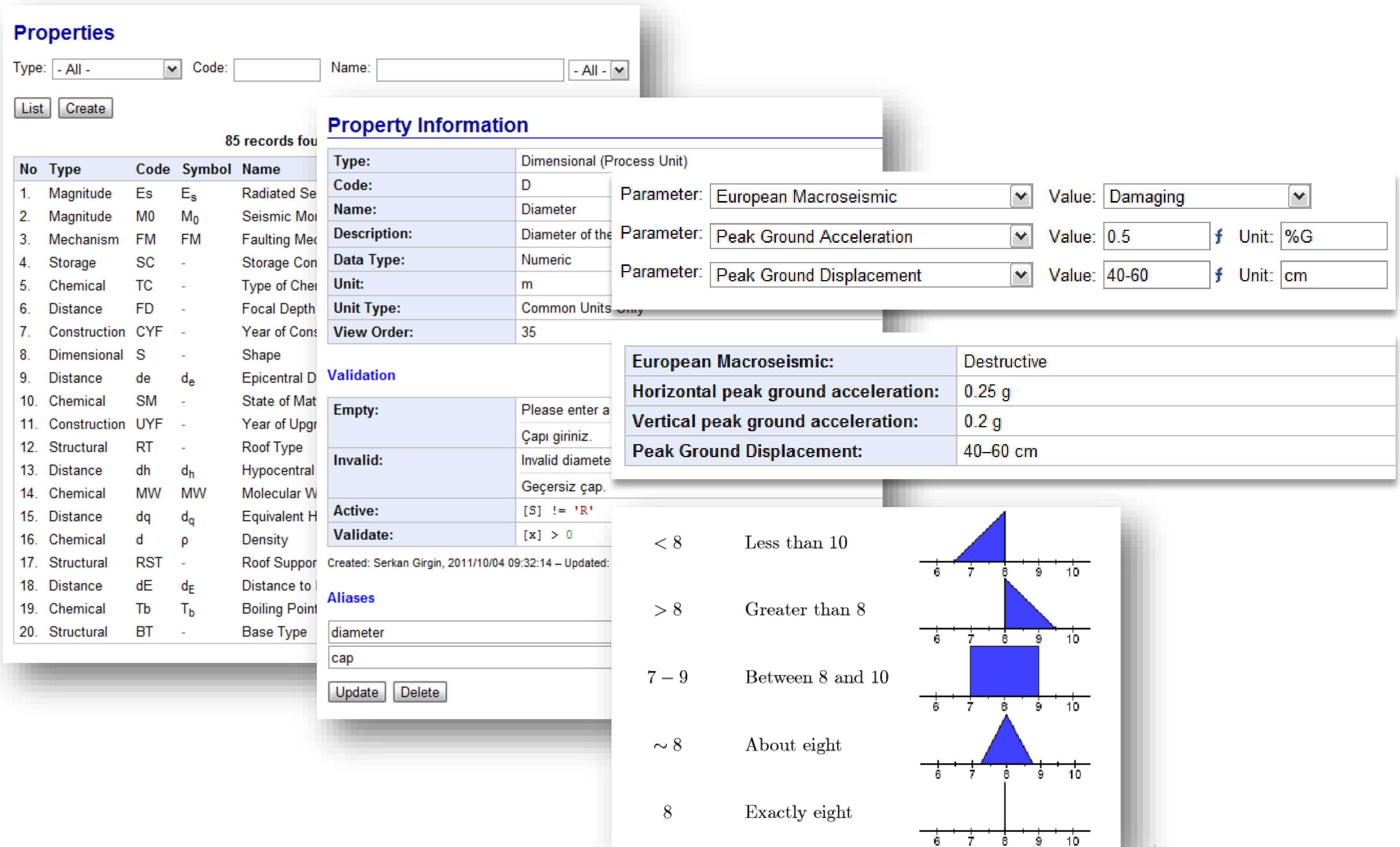
Scientific Module



Scientific Module



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Scientific Module

Update Property Estimator

Property: Peak Ground Acceleration *

Type: Function *

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

Duration of fireball	} else {
	return 2.6·*pow*([QFL:kg],1/6);
	}
		s	Fire/Explosion Event = *BLEVE*

Properties

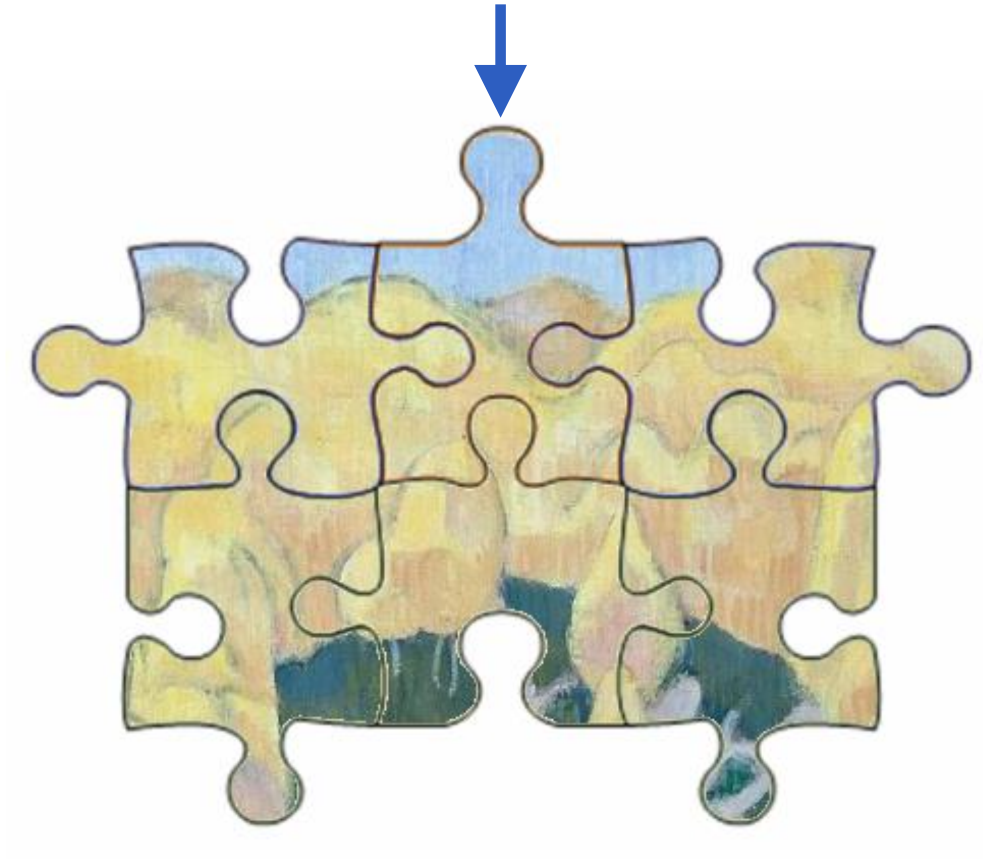
Storage Condition:	Atmospheric
Shape:	Cylindrical Vertical
Roof Type:	Floating Roof
Construction Material:	Steel
Volume:	22285 m³ *
Height:	14.00 m *
Diameter:	147.64 ft (45.00 m)
H/D Ratio:	0.3114 m/m *
Fill Level:	85 %v *

References

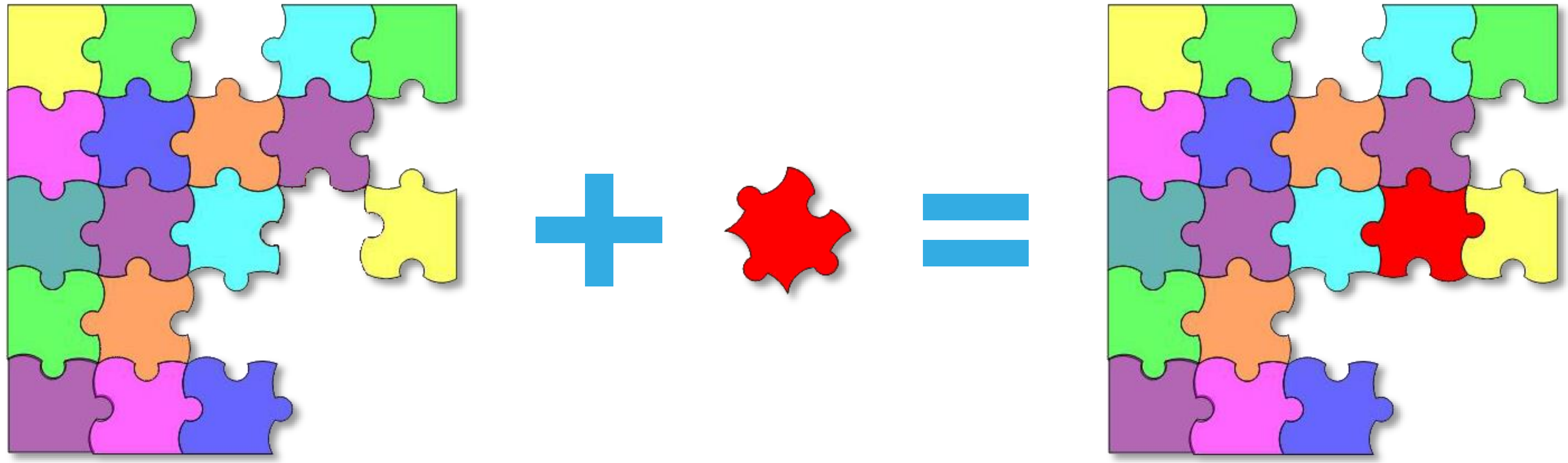
1. Margaris, B.; Papazachos, C.; Papaioannou, C.; Theodulidis, N.; Kalogeras, I.; Skarlatoud
attenuation relations for shallow earthquakes in Greece", 2002 *

Property Estimation Framework

Estimated property



Property Estimation Framework



Building Blocks

Tool Kit

Model

Property Estimation Framework

- Minimizes data input
  - **Estimates missing data**
- Provides extensibility
  - **Custom properties**
  - **Custom estimators**
- Increases flexibility
  - **Dynamic model building**
    - Uses most suitable estimators
    - Recursively
    - Exhaustively

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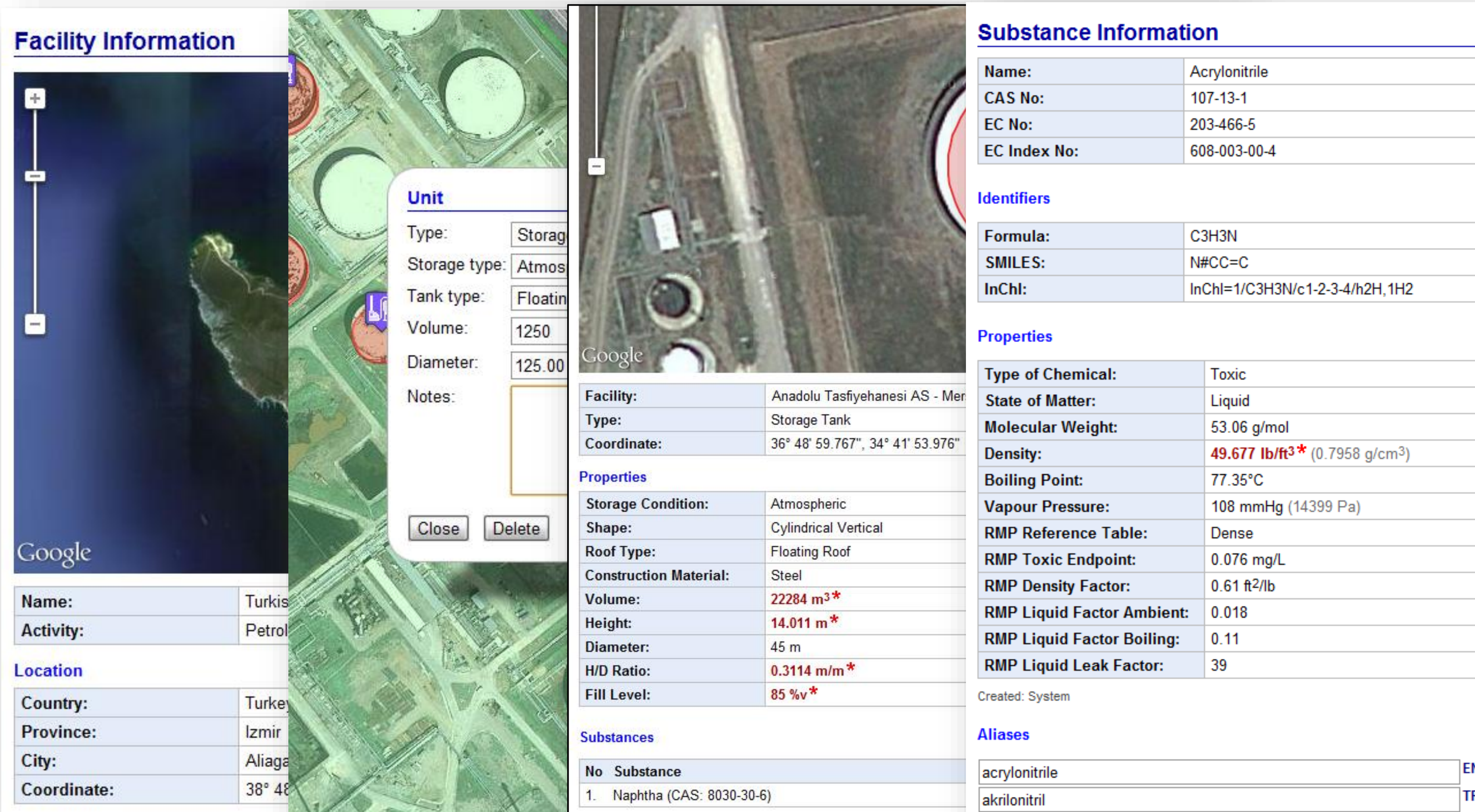
Plants Module



Facility Information

Name:	Turkis
Activity:	Petrol

Location

Country:	Turkey
Province:	Izmir
City:	Aliaga
Coordinate:	38° 48

Unit

Type:	Storag
Storage type:	Atmos
Tank type:	Floatin
Volume:	1250
Diameter:	125.00
Notes:	

Close Delete

Facility:	Anadolu Tasfiyehanesi AS - Mer
Type:	Storage Tank
Coordinate:	36° 48' 59.767", 34° 41' 53.976"

Properties

Storage Condition:	Atmospheric
Shape:	Cylindrical Vertical
Roof Type:	Floating Roof
Construction Material:	Steel
Volume:	22284 m^3 *
Height:	14.011 m *
Diameter:	45 m
H/D Ratio:	0.3114 m/m *
Fill Level:	85 %v *

Substances

No	Substance
1.	Naphtha (CAS: 8030-30-6)

Substance Information

Name:	Acrylonitrile
CAS No:	107-13-1
EC No:	203-466-5
EC Index No:	608-003-00-4

Identifiers

Formula:	C3H3N
SMILES:	N#CC=C
InChI:	InChI=1/C3H3N/c1-2-3-4/h2H,1H2

Properties

Type of Chemical:	Toxic
State of Matter:	Liquid
Molecular Weight:	53.06 g/mol
Density:	49.677 lb/ft^3 * (0.7958 g/cm^3)
Boiling Point:	77.35°C
Vapour Pressure:	108 mmHg (14399 Pa)
RMP Reference Table:	Dense
RMP Toxic Endpoint:	0.076 mg/L
RMP Density Factor:	0.61 ft^2/lb
RMP Liquid Factor Ambient:	0.018
RMP Liquid Factor Boiling:	0.11
RMP Liquid Leak Factor:	39

Created: System

Aliases

acrylonitrile	EN
akrilonitril	TR

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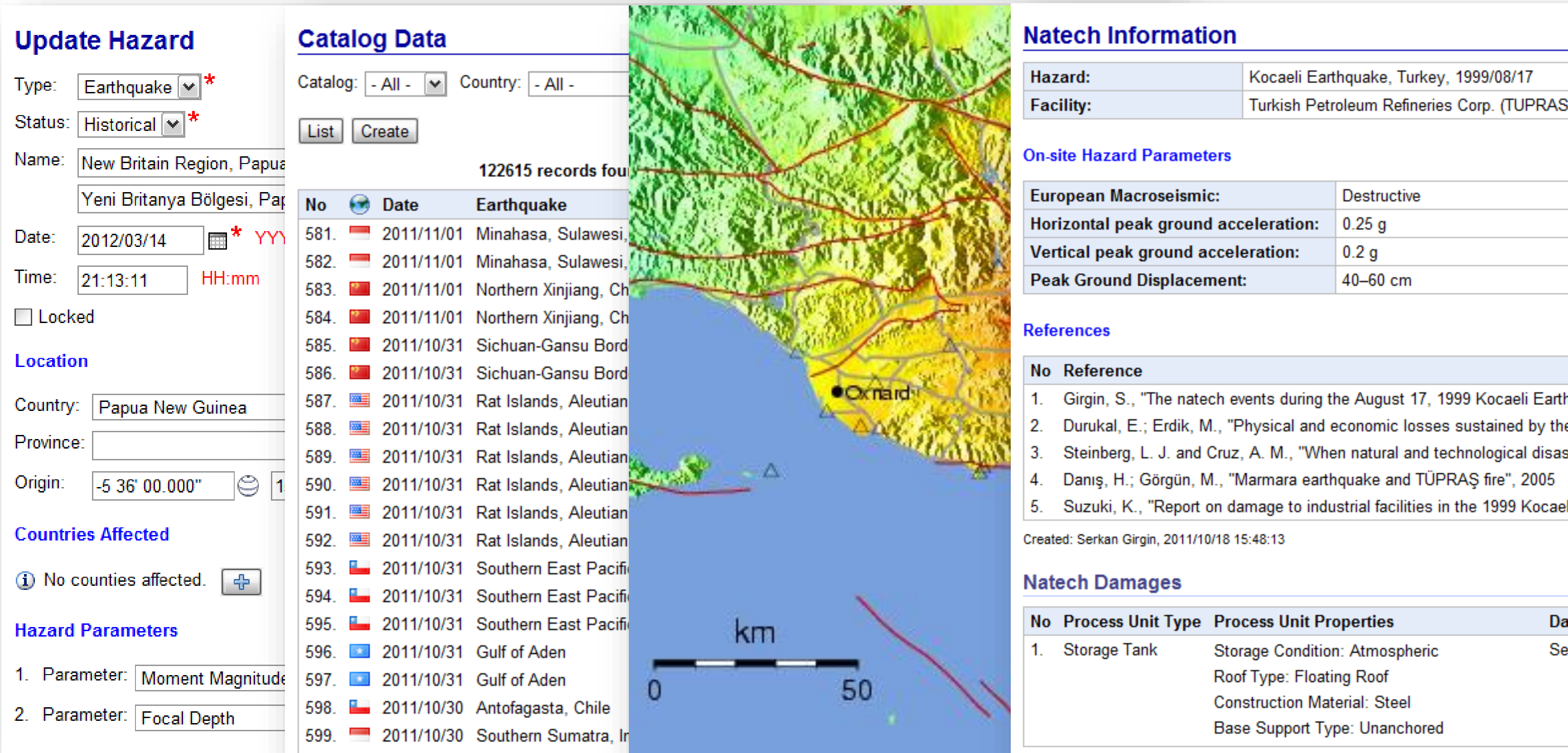
Hazards Module



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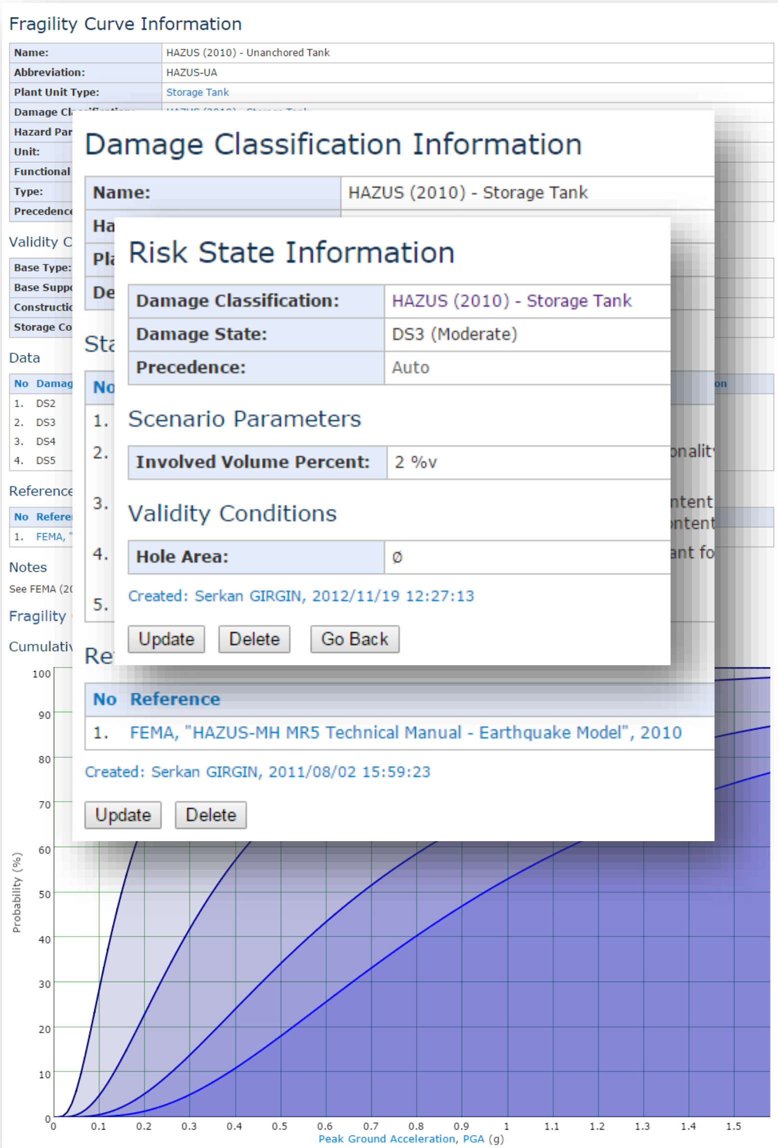
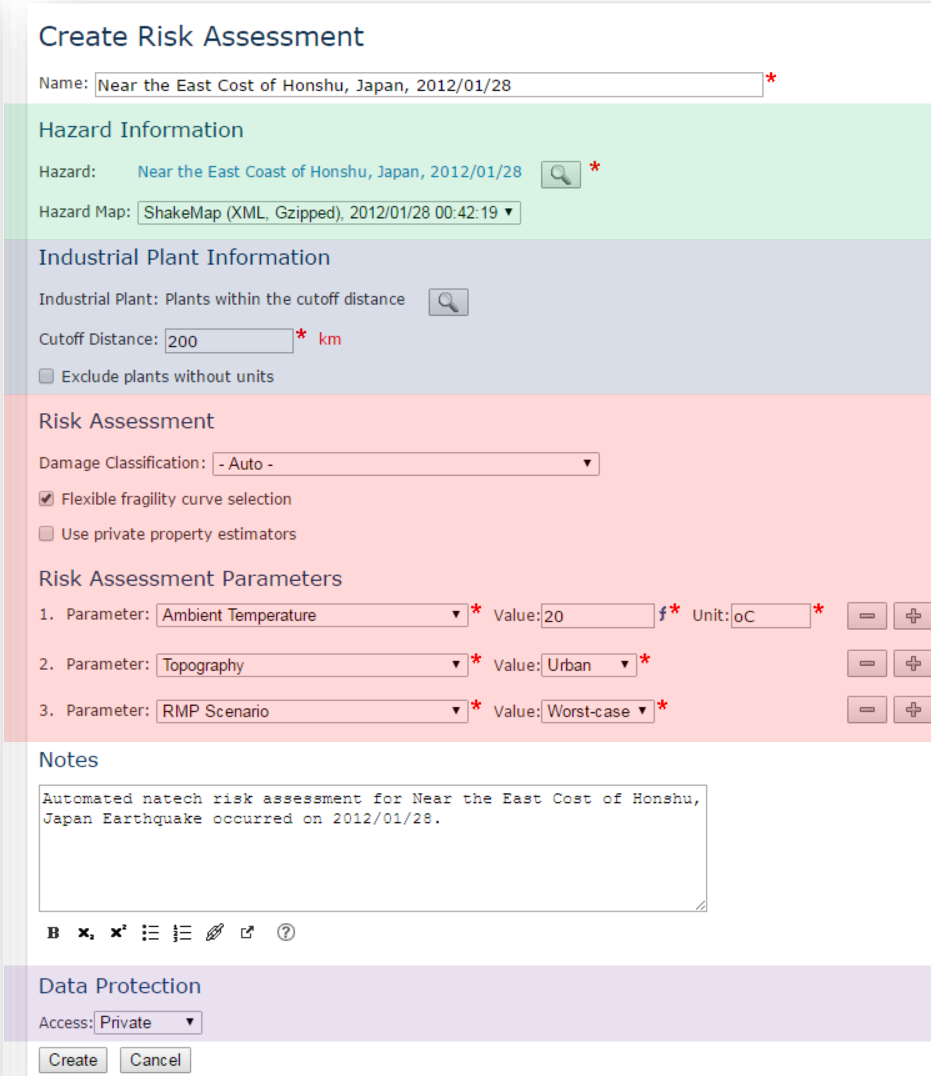
Risk Assessment Module





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Risk Assessment

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:	[illegible] Power Plant, Turkey

Damage Estimation

Damage Classification:	Auto
Flexible fragility curve selection:	Yes

Facilities

1. [illegible] 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; T_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	-	-

Data Availability

- Global coverage
- > 21,000 earthquakes (> M 5.5)
- > 56,700 earthquake catalog data
- > 12,000 ShakeMaps
- > 5,500 industrial facilities*
  - **Refineries**
  - **Power plants**
- > 64,500 plant units*
  - **Storage tanks**

* Not publicly available

Data Availability

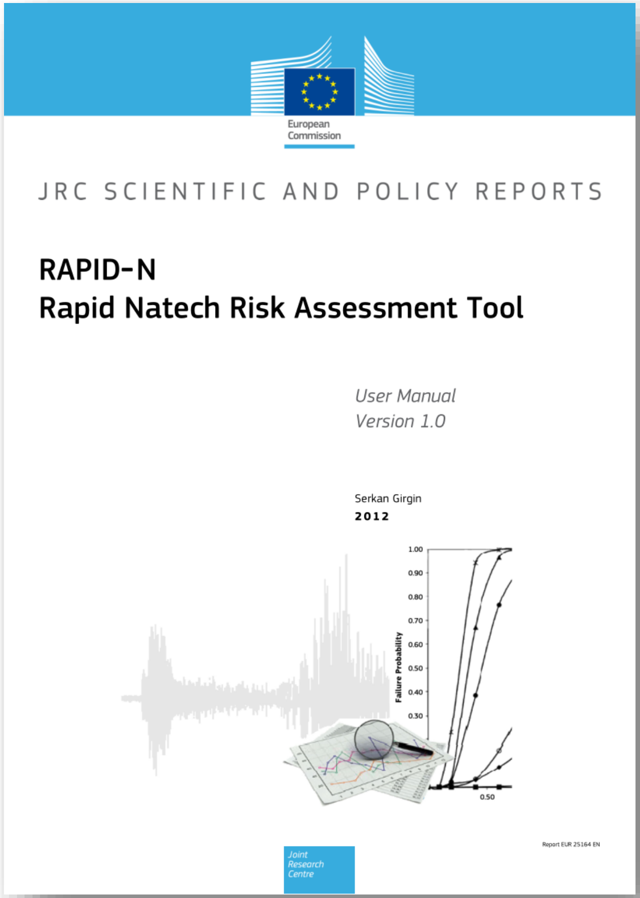
- > 375 properties
- > 590 property estimators

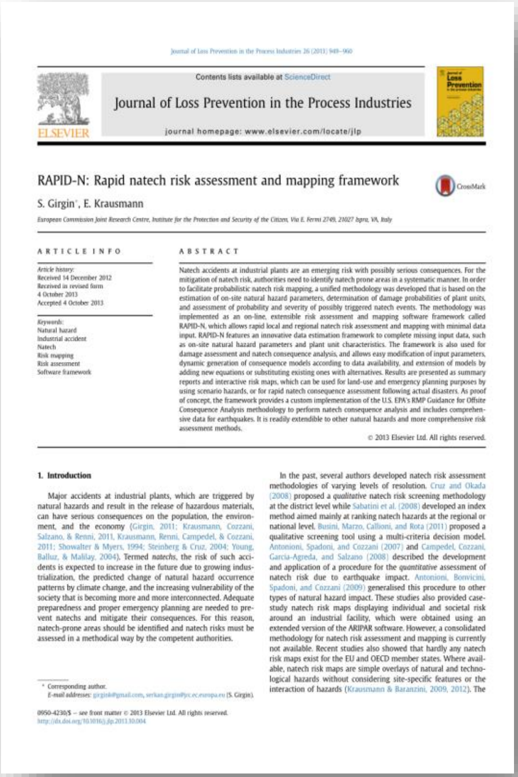
- Implemented methodologies
  - **U.S. EPA RMP Offsite Consequence Analysis** (U.S. EPA, 1999)
  - **Preliminary Natech Risk Assessment in Urban Areas** (Cruz and Okada, 2008)

Consequence models

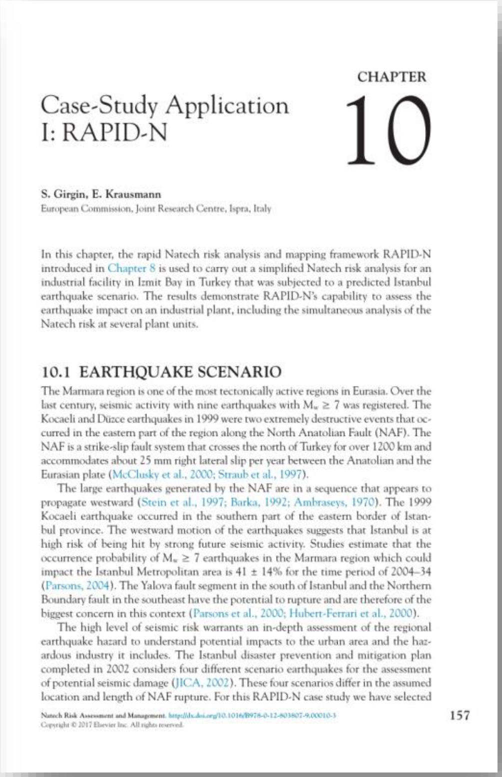
- Source term
  - Instantaneous release
  - Release from a hole
  - Pool Evaporation
- Atmospheric dispersion
  - Based on U.S. EPA ALOHA model
  - Bouyant / Dense
  - Rural / Urban
  - D stability, 3.0 m/s wind / F stability, 1.5 m/s wind
  - Chemical-specific: Ammonia, Chlorine, Sulfur Dioxide
- Fire/Explosion
  - Vapor Cloud Fire
  - Pool Fire (Point source, Solid-surface)
  - BLEVE
  - Vapor Cloud Explosion (TNT-equivalent, Multi-energy)

Resources





doi:10.1016/j.jlp.2013.10.004



doi:10.1016/B978-0-12-803807-9.00010-3

rapidn.jrc.ec.europa.eu/media/references/RAPID-N_Manual_1-0.pdf

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Application Areas

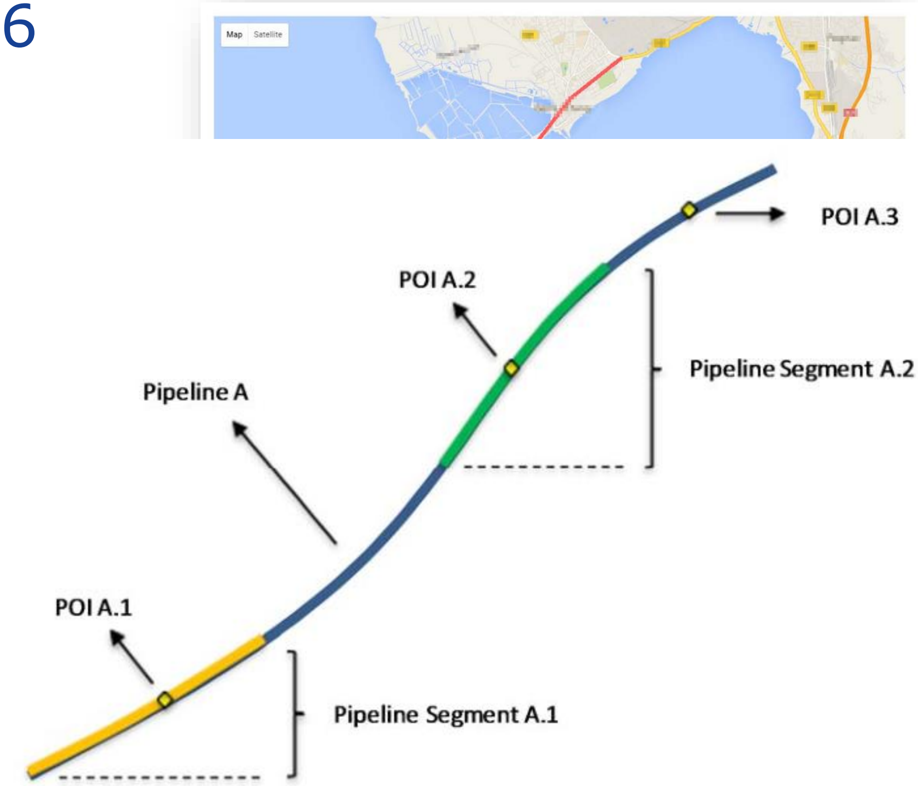
- Rapid local and regional natech risk analysis
- Land-use and emergency planning
- Identification of infrastructures at risk
- Preliminary damage and consequence assessment
- Early warning

Ongoing and Future Research

- Extension to other natural hazards (**Floods, Lightning**)
- Extension to other industrial facilities (**Pipelines**)
- Automated Natech damage and consequence assessment (**Natech Alert**)
- Multiple-scenario analysis
- Integration with ADAM
- Domino effects
- Consideration of risk receptors
- Statistical analysis of natech data (**Fragility Functions**)

Pipeline Natech Risk Assessment

- Prototype completed in 2016
  (JRC Technical Report JRC101463)
- Pipeline-specific entities
  - **Pipeline**
  - **Pipeline Segment**
  - **Point of interest (POI)**
- Pipeline-specific data
  - **Damage states**
  - **Fragility functions**
  - **Properties**
  - **Property estimators**

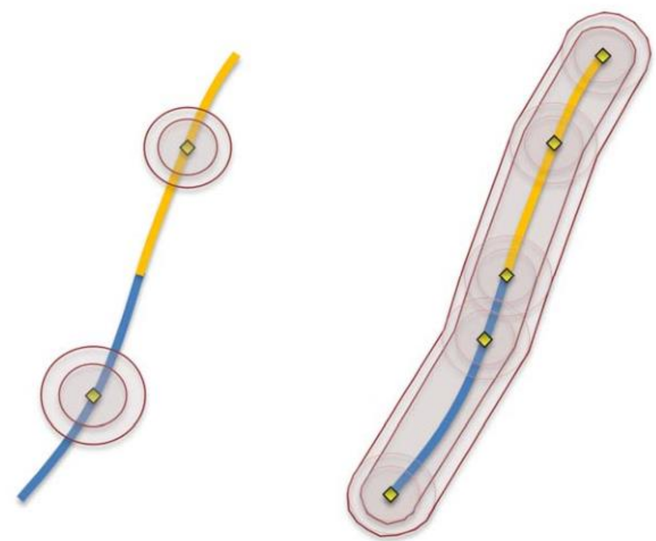


Pipe Specification:	API 5L
Pipe Location:	Underground*
Number of valve sites:	1
Average distance between valve sites:	2.2902 km*
Maximum Allowable Operating Pressure:	1351.5 psi*
Maximum Operating Pressure:	1351.5 psi*
Safe Operating Pressure:	1486.7 psi*
Nominal Capacity:	7000 barrel/d* (1112.9 m^3/d)

Pipeline Natech Risk Assessment

- Pipeline-specific features
  - **Overlapping segments**
  - **Auto-segmentation**
  - **Automated POI generation**
  - **Impact zone consolidation**

Pipeline A	Segment A.1	Segment A.2	Final Pipeline Segmentation
Diameter: 14” Cover depth: 2 m Topography: Rural NEHRP Site Class: C			14”, 2 m cover, Rural, NEHRP Class C
	Topography: Urban NEHRP Site Class: D		14”, 2 m cover, Urban, NEHRP Class D
		Cover depth: 3 m	14”, 3 m cover, Urban, NEHRP Class D
			14”, 3 m cover, Rural, NEHRP Class C
			14”, 2 m cover, Rural, NEHRP Class C



Hazard Parameter	POI 1	POI 2
Epicentral distance	33.7 km	42.8 km
Hypocentral distance	95.2 km	98.8 km
Modifie		
Europe		
Instrui		
Peak g		
Horizo		
Peak g		

Damage and Consequence Parameter	POI 1	POI 2
Damage probability, = RS1 (limited loss)	$1.7 \cdot 10^{-4}$	$1.3 \cdot 10^{-4}$
Damage probability, = RS2 (significant loss)	$8.1 \cdot 10^{-11}$	$2.1 \cdot 10^{-11}$
Release rate	5.3 kg/s	5.3 kg/s
Maximum pool diameter	11 m	11 m
End-point distance (5 kW/m²)	27 m	27 m

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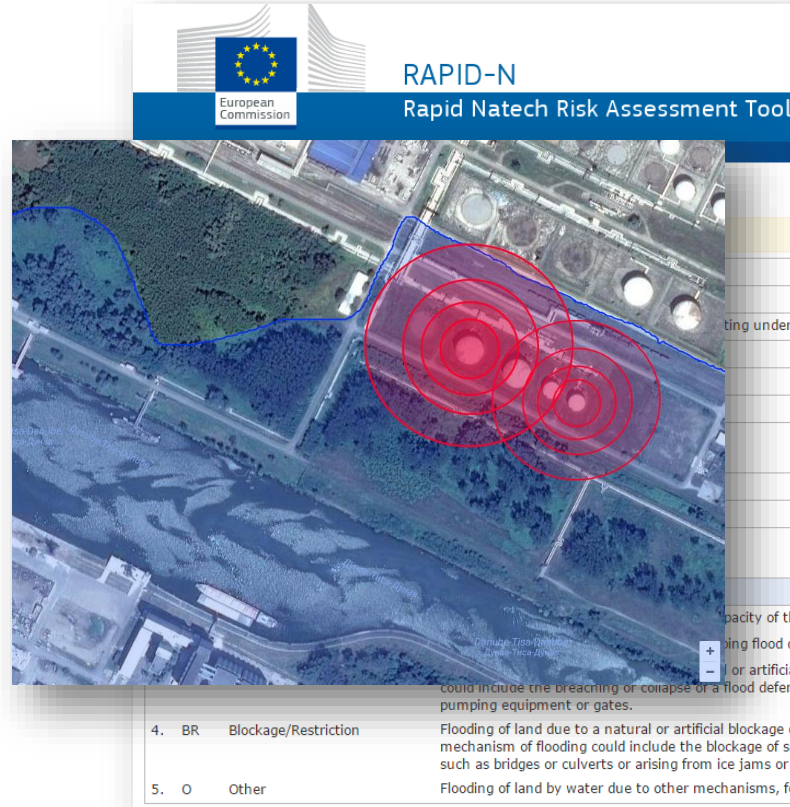
Flood Natech Risk Assessment

- 1st phase completed in 2016
  (MAHB-ECHO AA 2015-2016)

- Collection of scientific and technical knowledge
  - **Methodologies**
  - **Hazard data sources**
  - **Equipment vulnerability**
  - **Consequence analysis**

- Gap analysis
  - **Modifications**
  - **Further development**



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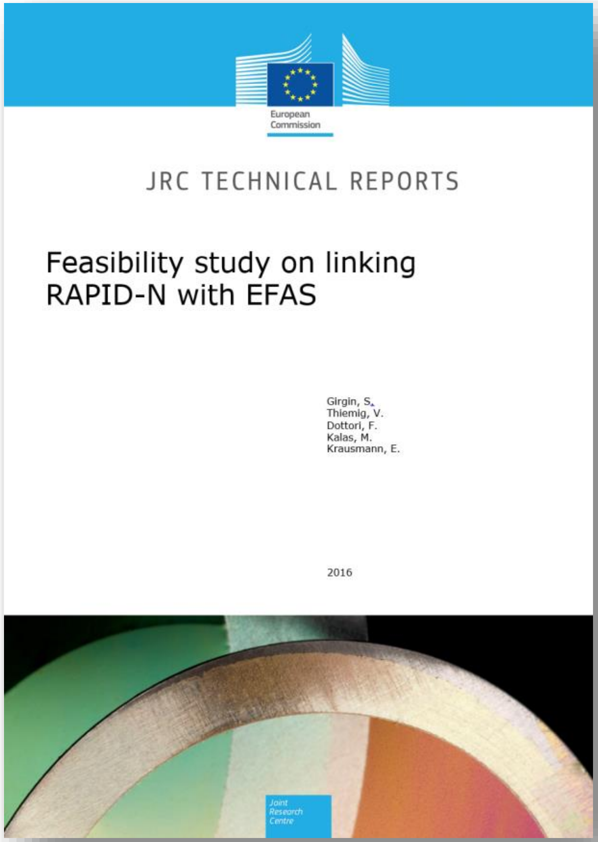
Flood Natech Risk Assessment

- EFAS/RAPID-N interoperability
  (JRC Technical Report JRC105055)
- Benefits
  - **Flood hazard data for natech risk assessment**
  - **Natech risk data for emergency management**
  - **Flood forecasts → Natech Alert**
  - **Data sharing between JRC systems**



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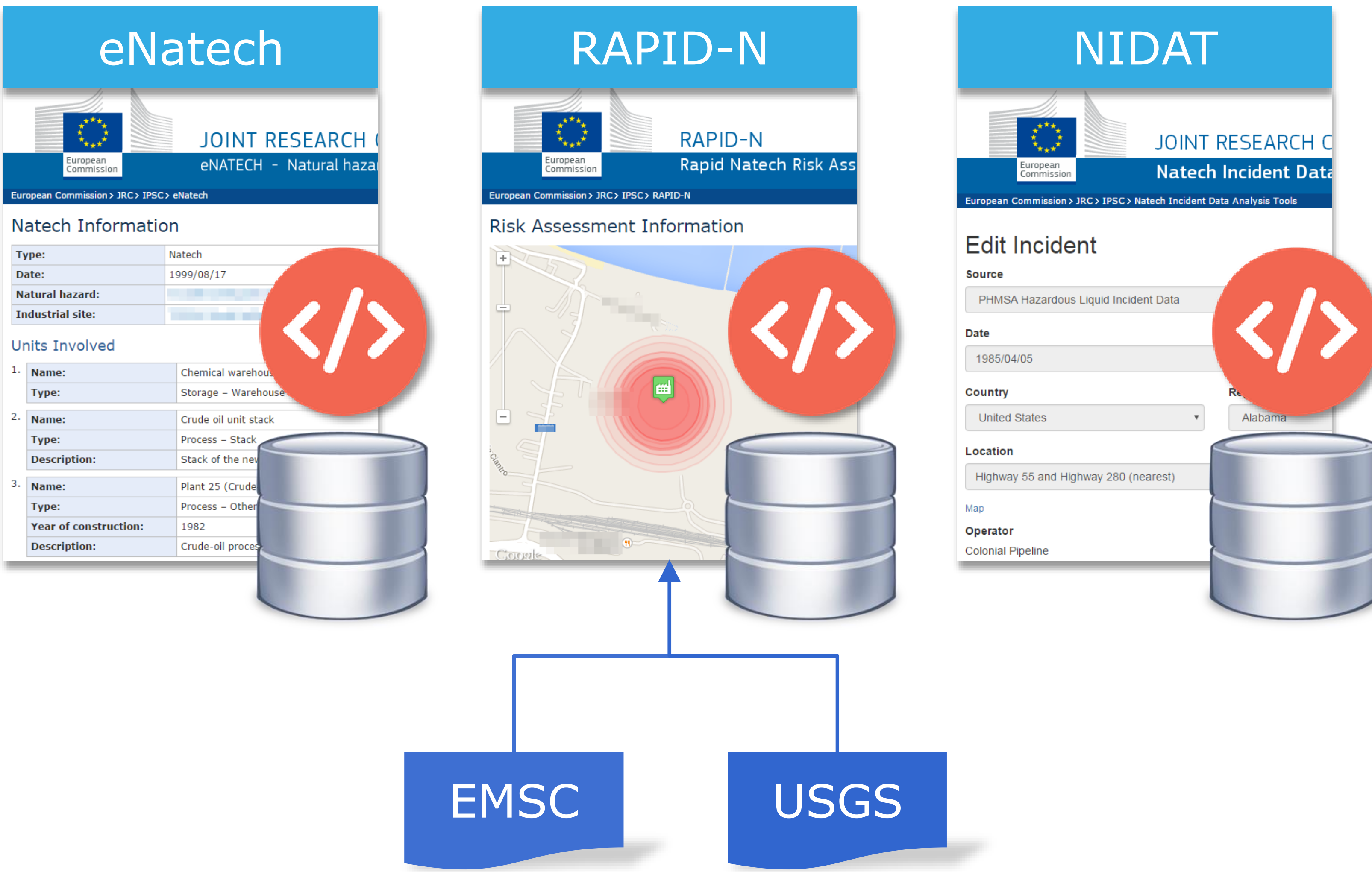
Today


eNatech
JOINT RESEARCH
eNATECH - Natural haza
European Commission > JRC > IPSC > eNatech
Natech Information
Type: Natech
Date: 1999/08/17
Natural hazard:
Industrial site:
Units Involved
1. Name: Chemical warehou
Type: Storage – Warehouse
2. Name: Crude oil unit stack
Type: Process – Stack
Description: Stack of the ne
3. Name: Plant 25 (Crude
Type: Process – Other
Year of construction: 1982
Description: Crude-oil proces
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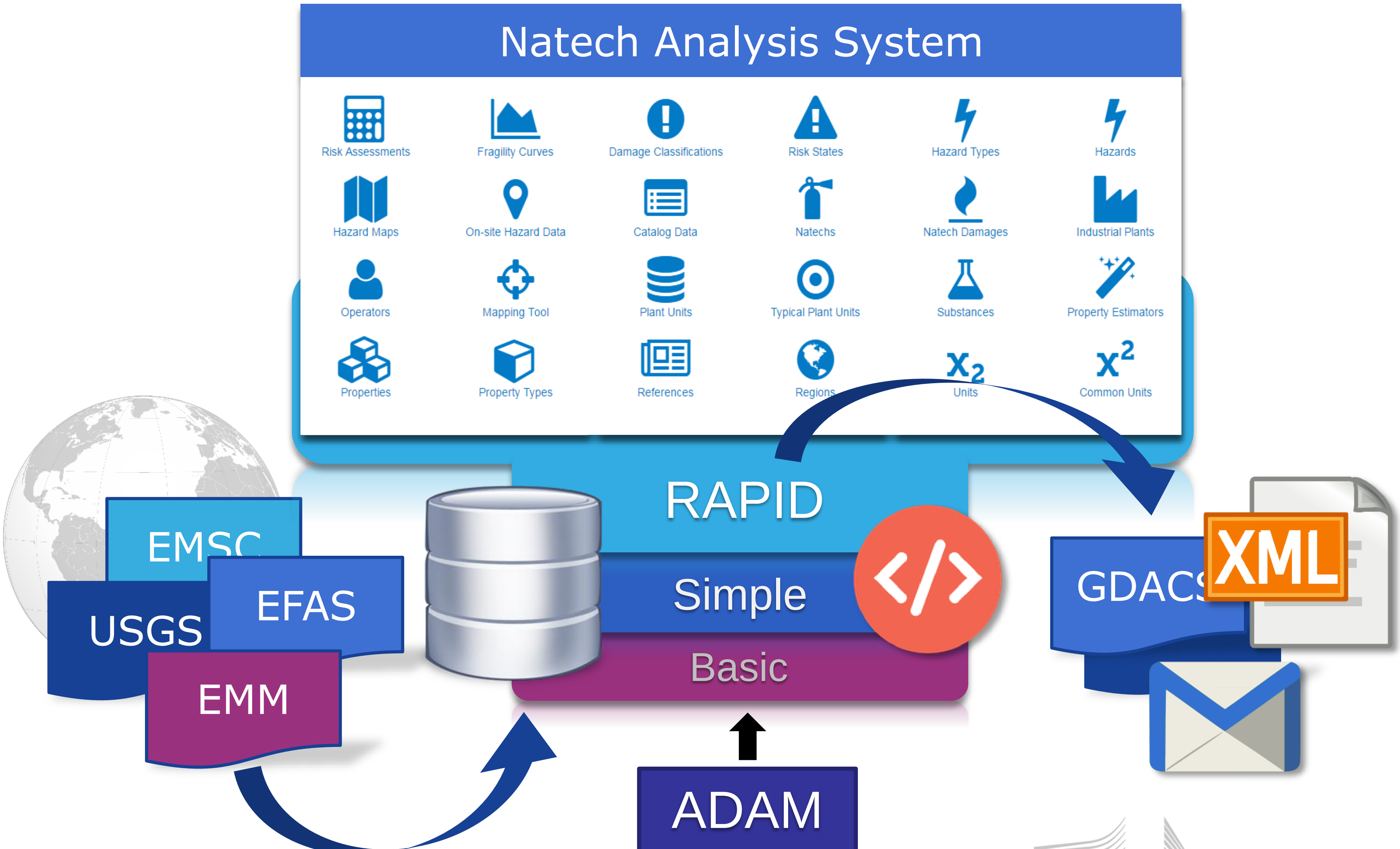
Rapid Natech Risk Ass
European Commission > JRC > IPSC > RAPID-N
Risk Assessment Information
NIDAT
JOINT RESEARCH C
Natech Incident Data
European Commission > JRC > IPSC > Natech Incident Data Analysis Tools
Edit Incident
Source
PHMSA Hazardous Liquid Incident Data
Date
1985/04/05
Country
United States
Alabama
Location
Highway 55 and Highway 280 (nearest)
Map
Operator
Colonial Pipeline
EMSC
USGS

Outlook



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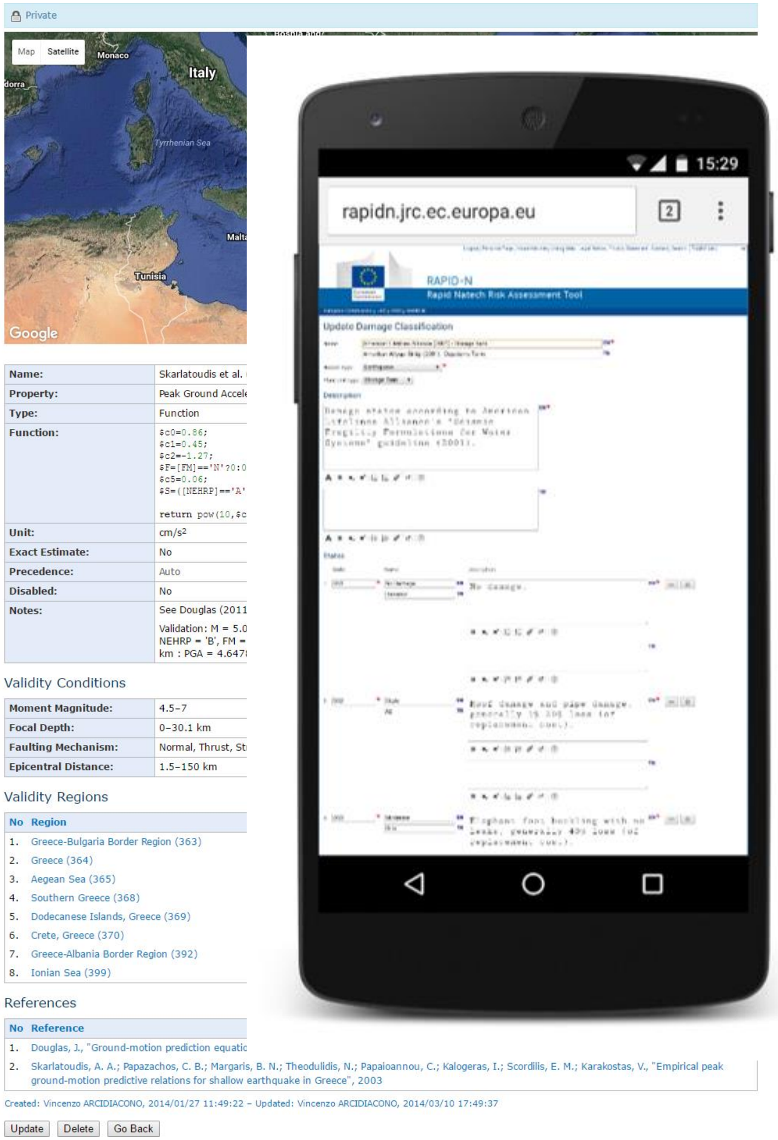
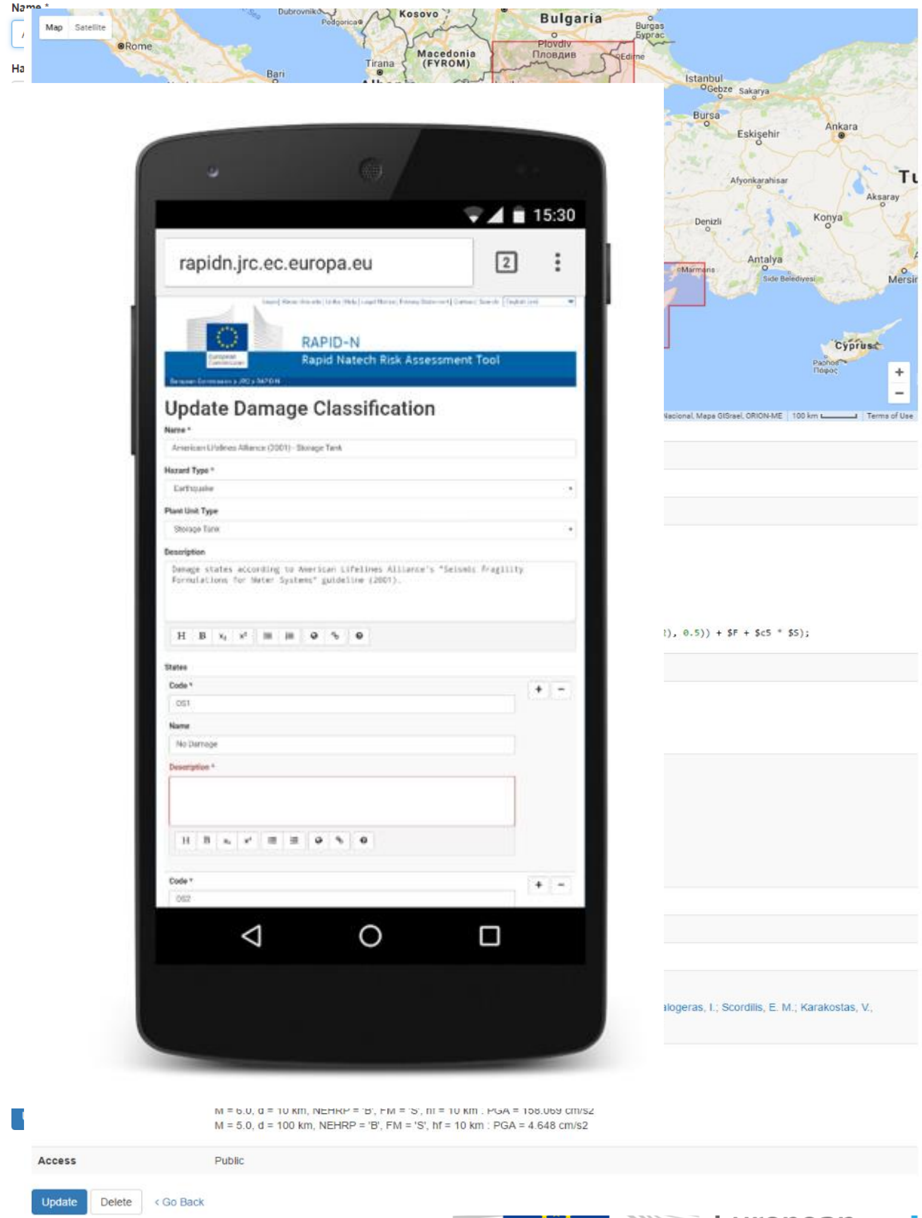
New Version

- Prototype is completed (NATECH WPK 984)
- Features
  - **Object-oriented code base**
    - Fully documented
  - **Modern architecture**
    - Stand-alone data definition/estimation framework
    - Data abstraction layer (advance query, DB-independent)
    - Simplified record definition syntax
  - **Improved user interface**
    - Responsive
    - Mobile friendly
  - **Advance data estimation/analysis**

New Version





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RAPID-N

- Integrated natech risk assessment framework
- User-friendly interface
- Publicly available **(web application)**
- Rapid regional and local analysis
- Ready-to-use data
- Data estimation **(minimum data input)**
- Extensible structure **(easily customizable)**
- Dynamic model building
- Regularly updated

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eNatech

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TecRisk

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