Safety and Security i.r.t. Business Security within the Industry: Developing Resilience-Oriented Indicators for Integrated Safety and Security Risk Management

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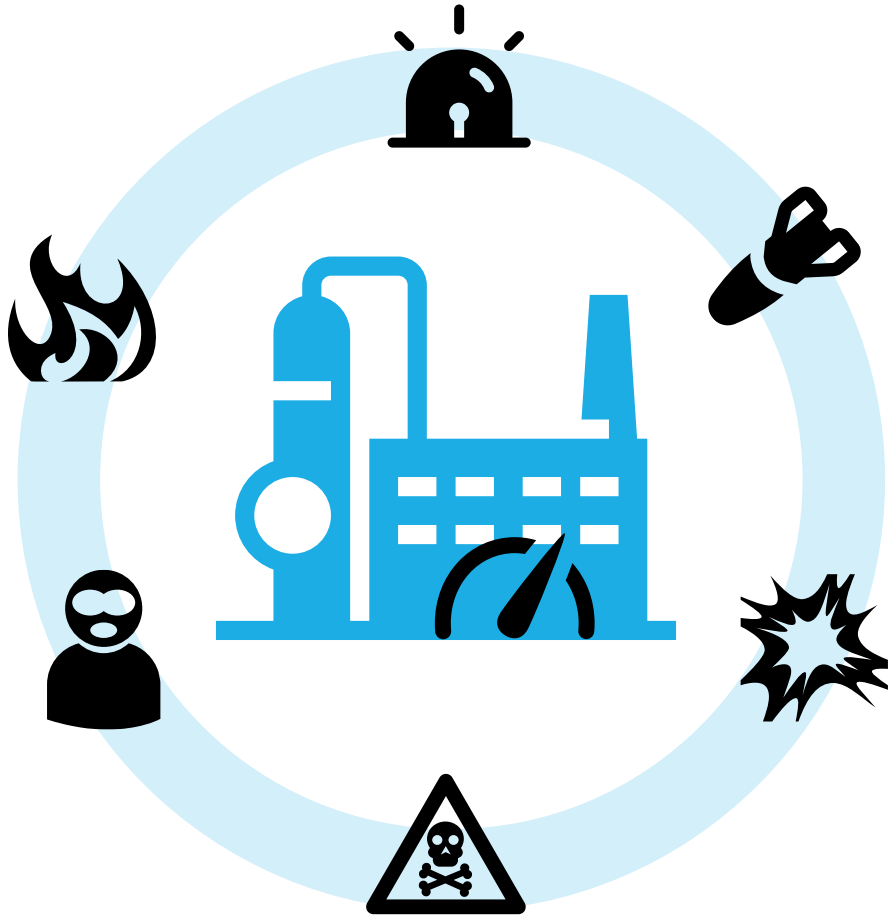
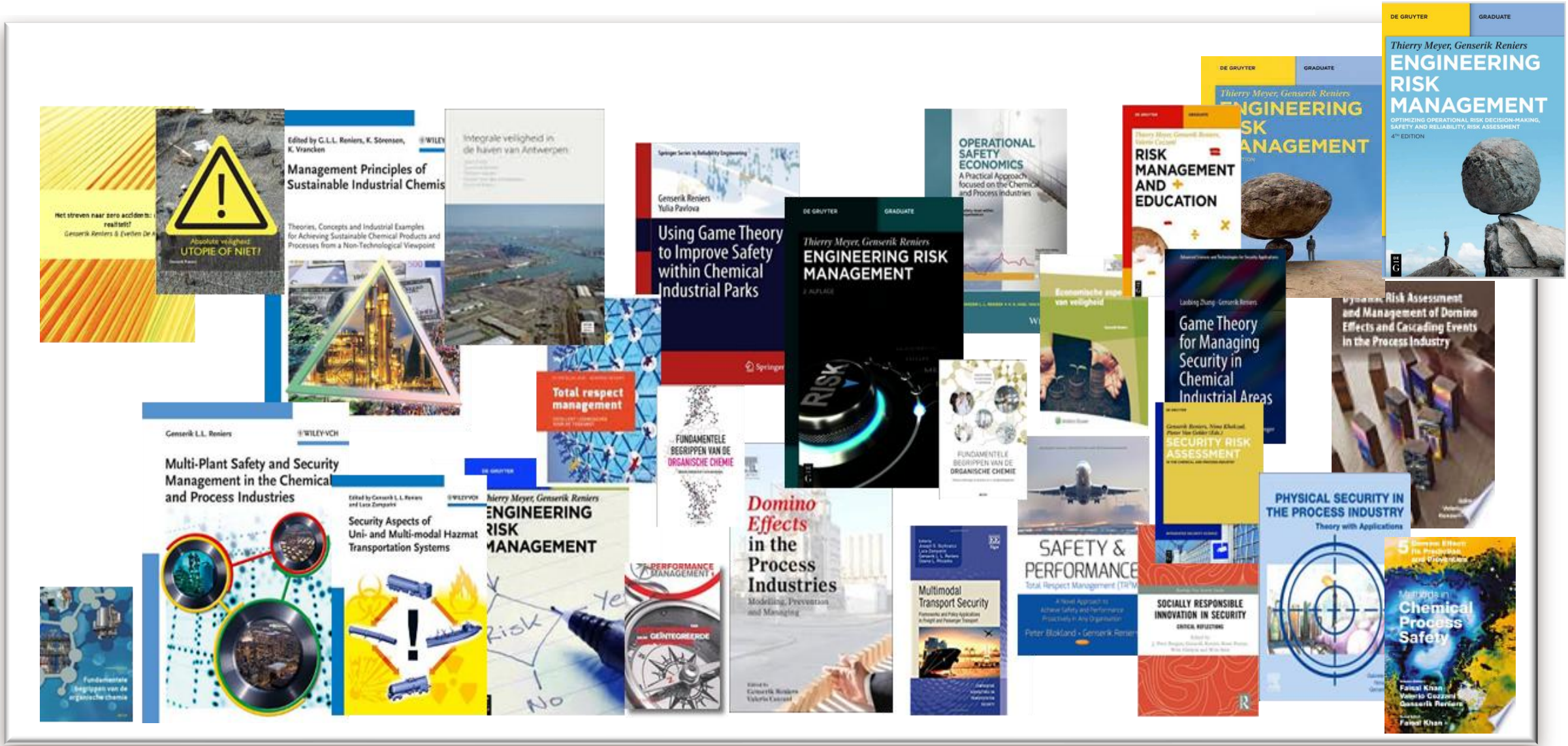
TU Delft Delft University of Technology



Who am I?

- Full Professor TUDelft (+ UA + KULeuven)
- Chair on Industrial Safety and Security
- Safety and Security Scientist
- Focus on industries using chemical substances
- Engineering & Technology
- Management & Economics
- Published about 40 books (author + editor)
- Published more than 350 scientific articles in peer-reviewed journals

Many books published…but not one on Resilience…nonetheless…



How for instance Nature-Driven Disasters Challenge Resilience Mgt – What seems to be the problem?

Imagine this:

- A **chemical plant hit by a flood** due to storm or tsunami (NaTech)
- **Performance** optimized for speed, **not for resilience**
- Alarms ring, protocols fail, **consequences get worse**

What is safety/security? What is risk?

- **Safety/Security is a state** (of the feeling/mind or real) of a person, a situation, a machine, and the alike. Safety/security **depends on the perspective** from which one looks at the state.

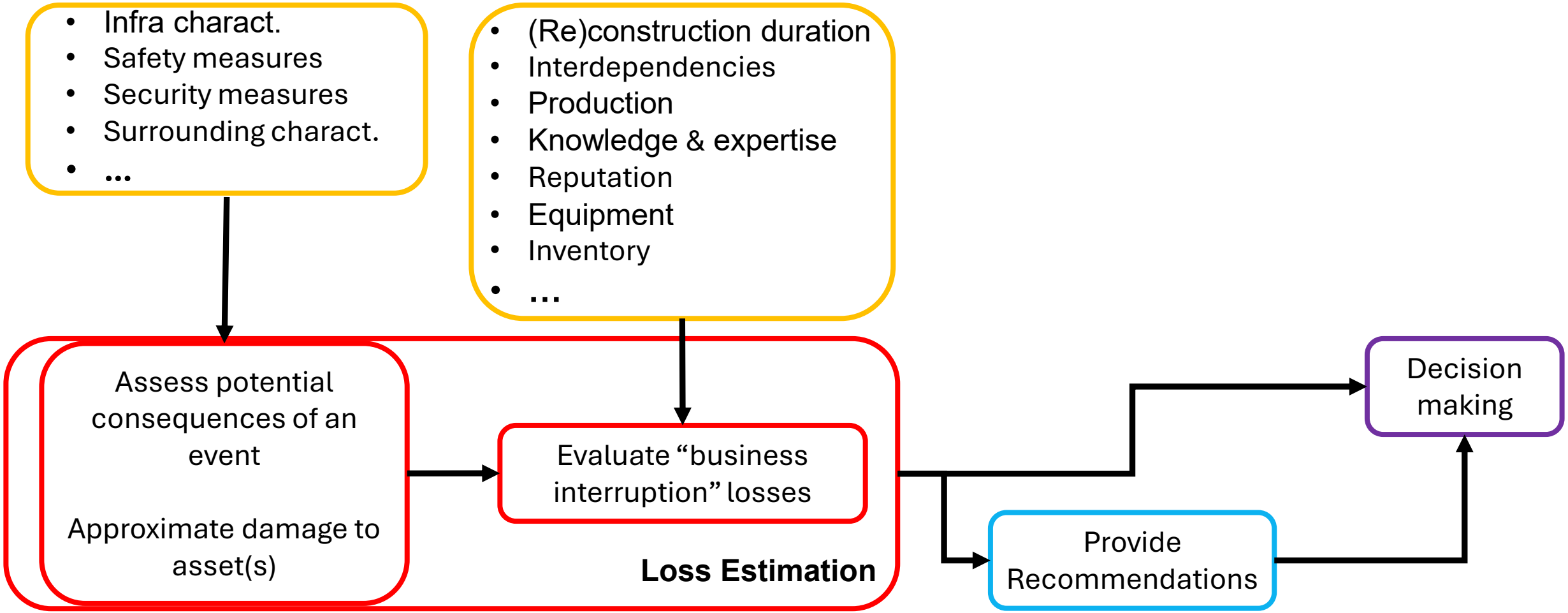
- Without quantification it is not possible to take optimal safety/security measures based on ‘a state’.

- Many states are thinkable, and they don’t tell anything about the consequences, probabilities, measures of states. Moreover, states change all the time and the **description of states doesn’t allow to quantify them**.

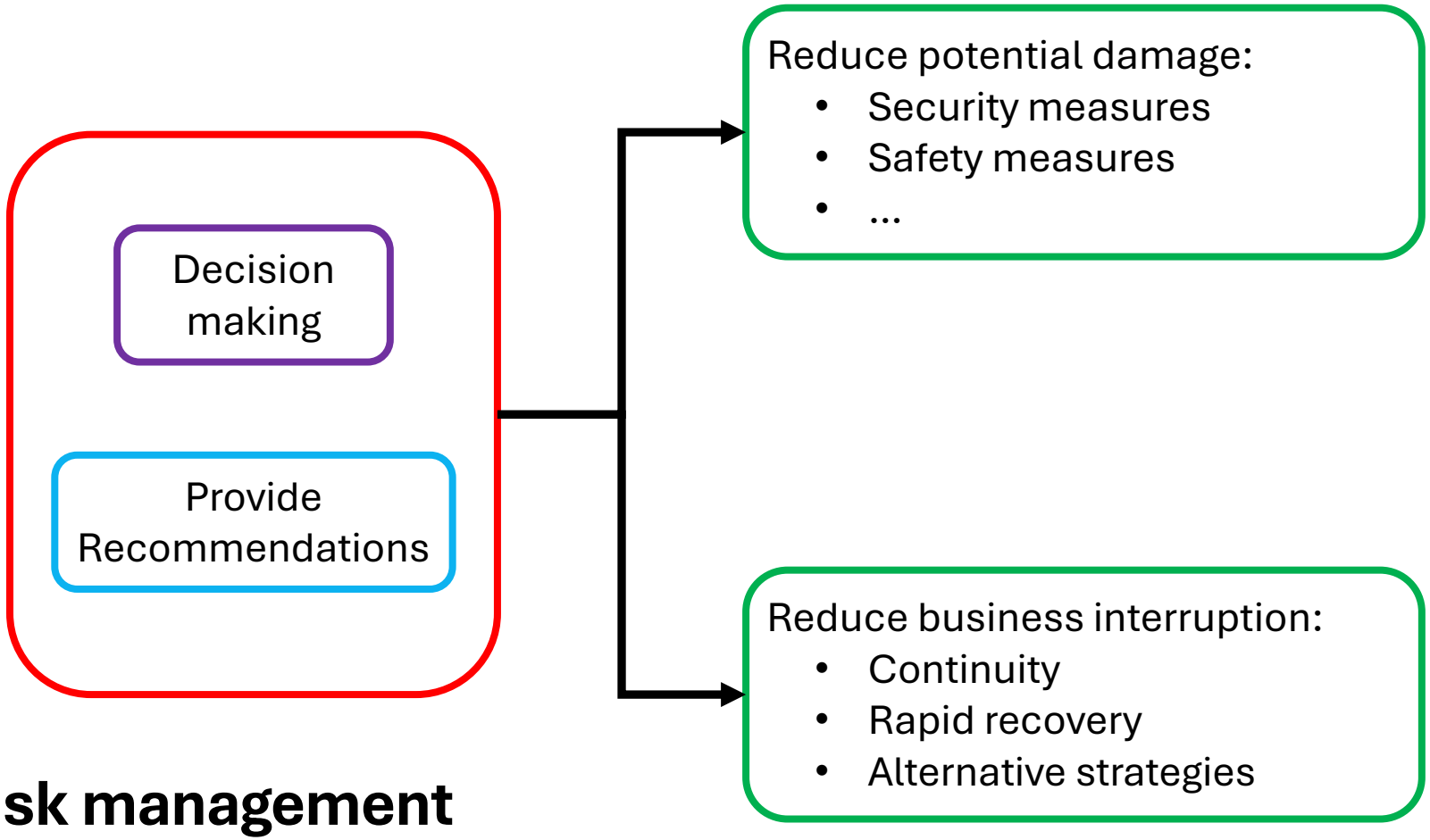
- For this, and to make the quantification of states possible, the **concept of ‘risk’** is introduced.

- Risk is a scenario; quantification of risk includes the likelihood of the scenario linked to certain consequences and the knowledge related to this

Risk assessment as the basis for decision making



- **Goal:**



- **Approach = Risk management**

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BUT: Resilience ≠ Risk

- Challenge:

Resilience ≠ Risk

- Resilience is:
  - a property of systems.

    Capacity to recover from disruption
  - Dynamic.

  Describes system performance over time
  - Capable of integrating quantitative and qualitative measures of loss of performance
  - Capable of providing system performance concerned with novel hazards

- Risk is:
  - An event-based measure.

  (Probability X consequences) of a scenario
  - Static.

  Snapshot of a scenario at a given point in time
  - Incapable of quantifying many decision attributes effectively
  - Struggling to quantify novel risks
    - Changing risk landscape (Terrorism, NaTech, Climate change, AI, …)

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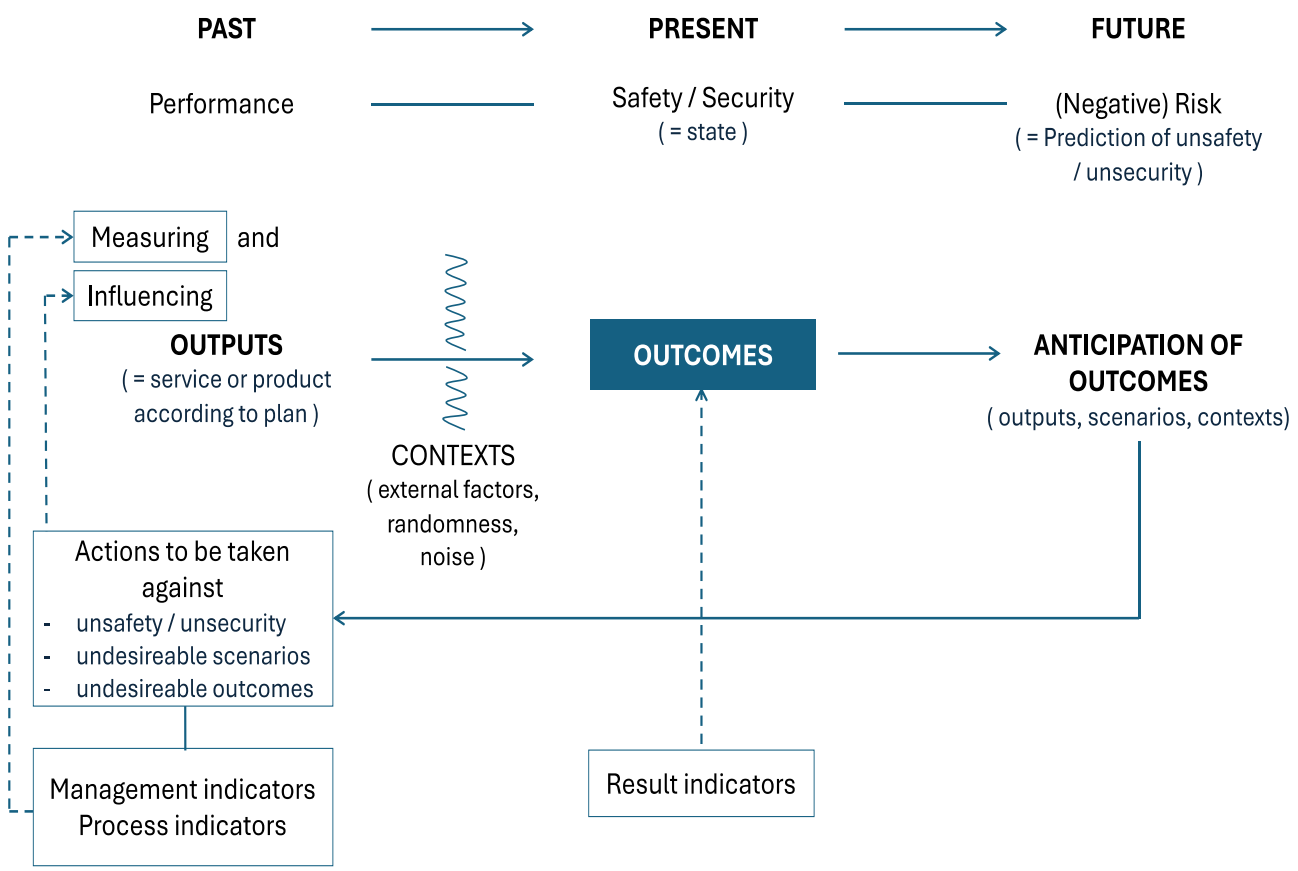
Performance, Safety, and Risk



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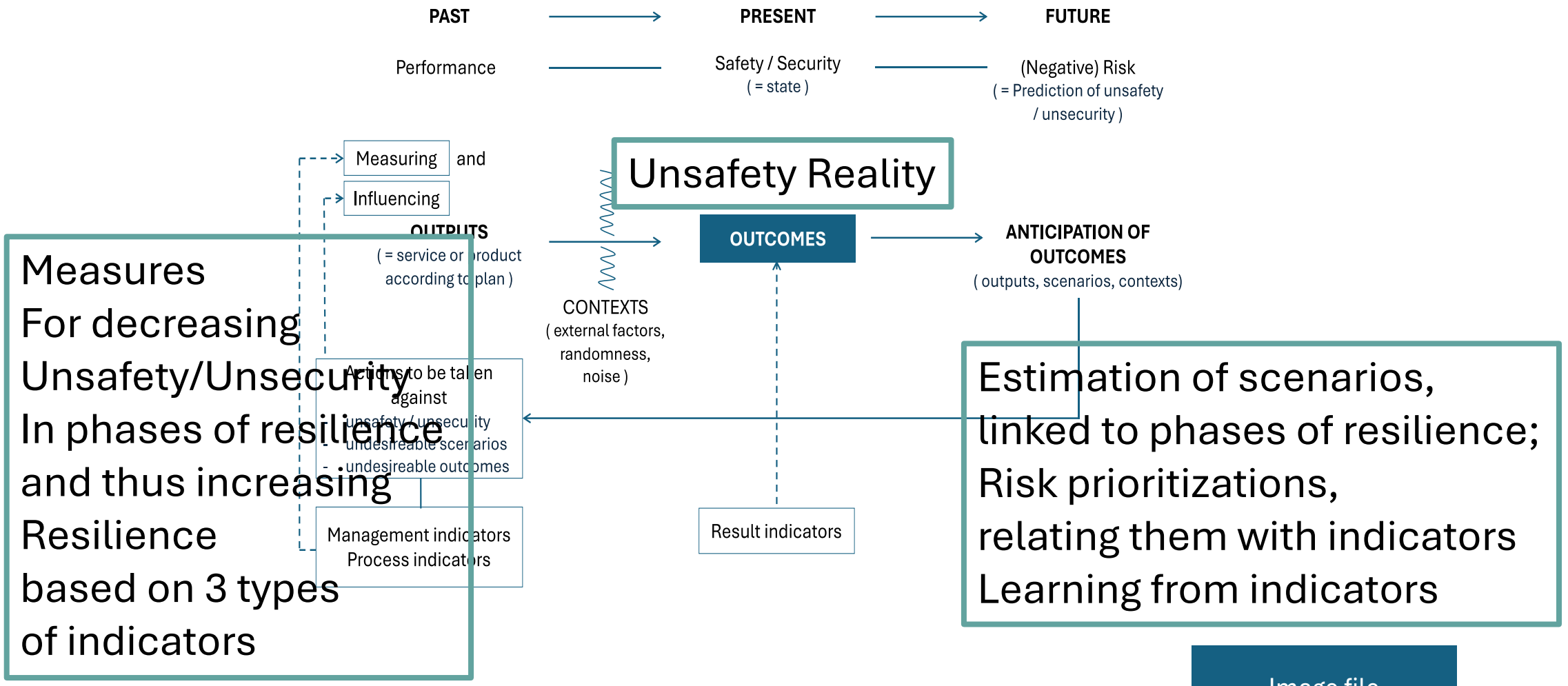
Performance, Safety, and Risk: link with resilience



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- Challenge:

Resilience Management

  - Risk management needs to be upgraded and be more dynamic: use different resilience phases
  - RM needs to include scenarios (always type II risks/scenarios) relevant for resilience thinking
  - Improving resilience may not reduce specific risks, but it should at least lead to improvement of dealing with the consequences of risks
  - Quantifying resilience improvement through risk management may be challenging

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“Resilience Engineering”/resilience management

- Why did the Resilience Engineering (RE) concept emerge?
  - Disruptions can’t all be anticipated, avoided, and prevented
  - Evolving socio-technical systems = overlooked scenarios
  - New hazards with uncertain frequency and severity

- Conclusion:
  - Risk-based preventive approach becomes unrealistic

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Resilience Engineering

- Core idea:
  - Not all disruptions can be prevented (systemic, novel hazards, etc.)
  - Systems must anticipate disruptions and plan to withstand (avoid catastrophic failures) their impact, continue operating while impacted by them, to recover and learn from them

  - Resilience Engineering:

    Anticipate, monitor, respond to, and learn from disruptions so an organisation can keep working, facing any disruption (ideally).

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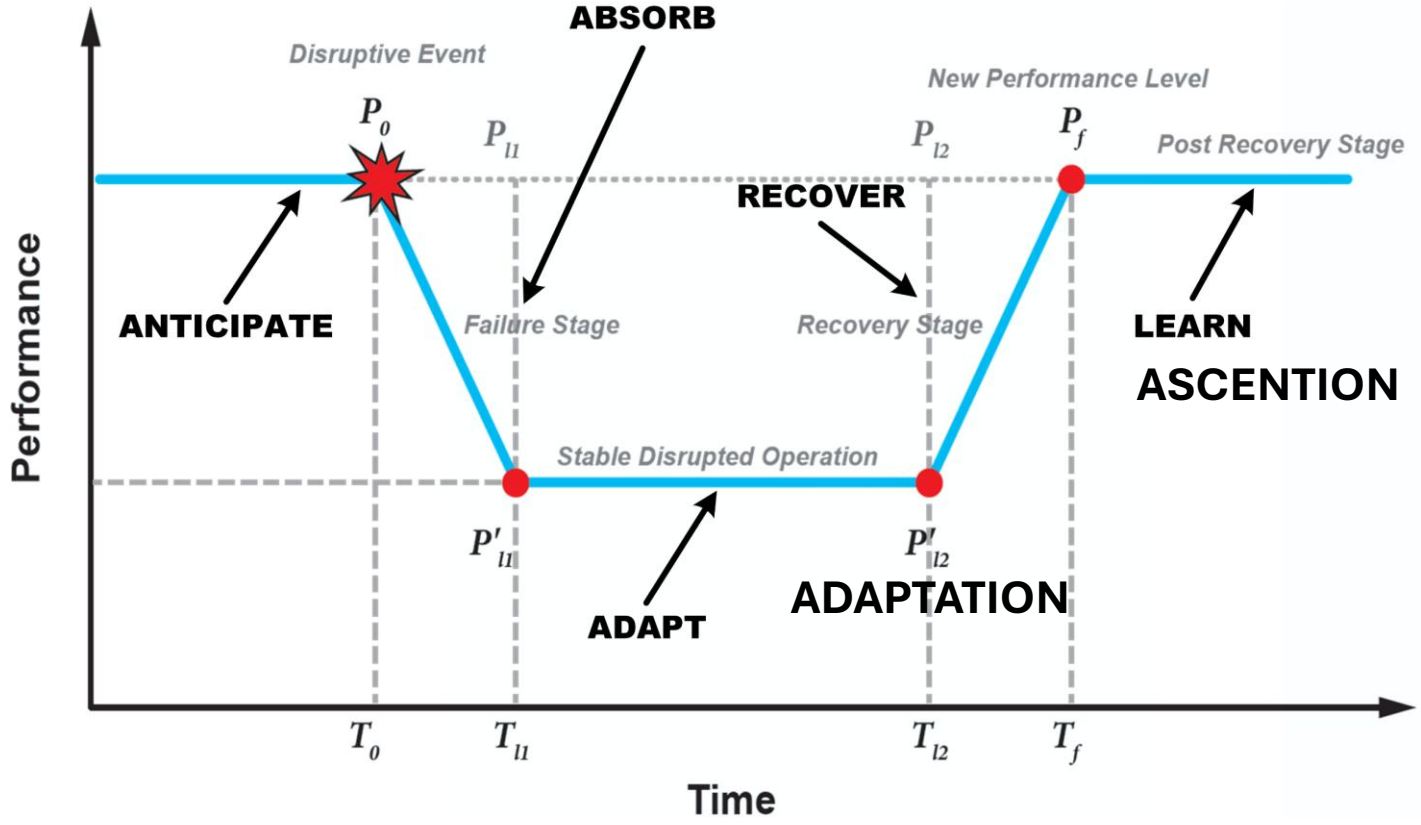
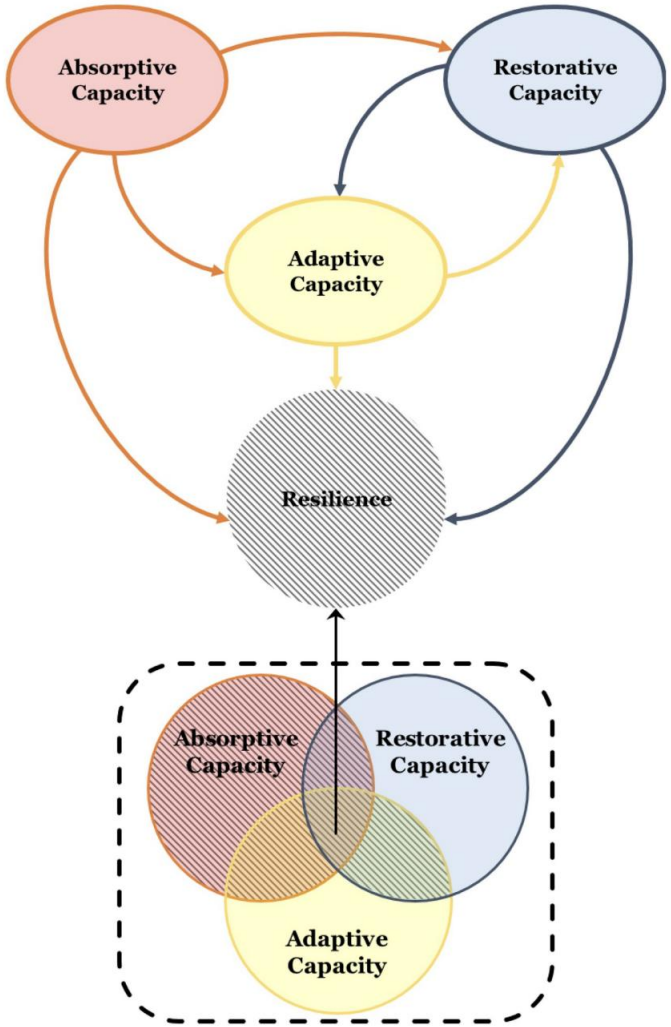
Resilience engineering

- Resilience curve
  - Dynamic performance of an indicator over time
  - Works for any indicator: building integrity or business continuity
  - Compare less resilient vs more resilient

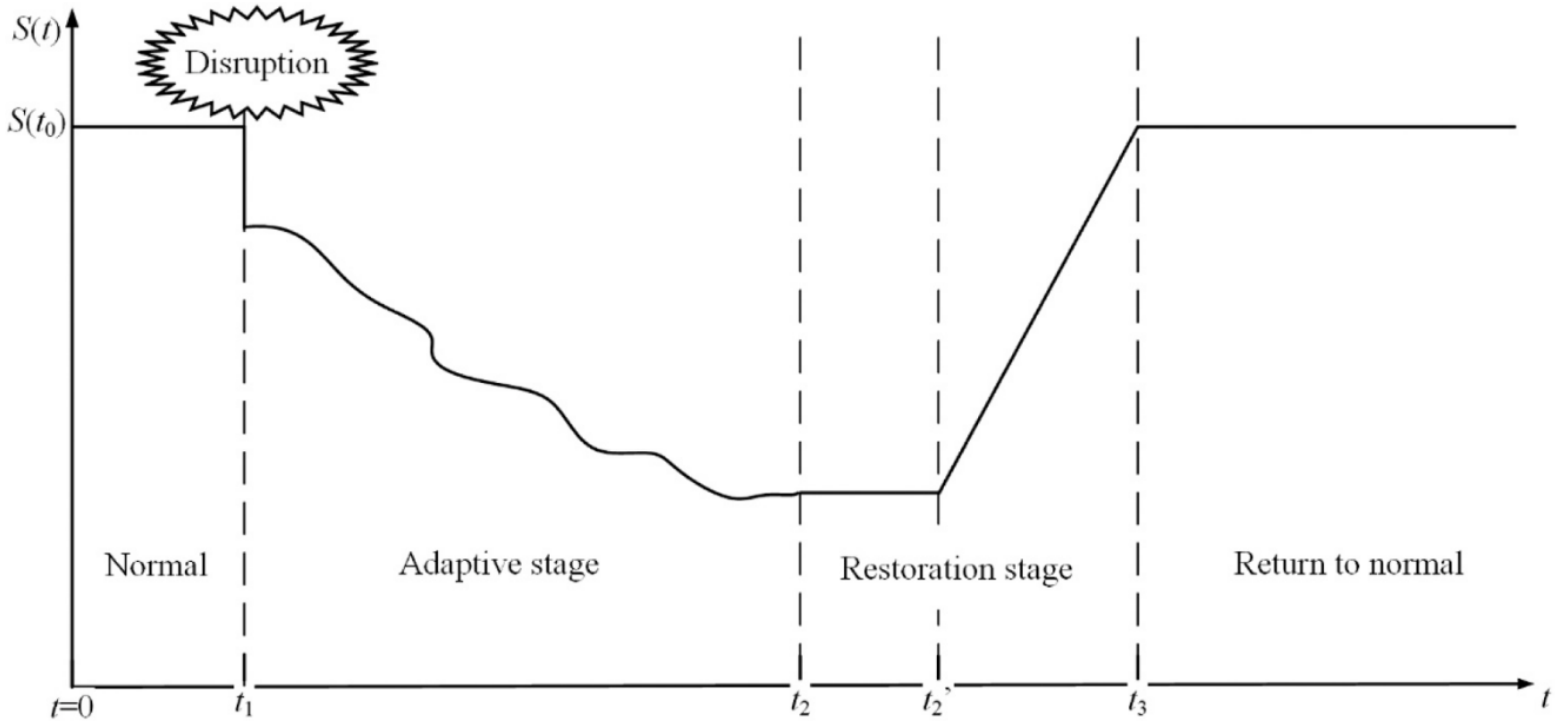


Resilience Concept



Logical relations of system capacities with resilience. (Yarveisy et al., 2020)

Resilience:
The ability of an organization (system) to withstand pressure, keep, or recover quickly to, a stable state, allowing it to continue operations during disruptions and after a major mishap or in the presence of continuous significant stresses. (Wreathall 2017; Hollnagel et al. 2012)



Generalized system performance model over time. (T.Zheng et al., 2025)

What SHOULD Performance management NOT BE?

Usually in companies (in general):

- make use of so-called “KPIs“ (such as cost, speed, result)
- With a goal to optimize business performance/efficiency, and measure unsafety results

Blind spots in performance logic in companies:

- Underestimate extreme events (such as natural disasters)
- Reward fragility (efficiency is usually optimized, and efficient systems = fragile systems)
- Efficient → weakened capacity to absorb shocks
- Measure what is easy, not what matters

This is **NOT good performance management** in companies!

What is Performance management (or should it be)?

3 types of indicators:

- **Management indicator** (pro-active):
  - tells you what to do to increase performance dramatically
  - answers the question "with what means?"
  - indicates whether the conditions are present to achieve certain goals

- **Process indicator** (pro-active):
  - tells you what to do
  - answers the question "How?"
  - indicates whether a predefined goal is achievable, and whether the efforts to this end, are carried out according to plan

- **Result indicator** (re-active):
  - tells you how you have done in a perspective
  - answers the question "What?"
  - indicates what was achieved and whether a predefined target/goal was reached

Indicators should be 'SMART':

- (i) **Specific** and clearly defined;
- (ii) **Measurable** so that one can check on a regular basis how the indicator is performing;
- (iii) **Achievable** so that each indicator provides a target that is stretching but not so extreme that it is no longer motivational (the indicator needs to have sufficient support);
- (iv) **Relevant** to the organization and what it is aiming to achieve;
- (v) **Time bound** in terms of (realistic) deadlines or timing for when each indicator will be achieved.

Some examples (in general) of performance indicators?

- **Management indicator:**
  - % of turnover used for safety per 2 years
  - % of biannually company strategic goals related to health and safety
  - % of yearly Service Level Agreements following safety requirements
  - # mgt reviews carried out / # mgt reviews planned every 3 years

- **Process indicator:**
  - # incident analyses / # incidents / year
  - # implemented improvement suggestions / year
  - % processes audited externally every 6 months
  - % examinations carried out according to plan every 3 months
  - # safety speeches per year

- **Result indicator:**
  - LTIFR (yearly)
  - # employees resigning per year
  - # first aids of contractors per month
  - yearly insurance premium for damages

How can we **combine resilience and performance mgt** to manage risks in case of a major disruption?

- Performance indicators should be linked to risks (=scenarios) and the objectives related to the risks/scenarios

- Watch out for the **'Grey Rhino' problem**:
  - Known but ignored risks
  - Organizational amnesia
  - Blind to looming threats

→Do not underestimate risks/disaster scenarios and make the company/organisation more resilient by using Performance Management!

The 4As Conceptual Framework

Anticipation

Identify potential disruptions and proactively prepare for them, reducing their likelihood or impact. It focuses on preventive measures and readiness.

Absorption

The capability of a system to minimise the impact of a disruption when it occurs. It emphasizes robustness and immediate responses to prevent minor disruptions from escalating into major incidents.

Adaptation

Modifying processes, procedures, and systems in response to a disruption or unexpected event, ensuring continuity of operations and reducing the chance of future recurrence.

Ascension

An organisation not only recovers from a disruption but also learns from it and implements continuous improvement measures to strengthen the system. It involves three interconnected elements: recovery, learning, and ongoing improvements to increase resilience.

Resilience Management?

Aim:
Translate the 4 A concept into measurable performance indicators.

RQ:

1. How can we structure indicators that address (safety and security) risks using the resilience engineering paradigm?
2. How important are these indicators for tracking resilience metrics?
3. What are the challenges and opportunities of monitoring these indicators?

Resilience management: approach

Disruption categories

- Human error
- Technical failure
- Management failure
- Internal labour disruption
- Natural disaster
- Terrorism / sabotage
- Supply chain disruption
- External social hazard

Resilience phases/ capabilities:

- Anticipation
- Absorption
- Adaptation
- Ascension

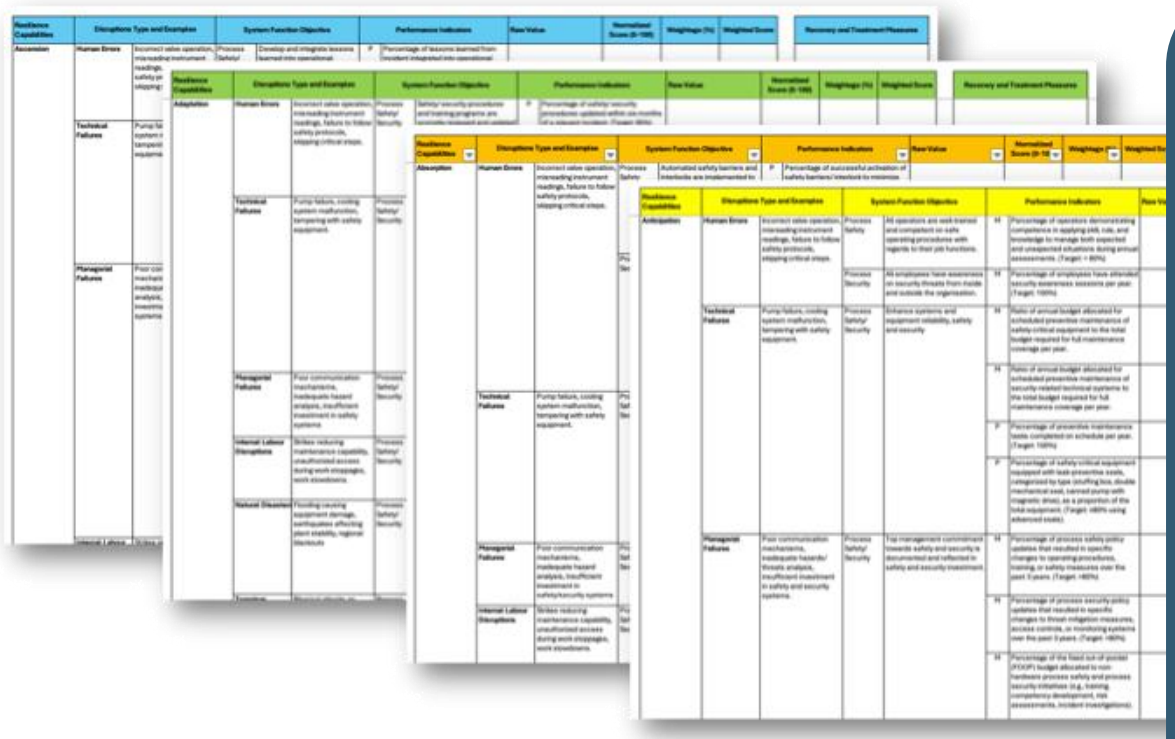
Indicator types:

- Management indicators
- Process indicators
- Result indicators

Example of Indicators

Disruption	Resilience Capability	Indicator Type	Performance Indicator	Dimension
Technical Failure	Anticipation	Management	Proportion of annual budget allocated to scheduled preventive maintenance vs. total required for critical safety/ security equipment.	Safety and security
Technical Failure	Absorption	Process	Percentage of equipment with functional secondary containment to mitigate immediate leaks or fires.	Safety
Technical Failure	Adaptation	Management	When a technical failure exposes a security vulnerability, to what extent are the security protocols updated?	Security
Technical Failure	Ascension	Process	Year-on-year reduction in repeated technical disruptions after corrective actions have been implemented.	Safety and security

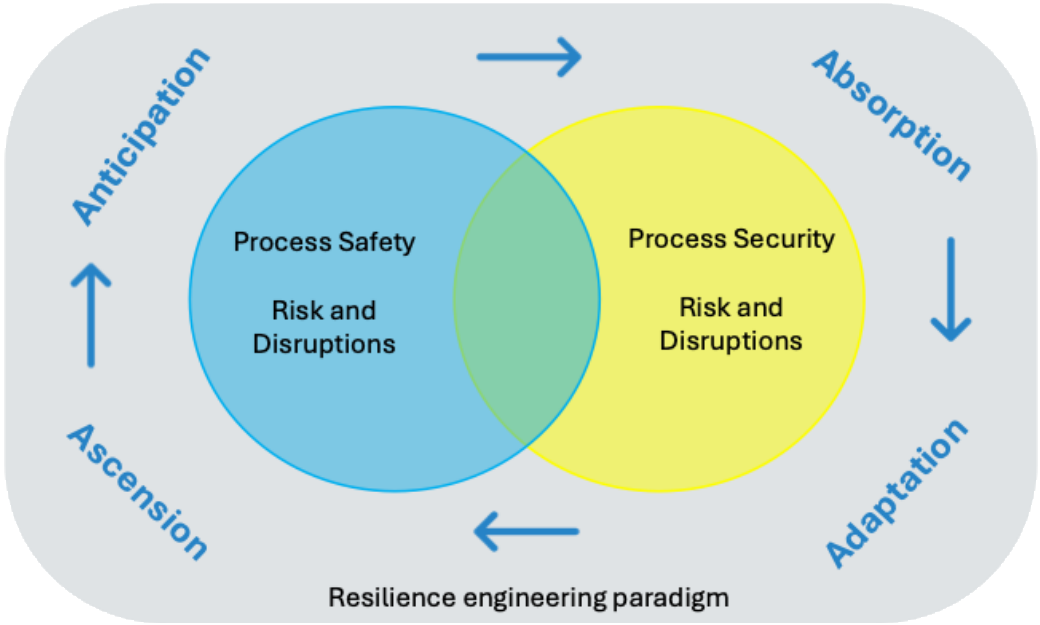
Current research: ongoing

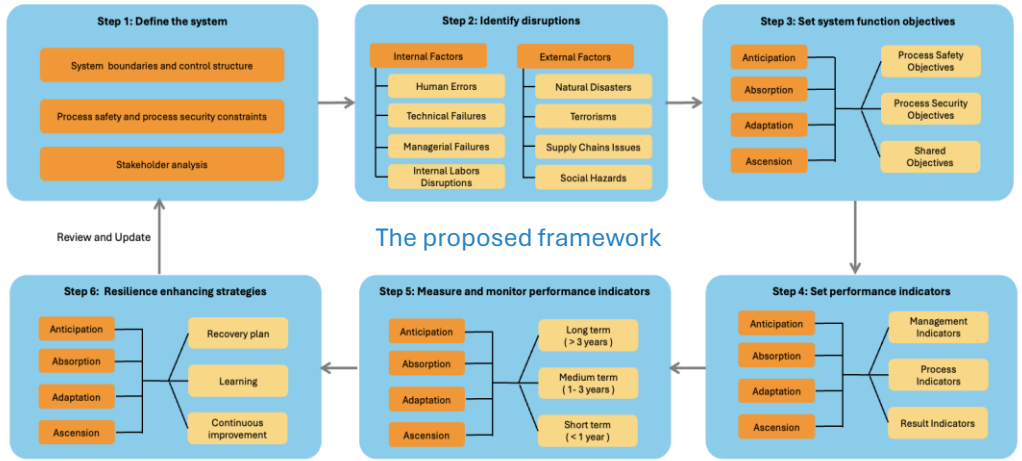


- 53 performance indicators.
  - ✓ 5 to 9 indicators per disruption
  - ✓ 10 to 15 indicators per res. capability

- **Management indicators** (8%), mainly support Anticipation
- **Process indicators** (77%), mainly support Absorption and Adaptation
- **Result indicators** (15%), mainly support Ascension

Results: Importance of Indicators





The proposed framework

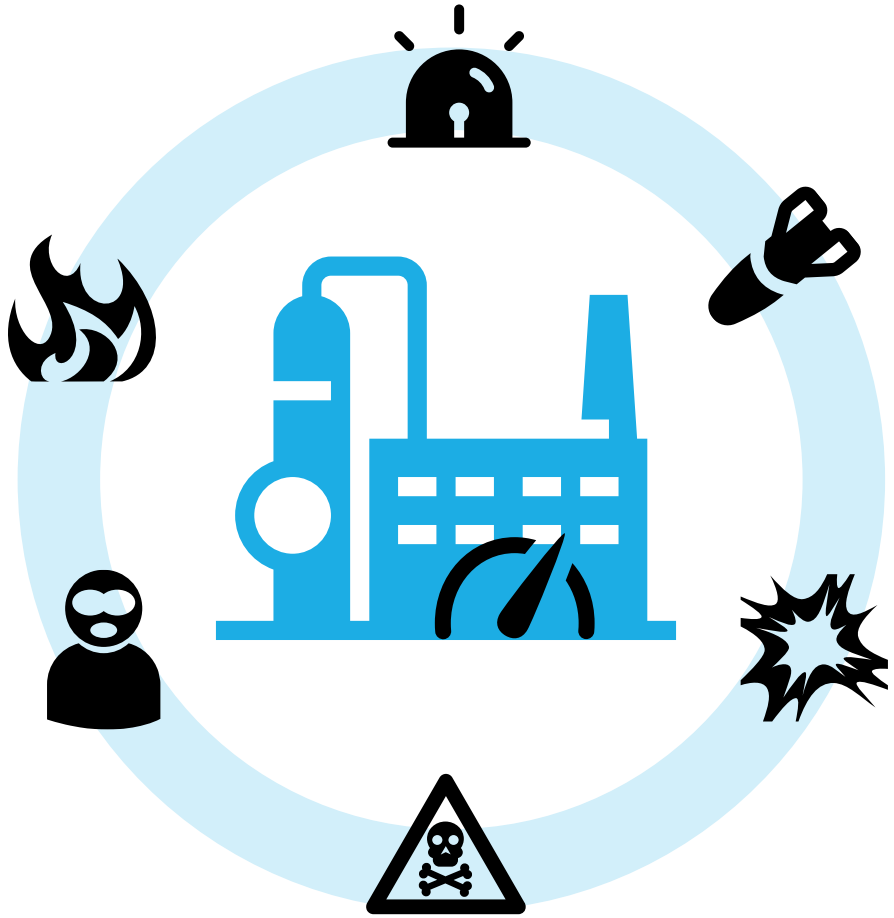
- Each indicator links to one of four resilience capabilities and process safety-security objectives.
- The indicators are the main ingredients for a resilience-oriented framework.
- The experts rank 83% of the indicators as important or very important.

Challenges and Opportunities

Challenges	Opportunities
Resource constraints Budgets favour quick fixes, not preventive/ resilience measures	**Cost-benefit analyses** Demonstrate the long-term return on investment
Resistance to change Personnel are reluctant to follow updated safety/ security procedures or the lessons learned	**Strengthen leadership support** Involve staff in shaping new protocols Provide cross-functional training
Technological and analytical gaps Real-time monitoring needs digital infrastructure and data skills.	**Gradual approach to tech. adoption** Strategic partnerships with technology providers

Conclusions

- The resilience concept was linked into practical and structured indicators.
- Resilience can be managed via managing type II risks related to disruptions
- 4 phases/capabilities need to be addressed: anticipation, absorption, ascention, adaptation
- 3 indicators need to be used: management, process and result indicators



Closing thoughts

- The **resilience concept** can be translated **into practical and structured performance indicators,** also for NaTech risks

- There should be an emphasis on **PREPAREDNESS (anticipation, absorption, adaptability, and ascension (learning)**, instead of mitigation (cfr. Amundsen versus Scott – the race to the South Pole)

- Design for flexibility (“flexible stability”)

- Cfr. **Bamboo: strong yet flexible and adaptable**

Thank you for your attention

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