Beyond Industrial Boundaries: Territorial Resilience in Natech Risk Management

La gestione del rischio Natech

Tzioutzios Dimitrios

Department of Mechanical and Industrial Engineering (MTP)

Norwegian University of Science and Technology (NTNU)

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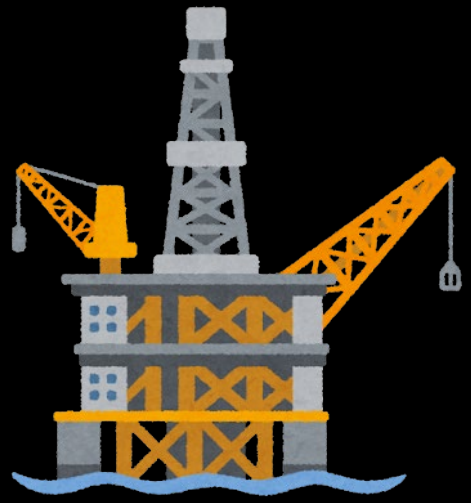
Norwegian University of Science and Technology

NTNU

Outline

- *Resilience Engineering in Process Industries*
- *Comprehensive Natech Risk Management Approach*
  - *Infrastructure*
  - *Organisation and Management*
  - *Risk Communication and Governance*
  - *External Environment*
- *Outlook*



Introduction

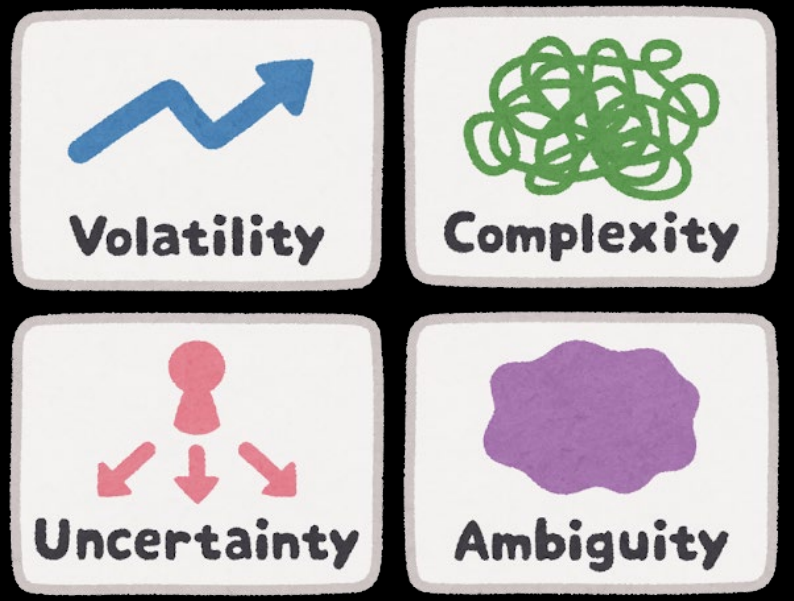
- Addressing ***safety*** in complex ***socio-technical systems*** in the process industries *(Shirali et al., 2016)*

Challenge

- Limitations of ***traditional risk analysis*** and ***probabilistic safety assessments***

Approach

- Emergence of ***Resilience Engineering (RE)*** as a new research field at the turn of the century



(Shirali et al., 2016)

Concept of Resilience

Definition (Aven, 2011)

- "the ability of a system to ***withstand*** a ***major disruption*** within ***acceptable degradation parameters*** and to ***recover*** within an ***acceptable time***, and composite ***costs***, and ***risks***" *(Aven, 2011)*
- Important implications for ***hazardous facilities***, such as ***chemical*** and ***petrochemical industries***

Application of RE in the Process Industries

- ***Goal***: Improve ***capacity*** to ***adapt*** to ***emerging risks*** and ***manage*** inherently ***risky systems***
- ***Focus***: ***Risk contributors*** like ***process failures***, ***organisational issues***, and ***human performance***
- Continuous ***Monitoring***: Essential due to omnipresent ***environmental changes*** *(Bergström van et al. 2015)*

Critique of Resilience Approaches

Focus on Individual Installations

- ***Overlooked*** Aspects: Crucial ***interconnections*** between ***organisational***, ***infrastructural***, ***environmental***, and ***community*** resilience
- Importance of ***Integration***: Necessary for ***comprehensive risk governance*** and managing ***complex***, ***nonlinear interactions*** within systems
- ***Gaps*** in ***Planning***: ***Business continuity*** and ***recovery plans*** often lack consideration of these interconnections *(Baba et al. 2014)*
- ***Natech*** Risks: Emphasis needed on ***area-wide risk assessments*** *(Krausmann et al., 2017; OECD, 2023)*
  - ***Growing populations*** and ***industrialisation*** in ***areas prone*** to natural hazards

Integrative Framework Components

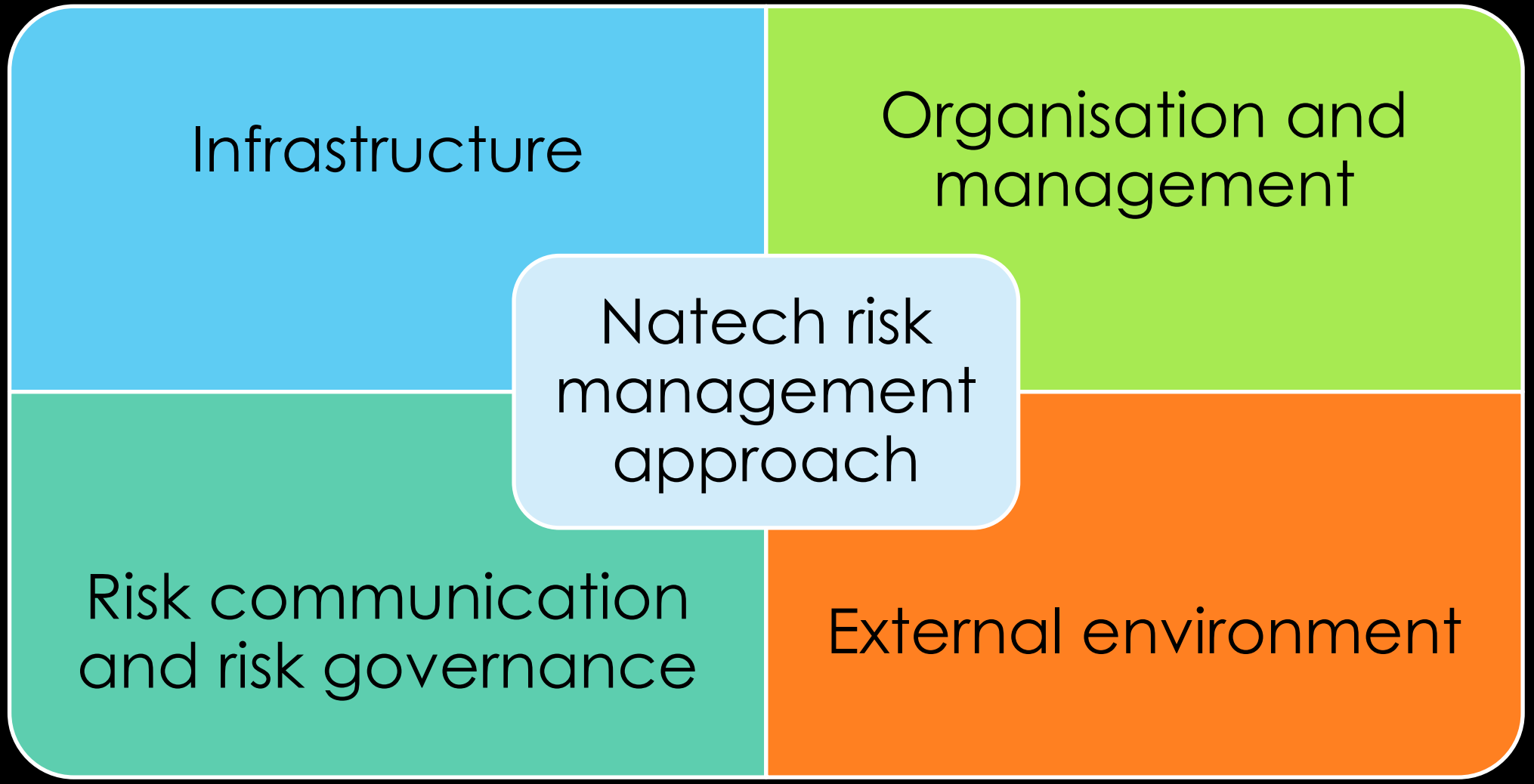
Resilience in Process Safety

- ***Ability*** to ***prevent*** and ***mitigate accidents*** affecting ***facility integrity*** *(Salzano et al., 2014)*
- Importance of ***Prevention*** and ***Preparedness***
- Equally vital as ***post-impact response*** and ***recovery strategies***

Comprehensive Risk Management Framework

- Interaction of ***socio-technical systems*** (technical and organizational components)
- ***Governance***, ***risk communication*** and ***community participation***
- Surrounding ***environment*** and ***assets***
- ***Purpose***: ***Evaluate industrial sites' performance*** in Natech scenarios

NATECH RISK MANAGEMENT FRAMEWORK (SUAREZ-PABA ET AL., 2020; 2022)



INFRASTRUCTURE – I

Severe Consequences

- Natech accidents severely impact physical infrastructure
  - i) ***Process equipment***, ii) ***building infrastructure*** and iii) ***internal utilities***

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Risk Assessment Methodologies

- Focus on ***securing industrial process equipment*** to ***prevent*** hazardous material ***releases*** *(ANTONIONI ET AL. 2007; NECCI ET AL. 2013; LANDUCCI ET AL. 2016)*
  - Various ***methodologies*** depending on the ***hazard type*** (mostly on earthquakes and floods)
  - Important to also ***consider building infrastructure*** and ***internal utilities*** for ***overall resilience*** *(COOK ET AL. 2017; MUKHERJEE ET AL. 2018)*

1 KRAUSMANN ET AL. (2017)*

Infrastructure – II

Mitigation Strategies

- Continuously revise and apply ***building standards*** *(Krausmann & Necci, 2021)*
- ***Backup systems*** for essential services (e.g., water, electricity, communications) *(Krausmann & Necci, 2021)*
- ***Reliability*** of the ***technical safety barriers*** in the aftermath of the natural hazard *(Misuri et al., 2020)*

Evaluation

- Analyses potential ***accident scenarios*** using ***screening methods***, ***checklists***, and ***rating systems*** to assess ***readiness*** and ***impact*** on ***casualties***, ***downtime***, and ***financial losses***

Organisation and Management – I

Human/Organisational Factors

- ***Often neglected*** in ***'traditional'*** risk assessments *(Jain et al. 2018)*
  - ***Integrative socio-technical*** approach is crucial for effective ***hazard identification*** and ***prevention***
- Impacts from Natech accidents extend beyond physical damage, ***affecting operational continuity***
  - e.g., from ***indirect damages*** and ***operational issues*** causing additional losses to ***critical service interruptions*** and ***business disruption***

Organisation and Management – II

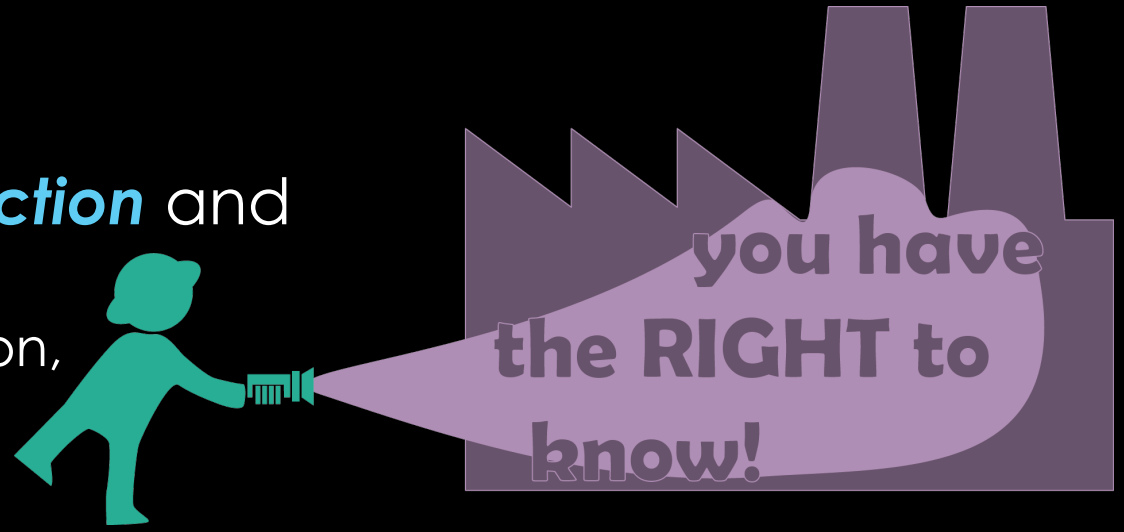
Organisational Resilience

- ***Planning*** and ***adaptive capacity*** are vital for ***mitigating disaster effects*** and ***ensuring business continuity*** *(Stephenson et al. 2010)*
- Holistic risk management strategies enhance ***industrial adaptability*** and ***economic resilience***, fostering better ***disaster preparedness*** and ***recovery capacity*** *(Villa et al. 2016)*
  - Consistent focus on ***disaster preparedness*** and ***prevention***, ***emergency planning*** and ***business continuity plans***

Risk Communication and Governance – I

Risk Information Disclosure

- Increasing focus on ***disaster risk reduction*** and **open communication channels**
  - e.g., Seveso Directive, Aarhus Convention, Sendai Framework, OECD Guidelines



Risk Communication

- ***Effective***, ***two-way*** and ***ethical*** risk communication *(Tzioutzios et al. 2022)*
  - Basis of ***community right-to-know initiatives***
- ***Mutual learning process*** based on ***public concerns***; 'what people ***want*** to know' *(Renn & Klinke, 2015)*
- Community Preparedness: Prior chemical risk ***information disclosure*** enhances ***community disaster preparedness*** and ***informed decision-making*** *(Tzioutzios et al., 2022; Tzioutzios & Cruz, 2021)*

Risk Communication and Governance – II

Transparency

- ***Fosters trust*** and ***stakeholder cooperation***, essential for risk management and governance
  - Necessary for handling ***complex*** and ***uncertain risks***, requiring ***continuous dialogue*** and ***social learning*** *(Shimizu & Clark, 2019)*

Participatory Approaches

- Advocates for ***inclusive risk management*** involving all ***stakeholders***, promoting ***democratic decision-making*** *(Tzioutzios & Cruz, 2021)*
- ***Stimulating public discourse*** about risk: ***citizen forums***, negotiated ***rule-making exercises***, mediation or advisory ***committees***, including experts and stakeholders *(Renn, 2017; Renn & Klinke, 2013)*

External Environment – I

External Environment Components

- ***Territorial resilience elements*** broad categories
- ***External Secondary Hazards***
- ***External Lifeline Disruption***, and
- ***Community-Environment Interactions***

Natech Scenarios

- Industrial facilities' ***interaction*** with ***surroundings*** is important
  - Urban areas face heightened risk due to ***dense population*** and ***industry coexistence***
  - ***Poor community-industry interaction*** can lead to ***safety barrier failures*** (e.g., unaware public of chemical risks and protective measures)
- Existing ***methodologies focus*** on ***internal facility hazards***, neglecting surrounding environment impacts
- Risks from ***external cascading/domino effects*** often not systematically analysed due to data ***complexity*** and ***scarcity***

External Environment – II

- Natural disasters can ***damage access roads***, ***critical infrastructure***, ***delaying*** and ***complicating*** emergency ***response*** *(Salzano et al. 2013; Krausmann et al. 2017)*
- Natech events cause ***long-term economic effects***, including ***labour market changes*** in ***neighboring communities*** *(Ohtake, 2012)*

Wide-Area Planning

- Industrial facilities should develop ***emergency response plans*** considering conjoint scenarios of both ***natural disasters*** and ***technological accidents***
  - Beyond EQ and floods as per Seveso Directive, e.g. storm wind
- Need for ***systemic risk*** approaches *(Reniers and Cozzani 2013)* → Methodologies for ***addressing cascading multi-hazard risks*** in National Risk Assessment *(Girgin et al., 2019)*

Risk Influencing Factors

Risk Influencing Factor (RIF)

- *'an **aspect** of a system or an activity that **affects** the **risk level** of this system/activity' (Øien, 2001)*
  - ***Influence*** risk scenarios and ***inhibit*** the effective operation of ***barrier systems*** *(Sonnemans et al., 2010)*

Critical Lifelines: Natech Implications

- E.g., poor ***vegetation management*** along power grids *(Tzioutzios et al. 2023)*
- Sudden ***power outages*** can lead to hazardous material ***releases***
  - Even ***without direct impact*** from a natural hazard on in situ ***industrial equipment*** by disrupting operations
  - ***Unavailability*** of ***safety barriers*** when most needed
- Poor ***safety culture*** in the organisation/industrial sector

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1* https://www.clayjenkins.com/blog/electrocution-injuries-from-trees-contacting-power-lines-2

The Way Forward in Natech Resilience

Holistic Approach

- Emphasises the ***significance*** of ***comprehensive*** approaches in managing Natech accident risks

System Complexity

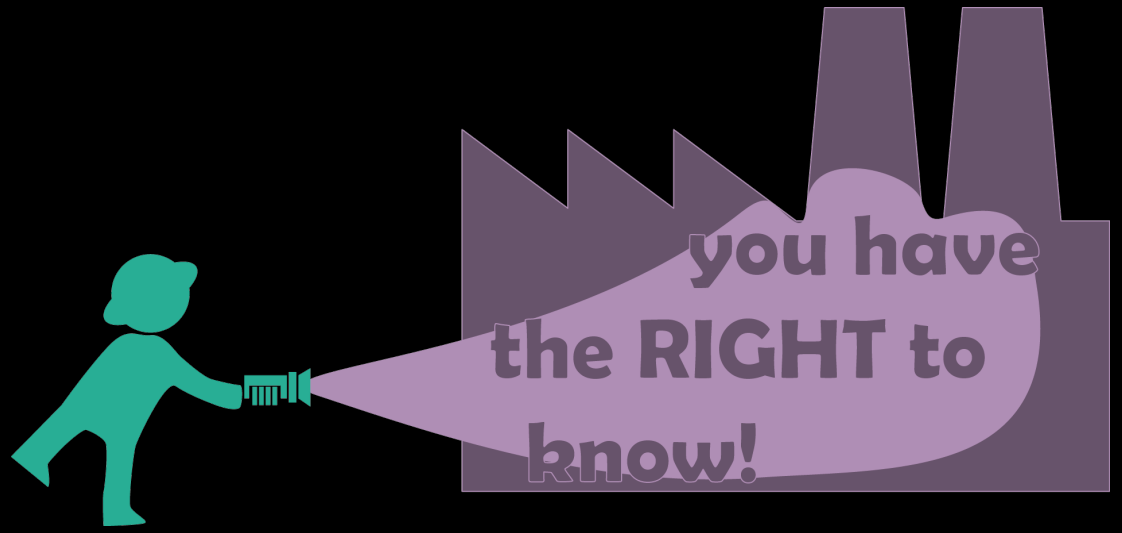
- Acknowledges the ***complexity*** of ***Natech accidents*** and the ***limitations*** of ***dissecting risks*** into ***individual components***

Comprehensive Understanding

- Highlights the need to understand the ***interactions*** and ***contextual settings*** of each ***component*** for effective risk assessment

Shifting Risk Management Perspectives

- ***Step forward*** rather than a definitive solution, paving the way for ***more sophisticated disaster resilience*** methods



TZIOUTZIOS DIMITRIOS

POSTDOCTORAL FELLOW

RELIABILITY, AVAILABILITY, MAINTAINABILITY AND SAFETY (RAMS) GROUP

DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING (MTP)

NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY (NTNU)

*SUSHY PROJECT (**sushyproject.com**)*

*E-MAIL: **dimitrios.tzioutzios@ntnu.no***

THANK YOU

ありがとう ございました

Tusen takk

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