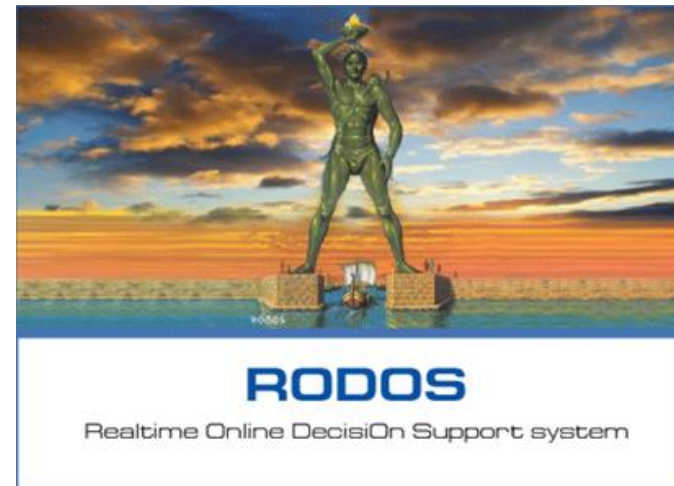


Towards an Analytical Resilience Framework for EPR&R Systems for Radio Protection

S.S. Ottenburger



1. Motivation

- Make Resilience more tangible
- Findings & Simulation

2. Analytical Resilience Framework

- State of the Art: JRODOS-EmerSim
- Expected Capabilities

3. Coupling: Early Measure Simulation

- FRAMESS: Agent-, network-based framework, including a war time damage scenario generator
- JRODOS: nuclear hazard generator

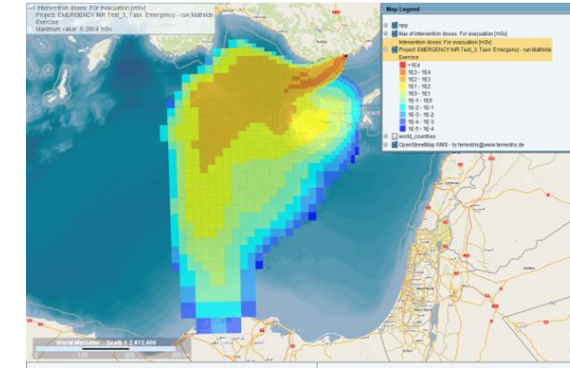
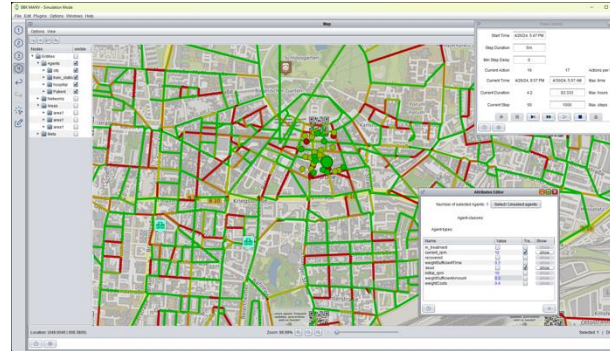
4. Simulation & AI

- Mitigation, Preparedness [and Response]
- Reinforcement Learning for optimized mitigative measures

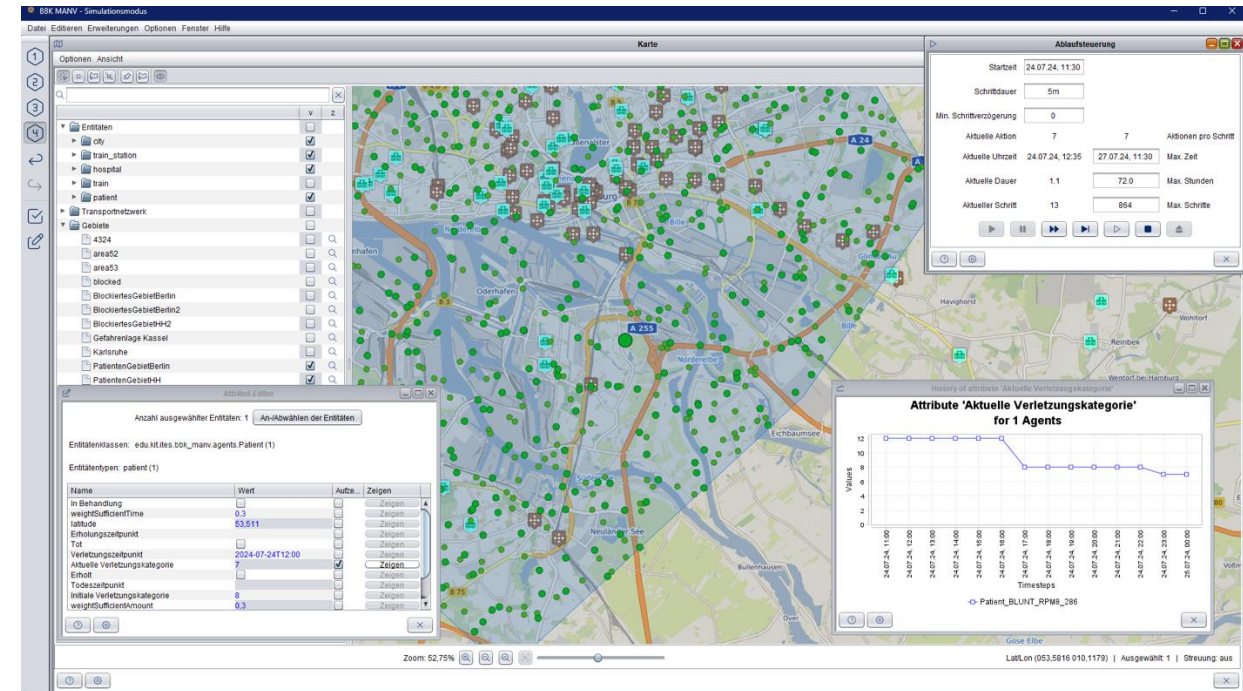
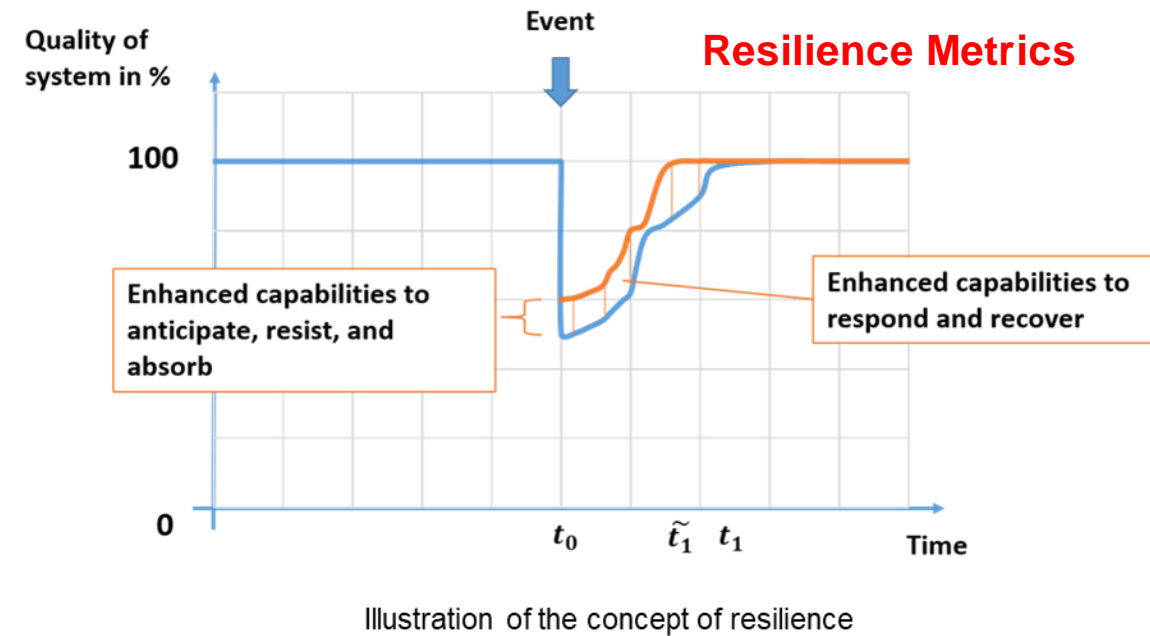
Motivation

Infrastructure Damage (war time conditions)

- Make Resilience **more tangible**
- Findings: Explanations/descriptions & **Simulation**



Nuclear Accident



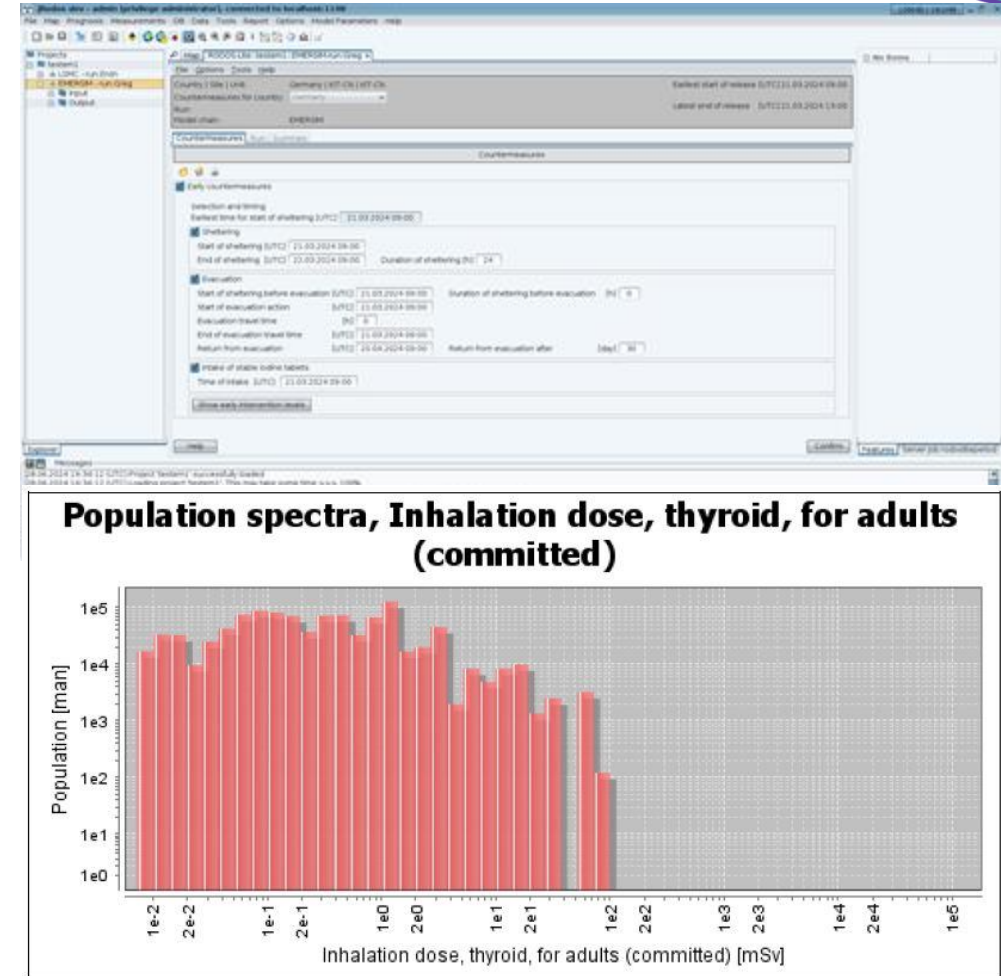
Metric-based Analysis of Measures

Towards an Analytical Resilience Framework



State of the Art: EmerSim

1. Model for simulating early emergency measures and resulting doses with and without actions (24h, 48h, 7 days)
2. Timing of the early phase countermeasures “Evacuation”, “Sheltering” and “Intake of stable Iodine” can be changed
 - **No** optimization
 - **No** dose assessment per time step
 - **Not** sensitive to infrastructure states and existing resources



Towards an Analytical Resilience Framework

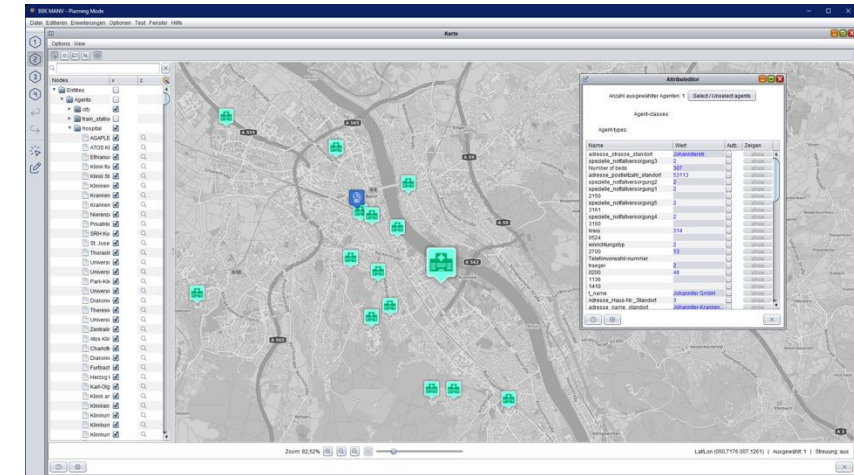
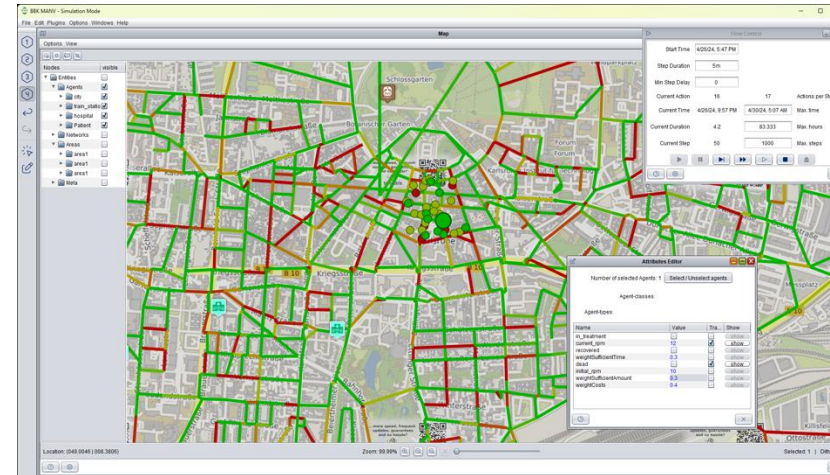
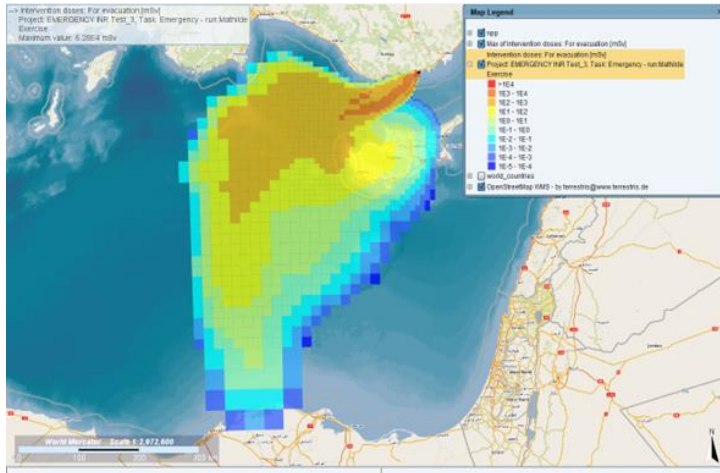
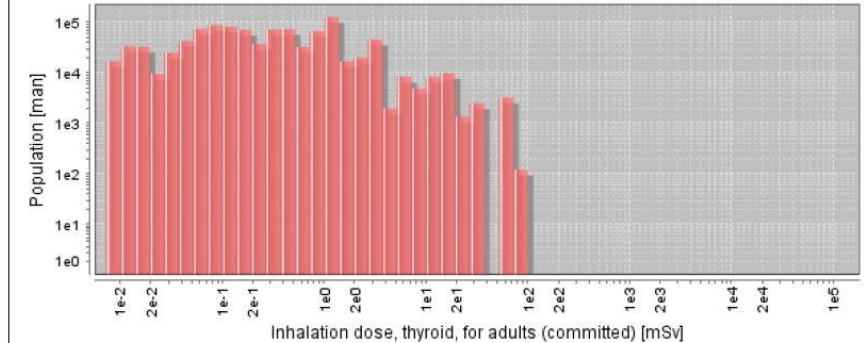


Expected Capabilities

More detailed simulation & Optimization

- for complex situations and scenarios, taking into account:
 - **dose assessment:** spatio-temporal modelling
 - **infrastructure states** and existing resources for conducting measures

Population spectra, Inhalation dose, thyroid, for adults (committed)



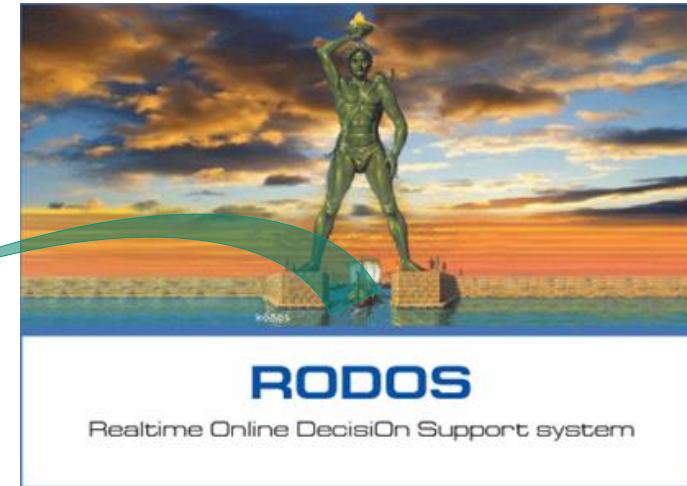
Coupling: Early Measure Simulation

New Approach: No EmerSim!

- **FRAMESS**: Framework for System Risk Analysis and Exploring Sustainable Solutions
 1. Agent-, network-based framework, including a war time damage scenario generator
- **JRODOS**: nuclear hazard generator

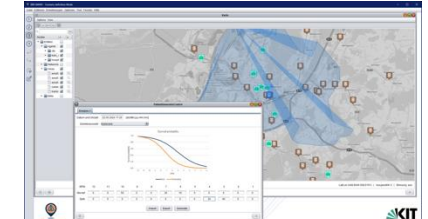
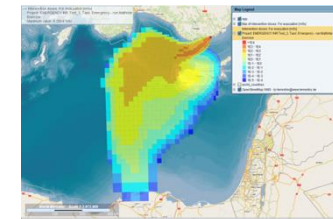
Designed for Resilience Assessment

- Scenario-based: **destroyed or reduced infrastructure**
- Agents: having goals and sensitive to environment
- Scalable for complex system analysis + rather simple integration
- Open for AI



Nuclear Hazard Generator

- Dispersion Modelling
- Dose Assessment



Simulation of early countermeasures

- 24h, 48h, 7days
- **Resilience (Quality) Metrics: Sheltered people, dose assessment, evacuated areas, iodine tablets distributed...**



Simulation & AI



- **Mitigation, Preparedness [and Response] – focus on communities**

1. On the base of resilience metrics: **Understand** the **impact** of **measures** - **not pre-defined, only types are known** - **on metrics** – effect visible in the metric graph per simulation:

- shelters, transport means
- iodine tablets, existing dosimeter [household...]
- communication infrastructure
- policies & coordination/communication structures
- ...

- **Focus is not on optimization of emergency management and measures [coming projects]! Working with heuristics, community not too complex...**
- **Focus is on optimized mitigative/preparedness measures, see types above!**

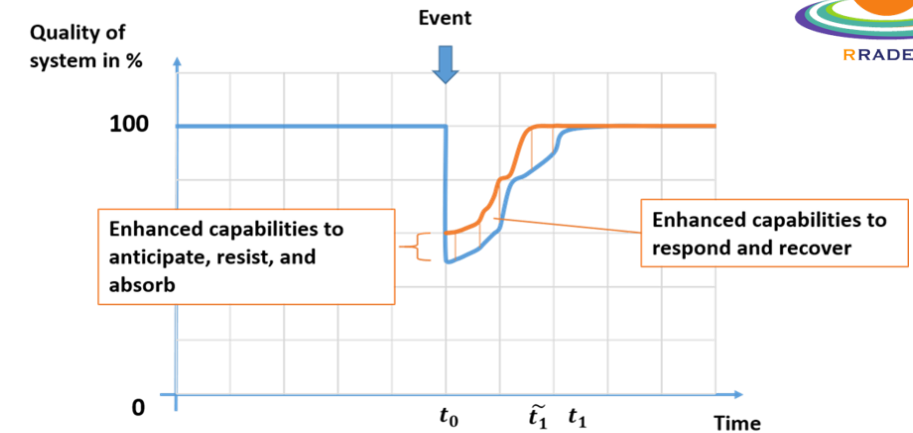
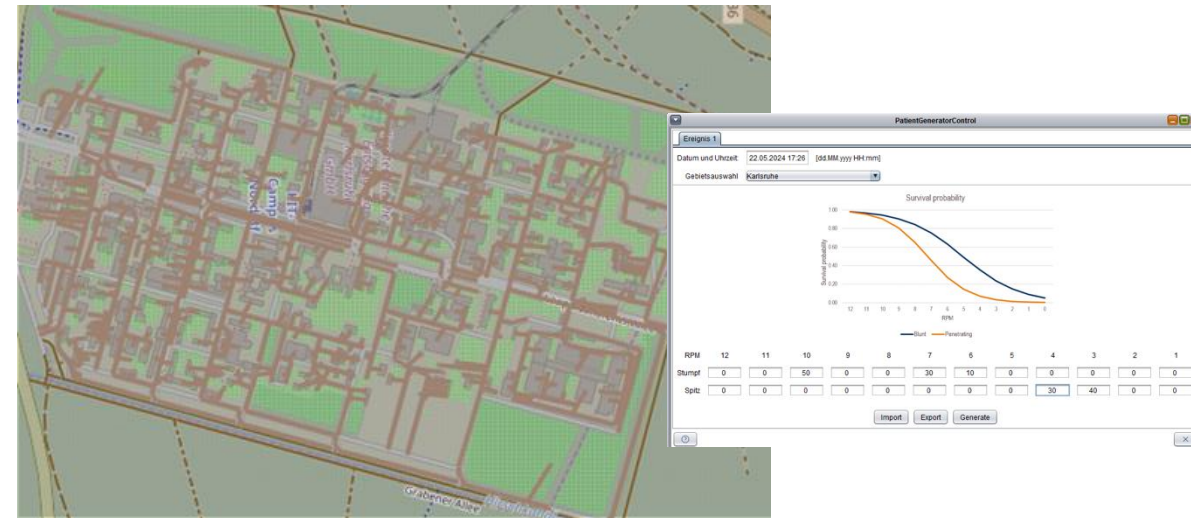


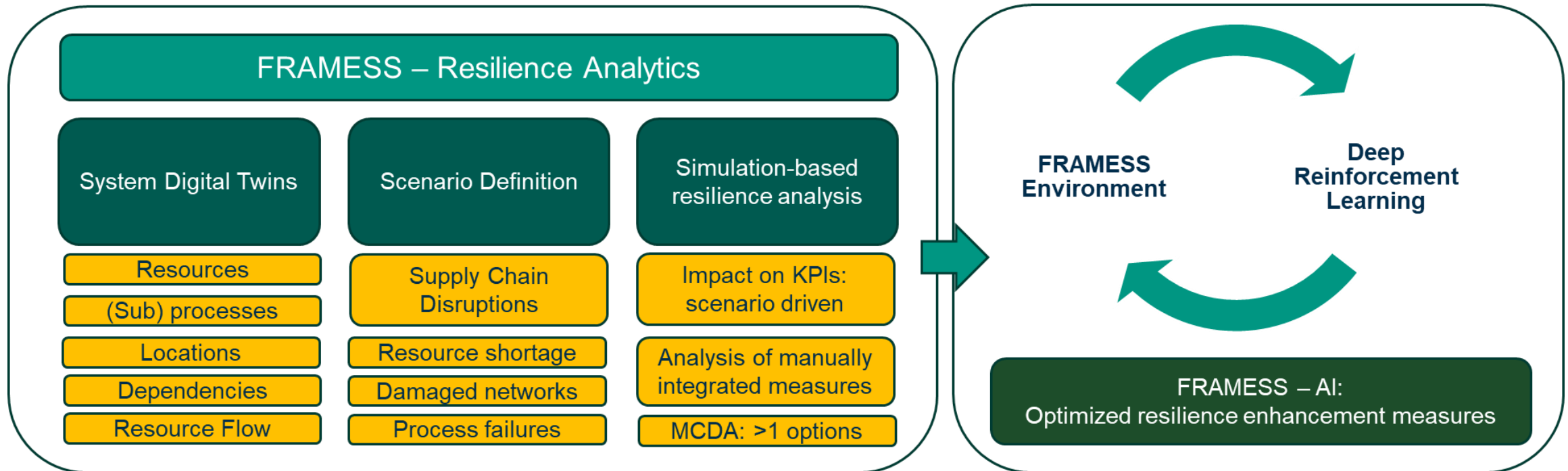
Illustration of the concept of resilience



Simulation & AI



- Reinforcement Learning for **optimized mitigative measures**



FRAMESS approach



FRAMESS@ITES: Framework for Systemic Risk Analysis and Exploring Sustainable Solutions

FRAMESS is a
context open and process driven
model-agnostic framework based on
customizable ontologies and
multi-agent- and network-based modelling

