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CIPRNet

Critical Infrastructure Preparedness and Resilience Research Network

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D9.4 Draft training material of the 'what if' analysis demonstrator system

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Fraunhofer Institute for Intelligent Analysis and Information Systems (Fraunhofer)

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Dissemination Level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Approval Date	09/07/2016
Remarks	ACCEPT (one slide modified)

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LIST OF ABBREVIATIONS

Acronym	Explanation
CA	Consequence Analysis
CI	Critical Infrastructure
CIP	Critical Infrastructure Protection
CIPRNet	Critical Infrastructure Preparedness and Resilience Research Network
CM	Crisis Management
DBMS	Database Management System
DSS	Decision Support System
GIS	Geographic Information System
GUI	Graphical User Interface
M&S	Modelling and Simulation
WIA	'What If' Analysis

1 Introduction – Rationale of this document

This document contains the draft training material of CIPRTrainer, a training system for providing crisis managers 'what if' analysis capabilities for exploring different courses of action in complex crisis scenarios. CIPRTrainer is based on federated modelling and simulation of Critical Infrastructures and on Consequence Analysis. The latter provides metrics for roughly estimating consequences of the overall crisis scenario evolution, a novel approach that started from the 'cross-cutting' criteria of the Directive on European Critical Infrastructures. CIPRTrainer aims at providing realistic scenarios including critical infrastructures and cross-border aspects.

The draft training material will be used within the third edition of the two-day CIPRNet Course on "Modelling, Simulation and Analysis of Critical Infrastructures" at the Master in Homeland Security study at Università Campus Bio-Medico di Roma. As part of CIPRNet's capacity building activities, the course comprises a Training Session and aims at performing training and demonstration activities to professionals in homeland security and crisis managers of civil protection agencies. The first day of the course will devoted to general training on modelling, simulation and analysis of Critical Infrastructures, using mature material developed for previous editions and for the Master Classes. This material will not be duplicated in this deliverable. The new material on CIPRTrainer will cover the second day of the third edition of the course and can be found in the appendix of this deliverable.

Lessons learnt from the CIPRNet course will be employed for improving the training, and for an optimal preparation of the CIPRNet Master Class 3 in November 2016 (same contents, different audience).

The third edition of the CIPRNet Course is scheduled for July 14–15, 2016. Editions 1 and 2 took place in 2014 and 2015 [1] [2]. The third edition comprises three training modules:

- **Module 1** (14th July 2016): notions and theories regarding Critical Infrastructure modelling, simulation and analysis. This part 1 is addressed to researchers and professionals requiring a general presentation to the topic;
- **Module 2** (15th July 2016, morning): CIPRNet's new capabilities: Introduction to CIPCast, CIPRTrainer, 'what if' analysis and Consequence Analysis. This module provides an extensive presentation of the training system CIPRTrainer developed by Fraunhofer with support from CIPRNet partners UCY, UTP, Deltares, TNO, JRC, CEA, UIC and ENEA. This part 2 is addressed to researchers, young professionals in homeland security, and crisis managers of civil protection agencies;
- **Module 3** (15th July 2016, afternoon): Hands-on exercises with CIPRTrainer. This part 3 is addressed to researchers, young professionals in homeland security, and crisis managers of civil protection agencies.

1.1 Target audience

This training event is mainly addressed to professionals in homeland security and public/governmental authorities in charge of Crisis Management or Civil Protection matters.

1.2 Topics of the CIPRNet training event focusing on CIPRTrainer

The first module of the training course will be devoted to introducing the basic notions and theories regarding CI modelling, simulation and analysis, whereas in the following two modules the training event will focus on two of CIPRNet's new capabilities. The second module starts with a brief introduction to the advanced decision support system CIPcast that had been

presented extensively in the previous CIPRNet course [2]. The main parts of modules 2 and 3 present the basic functions and technologies of CIPRTrainer and give the attendees the opportunity to practice with the system.

The agenda of the training event covers the following topics:

	Title / Topics / Description of Contents
Module 2	**CIPRTrainer – training the exploration of different courses of action**
	○ »what if« analysis as a new capability for crisis management training ○ CIPRTrainer system overview ○ Modelling in CIPRTrainer ○ Event processing in CIPRTrainer ○ fMS&A and rollback for »what if« analysis
	This session focuses on the essential CIPRTrainer functions and technologies and illustrates how their interplay has been employed to form a new capability for training crisis management staff.
	Federated simulation in CIPRTrainer
	○ Infrastructure Simulators ○ Infrastructure Models ○ Modelling dependencies ○ Preserving causality
	This session focuses on the federated simulation system for Critical Infrastructures developed by Fraunhofer with support of CIPRNet partners UCY and UTP. The federated CI simulation must be able to react to a harm scenario and simulate impacts, including cascading effects. Modelling includes domain specific modelling of CI and modelling of their dependencies. Recorded impacts are employed as one of many inputs for Consequence Analysis.
	Consequence analysis as a basis for »what if« analysis
	○ CIPRNet's hybrid CA approach ○ Data elicitation ○ Data handling ○ Methods for assessing consequences of crises and disasters ○ Ethical aspects ○ CA assessment and presentation in CIPRTrainer
	This session focuses on the methods for estimating consequences in large complex damage scenarios. The Consequence Analysis provides metrics for performing 'What if' Analysis. It describes the overall outcome of a scenario at a given point in time. The work in the field is novel and takes the 'cross-cutting criteria' of the European Critical Infrastructure directive as a starting point. The session discusses also ethical aspects of Consequence Analysis.
	CIPRTrainer derailment scenario with cross-border aspects
	○ Scenario storyline ○ Rules ○ Scenario database
	This session focuses on describing the CIPRTrainer derailment scenario. It prepares for the crisis management training exercise in Part 3 of the training.

	Title / Topics / Description of Contents
Module 3	**CIPRTrainer demonstration and hands-on experience – Basic features**
	○ CIPRTrainer GUI ○ GIS functionality ○ Tactical icons ○ User roles: Trainer, trainees
	This session prepares the attendees for the hands-on exercise of the CIPR-Trainer platform (functionalities, main features, use, etc.). In particular, during this basic part, the attendees will learn how to: • *Logging in as users of different roles: Trainer, trainees* • *Work with CIPRTrainer: add and manage layers, zoom in and out* • *Understand the tactical icons* • *Read the timeline and information display at the CIPRTrainer GUI*
	Hands-on Basics: Familiarising with the CIPRTrainer GUI
	○ Trying the basic functions of the CIPRTrainer GUI ○ Understanding the displayed information
	In this session, the attendees will have the opportunity to practise the basic features of CIPRTrainer introduced in the previous lecture. In particular, during this session, the attendees will practice how to: • *Start CIPRTrainer* • *Trying GIS functionality: Selecting base layers, adding information layers, zooming in and out* • *Logging in as users of different roles: Trainer, trainees*
	CIPRTrainer demonstration and hands-on experience – Advanced
	○ Crisis management actions in CIPRTrainer ○ Trainees' crisis management roles ○ Concept of zones and resource allocation ○ 'what if' analysis
	This session prepares the attendees for a crisis management training run with the CIPRTrainer platform. In particular, during this advanced part, the attendees will learn how to: • *Perform role-specific actions in CIPRTrainer* • *Allocate responders' resource for response actions* • *Perform 'rollback' and 'what if' analysis*
	Hands-on Advanced: Using CIPRTrainer for exploring different courses of action
	○ Performing a training session in CIPRTrainer ○ Performing 'what if' analysis ○ Analysing the training runs
	In this session, the attendees will have the opportunity to practise the advanced CIPRTrainer functions introduced in the previous lecture. In particular, the attendees will practice an entire training run of CIPRTrainer.

2 Training material on CIPRTrainer

2.1 Lecture material

The introduction to the different parts of the CIPRTrainer is presented during the Training Session / Course in **Module 2** and **Module 3**. The teaching material for the audience is divided in the following parts:

1) CIPRTrainer – training the exploration of different courses of action
2) Federated simulation in CIPRTrainer
3) Consequence analysis as a basis for »what if« analysis
4) CIPRTrainer derailment scenario with cross-border aspects
5) CIPRTrainer demonstration and hands-on experience – Basic features
6) CIPRTrainer demonstration and hands-on experience – Advanced features

2.2 Exercises

The exercise or hands-on part is divided into two sessions. In the first session, the attendees will be familiarised with the basic functions of CIPRTrainer's graphical user interface (GUI), learn how to operate the GIS functions, and how to read the displayed information, including tactical icons. In the second session, the attendees will perform an entire training session in CIPRTrainer, including rollback and 'what if' analysis for performing different courses of action.

3 Learning goal

The main learning goal of the attendees is to:

- acquire the methodologies and technologies used within CIPRNet
- understand the main modelling and simulation challenges in the field of CIP
- acquire and exercise the different "functional blocks" of the main functionality implemented in CIPRTrainer, that is, the 'what if' analysis for performing different courses of action
- get an impression of the behaviour of Critical Infrastructures and cascading effects in complex damage scenarios, including cross-border aspects.

References

[1] FP7 CIPRNet Project, Deliverable 9.1 "Training Plan".
[2] FP7 CIPRNet Project, Deliverable 9.82 "Courses inside the Homeland Security Master".

Appendix

This section contains the detailed agenda of the CIPRNet Course (Appendix A) and all slides that will be used for Modules 2 and 3 of the Training Session (Appendix B).

Appendix A: Agenda of the training session on Modelling, Simulation and Analysis of Critical Infrastructures

Day 1 – 14th July 2016

Teacher	TOPIC	TIME
	Taking seats	*9.30 – 10.00*
Roberto Setola (UCBM)	Welcome	10.00 – 10.10
Roberto Setola (UCBM)	Introduction to CIPRNet	10.10 – 10.50
Vittorio Rosato (ENEA)	CIPcast – a decision support system for CI related crisis management	10.50 – 11.30
Marianthi Theo-charidou (JRC)	From Critical Infrastructure (CI) Protection to CI Resilience	11:30 – 12.10
	Coffee break	*12.10 – 12.30*
Eric Luiijf (TNO)	Simulation of CI: relevant applications	12.30 – 13.10
Mohamed Eid (CEA)	Principal modelling techniques: applications and limitations	13.10 – 14.00
	Lunch	*14.00 – 15.00*
Roberto Setola (UCBM)	Modelling and investigating dependencies of CI	15.00 – 15.40
Edwin van Veldhoven (TNO)	Introduction to Federated Simulation	15.40 – 16.20
	Coffee break	*16.20 – 16.40*
Alberto Tofani (ENEA)	Simulation approaches of System of Systems	16:40 – 17:20
Edwin van Veldhoven (TNO)	Verification and validation techniques	17.20 – 18.00

Day 2 – 15th July 2016

Teacher	TOPIC	TIME
Erich Rome & Jing-quan Xie (Fraunho-fer)	CIPRTrainer – training the exploration of different courses of action • »what if« analysis as a new capability for crisis management training • CIPRTrainer system overview • Modeling in CIPRTrainer • Event processing in CIPRTrainer • fMS&A and rollback for »what if« analysis • Training concept • Q&A	9:15 – 10:15

Coffee Break		*10:15 – 10:30*
Stefan Rilling (Fraunhofer) **Elias Kyriakides (UCY)**	Federated simulation in CIPRTrainer • Infrastructure Simulators • Infrastructure Models • Federated Simulation • Modelling dependencies • Preserving causality • Conclusion • Q&A	10:30 – 11:15
Norman Voß (Fraunhofer)	Consequence analysis as a basis for »what if« analysis • Application areas • CIPRNet's hybrid CA approach • Methods for assessing impact and consequences of crises and disasters • Data elicitation • Data handling • CA assessment and presentation in CIPRTrainer • Conclusion • Q&A	11:15 – 12:00
Lunch break		*12:00 – 13:00*
Stefan Rilling (Fraunhofer)	CIPRTrainer derailment scenario with cross-border aspects • Scenario storyline • Rules • Scenario database • Q&A	13:00 – 13:40
Betim Sojeva (Fraunhofer)	CIPRTrainer demonstration and hands-on experience Part I • CIPRTrainer GUI, GIS functionality, User roles: Trainer, trainees • »what if« analysis for exploring different courses of action	13:40 – 14:15
Coffee break		*14:15 – 14:30*
Participants	Hands-on Part 1: Familiarising with the CIPRTrainer GUI	14:30 – 15:15
Erich Rome & Betim Sojeva (Fraunhofer)	CIPRTrainer demonstration and hands-on experience Part II • Crisis management actions in CIPRTrainer	15:15 – 15:45
Participants	Hands-on Part 2: Using CIPRTrainer for exploring different courses of action	15:45 – 17:15
All	Wrap-up	17:15 – 17:30

Appendix B: CIPRTrainer slides

CIPRNet

Critical Infrastructure Preparedness and Resilience Research Network

CIPRTrainer – training the exploration of different courses of action

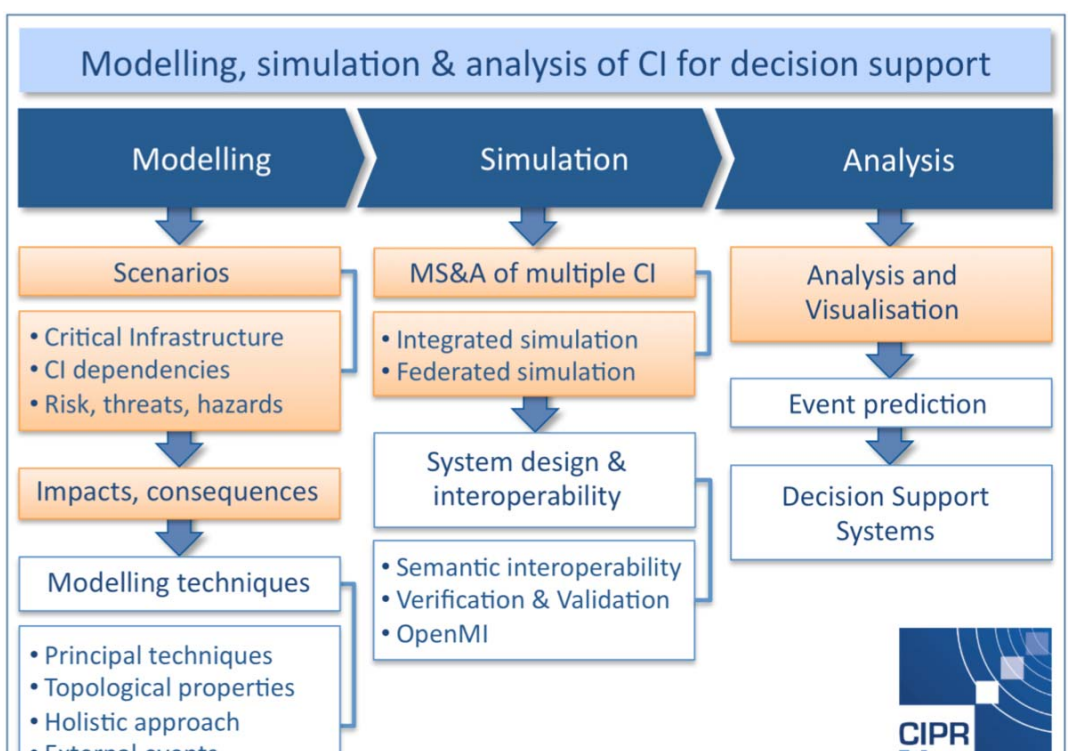
Erich Rome, Jingquan Xie

Fraunhofer IAIS (Sankt Augustin, Germany)

3rd CIPRNet Course on Modelling, Simulation and Analysis of Critical Infrastructures

UCBM – Rome (Italy) – 14-15 July 2016

Locating the presentation topic



Agenda

- **»what if« analysis as a new capability for crisis management training**
- **CIPRTrainer system overview**
- **Modelling in CIPRTrainer**
- **Event processing in CIPRTrainer**
- **fMS&A and rollback for »what if« analysis**
- **Training concept**

»What-if« analysis as a new capability for Crisis Management

Crisis Management (CM)

- Typical:
  - Cycles of situation update, decision taking, planning and execution of response actions
  - Sometimes under time pressure
- Room for improvement:
  - Insufficient awareness of the role of critical infrastructures
  - Incomplete information on consequences of crisis or disaster evolution

Source: http://www.e-isg.com/wp-content/uploads/2012/03/emergency-management-_team.jpg

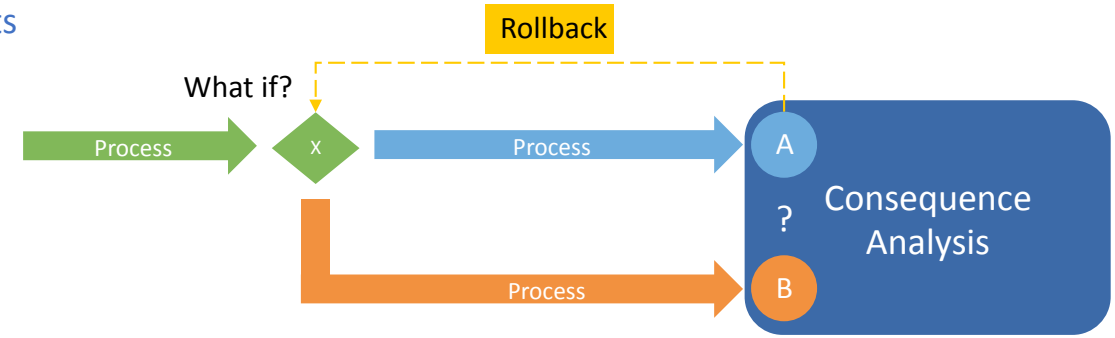
»What-if« analysis as a new capability for Crisis Management

- In reality mostly not possible:

  Revert decisions and actions and explore different courses of action

- But possible in simulation: Exploring different courses of action
  - via '**rollback**' to past decision points and
  - consequence analysis for comparing effects of different courses of action:

    Which action helps producing the least severe consequences?



»What-if« analysis as a new capability for Crisis Management

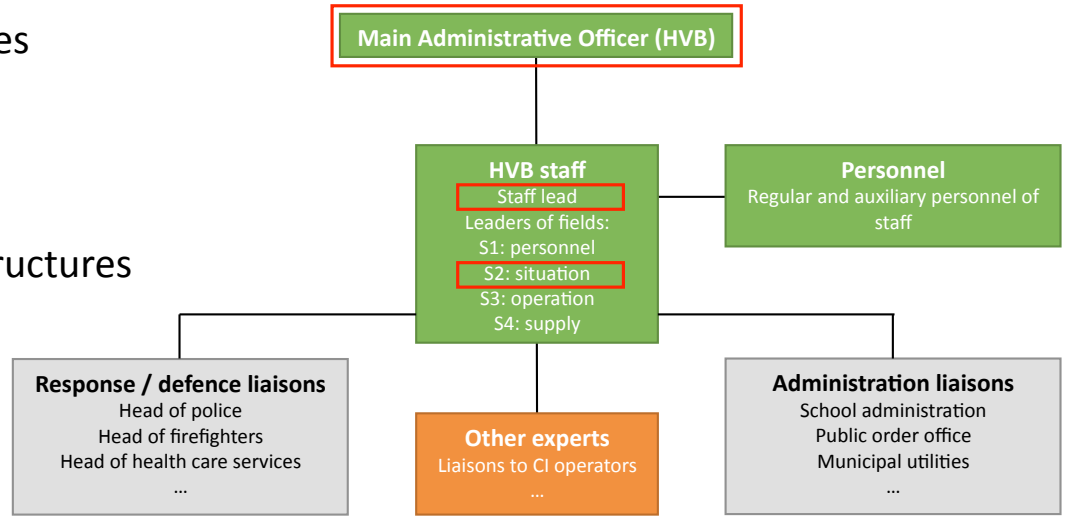
CIPRTrainer: demonstrator for 'what if' analysis capability

- Target users: crisis managers on the tactical level
- Application: Simulation-based CM training
- Additional training opportunity (besides other types of exercises) with benefits:
  - Increased awareness of role and behaviour of interconnected Critical Infrastructures in disasters, emergencies, crises
  - Better understanding of possible consequences of scenario evolution and influence of own actions
- Challenge for the wide applicability of CIPRTrainer:
  Different CM governance structures in different countries

»What-if« analysis as a new capability for Crisis Management

Crisis Management – Example from Germany

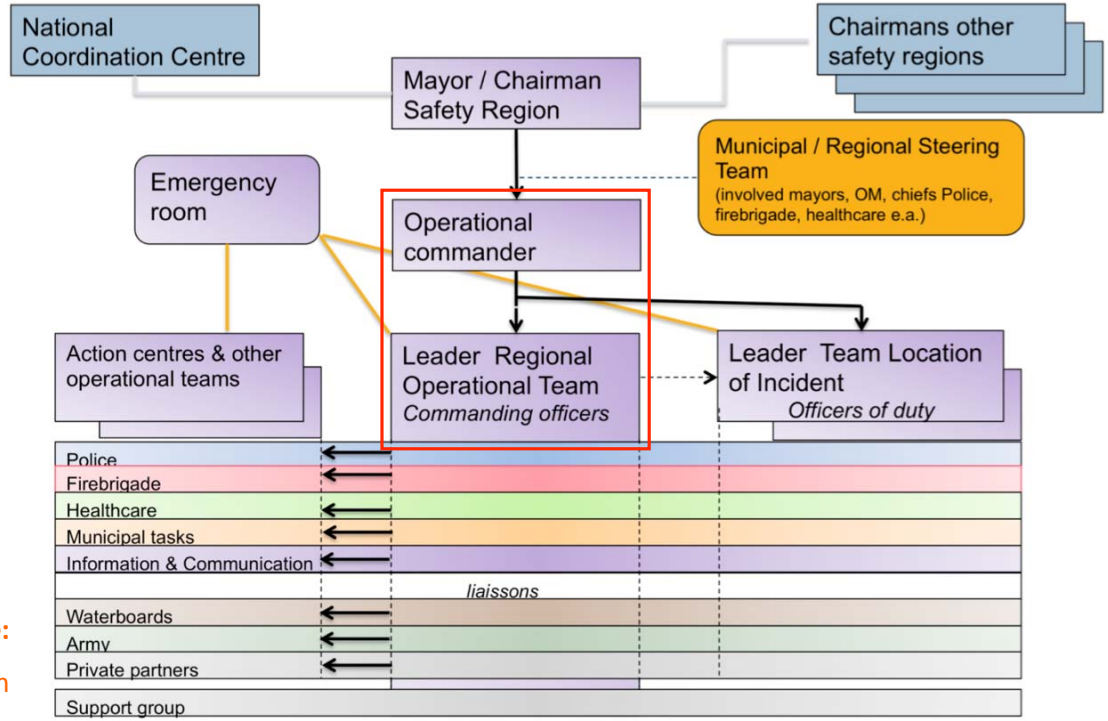
- HVB, staff lead: the decision takers
- Situation staff: collects information, prepares decisions
- Similar roles detected in CM governance structures in NL and FI
- Target users for CIPRTrainer: Decision-taker and situation staff



»What-if« analysis as a new capability for Crisis Management

Crisis Management in NL

- Operational commander: the decision takers
- Situation staff: in regional operational team



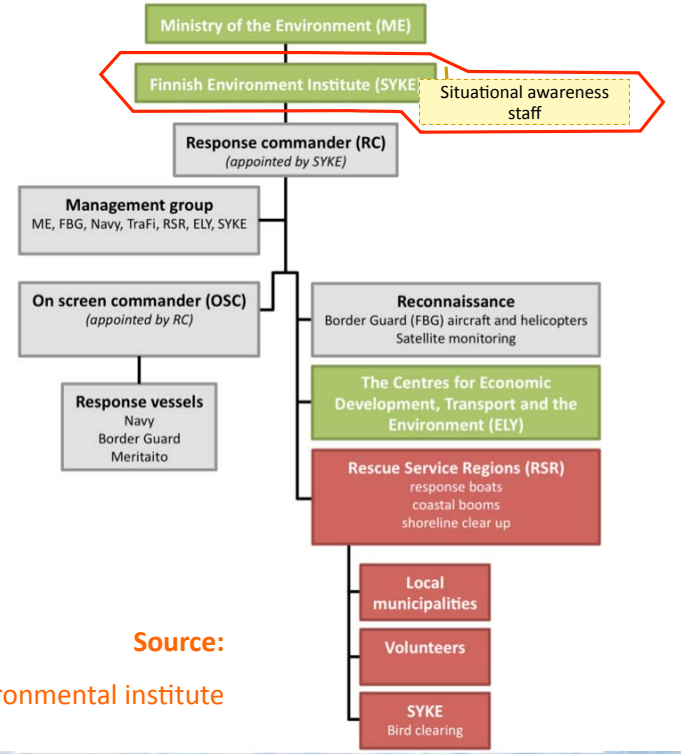
Source:

VRZHZ, Safety Region South Holland-South

»What-if« analysis as a new capability for Crisis Management

Crisis Management in FI

- SYKE (Finland)
- Response organisation of a major marine oil pollution incident
- RC: decision-takers
- Situational awareness staff

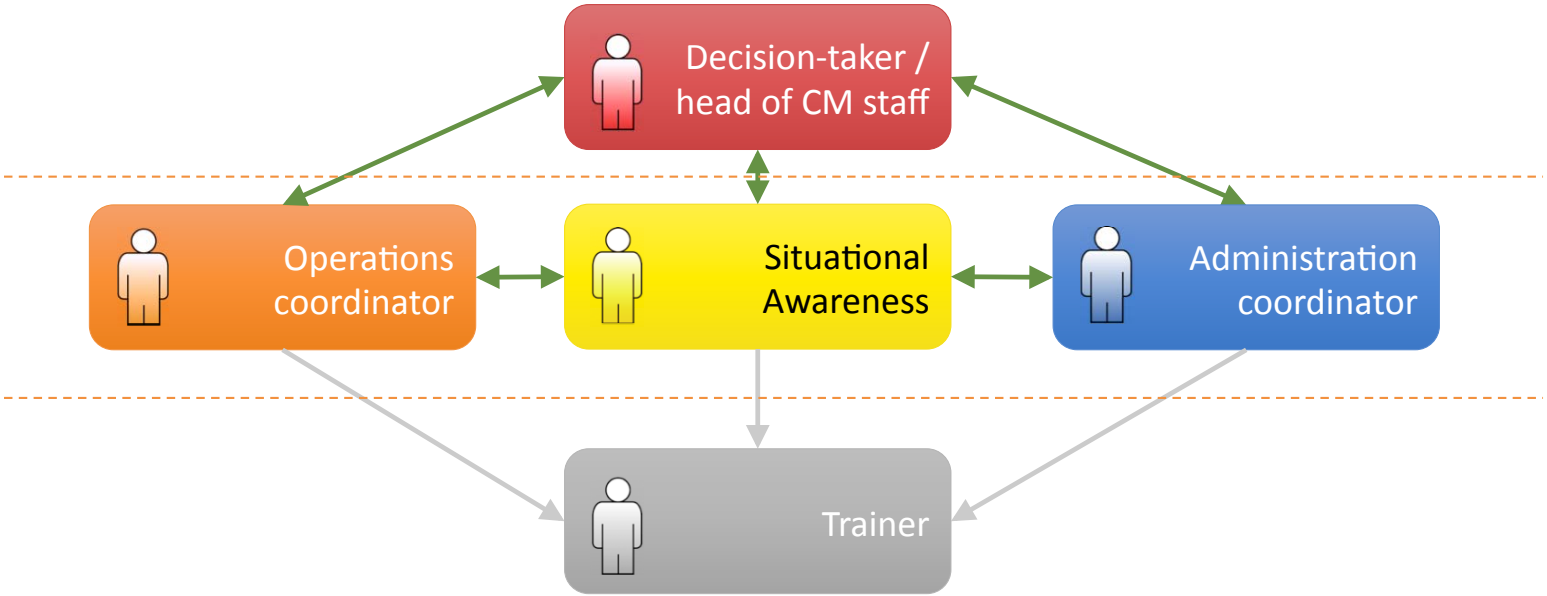


Source:

SYKE, Finnish environmental institute

»What-if« analysis as a new capability for Crisis Management

Generic Crisis Management roles for CIPRTrainer



»What-if« analysis as a new capability for Crisis Management

CIPRTrainer Application: General properties

- **'What-if' analysis (WIA)** uses computer-based federated modelling, simulation & analysis **(fMS&A)** of complex scenarios involving CI and threats
- **Impact and consequence analysis** based on socio-economic data and damage models
- **Training** disaster / crisis scenarios with cross-border aspects and including CI
- Developed using **internal and external expertise**
  - Electrical and telecommunications/IT engineers, security professionals, railway security experts, crisis management experts, water domain experts
  - Head of firefighters in a large German city
  - Advisory board: INHESJ, BBK, e-GEOS, …

»What-if« analysis as a new capability for Crisis Management

CIPRTrainer Application: Scenarios for demonstration and training

- **Cross-border scenario** (Germany / The Netherlands) with two storylines
  - Train derailment in a city center
  - Regional flooding by river Rhine

Derailment scenario: Incident, events and impacts

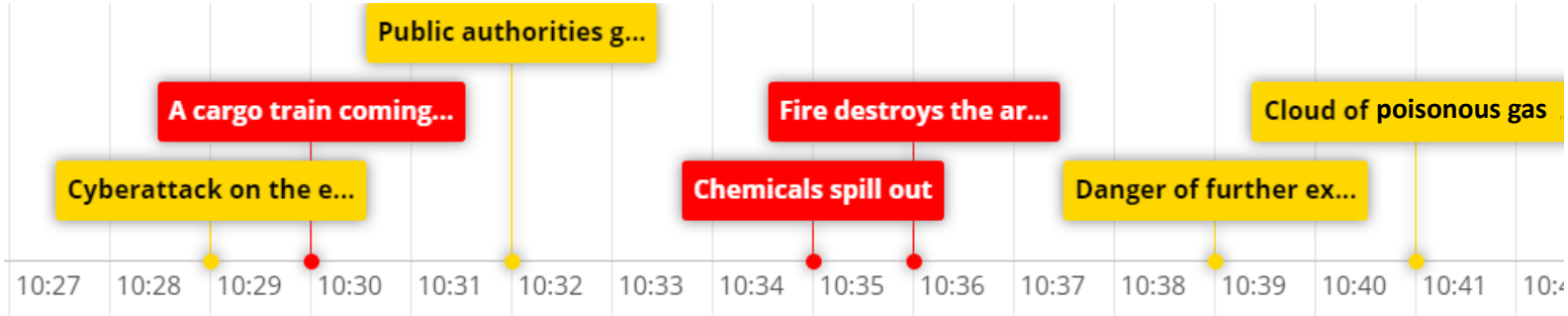
Train derailment in the German city of Emmerich due to cyber attack

- Direct and indirect **impacts**
  - Interruption of major railway line: Betuwe line (Rotterdam ↔ Italy)
  - Direct damage to railway and built infrastructure
  - Explosion of chemicals leaked into sewer system leads to Power and TelCo CI failure
  - Gas and smoke cloud of burning chemicals causes
    - Curfews for and severe intoxications of people in DE and NL
    - Blocking of a major highway
    - Safety shutdown of data centres in s'Heerenberg (NL) due to endangered fresh air supply

CIPRTrainer derailment scenario

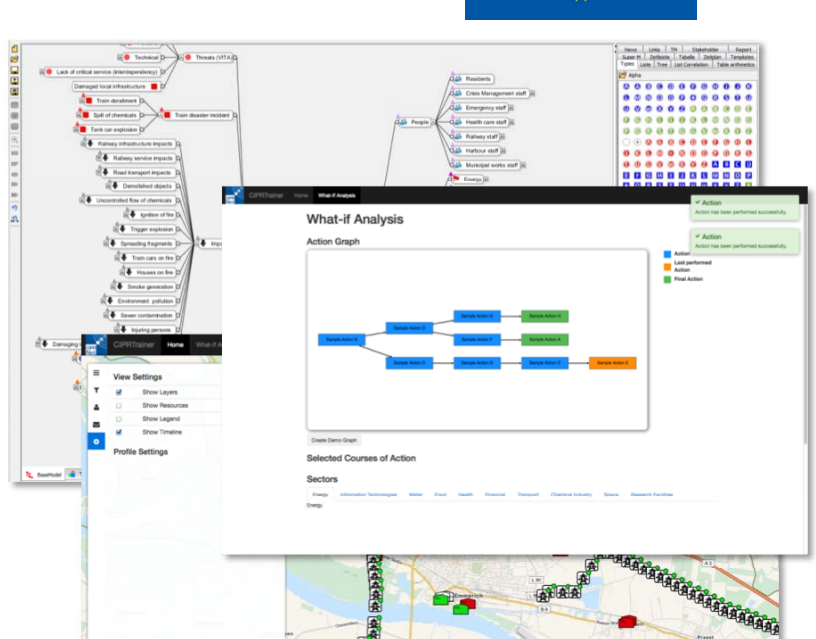
Scenario storyline

- The scenario consists of a sequence of events that simulates the different stages of an incident that leads to the destruction of components



CIPRTrainer System Overview

- Three major CIPRTrainer components
  - Design engine: offline Scenario Editor
  - Training engine frontend:
    HTML5 web application for online training
    (Graphical User Interface (GUI))
  - Training engine backend: internal simulation ‘machinery’

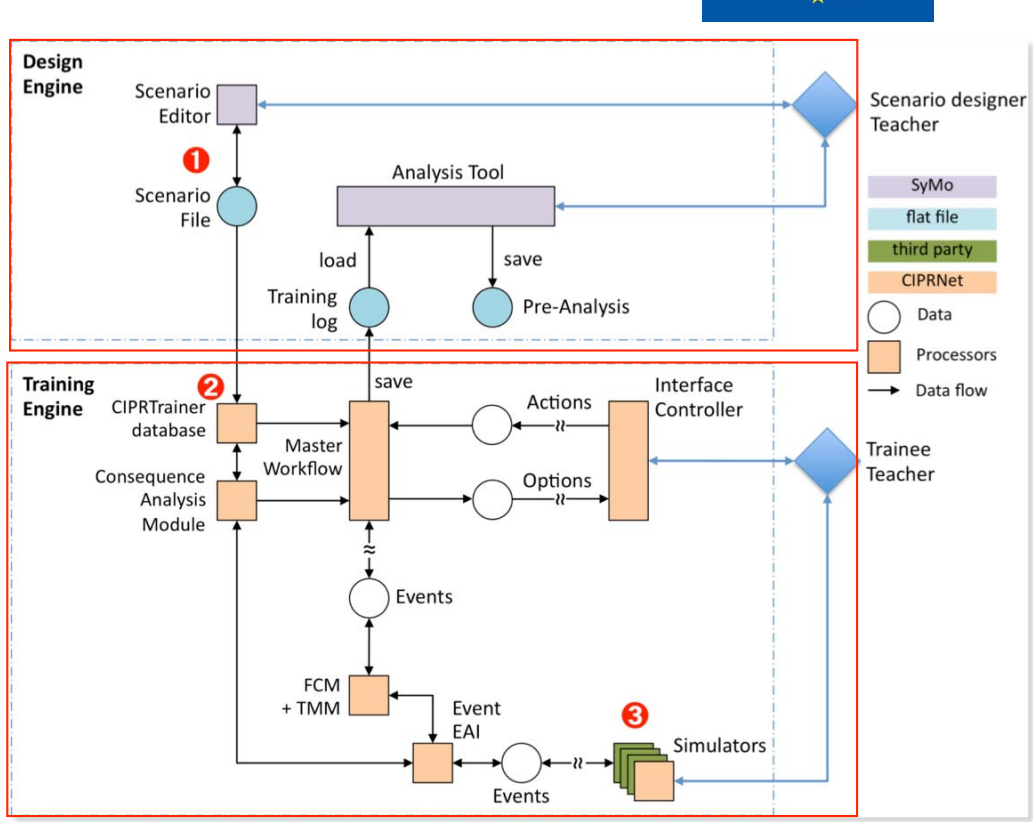


- Graphical environments for system modelling

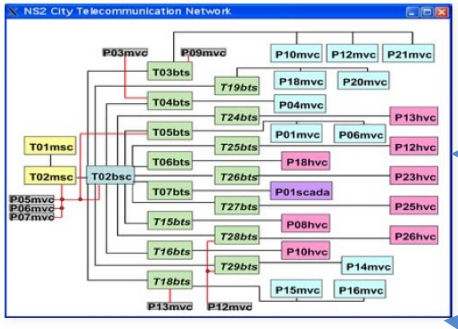
- Web-based training with **»what-if« analysis**
  - Rollback support in simulated world
  - Built-in consequence analysis with advanced visualisation

CIPRTrainer Architecture

- Design Engine
  - Scenario Editor – scenario creation
  - Analysis Tool – training evaluation
- Training Engine
  - GUI for the trainer/trainee
  - Federated simulation environment with simulators
  - Rollback module for WIA
  - Event processing engine
  - Consequence analysis used by WIA

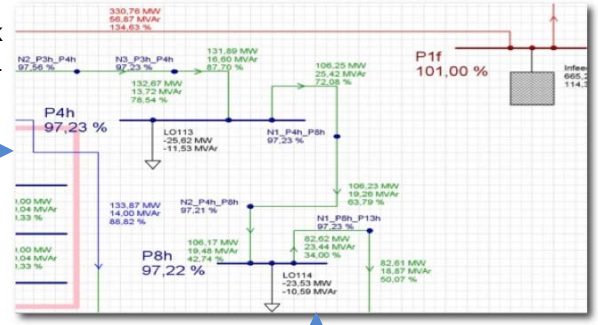


CIPRTrainer – Federated Simulation

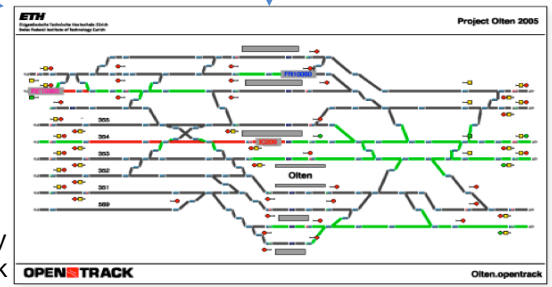


Telecommunication Network Simulator NS2

Electricity network Simulator SINCAL



Data exchange and synchronisation

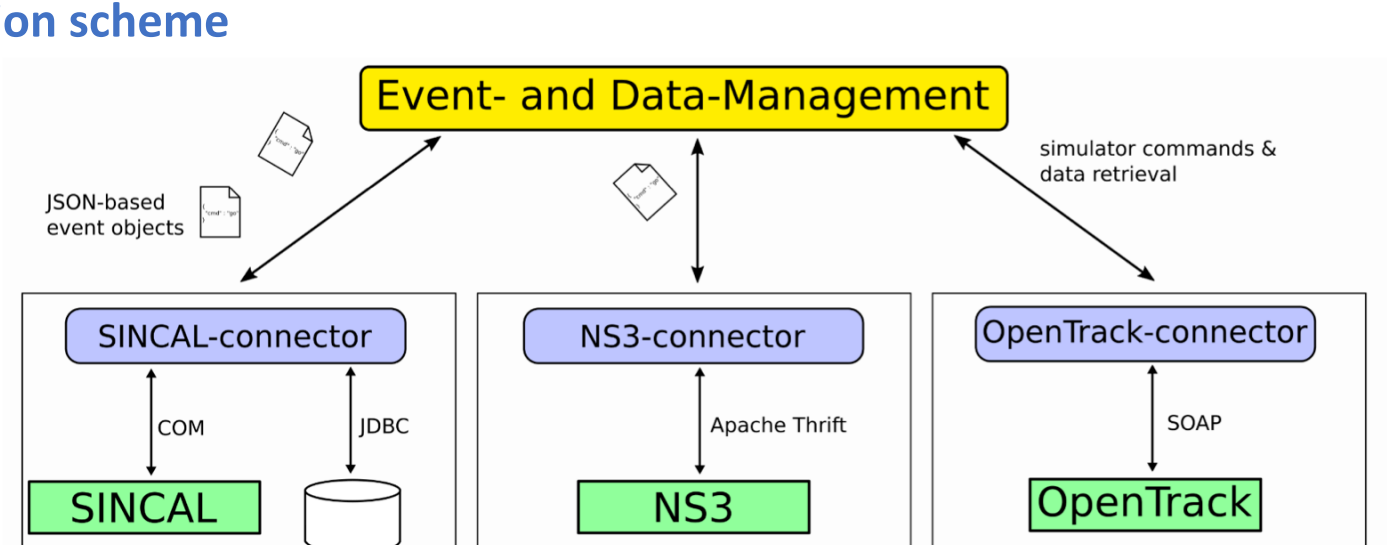


Railway Simulator Opentrack

- Three domain simulators (two commercial)
- Interconnections necessary for simulating dependencies and cascading effects
- Synchronisation for preserving causality
- Data exchange for propagating cascading effects

CIPRTrainer – Federated Simulation

Federation scheme

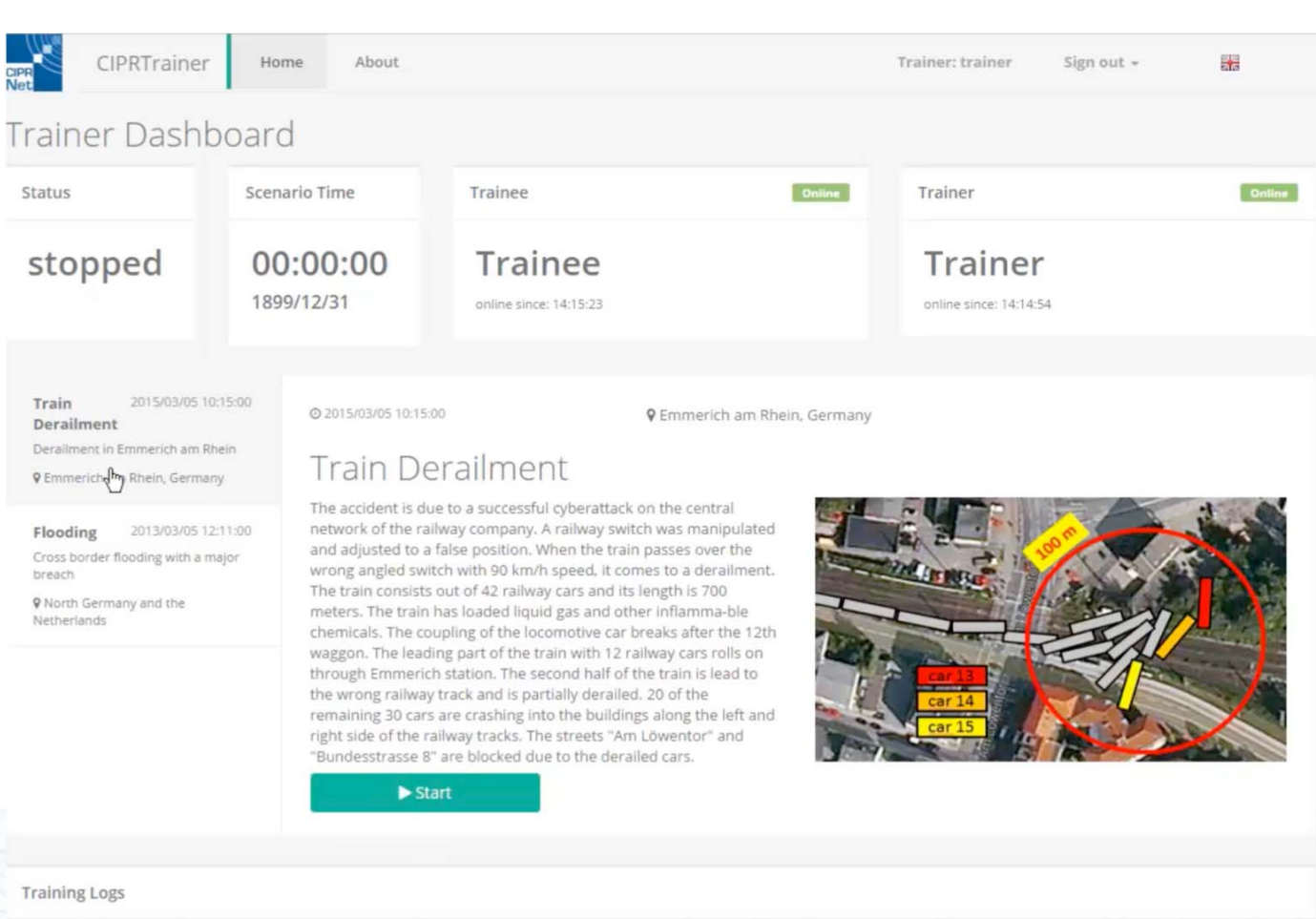


CIPRTrainer – Frontend

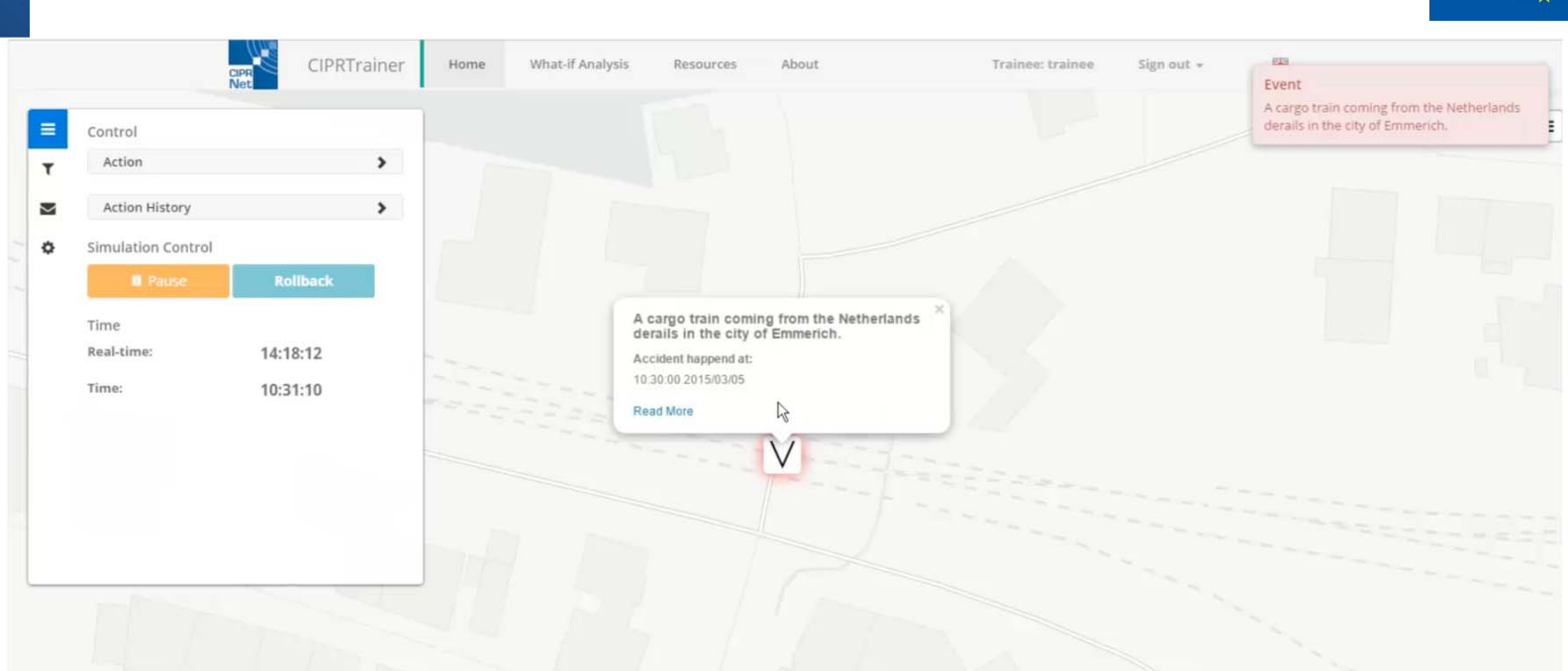
Graphical User Interface

- Single web page application (HTML5)
- Up to four online users: trainer, decision-taker, operations coordinator, administration coordinator
  - Action menus depend on trainee role
  - Trainer has different view
- Localisable interface (English, German, Dutch)
- German civil protection icons (can be switched to Dutch icons)

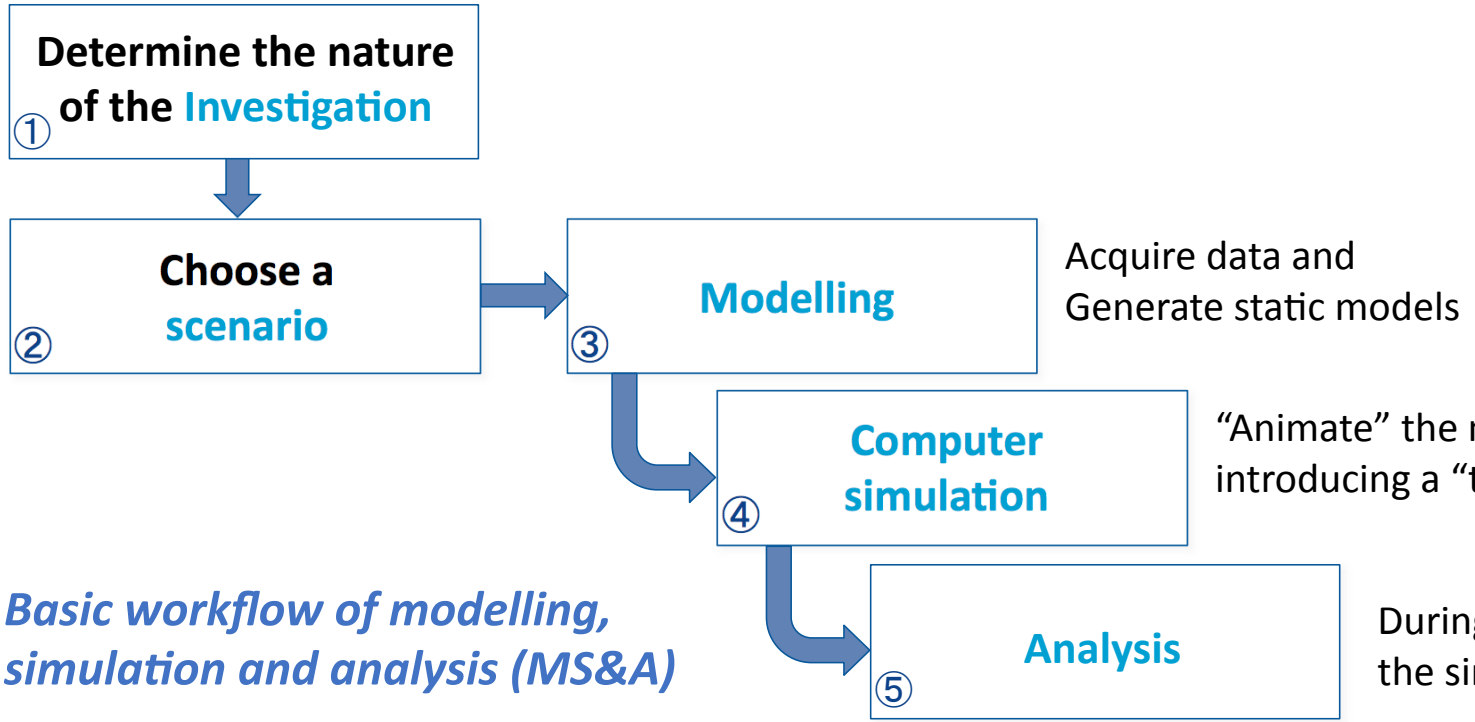
CIPRTrainer – GUI



CIPRTrainer – GUI



CIPRTrainer – MS&A



Acquire data and
Generate static models

"Animate" the model by introducing a "time" component

During or after the simulation

Basic workflow of modelling, simulation and analysis (MS&A)

① ≙ DSEEP step 1

② ≙ DSEEP steps 2,3

③ ≙ DSEEP step 3,4

④ ≙ DSEEP step 4,5,6

⑤ ≙ DSEEP step 7

Challenges in Modelling & Simulation

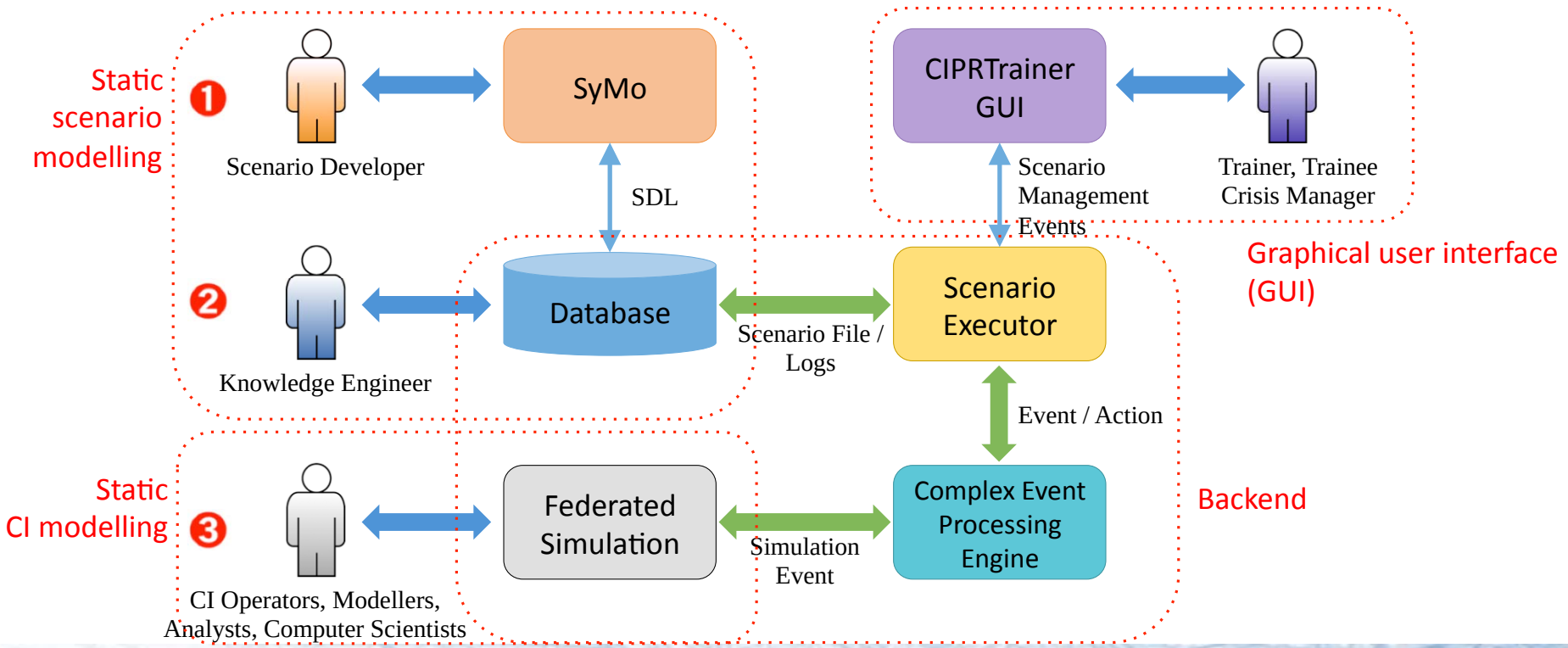
Simplification, usefulness and expressiveness

- All models are necessarily simplifications of the real world
- Even complex scenarios need to be manageable
  - Models need to be realisable with feasible effort
  - Simulations need to run without prohibitive waiting time
- Models need to be correct and as precise as possible
- Models and simulations must not be trivial
- Predicitive abilities are typically very limited

"Essentially, all models are wrong, but some are useful."
George E. P. Box

M&S task:
Find a good trade-off between feasibility and expressiveness, yielding a useful model

CIPRTrainer Building blocks



Overview on Modelling for CIPRTrainer

Multi-part modelling of the crisis scenarios

❶ SyMo: Scenario model generated by means of the scenario editor, describing parts of the scenario that are not directly related to the CI models
(like threats, responders, response and mitigation actions, …)

❷ CIPRTrainer database:

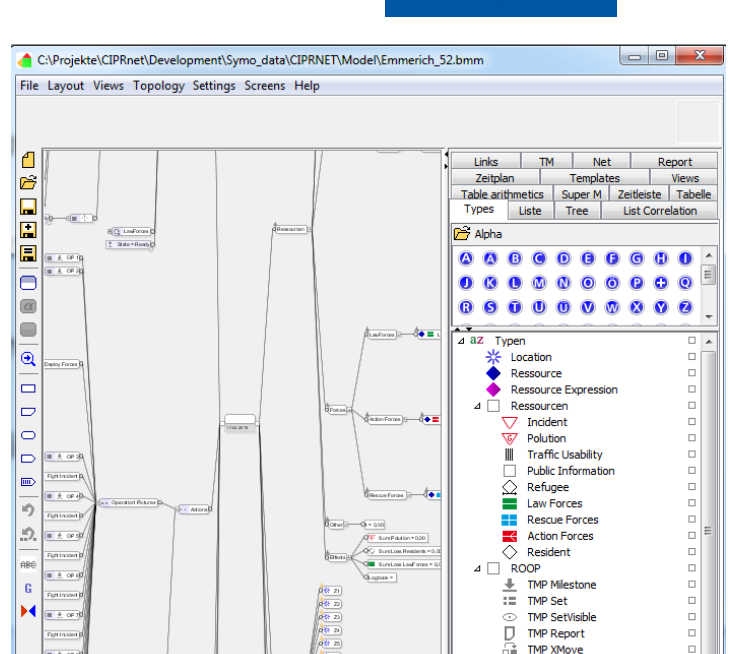
- Scenario and event models (imported from SyMo)
- Scenario-specific rules (for user actions and for CI dependencies)
- Flood models
- Scenario specific models of impacts and consequences

❸ Federate simulators: CI modelling – networks, their elements, their behaviours & dependencies

Scenario Editor – static models

1

- Tool SyMo plus scenario file exporter
- SyMo: desktop application for offline scenario design and analysis
- Generates scenario files in JSON* for training engine's scenario loader

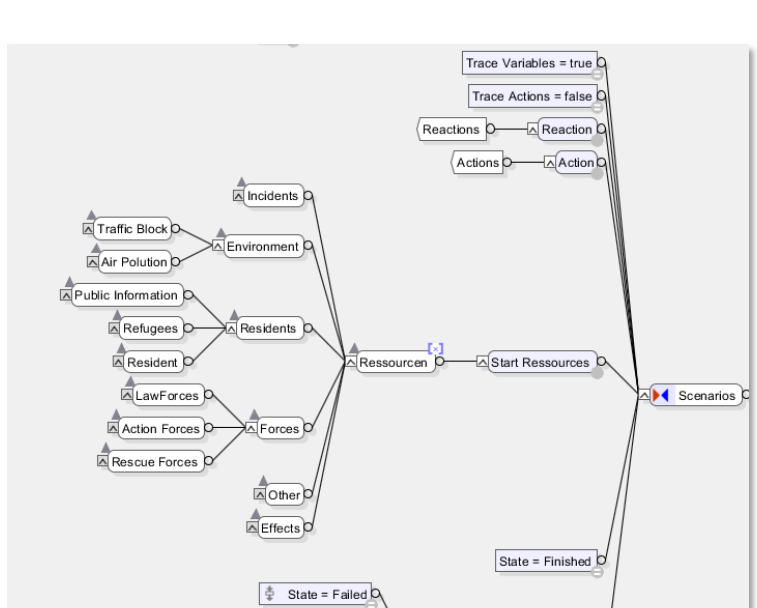


* JSON: JavaScript Object Notation – "open-standard format that uses human-readable text to transmit data objects consisting of attribute–value pairs" (Wikipedia)

Scenario Editor – static models

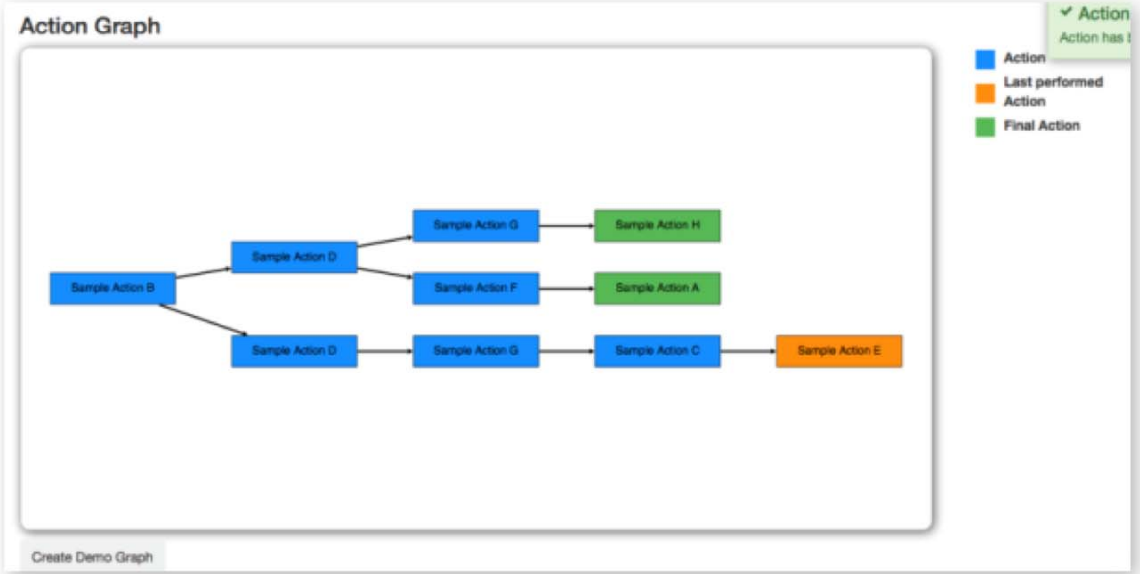
Modelling with SyMo consists of three steps:

1. Create a static model and a process model of the scenario
2. Configure the model by choosing concrete values for variables and parameters
3. Export the configured SyMo model into a scenario file and store it in a scenario database



Modelling for WIA and Consequence Analysis

- Rollbacks enable a trainee to revoke a decision and explore a different course of action in a simulated scenario
- Each rollback creates a new branch in the action tree
- Consequence Analysis can be performed to compare overall outcomes and possible influences of decisions/actions



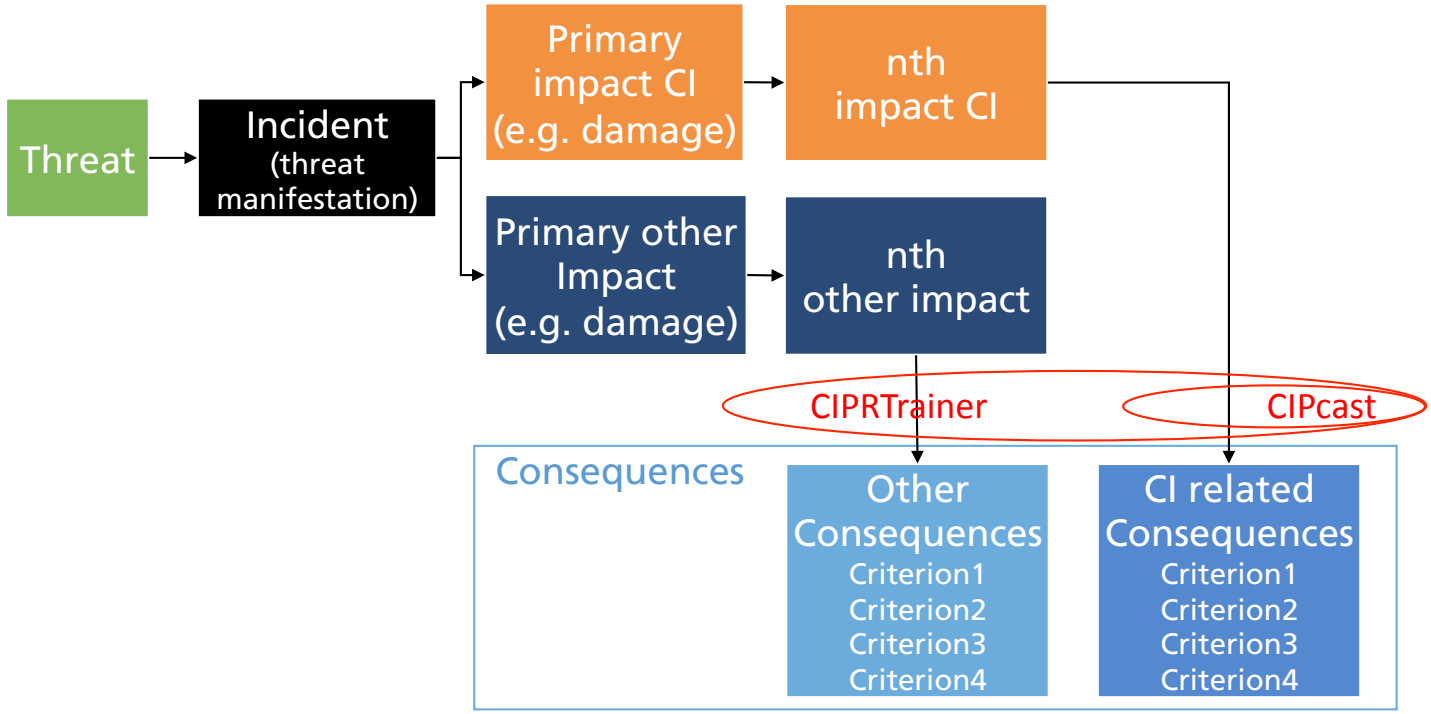
Consequence Analysis (CA)

❷ Aim of the Consequence Analysis

- **The overall goal for the CA is to provide the CIPRTrainer users with the capability**
  - **to understand the effects of their actions and inactions on the broader consequences of the incident evolution during and at the end of a training**

- CA goes beyond impacts, as it clarifies the consequences / meaning of the impacts for the population and the economy
- The CA is able to analyse
  - the direct consequences to CI, built-up area and the surroundings
  - and the indirect consequences due to the inoperability of CI and economic sectors
- CA provides measures for comparing different simulation runs (rollbacks)

CA: Distinction between CI related and other consequences

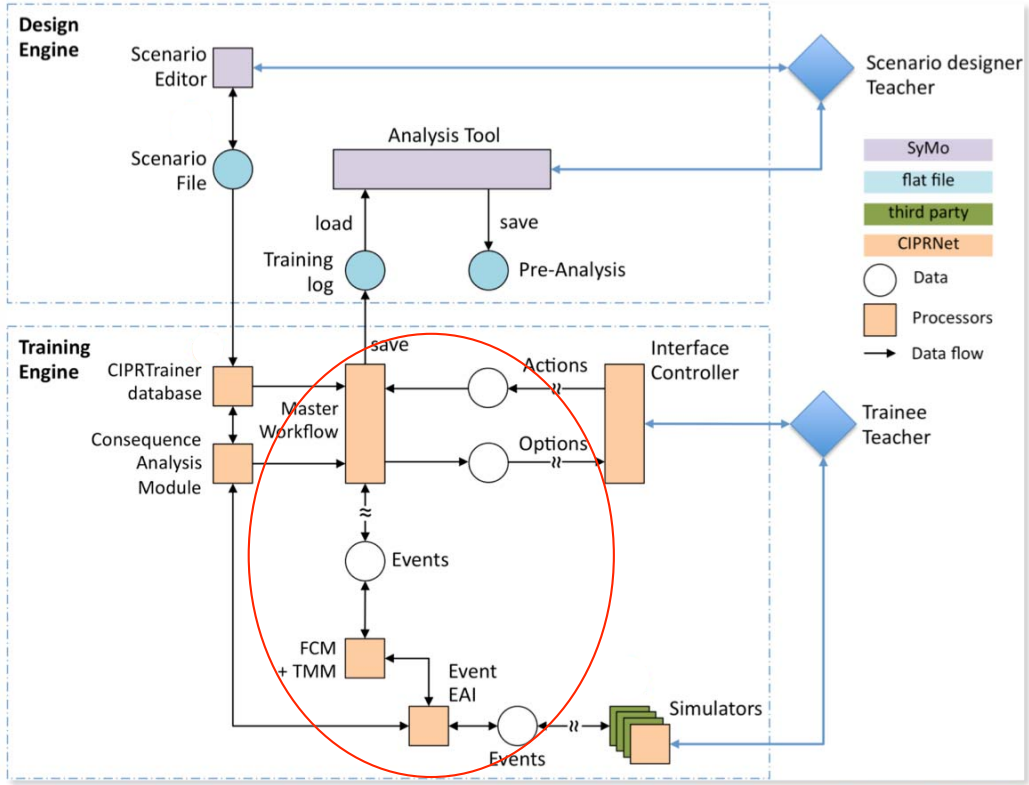


CIPRTrainer – Complex Event Processing (CEP)

Complex Event Processor

- General event processor
- Orchestrator of CIPRTrainer (Master workflow)
- Animates storylines as sequences of events

- Rule base with declarative CEP rules
  ➔ see next slide



Scenario events and rules …

… for Complex Event Processing

❷ Complex Event Processing

- All activities in CIPRTrainer that require exchange of data or execution of an action are considered 'events'
  - 'incidents' in the scenario storyline
  - user actions at CIPRTrainer's front end
  - CI simulator events
  - triggering of internal computations and database access
- Certain events may trigger rule execution, giving the scenario evolution some variability
- CIPRTrainer contains a component that processes events and rules:
  the Event Processor (also called master workflow engine)

Scenario events and rules …

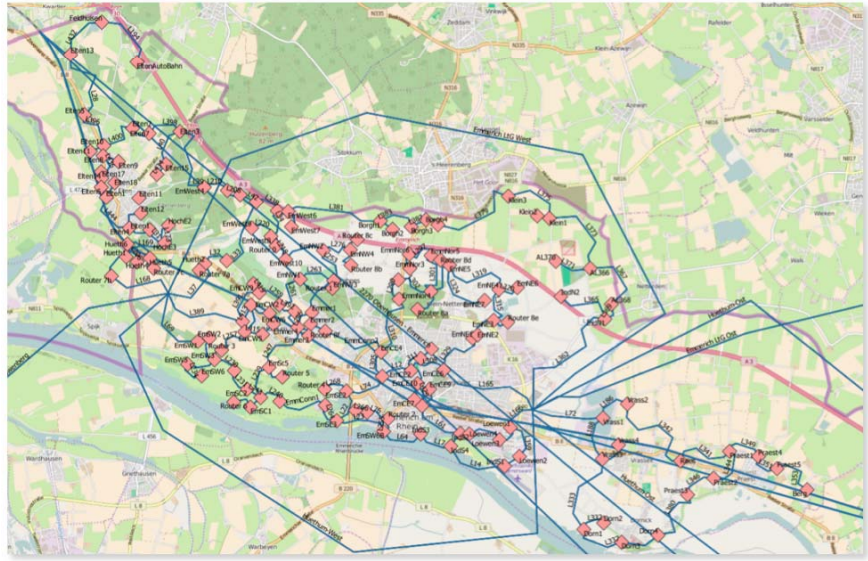
… for Complex Event Processing

SimTime	Storyline Event: Red: On map Yellow: Timeline only	Event Processing Rule
10:29:00	Cyberattack on the electronic railway control centre Emmerich. Manipulation of a railway switch.	
10:30:00	A cargo train with tank cars coming from the Netherlands derails in the city of Emmerich.	- disable railway track in OpenTrack simulator / database - mark humans dead in database - mark humans injured in database - mark buildings as damaged in database
10:31:00 10:35:00 10:35:00 10:38:00	Waggons crash onto the street and into buildings. Train conductor and witnesses inform the public authorities. Incidentally a police car arrives at the crash site. Disaster event is officially called by the mayor	
10:40:00	Chemicals spill out of the railway cars and ignite.	
10:40:00	Cloud of smoke and toxic gas emerges from the fire.	
10:44:00	Fire destroys part of the railway infrastructure.	- mark railway track as damaged in database
10:45:00	Fire heats other railway cars with the danger of further explosions.	

Federated CI Models

❸ CI simulation – SINCAL, ns-3, OpenTrack

- Infrastructure models in the scenario area
- Based on real data:
  - Electrical transmission network (Fraunhofer IAIS)
  - Railway network (Fraunhofer IAIS)
- Realistic models:
  - Electricity distribution network (University of Cyprus)
  - Telecommunication network (University of Science & Technology Poland)



Artificial electricity distribution network for Emmerich (UCY)

CIPRtrainer Modelling Summary

"Take home messages"

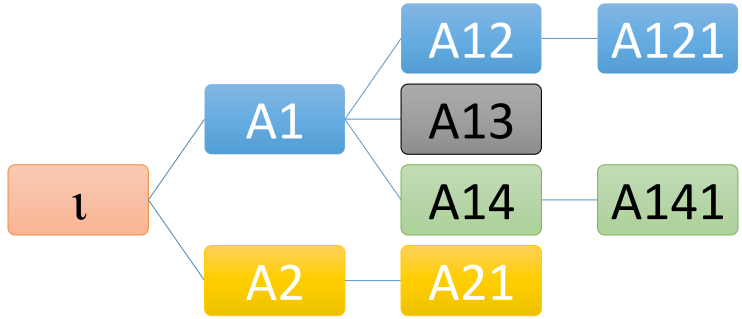
- Modelling in CIPRTrainer is heterogeneous and roughly divided into three areas
- Static modelling of non-CI model elements (similar to creating an ontology) with scenario editor tool based on SyMo
  - static models created with the Scenario Editor are parameterised
  - concrete values for parameters yield a storyline
- Domain-specific CI modelling in the CI simulators:
  electricity networks, telecommunication networks, railway network
- Modelling in the CIPRTrainer database
  - impacts and consequences for consequence analysis
  - CI dependencies and event processing rules for Complex Event Processing (orchestrating the CIPRTrainer workflow)

Rollback for »what-if« analysis

Support for CIPRTrainer level

- Rollback means ‘going back in (simulated) time’
- It results in branching of different possible ‘worlds’
  - … at certain points in simulation time
  - Events, actions, and resource states belong to a certain branch
- Using concepts from temporal database technology facilitates the implementation
  - Transaction time, valid time, temporal-joins etc.

Tree showing four different courses of actions (four rollbacks performed)

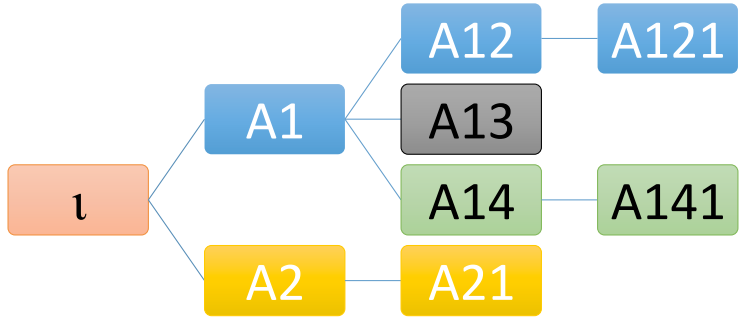


Rollback for what-if analysis

Support on simulator level

- Implementation of rollback varies and depends on the data model of the federate simulator
- Use code revision techniques e.g. with Git branches (CIPRTrainer database)
- Dump and restore simulation models at runtime to handle rollback in simulators (SINCAL)
- Use in-simulator rollback support (e.g. ns-3)

Tree showing four different courses of actions (four rollbacks performed)



CIPRtrainer – Training Concept

- Supervised training with preselected scenario / storyline
- Two-part hands-on
  1. Familiarise with the GUI
  2. Conduct a full training session

- Trainer
  - starts, monitors and stops training sessions
  - can download and training log files

- Trainees
  - can assume three roles: decision taker, operations coordinator, administration coordinator
  - can work simultaneously with the system
  - have different action menus depending on their roles

CIPRtrainer Introduction

Conclusion – "Take home messages"

- CIPRTrainer is a new training system for crisis / disaster management
- »What-if« analysis with consequence analysis provides a new capability for crisis managers, allowing the exploration of different courses of action
- CIPRTrainer provides complex scenarios, simulating crises and disasters including perturbations of CI and cascading effects
- Modelling of complex disaster scenarios including CI requires extensive preparation and domain expertise
- Modelling and simulation challenge:
  Find a good trade-off between feasibility and expressiveness, yielding a useful model
- CIPRNet provides new methods for comprehensive impact and consequence analysis

Disclaimer
This presentation was derived from the FP7 project CIPRNet, which has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 312450.
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Thank you for your attention!

project website: ciprnet.eu

online glossary: cipedia.eu

Acknowledgements: CIPRNet team

CIPR Net

Fraunhofer IAIS

CIPRNet

Critical Infrastructure Preparedness and Resilience Research Network

Federated simulation in CIPRTrainer

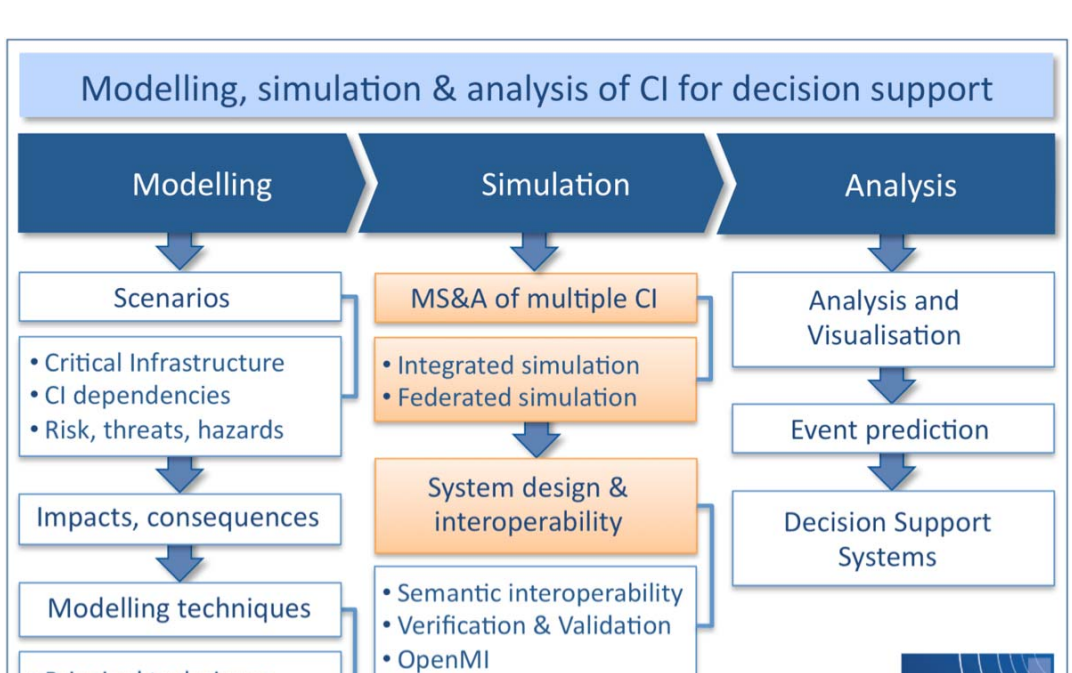
Stefan Rilling / Fraunhofer IAIS (Sankt Augustin, Germany)

Elias Kyriakides / University of Cyprus (Nikosia, Cyprus)

3rd CIPRNet Course on Modelling, Simulation and Analysis of Critical Infrastructures

UCBM – Rome (Italy) – 14-15 July 2016

Locating the presentation topic



Agenda

- Simulators in CIPRNet
- Infrastructure Models
- Federated Simulation in CIPRTrainer
- Modelling dependencies
- Conclusion
- Q&A

Federated Simulation and CI

Some applications areas

- **General (offline) CI analysis**
  - Investigating (inter)dependencies between critical infrastructures
    - Implicit, indirect and hidden relations
    - Feedback loops and cascading effects
    - Stability analysis and risk estimation
  - Testing existing and benchmarking new CI control methods
- **Improving preparedness**
  - Soft exercises and real-time training
    - Confrontation with a wide spectrum of emergency situations
- **Operational support**
  - Decision support
    - Extended representation of current situation
    - What-if analysis

Simulators in CIPRNet / CIPRTrainer

- System supports the connection of various simulators
  - Flexibility in the number and types of simulators
- Two categories of simulators in CIPRTrainer
  - Critical infrastructure simulators
    - Electrical infrastructure
    - Telecommunication infrastructure
    - Railway infrastructure
  - Threat simulators
    - Flooding simulation

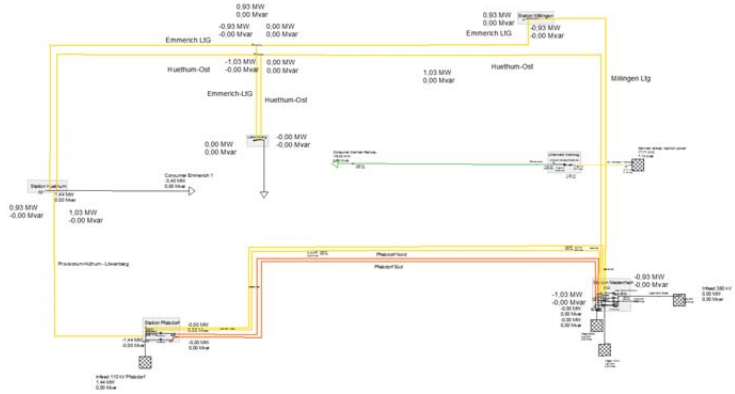
Critical Infrastructure Simulators

- Multitude of different CI simulators exist
  - Commercial simulators
  - Open source projects
- Examples for CI simulators
  - EPANET water distribution simulator
  - PSCAD power system simulator
  - I2Sim
- CI simulators used in CIPRNet
  - **PSS Sincal** for the simulation of electrical networks
  - **ns-3** for the simulation of telecommunication networks
  - **OpenTrack** for the simulation of railway networks

Critical Infrastructure Simulators

Siemens PSS® SINCAL

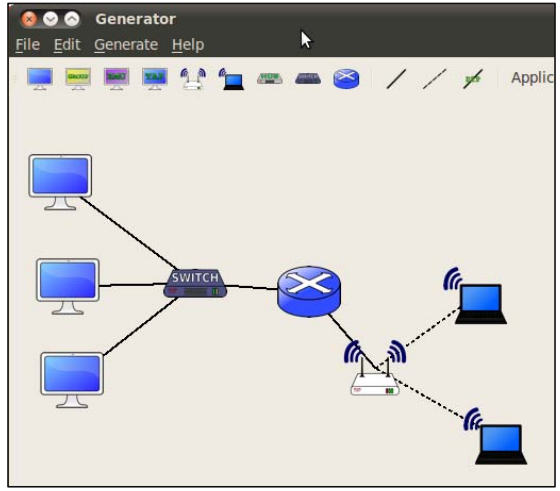
- Software package for planning and analysing electrical power systems
  - System model for high-, medium-, and low-voltage grids
  - Can also be used for the modelling and simulation of pipe networks
- Various Load Flow analysis methods
- Graphical user interface
- Automation and integration through interfaces
  - Microsoft COM
  - Connection to various Database Management Systems
    - Microsoft Access, Oracle etc.



Critical Infrastructure Simulators

ns-3

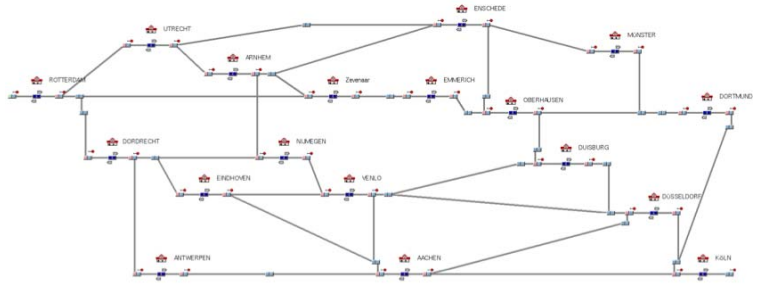
- ***N**etwork **S**imulator **3*** for the simulation of telecommunication systems
  - Free software (GNU GPLv2)
  - Intended for research and education
  - C++ and Python based API
- Discrete Event simulation
  - IP and non-IP based networks
  - Wi-Fi, WiMAX, LTE
  - Various Routing protocols
- Modelling in ns-3 involves
  - Nodes definition (names, types , positions, etc.)
  - Communication links definition (data rates and delays)
  - Topology definition



Critical Infrastructure Simulators

OpenTrack

- Simulation Software for railway systems
  - High-speed trains, commuter trains, freight trains, …
- Input to the simulation:
  - Railway network definition
  - Rolling stock data
  - Timetable data
- Various Output of the simulation results
  - Via a graphical user interface and text files
  - Diagrams, statistics, train graphs, track occupations etc.

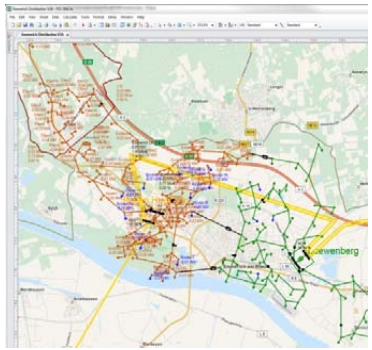


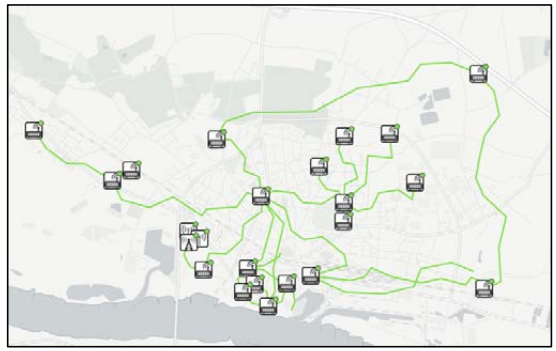
Critical Infrastructure Models

- Models are the description of how the virtual world “looks”
  - Always a simplification of the real world
- Behaviour through simulation
  - Behaviour = Change of model state over time
- Aspects building the models
  - Getting information about real world conditions is the crux of the matter
  - Various data sources exist
  - Not everything is available to the public
- Fictive CI models when no suitable information available
- **Building the models is the time-consuming part**

Critical Infrastructure Models

CI-Models in CIPRNet



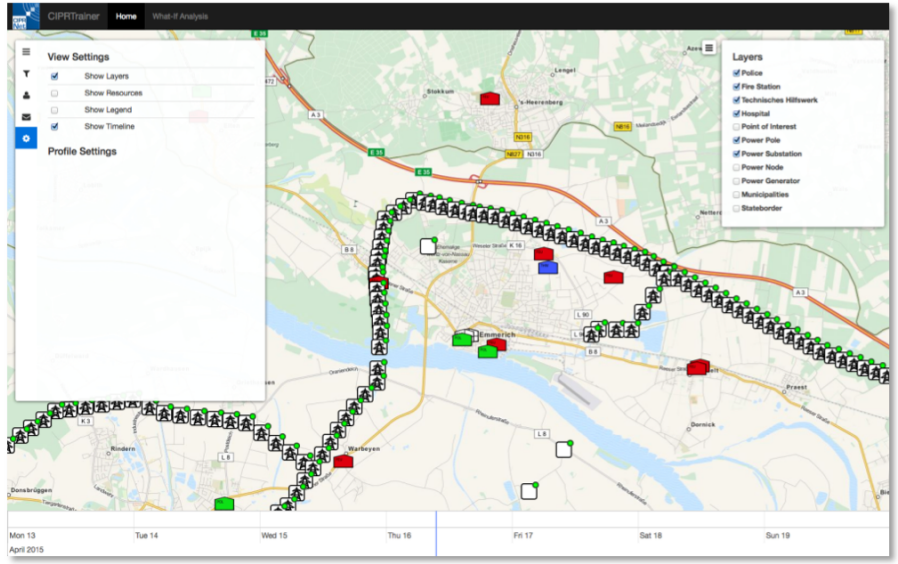


- Electrical infrastructure models
  - Transmission network
  - Distribution network
- Telecommunication infrastructure models
- Railway infrastructure models

Critical Infrastructure Models

Electrical Infrastructure Model

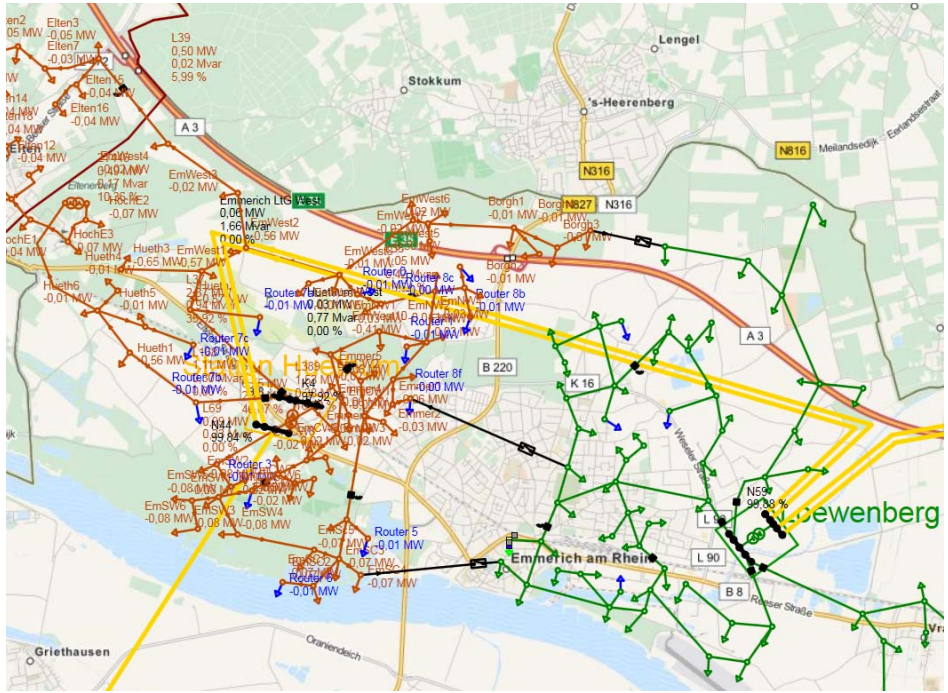
- Transmission network model could be obtained from public data sources
- Manual modelling in PSS® SINCAL
  - Powerlines, transformers, substations
  - Various parameters for each element



Critical Infrastructure Models

Electrical Infrastructure Model

- Fictive distribution network model
- Manual modelling in PSS® SINCAL
  - Few hundred elements
  - Underground cables, load elements



Critical Infrastructure Models

Electrical Infrastructure Model

- Distribution Network modelled up to the 20 kV medium voltage distribution network layer
  - Cabinet feeders for 400 V low voltage grid connection as endpoints
  - Network of underground cables
- Cabinet feeders are modelled as Load elements in PSS® SINCAL

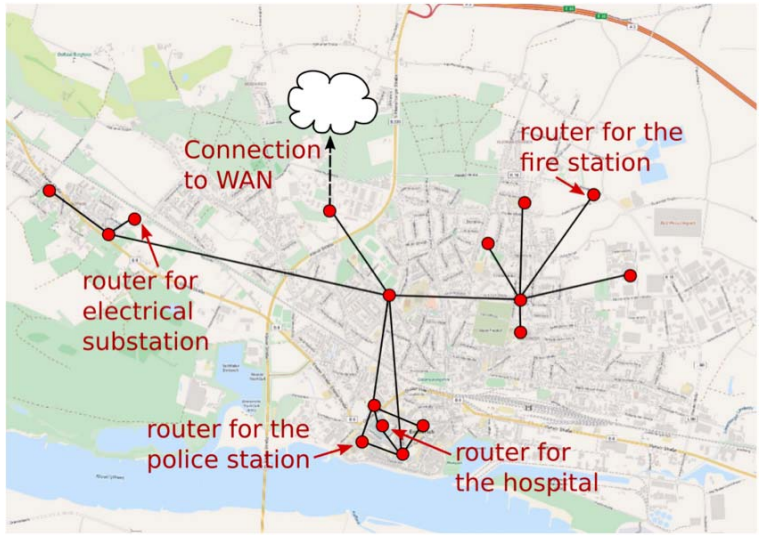
Critical Infrastructure Models

Electrical Infrastructure Model

- Cabinet feeders provide electricity to the houesholds
- Each Cabinet feeder provides electricity to 200 households
- Load for the feeders is approximated
  - 2000 kw / a per person
  - 2.3 persons per household (slightly above German average)
  - Average installed continuous power per person: 228 W
- Additional feeders for industry, hospitals etc.

Critical Infrastructure Models

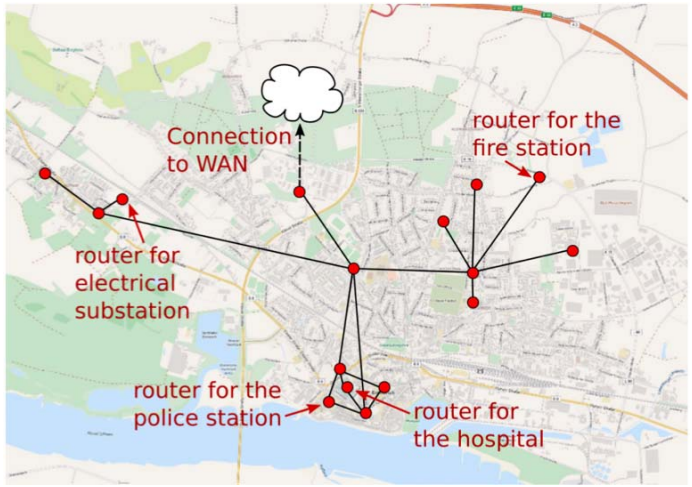
Telecommunication Infrastructure Model



- Fictive telecommunication infrastructure model
- Set of routers and interconnecting cables

Critical Infrastructure Models

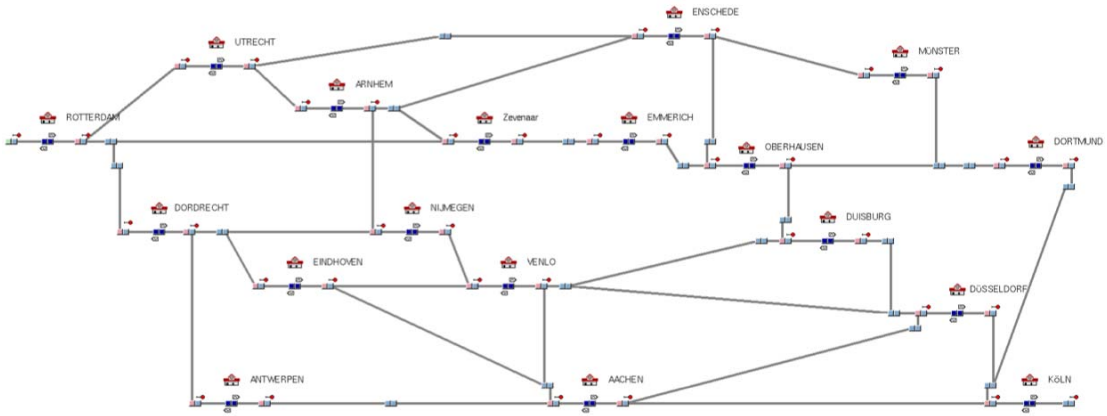
Telecommunication Infrastructure Model



- Plausible model topology and parameters through expert knowledge
- Positions of the network elements based on available map data
- Still some creativity involved

Critical Infrastructure Models

Railway Infrastructure Model



- Model of railway tracks depicts the real world conditions
- Modelled manually with OpenTrack
- Simplified signalling and security elements

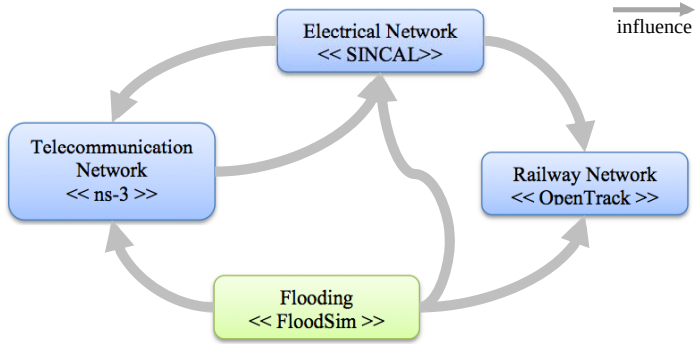
Critical Infrastructure Models

Railway Infrastructure Model

- Trains, Itineraries, Timetables are modelled based on the data provided by railway operators
  - Possible for passenger trains
  - Freight trains are fictive – no public timetable information available

Federated simulation in CIPRTrainer

Dependency between Critical Infrastructures



- Various dependencies between infrastructures
- High-Level overview needs to be mapped down to single infrastructure elements
- Dependencies need to be modelled

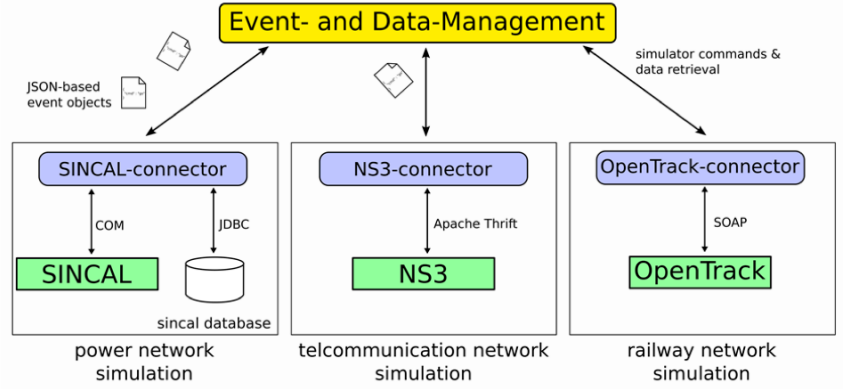
Federated simulation in CIPRTrainer

Dependency between Critical Infrastructures

- Federated simulation = interconnecting **independent** simulators
  - Synchronizing the simulation steps
  - Semantic interconnection
- Orchestrating simulation execution by superordinate software layer
  - Sending commands to the simulators
- Typical commands to a (CI) simulator
  - Start / stop the simulation
  - Advance the simulation by a given time step
  - Manipulate the simulation model
  - Query simulation results

Federated simulation in CIPRTrainer

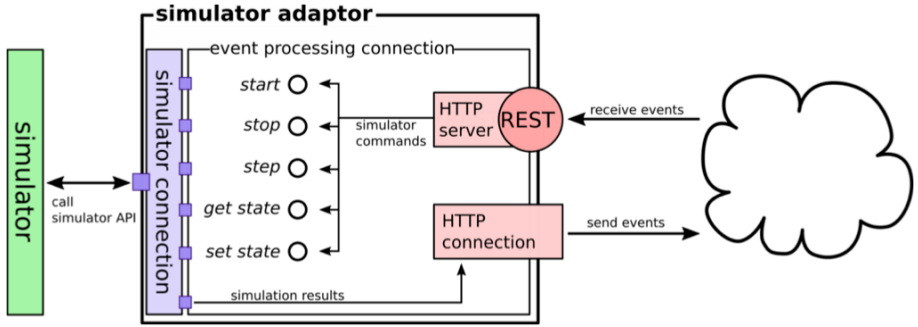
System Overview



- Interconnection between the simulators
  - Event system
  - Simulation Adaptors
- Each simulator provides its own API to access the functionality
  - Simulation Adaptors as interconnecting layer

Federated simulation in CIPRTrainer

Simulation Adaptors



- Web-Technologies to implement the interconnection
- REST API to send and receive events
- Provides access to a common set of simulator commands
  - „Translation“ within the simulator adaptor

Federated simulation in CIPRTrainer

CI-Elements

- CI-Elements as the basic behavioural entity
  - Identified by a unique name
- Hold information about operational state
  - Normal, stressed, failed, recovery
- Operational state is mapped to concrete simulator within the adaptor
  - Specific simulation result needs to be interpreted
  - Example: When is a transformer considered as not working?
  - **Expert knowledge during the implementation of the adaptor needed**
    - IT expert & domain expert

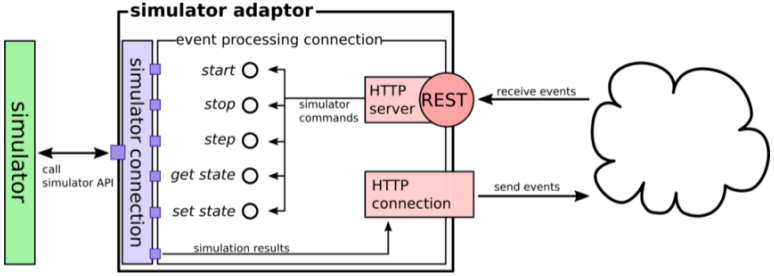
Federated simulation in CIPRTrainer

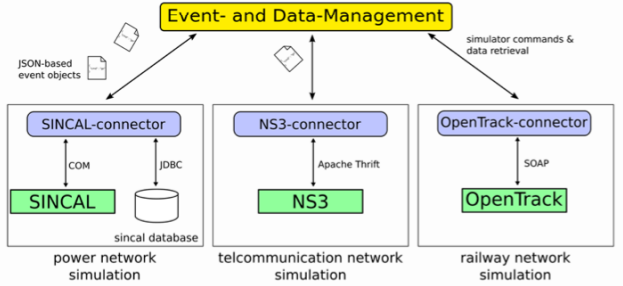
CI-Elements

- CI-Elements subject to CI interdependency need to be represented in multiple simulators
- Example: Mobile Communication Antenna (GSM etc)
  - Within the telecommunication simulator (of course)
  - Within the electrical network simulator (because it needs power)
- **Change of operational state needs to be synchronized in all relevant simulators**
  - If the element fails in the electrical power simulation, it needs to be deactivated in the telecommunication simulation

Federated simulation in CIPRTrainer

Interconnecting Simulation Adaptors

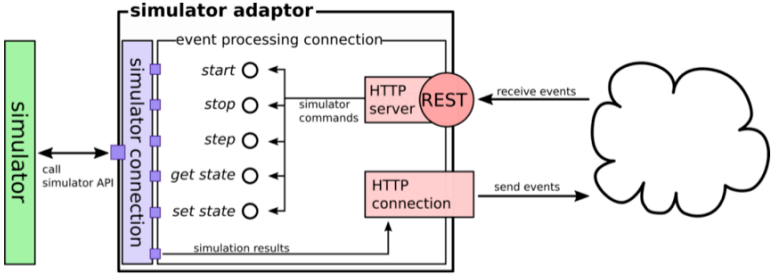


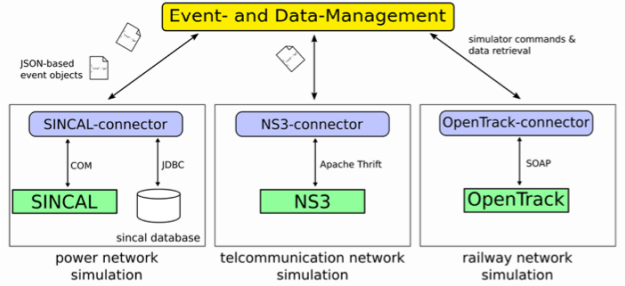


- Simulation adaptors can receive and send events
  - From other simulators
  - From other software components (user interaction etc.)
- "Conversation" between the simulators through passing of events to the event processing system

Federated simulation in CIPRTrainer

Modelling CI-Interdependency through CEP

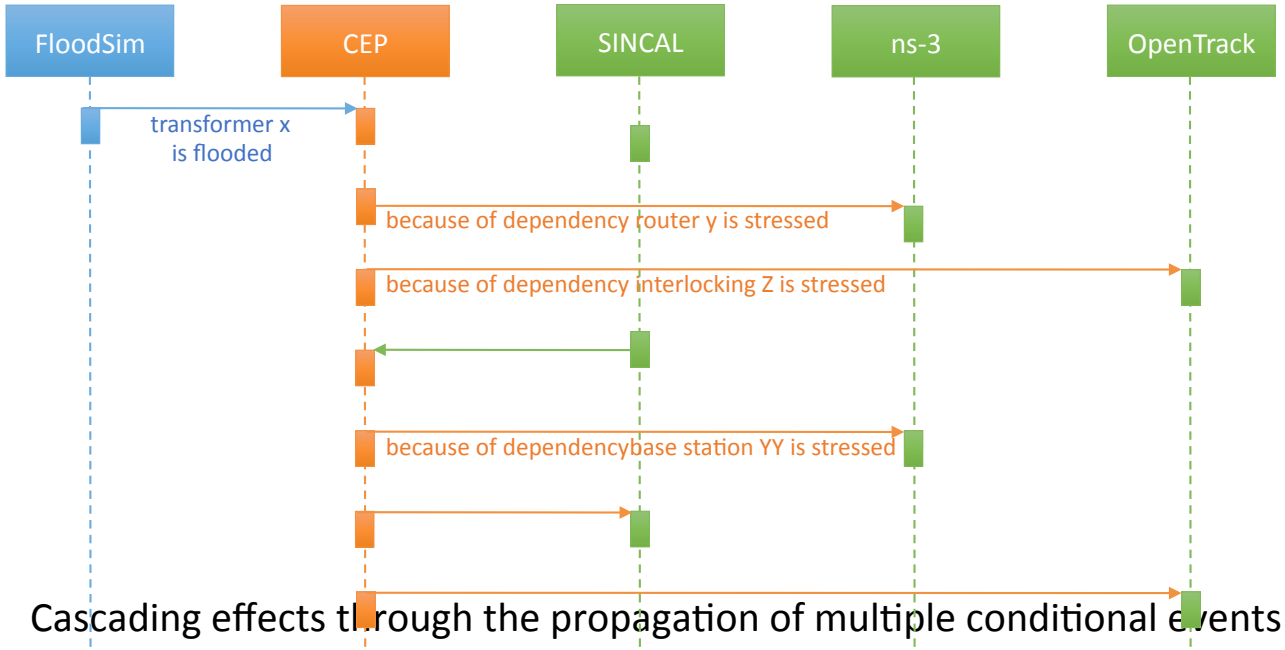




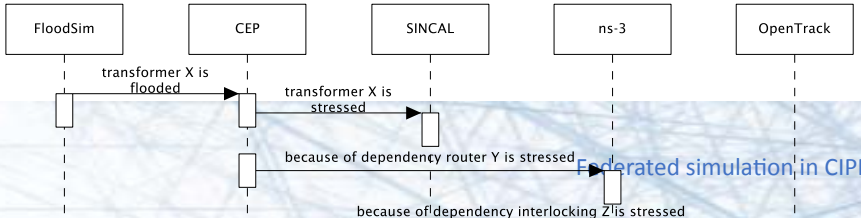
- Simulator events are passed to the event processing system
  - Example: Event is sent when a CI-Element changes the operational state
- A rule base defines which events are generated as an “answer”
  - Example of a rule: “*If element X fails in simulator A, deactivate element Y in simulator B*”

Federated simulation in CIPRTrainer

Example



- Cascading effects through the propagation of multiple conditional events



Federated simulation in CIPRTrainer

Conclusion

- The critical infrastructure simulators used in the CIPRTrainer
- Aspects of building the infrastructure models
- Interconnection of different simulators through a complex event processing system
  - Web-technologies for flexibility and scalability

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project website: ciprnet.eu

online glossary: cipedia.eu

Acknowledgements: CIPRNet team

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CIPRNet

Critical Infrastructure Preparedness and Resilience Research Network

Consequence analysis as a basis for »what if« analysis

Norman Voß

Fraunhofer IAIS (Sankt Augustin, Germany)

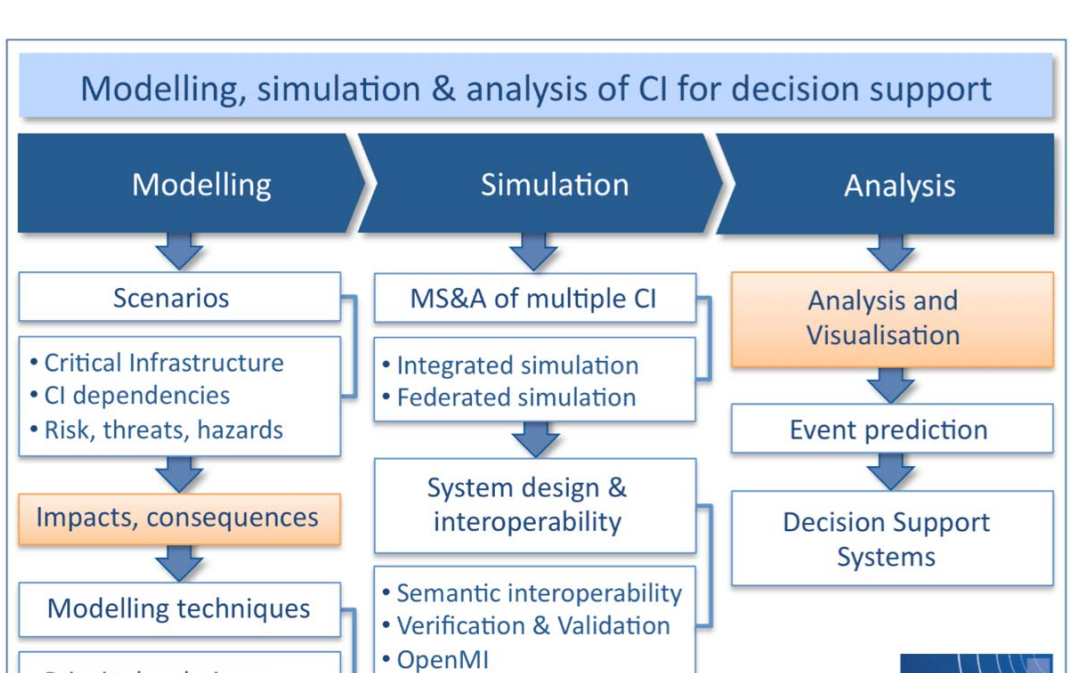
3rd CIPRNet Course on Modelling, Simulation and Analysis of Critical Infrastructures

UCBM – Rome (Italy) – 14-15 July 2016

Agenda

- **Application areas**
- **CIPRNet's hybrid CA approach**
- **Methods for assessing impact and consequences of crises and disasters**
- **Data elicitation**
- **Data handling**
- **CA assessment and presentation in CIPRTrainer**
- **Conclusion**
- **Q&A**

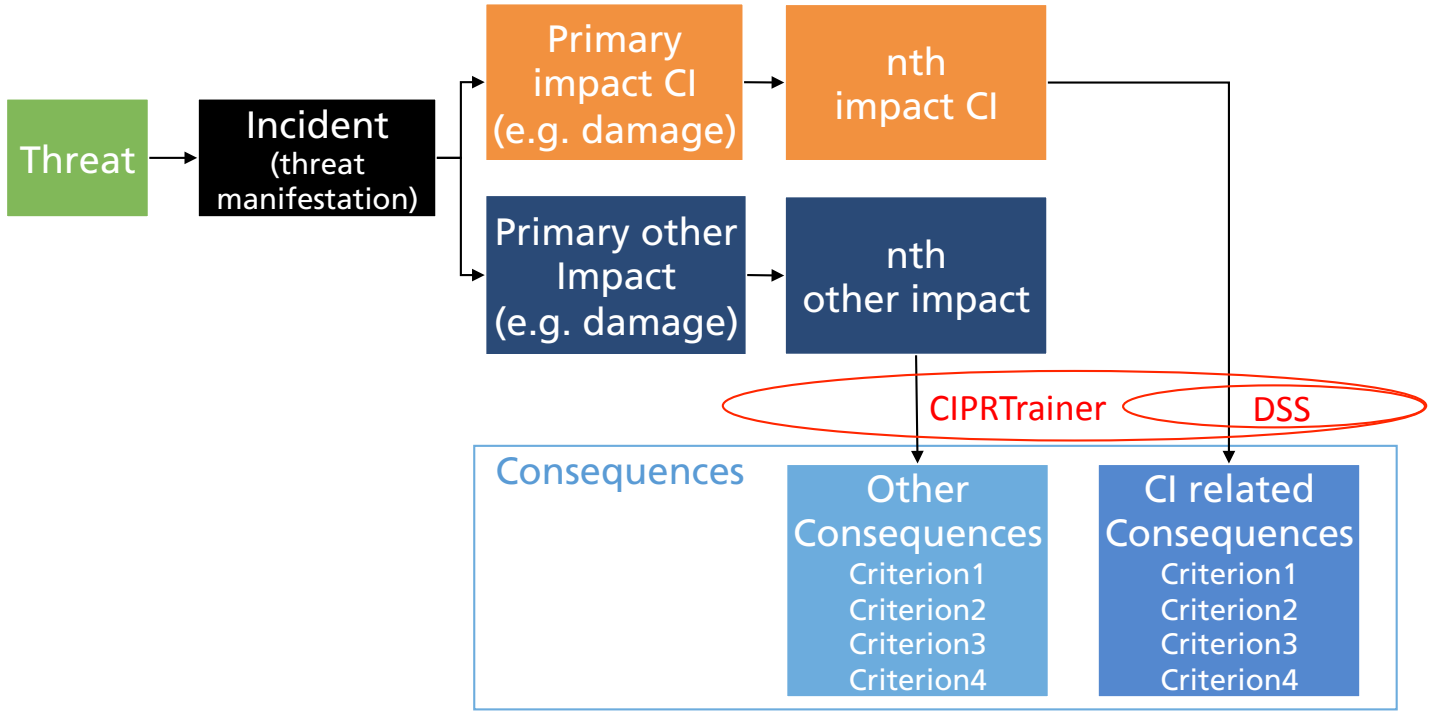
Locating the presentation topic



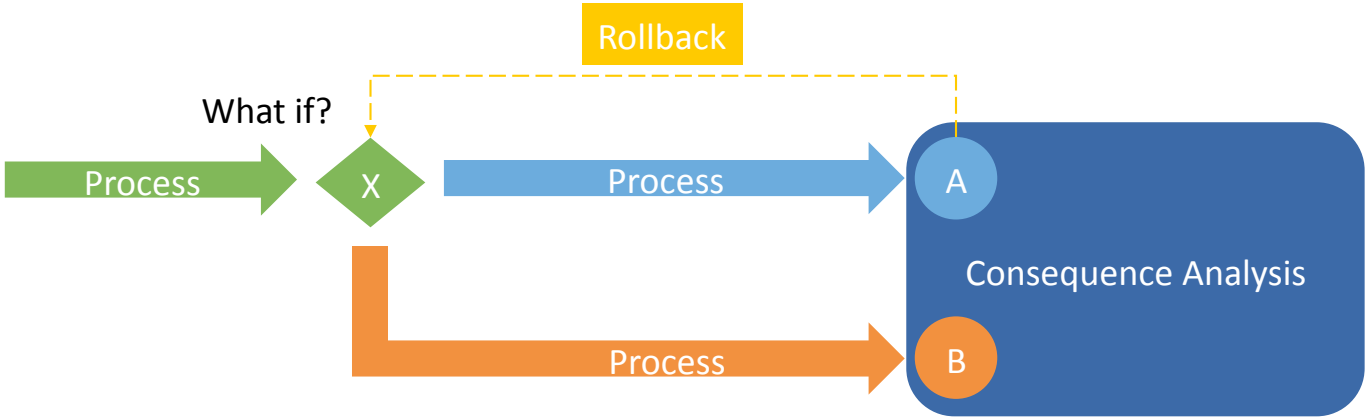
Aim of the Consequence Analysis (CA)

- The overall goal for the CA is to provide the CIPRTrainer users with the capability to understand the broader **consequences** of the incident evolution and of their actions and inactions during and the end of a training.
- CA goes beyond impacts, as it clarifies the **meaning of the impacts** for the population and the economy.
- The CA should be able to analyse (application areas):
  - the direct consequences to CI, build-up area and the surroundings.
  - and the indirect consequences due to the inoperability of CI and economic sectors.
  - The CA should give measures for comparison between different simulation runs and rollbacks.

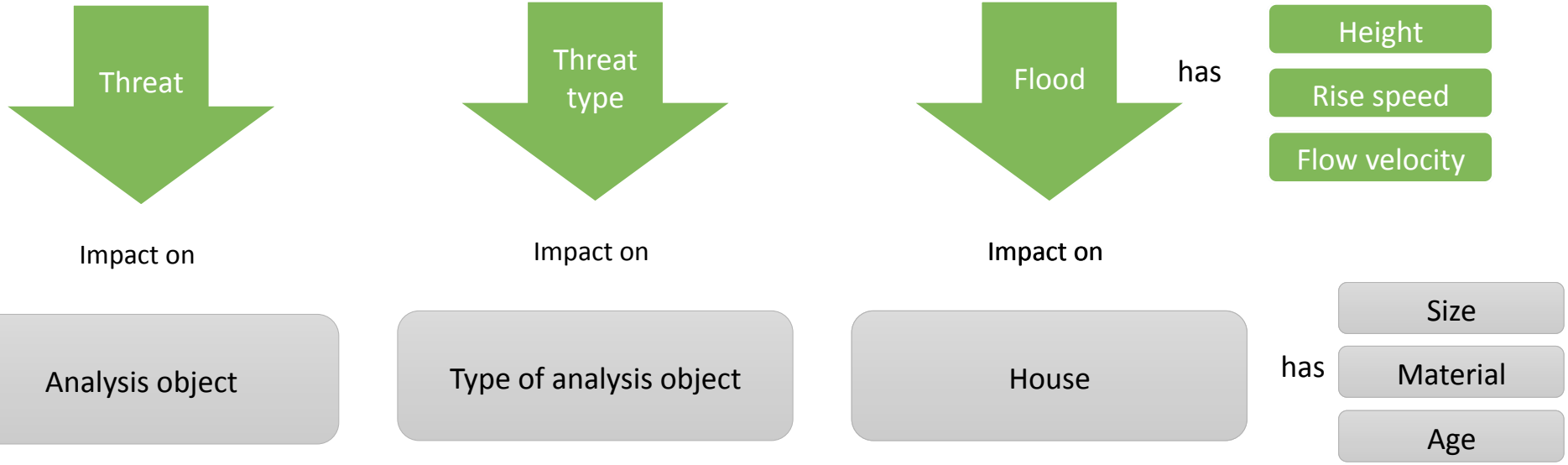
Hybrid CA approach of CIPRNet



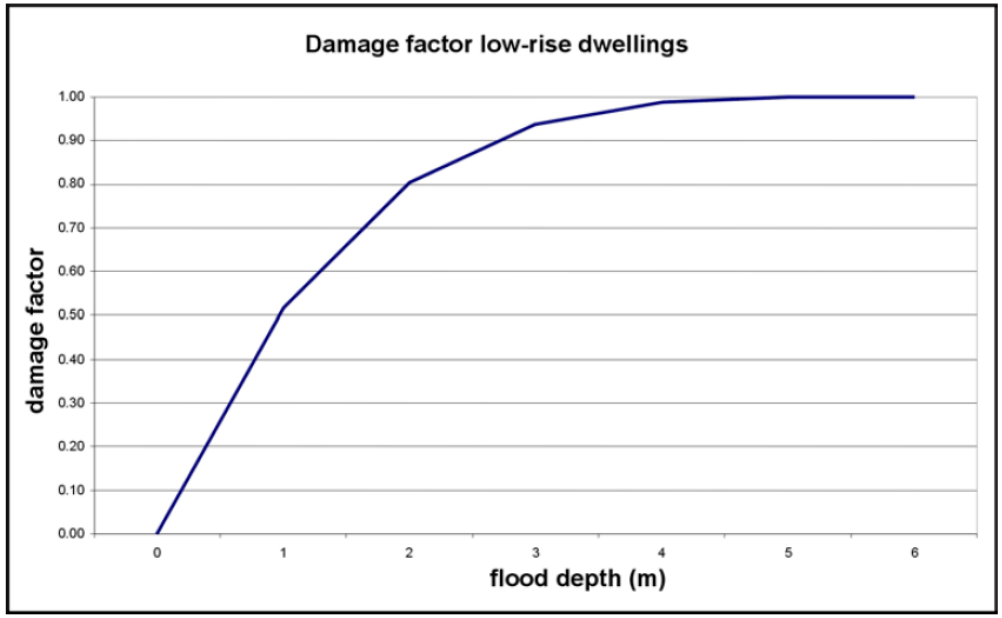
Usage of CA for what-if analysis



Methods for assessing direct impacts – From generic to specific



Example: Flood damage function for low-rise dwellings in the Netherlands



Source: Kok, M.; Huizinga, H.; Vrouwenvelder, A.; Barendregt, A. (2005): Standard Method 2004 Damage and Casualties Caused by Flooding. DWW-2005-009. Ministerie van Verkeer en Waterstaat.

Indirect impacts on CI

- Indirect impacts can happen through cascading effects in a critical infrastructure system or between different critical infrastructure systems.
  - Dependency as unidirectional relationship.
  - Interdependency as bidirectional or multidirectional relationship.
- In the CIPRTrainer this is simulated by the federate simulators and the event processor.

Special case humans

- Humans are a special case because:
  - This is a highly ethical topic!
  - Saving the life of Humans is paramount in crisis situations.
  - Humans are alive and therefore more susceptible to specific Threats than lifeless objects, e.g. intoxication, drowning.
  - Prediction of injuries and death is very difficult.
  - Rough estimates can be derived from statistical data of past disasters.

Dynamic population

- Humans are mobile, i.e. they can move around (and can be evacuated) in contrast to a building.
  - For the impact analysis on humans you need to know where they are in the case of a disaster.
  - Usually only residential data is available.
  - There are proposals for a dynamic modelling of the population with day, night and commuting hours, e.g. CRISMA Project http://www.crismaproject.eu/
  - Lack of data is an obstacle for this endeavour.
- In the CIPRTrainer use residential data only.

Methods for assessing direct consequences

- As stated above CA goes beyond impacts, as it clarifies the meaning of the impacts for the population and the economy.
- A simple method is to count the number of damaged object, e.g. 387 buildings are damaged.
- An advanced method is to qualify the damage, e.g. 200 building are lightly damaged and 187 are heavy damaged.
- A more complex approach is an economic appraisal of the direct damage to buildings, infrastructure and the environment, e.g. the damage is 17 million euros.
- The most common measure for direct damages is reconstruction cost, e.g. how much does it cost to repair a damaged house or infrastructure or landscape.

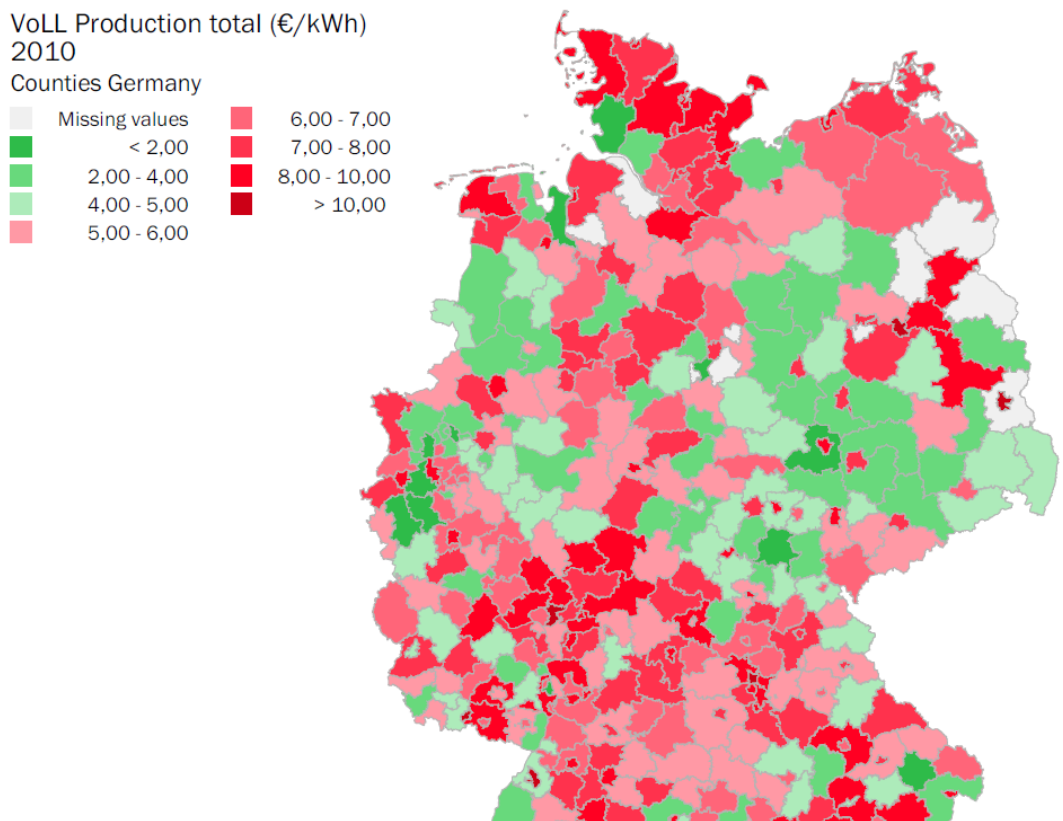
Special case Humans

- For the CA we decided to only count the number of injuries and deaths.
- An economic evaluation of life would be a highly ethical issue.

Method for assessing indirect consequences of a power outage

- For the estimation of power outage cost empirical studies are a common method.
- Some use historical data to derive cost estimates.
- Others collect new data from power customers and smart meters.
- As metric the 'value of lost loads' per hour (VOLL) is favoured.
- VOLL postulates a proportional relationship between output and electricity use.
- There are different conceptualisations of this measure.
- This definition of HWWI (Hamburgisches WeltWirtschaftsinstitut) gives a value of the lost output for one kWh (kilowatt hour) for businesses (production and services):

$$VOLL_{business} = \frac{GrossValueAdded}{ElectricityConsumption}$$



Source: Piaszeck, S.; Wenzel, L.; Wolf, A. (2013): Regional diversity in the costs of electricity outages. Results for German counties. HWWI (HWWI Research, 142), page 17.

Methods for assessing indirect consequences on region & nation level

- There are basically two major streams in economic theory for the consequence analysis of disastrous events:
  - Input-output models (IO)
  - Calculable general equilibrium models (CGE)
- Both modelling approaches address the interaction of the different economic sectors.
- They differ however in which manner these sectors interact and how the sectors react to external shocks.
- IO-models focus on the interrelations of production, where a sector needs inputs from other sectors to produce goods.
- CGE-models focus on the effects of price variations to the supply and demand in the different sectors.

Data elicitation: How to get the data?

- The data needed for CA is often scattered about a wide range of sources and comes in diverse formats and quality levels.
- This is even more likely if you need data from different EU Member States!
- Typical issues:
  - Data source is unknown. Where to get the data?
  - Data is only available on websites in a foreign language. Google Translator can help, but is limited.
  - Data is not free available.
  - Data is in a format that cannot easily processed (very often PDF).
  - Data is from different years. Problematic for demographic data.
  - Data is not complete. Open Source data is often incomplete, e.g. OpenStreetMap data.

Useful European data sources

- Use standardised European data if possible:
  - http://ec.europa.eu/eurostat
  - http://www.europeandataportal.eu/
- Alternatively there is an European open data platform
  - http://data.europa.eu/euodp/en/data

Data handling: How to make the data usable for a data base

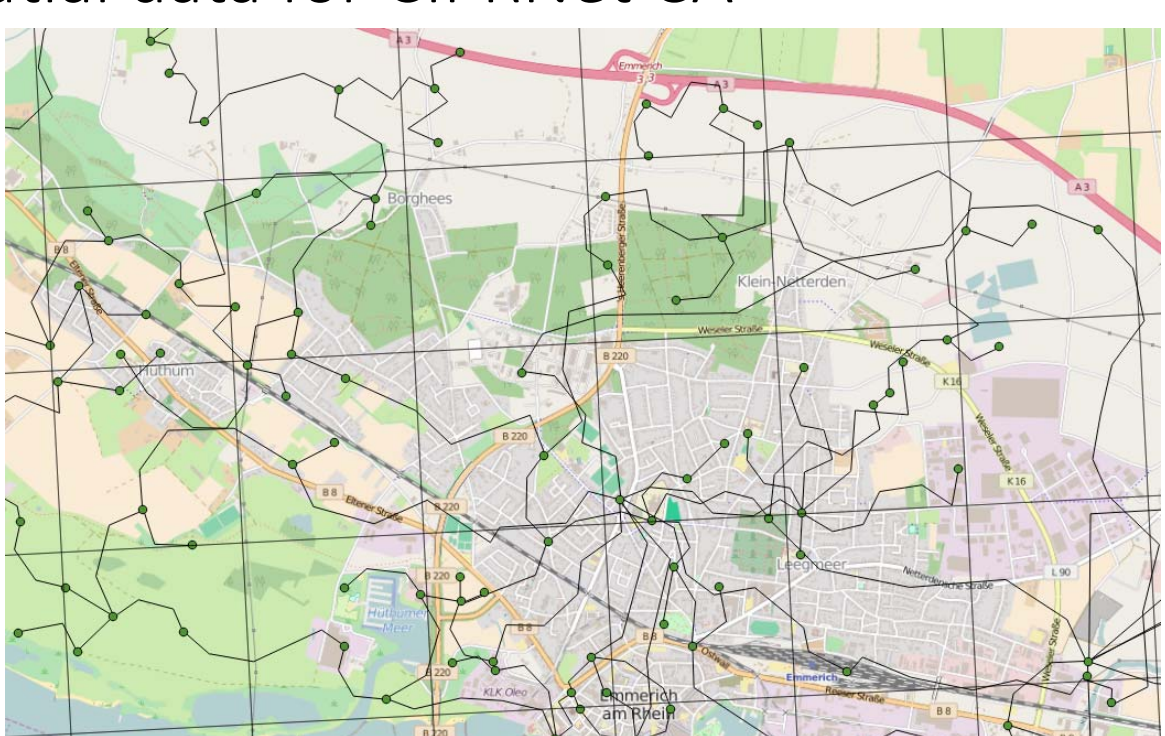
- To use the data from the different sources in a data base, it has to be harmonised and organised in a structured way.
- To do this is you have to design a data base schema (for example an entity relationship model).
- Which schema you choose depends heavily on your type of database management system.
- In CIPRNet we us the relational open source database PostgreSQL, which offers some features for spatial data.
- During the design phase you have to think ahead how the data is used and how to minimise redundancy.
- After your schema is ready and implemented in the data base, you have to import the collected data in the data base.
- This can be a daunting task if the data is not machine readable.

Spatial data for CIPRNet CA

German inspire grid
1km² EPSG 3035
https://www.zensus2011.de
http://inspire.ec.europa.eu/

Dutch inspire grid
500m² EPSG 28992
(Not visible in screen shot)
http://www.cbs.nl/

Map from OpenStreetMap
https://www.openstreetmap.org/



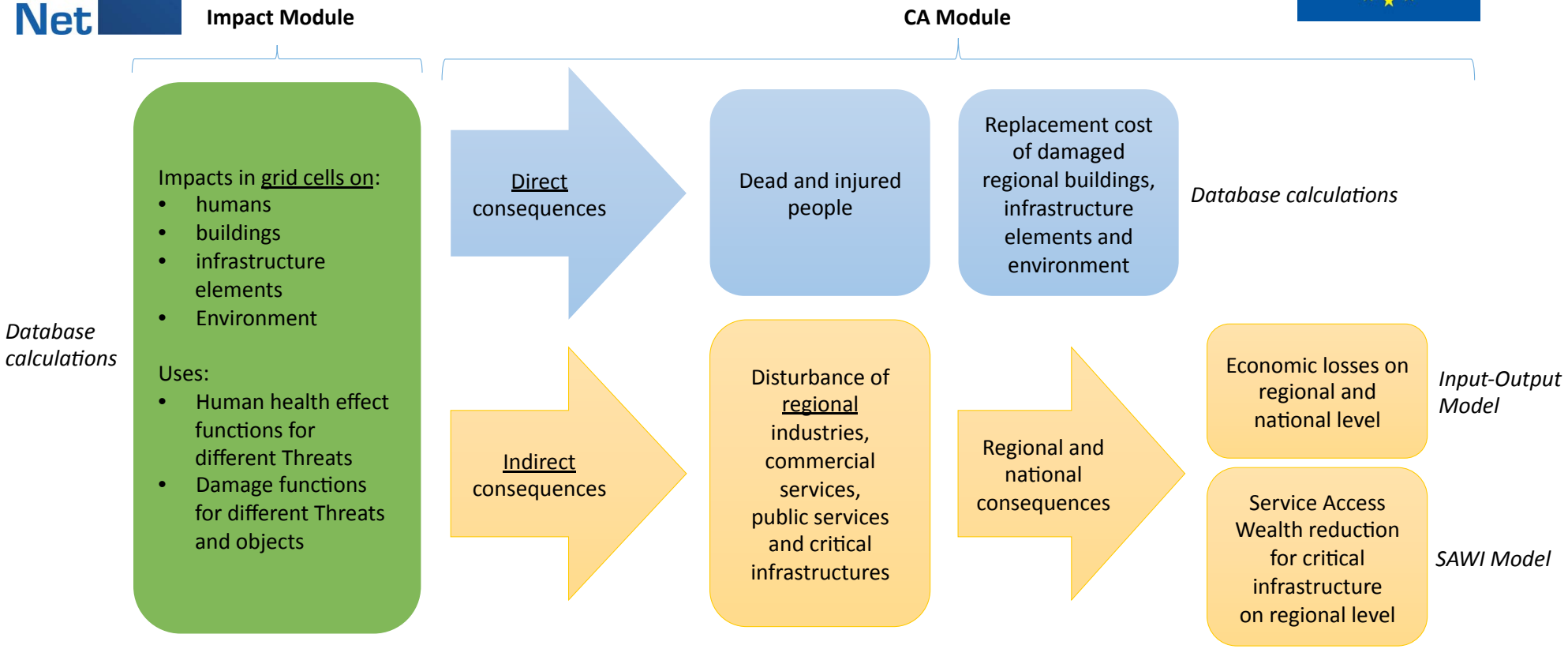
Grid cells contain information and data about:

- Residents
- Residential buildings
- Business buildings
- Environment (Land-use)
- Infrastructure elements
- Manifestation of Threats
  - Power outage
  - Flooding
  - Chemical cloud

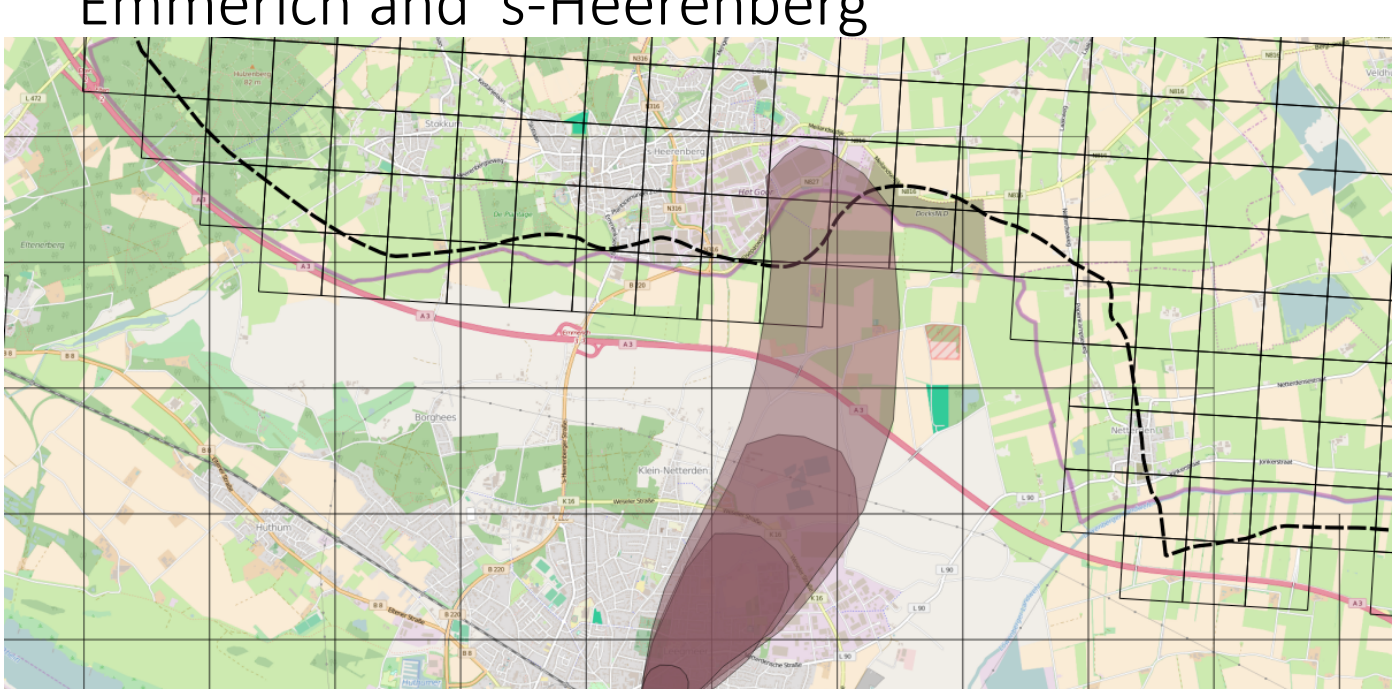
Examples for non-spatial data for the CIPRNet CA

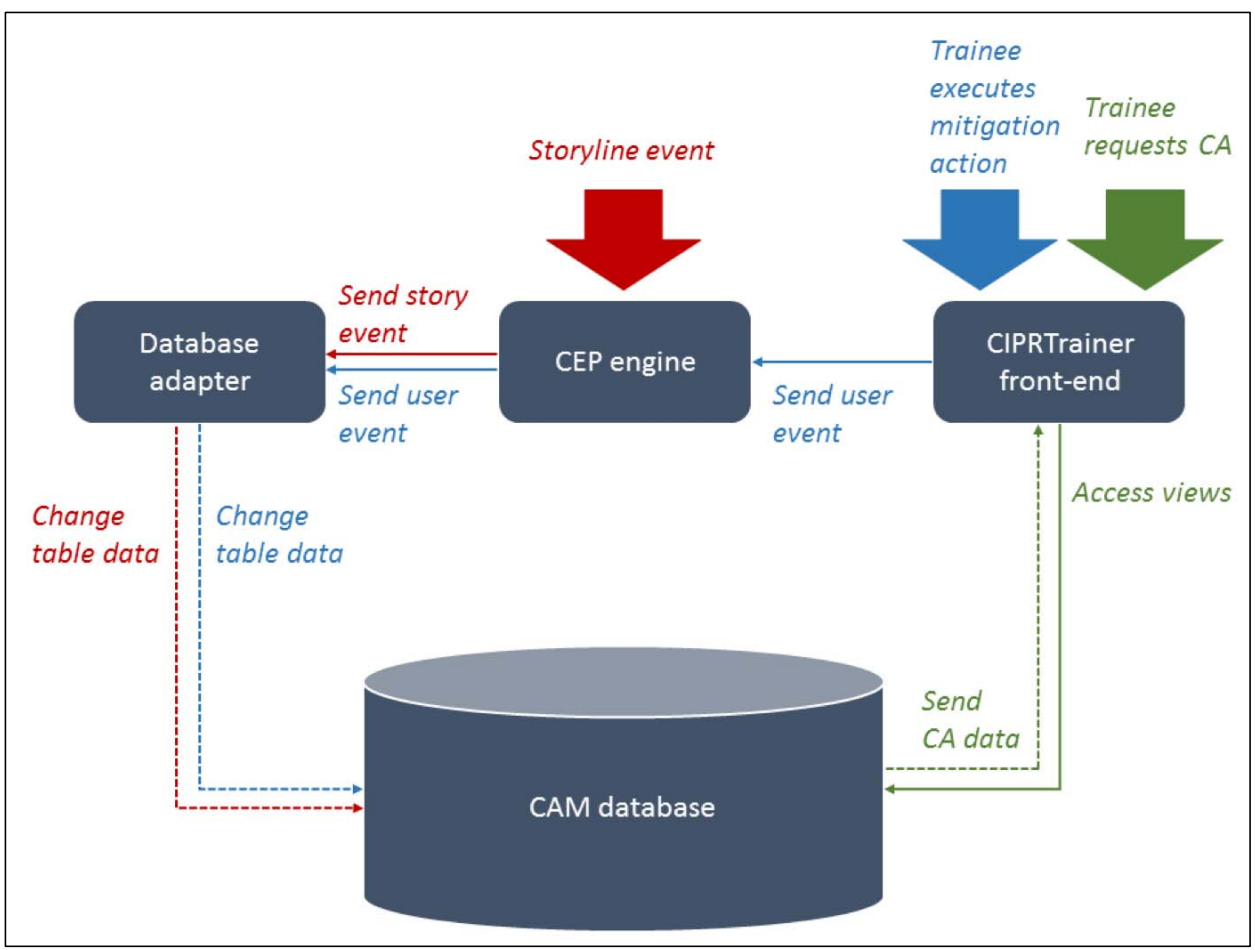
- **Cost data**
  - reconstruction cost for building types
  - reconstruction cost for infrastructure element types
  - reconstruction cost for environment types
  - cost of emergency force actions
  - cost on value of lost loads due to a power outage
- **Macro-economic data**
  - national input-output tables
  - input coefficients
  - data on number of firms on district level
  - data on value-added on district level

CA Concept


Impact Module
CA Module
Impacts in grid cells on:
• humans
• buildings
• infrastructure elements
• Environment
Uses:
• Human health effect functions for different Threats
• Damage functions for different Threats and objects
Database calculations
Direct consequences
Indirect consequences
Dead and injured people
Replacement cost of damaged regional buildings, infrastructure elements and environment
Database calculations
Disturbance of regional industries, commercial services, public services and critical infrastructures
Regional and national consequences
Economic losses on regional and national level
Input-Output Model
Service Access Wealth reduction for critical infrastructure on regional level
SAWI Model

Example: Gas cloud over the cities of Emmerich and 's-Heerenberg




Trainee executes mitigation action
Trainee requests CA
Storyline event
Send story event
Database adapter
CEP engine
CIPRTrainer front-end
Send user event
Send user event
Access views
Change table data
Change table data
Send CA data
CAM database

CA Presentation in the CIPRTrainer – Example from the derailment scenario

TOTAL COSTS AND DAMAGES	
Category	**Value (EUR/Amount)**
Reconstruction Cost Residential Building	433860 EUR
Reconstruction Cost Business Building	0 EUR
Reconstruction Cost Infrastructure	8000000 EUR
Value of Lost Loads Households	0
Emergency Forces Cost	0
Number of Injured Humans	2959
Number of Dead Humans	4

Conclusion

- Consequence analysis enables the trainee to better understand the broader consequences of the incident evolution and his actions and inactions during training.
- Together with the rollback functionality the CA enables the trainee to try out different courses of action and evaluate their performance.
- The precise numbers of the result should be taken with a grain of salt, as it is very difficult to predict real consequences.
- The lack of detailed input data is the biggest obstacle for are more realistic analysis.
- The ‘European Union's Open Data Portal’ is a step in the right direction, but the Member States have at the moment no strong incentive to include more data than absolute necessary.
- Constraints due to security issues of critical infrastructure data will remain for the public.
- The planned European Infrastructures Simulation & Analysis Centre (EISAC) could have better data access.

Disclaimer
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Thank you for your attention!

project website: ciprnet.eu

online glossary: cipedia.eu

Acknowledgements: CIPRNet team

CIPR Net

Fraunhofer IAIS

CIPRNet

Critical Infrastructure Preparedness and Resilience Research Network

CIPRTrainer derailment scenario with cross-border aspects

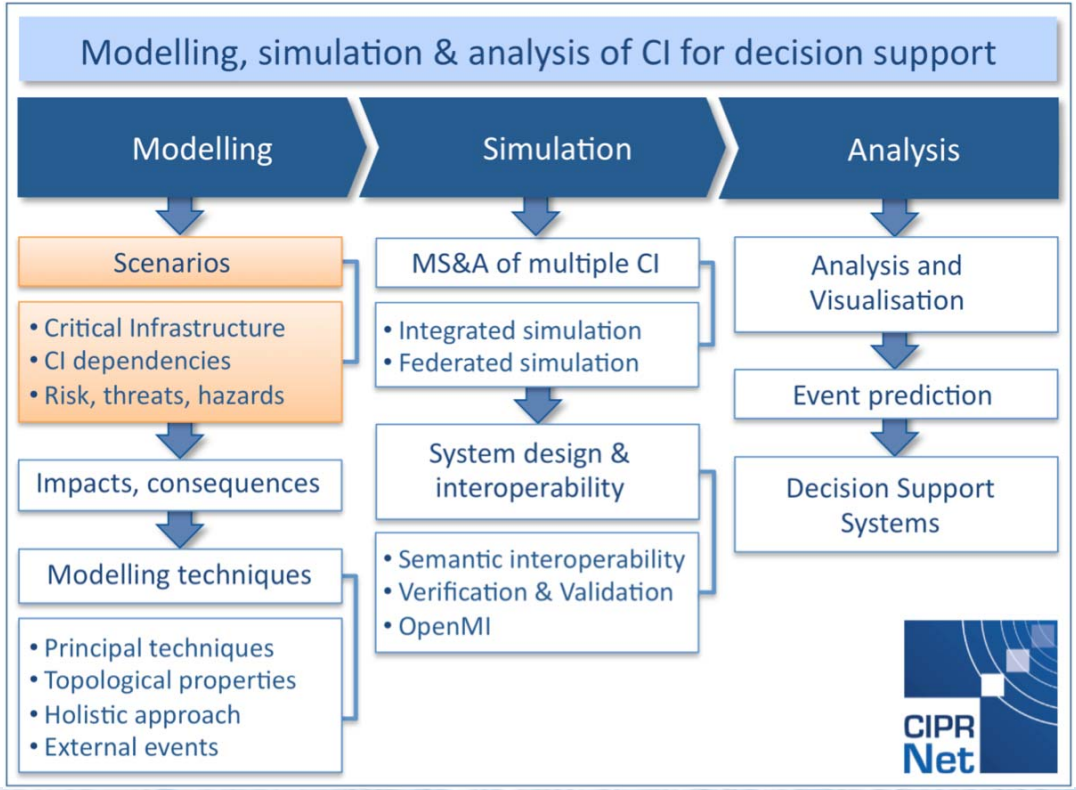
Stefan Rilling

Fraunhofer IAIS (Sankt Augustin, Germany)

3rd CIPRNet Course on Modelling, Simulation and Analysis of Critical Infrastructures

UCBM – Rome (Italy) – 14-15 July 2016

Locating the presentation topic



Agenda

- Scenario storyline
- Crisis Management Actions
- Dynamic Behaviour in the CIPRTrainer
  - Rules
  - Scenario database
- Conclusion
- Q&A

Scenario Storyline

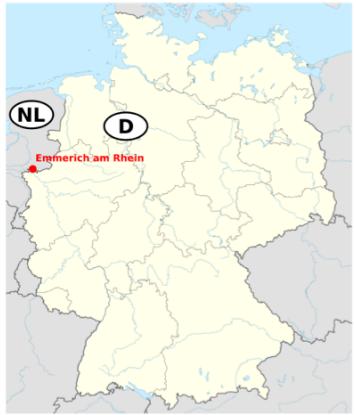
The scenario at a glance

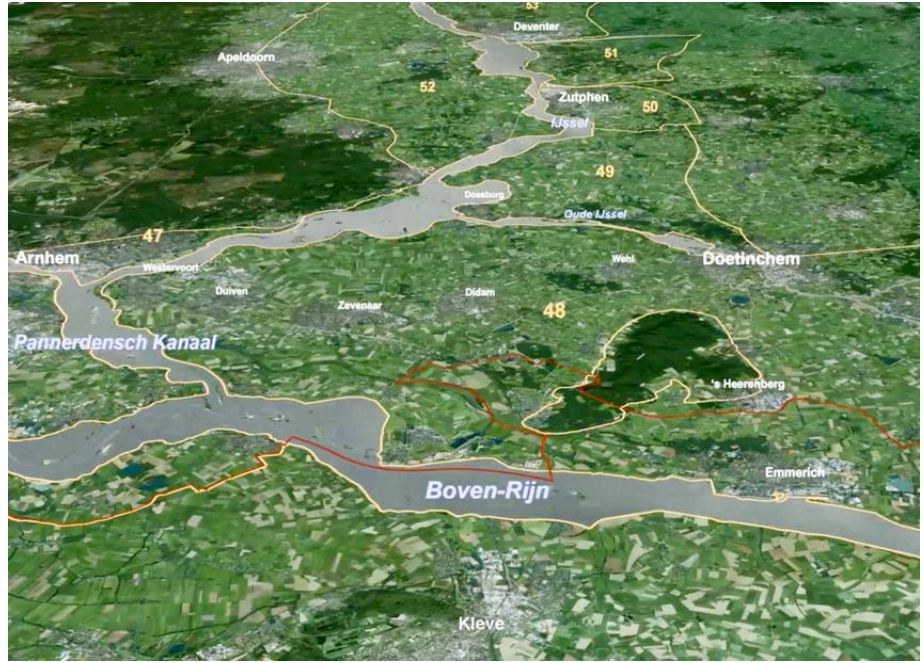
- A cargo train derails in the city of Emmerich due to a cyber attack
- Chemicals spill out and ignite, causing devastation among buildings and infrastructure
- A toxic gas cloud spreads over the area

Scenario Storyline

Overview of the geographical locations

- The fictive train accident is located in the City of Emmerich, Germany
  - Small city in Germany (ca. 30.000 inhabitants)
  - Located at the Dutch-German Border

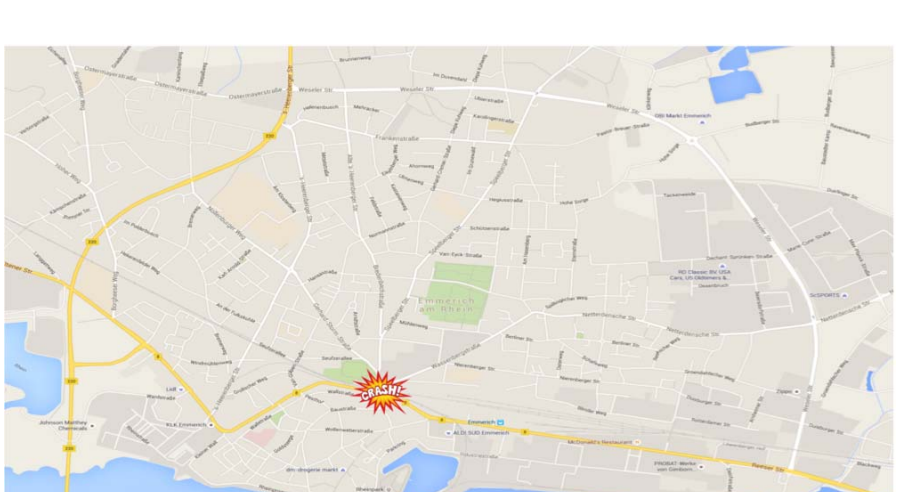


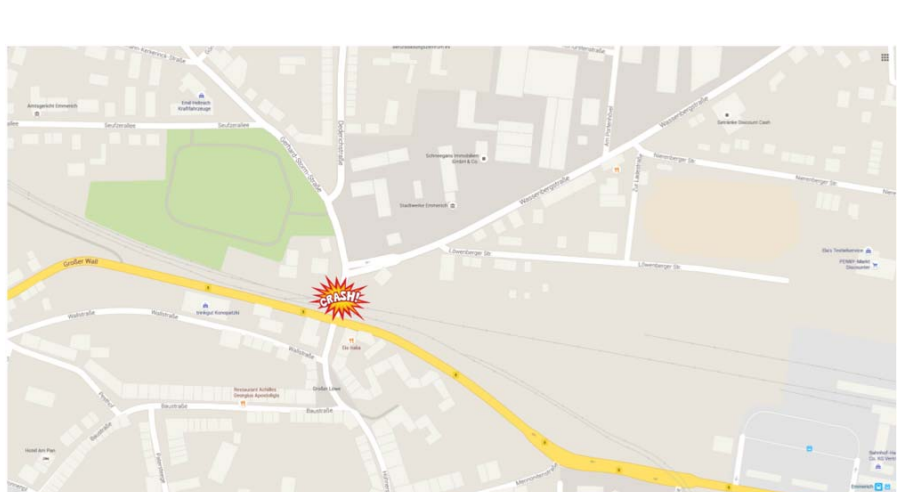


Source: Youtube video from LievenseCSO Adviesbureau – https://www.youtube.com/watch?v=hPlz52BiRA0

Scenario Storyline

Location of the Incident

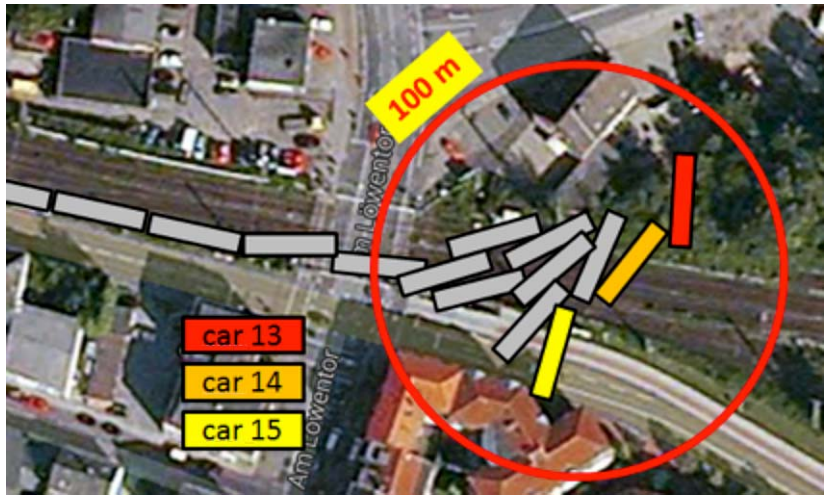




- Location of the derailment in the city center

CIPRTrainer derailment scenario

Scenario storyline



Source: Google maps / Fraunhofer

Source: Open Street Map

- **Fire, toxic gas and leaking chemicals** affect citizens, buildings, and (critical) infrastructures.

Scenario Storyline

Infrastructure in the Area

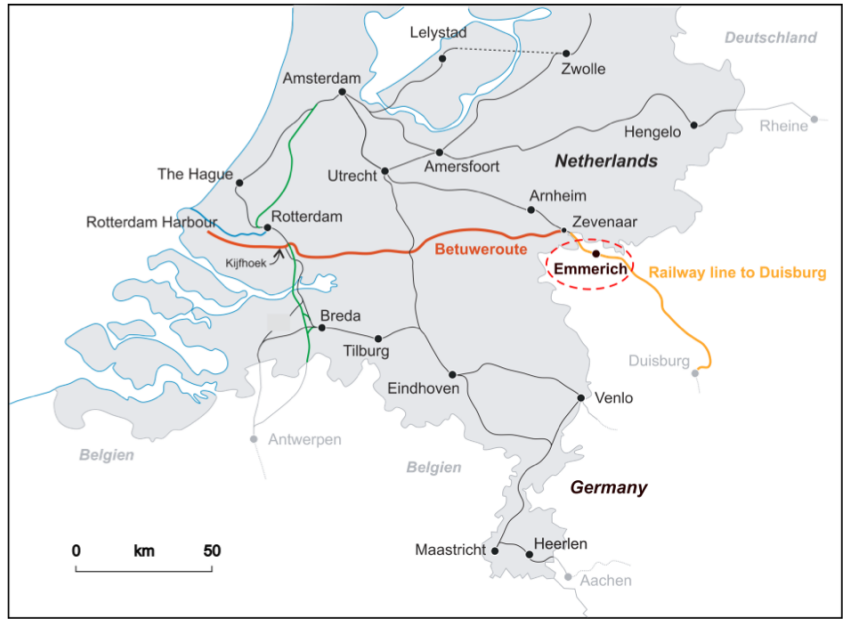



- Major railway line (Betuweroute)
- Emmerich railway station (border station with Dutch / German traction power voltages)
- Facilities requiring air cooling in s'Heerenberg
- Connection of electrical transmission and distribution networks in Emmerich

Scenario Storyline

Infrastructure in the Area - Betuweroute

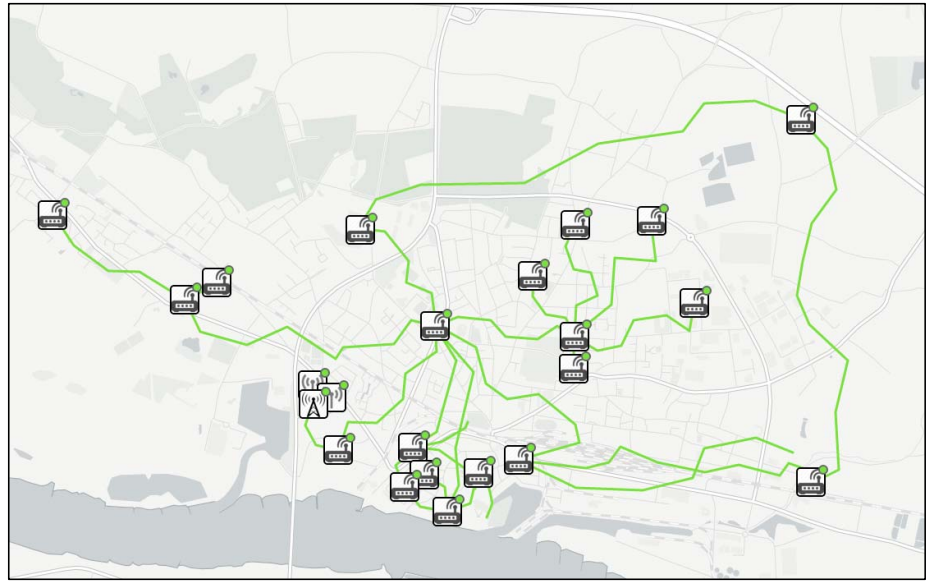
- Major railway line for freight trains
- Connects to the railway line to Duisburg
- About 450 trains per week in both directions (2 – 3 trains per hour)



Scenario Storyline

Infrastructure in the Area – Telecommunication

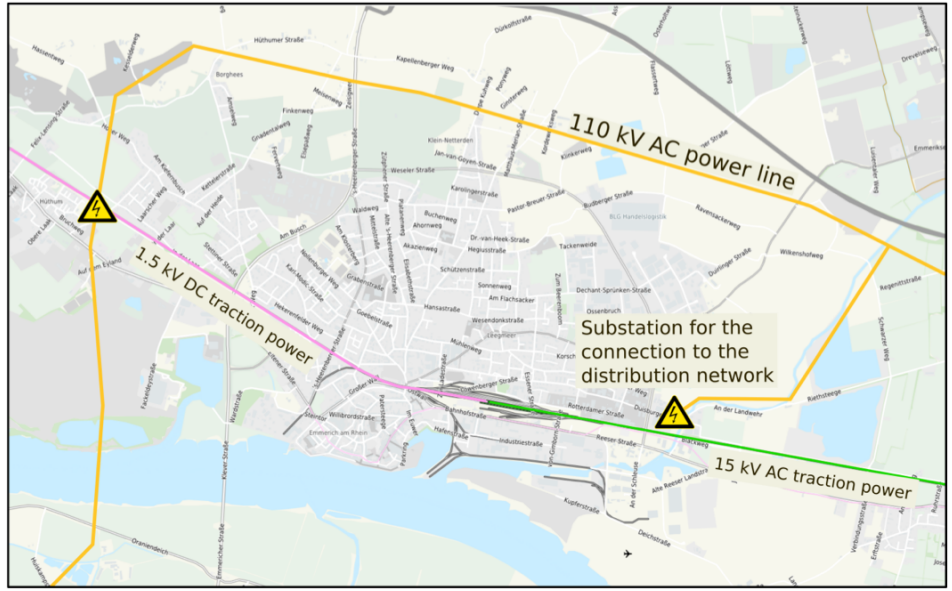
- Routers, mobile antenna masts and cables
- Fictive telecommunication network (by University of Science and Technology at Bydgoszcz, Poland)



Scenario Storyline

Infrastructure in the Area – Transmission Network

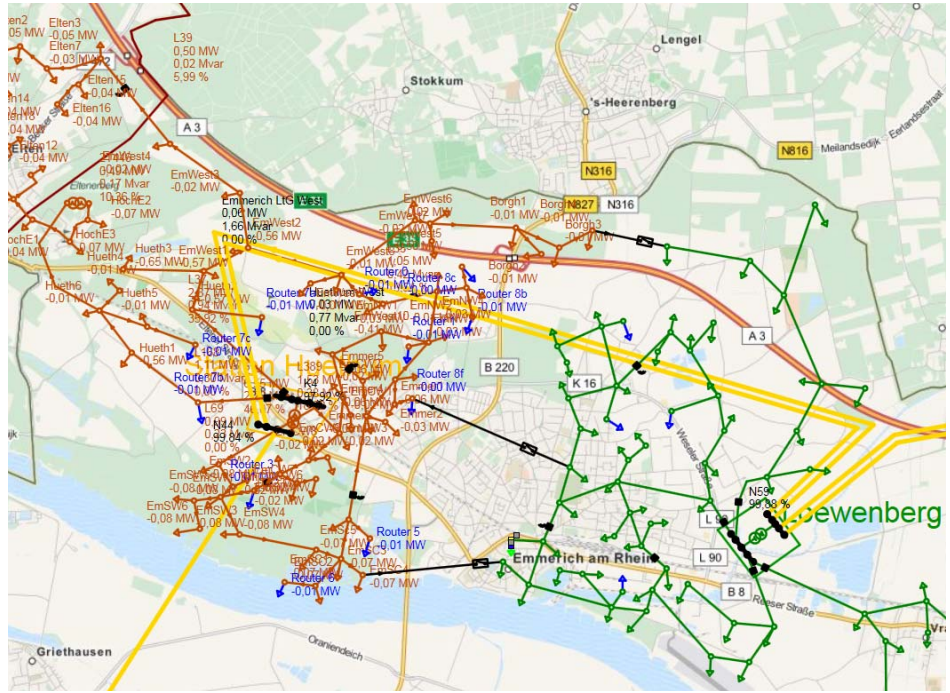
- 110 kV overhead lines and railway traction
- Two substations connect the distribution network in Emmerich



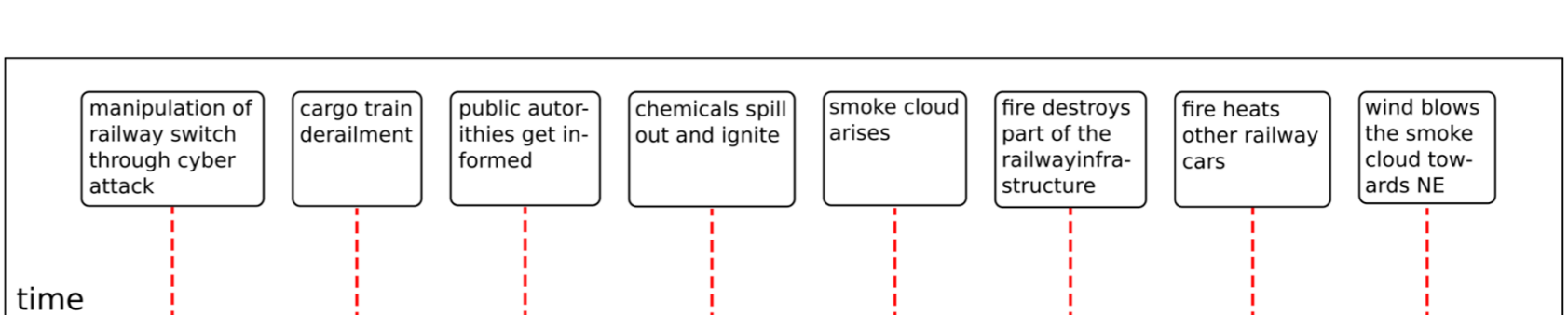
Scenario Storyline

Infrastructure in the Area – Distribution Network

- Fictive electrical distribution network (by Univ. of Cyprus)
- Modelled up to the 20 kV medium voltage distribution network layer
  - Cabinet feeders for 400 V low voltage grid connection as endpoints
  - Network of underground cables



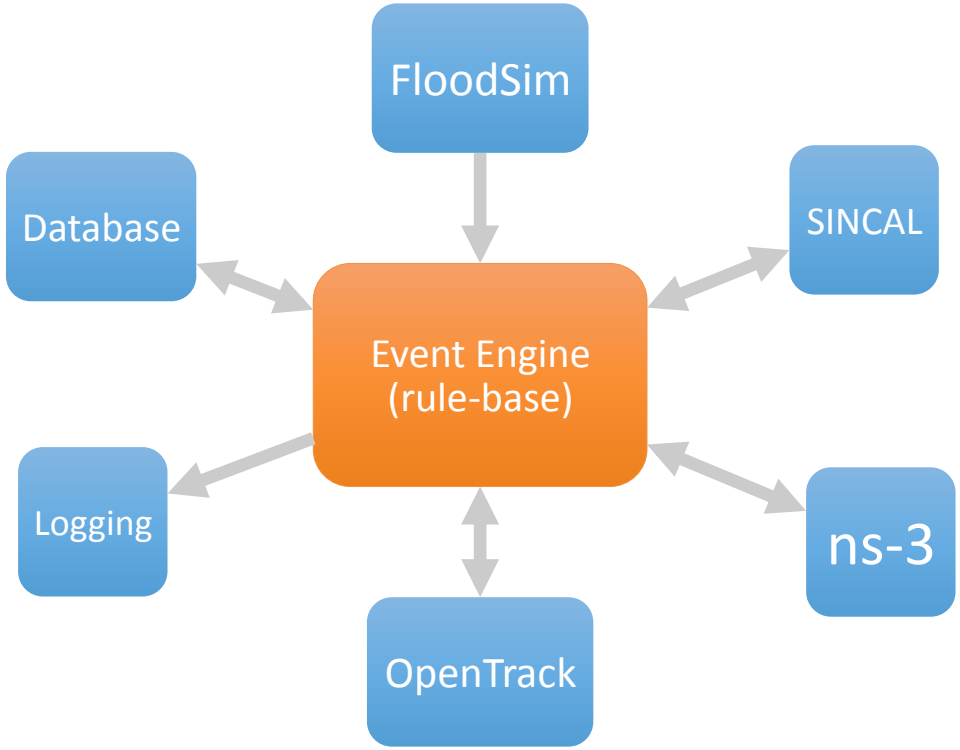
Scenario storyline overview



Counter measures / actions

- The different events require actions that are supposed to minimize the expansion of destruction and injuries:
  - Send action forces / rescue forces / law forces from A to B
  - Cordon off the scene of accident
  - Recover affected victims / humans
  - Evacuate the accident site
  - Inform the public by media (press, radio, television)
  - Inform hospitals to prepare for casualties

General schema of CEP engine

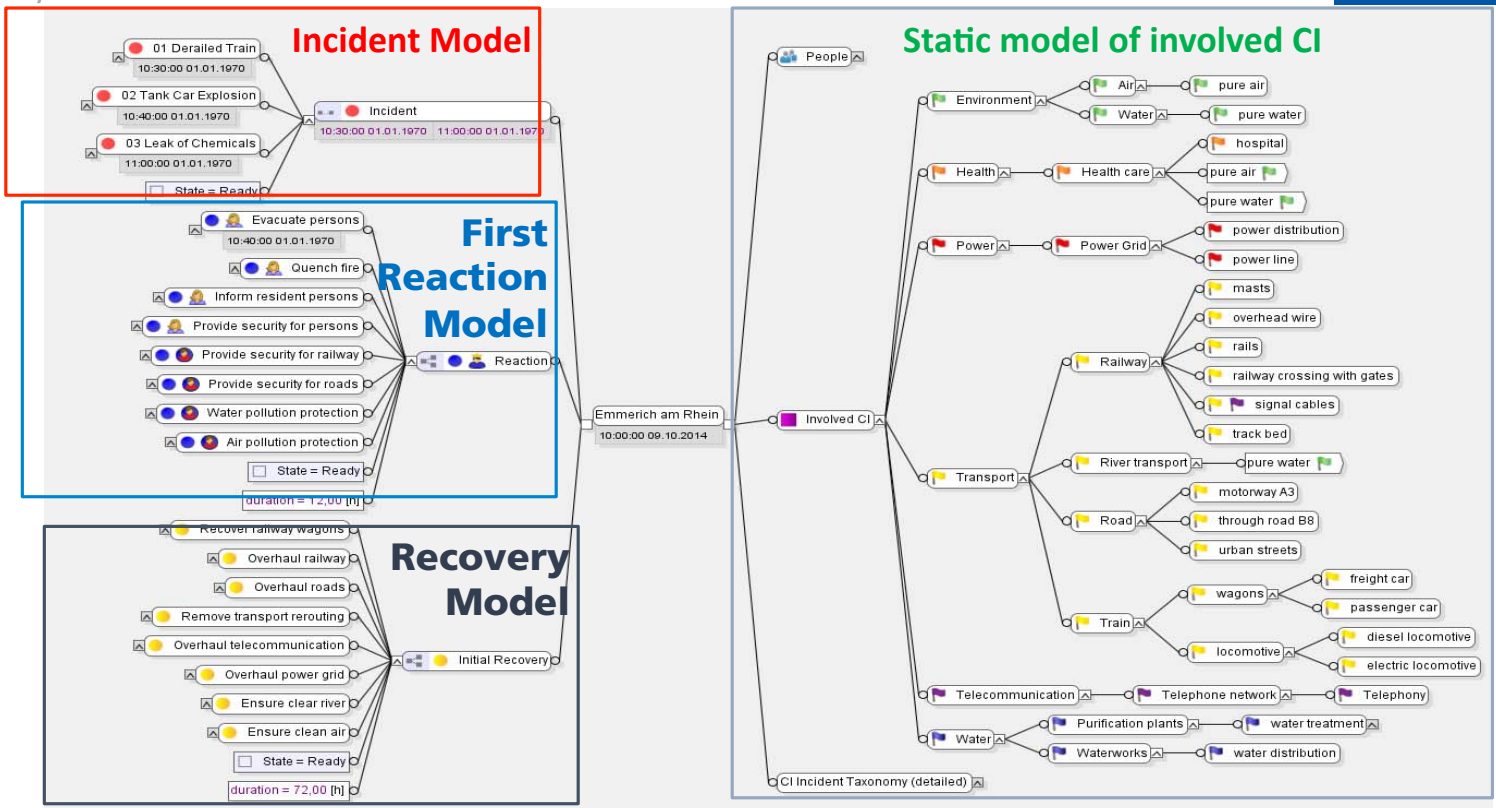


Data flow

Event producer and consumer

Editing the derailment scenario

SyMo model

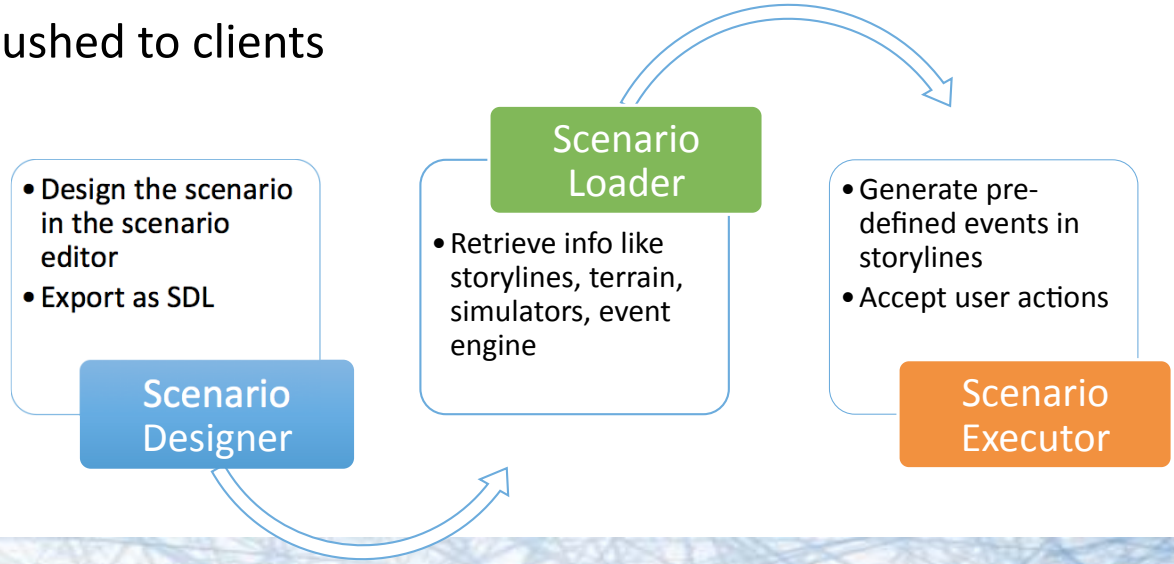


Derailment scenario as SDL

Scenario Description Language

From Scenario Editor and Scenario Runner

- Initialising the whole training system based on selected scenarios
- Execute the selected scenarios on the server
- Scenario execution pushed to clients

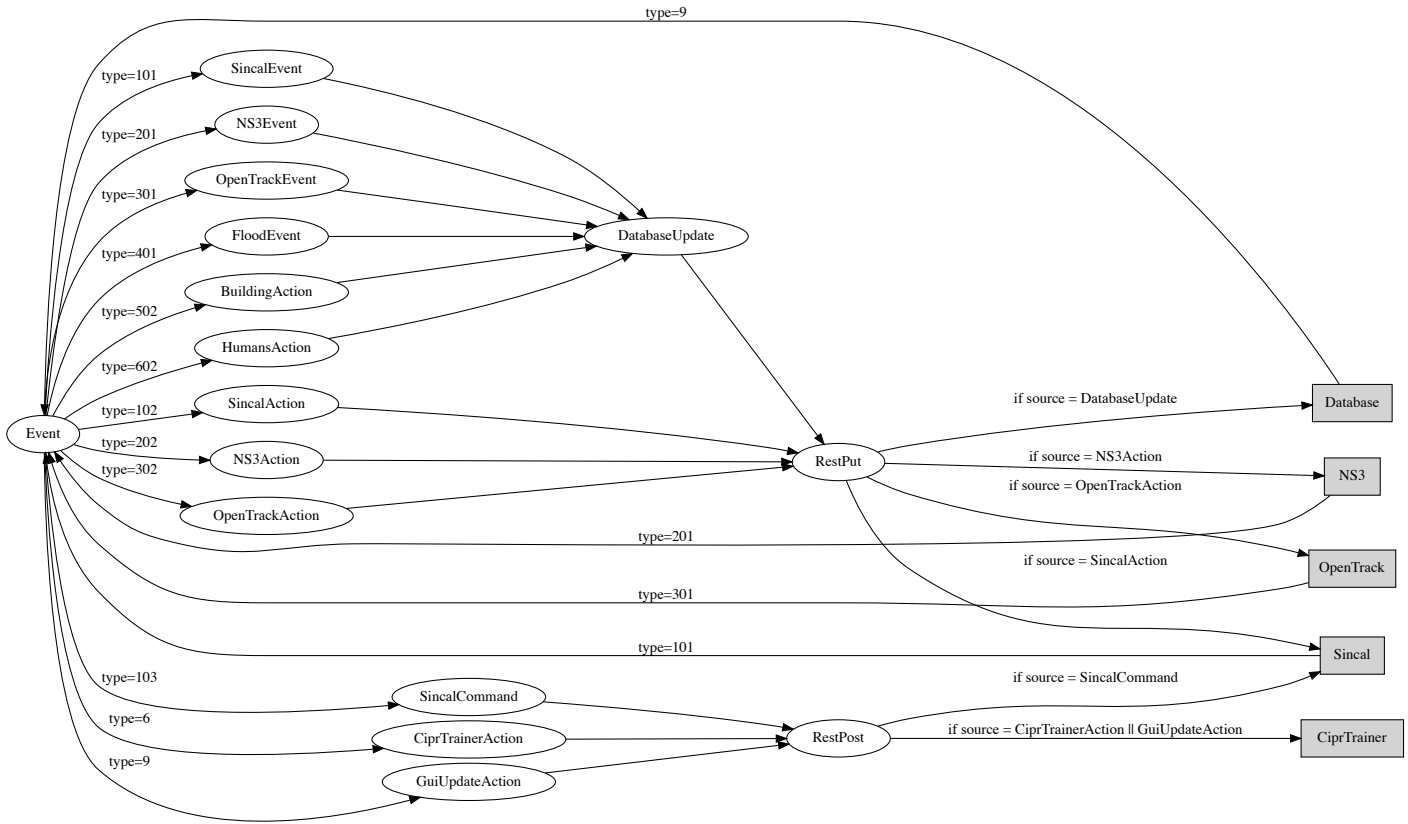


Sample event processing rules

```
@Name('Sincal-Change-State-Rule')
@Description('Detect flooding event and update state/location to stressed in
Sincal')
select post("sincal", "stressed" + Event(location)) from
Event(type=2).win:length(10) having avg(payload.waterheight) >= 5;
```

```
@Name('NS3-Disable-Rule')
@Description('Change NS3-status to disabled at a specific location')
select post("ns3", "disabled" + Event(location)) from Event(type=3) where
payload.status = "stressed"
```

Complete rule base: derailment



Events and rules

SimTime	Storyline Event: Red: On map Yellow: Timeline only	Event Processing Rule
10:29:00	Cyberattack on the electronic railway control centre Emmerich. Manipulation of a railway switch.	
10:30:00	A cargo train with tank cars coming from the Netherlands derails in the city of Emmerich.	- disable railway track in OpenTrack simulator / database - mark humans dead in database - mark humans injured in database - mark buildings as damaged in database
10:31:00 10:35:00 10:35:00 10:38:00	Waggons crash onto the street and into buildings. Train conductor and witnesses inform the public authorities. Incidentally a police car arrives at the crash site. Disaster event is officially called by the mayor	
10:40:00	Chemicals spill out of the railway cars and ignite.	
10:40:00	Cloud of smoke and toxic gas emerges from the fire.	
10:44:00	Fire destroys part of the railway infrastructure.	- mark railway track as damaged in database
10:45:00	Fire heats other railway cars with the danger of further explosions.	

Contents of the scenario database

- Scenario file: Storylines with (conditional) events
- Data for Consequence Analysis
- Spatial data: street, river, CI location, etc.
- Subset of CI model elements: sector, id, name, type, etc.
- Specific data for threat simulation like pre-calculated flooding

Conclusion
"Take home messages"

- Overview of the CIPRTrainer derailment scenario
- Various infrastructure models and their interdependency
- Dynamic behaviour through complex event processing
  - Events and Rules

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Thank you for your attention!

project website: ciprnet.eu

online glossary: cipedia.eu

Acknowledgements: CIPRNet team

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Critical Infrastructure Preparedness and Resilience Research Network

CIPRTrainer demonstration and hands-on experience – the basics

Betim Sojeva

Fraunhofer IAIS (Sankt Augustin, Germany)

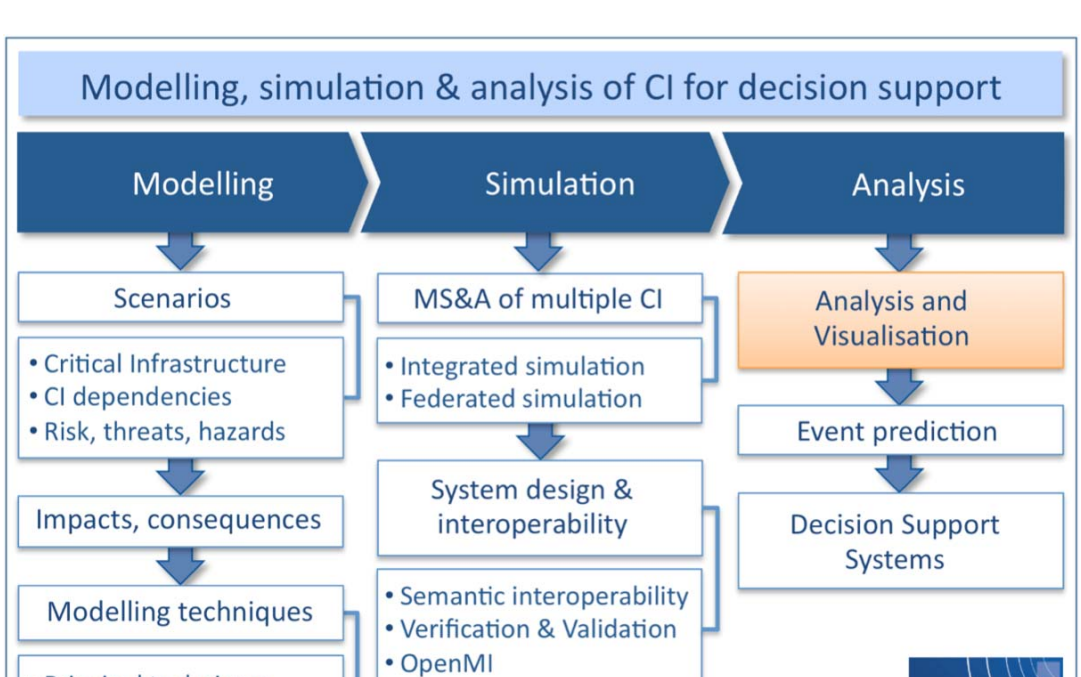
3rd CIPRNet Course on Modelling, Simulation and Analysis of Critical Infrastructures

UCBM – Rome (Italy) – 14-15 July 2016

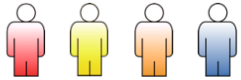
Agenda

- Training Concept
- CIPRTrainer's Graphical User Interface (GUI)
- User roles: Trainer, trainees
- CIPRTrainer's GIS functionality
- »what if« analysis for exploring different courses of action
- Conclusion
- Q&A

Locating the presentation topic



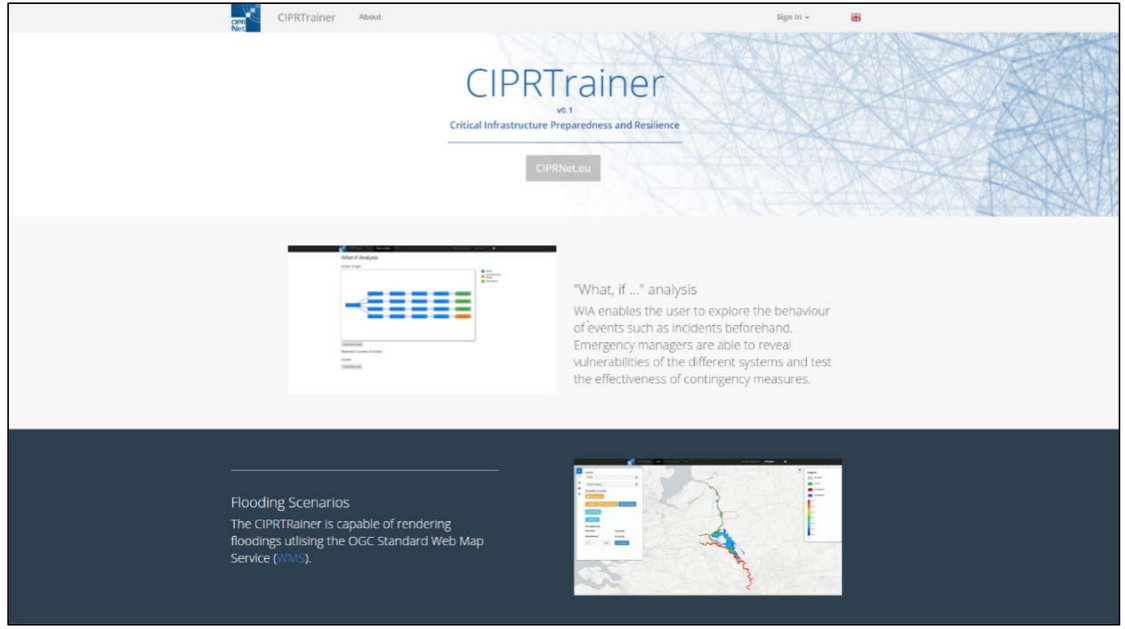
CIPRtrainer – Training Concept

- Supervised training with preselected scenario / storyline
- **Two-part hands-on**
  1. **Familiarise with the GUI**
  2. **Conduct a full training session**
- Trainer 
  - starts, monitors and stops training sessions
  - can download and view training log files
- Trainees 
  - can assume four roles: decision taker, situational awareness, operations and administration coordinator
  - all but decision-taker can work simultaneously with the system
  - have different action menus depending on their roles

CIPRTrainer's Graphical User Interface

Landing Page

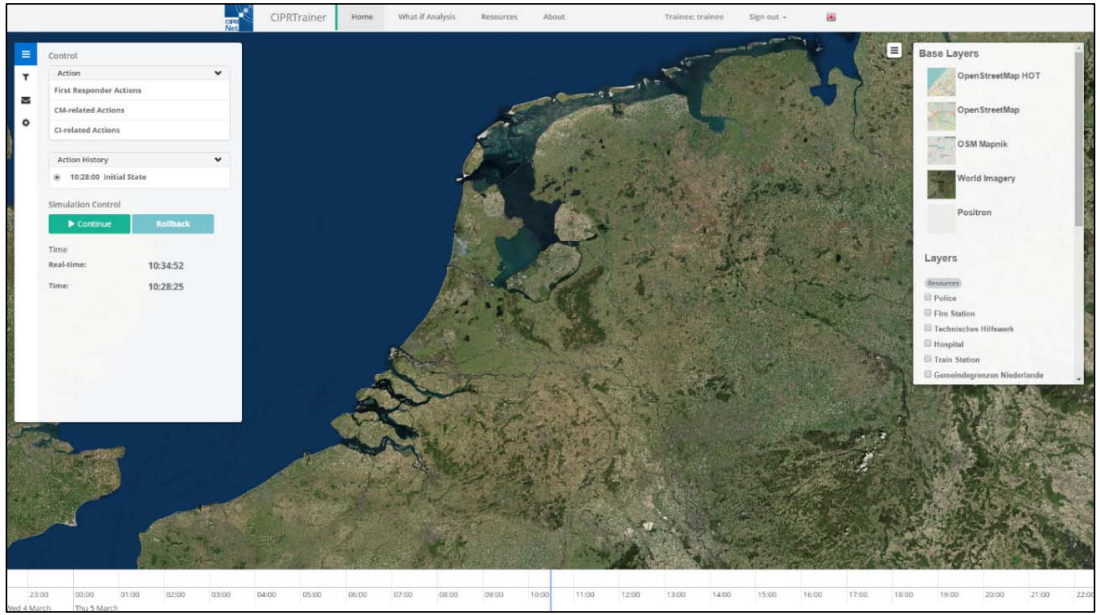
- CIPRTrainer's Landing-page
  - Authentication panel
  - I18n
  - About view



CIPRTrainer's Graphical User Interface

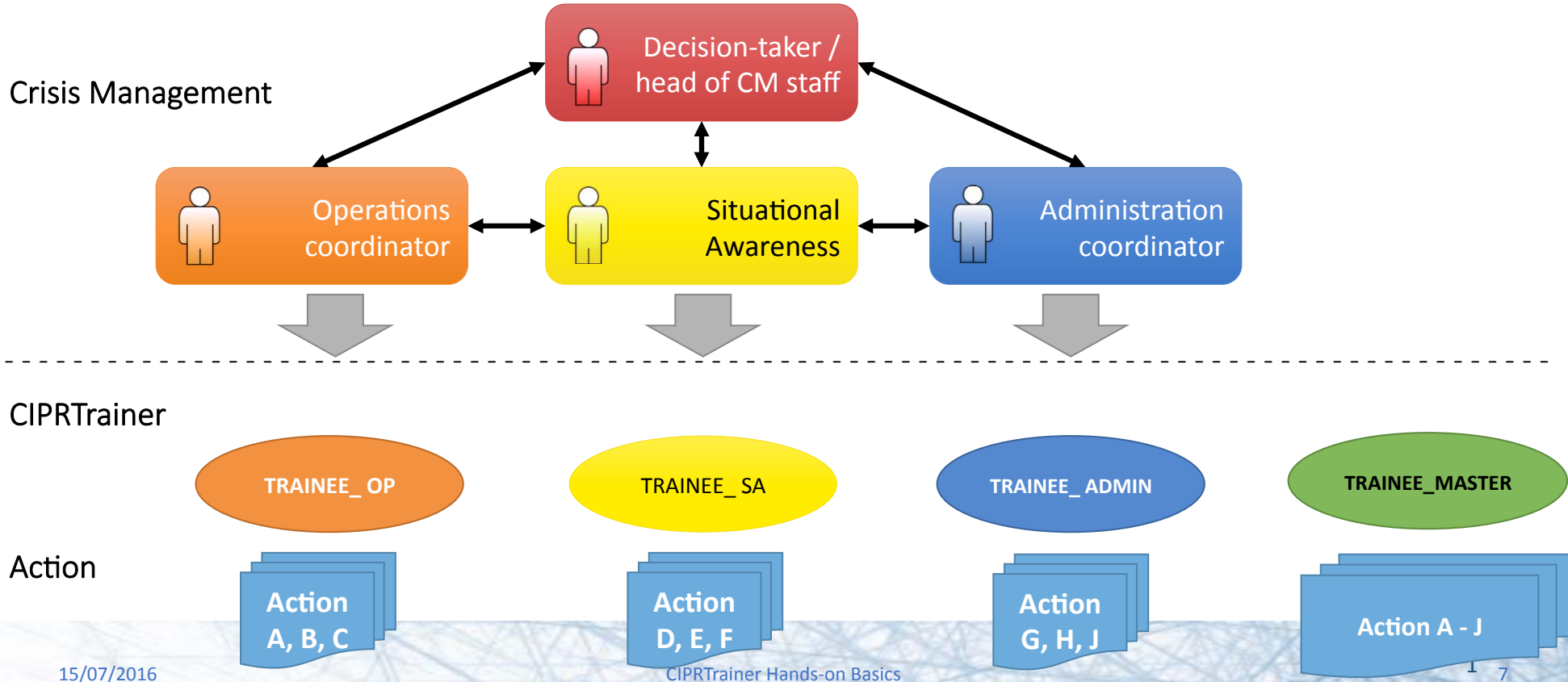
TRAINEE Module

- CIPRTrainer's Trainee Module
  - Navigation bar
    - WIA view
  - GIS map
  - Control panels (left and right)
    - Simulation controls panel
    - Layers panel
  - Timeline



CIPRTrainer's Graphical User Interface

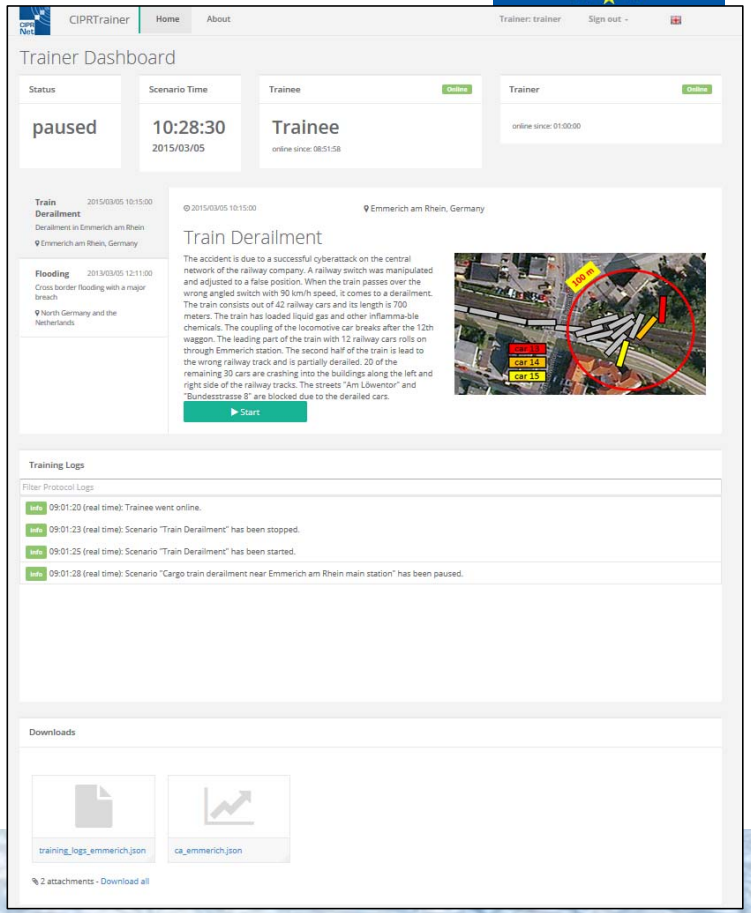
USER ROLE TRAINEE



CIPRTrainer's Graphical User Interface

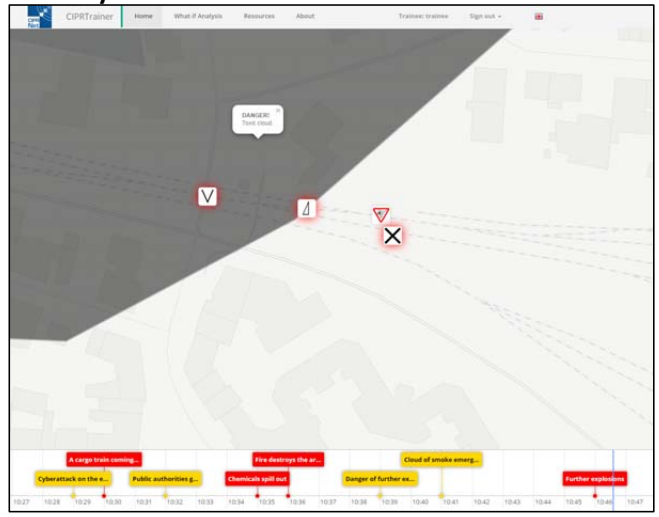
TRAINER Module

- CIPRTrainer's Trainer Module
  - Accessible only by TRAINER
  - Simulation and participant status
  - Scenario picker
  - Training logs
  - Downloads
    - Logs & CAM results



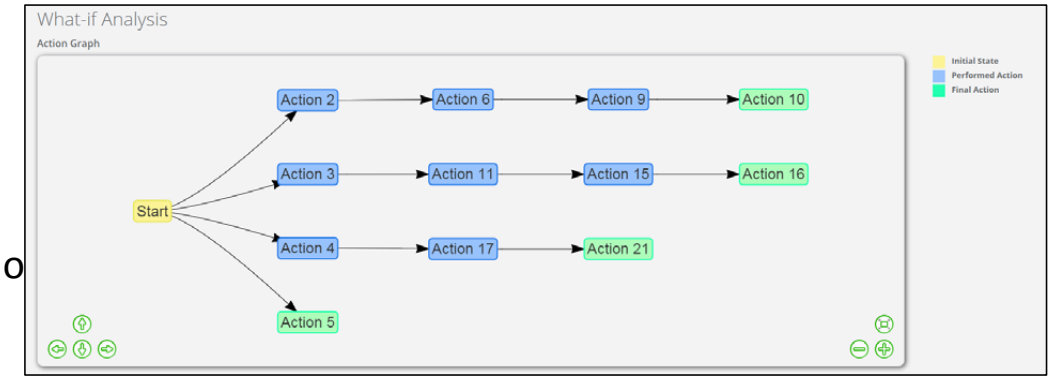
CIPRTrainer's GIS functionality

- GIS provides **data** & **information** but NOT **knowledge**
- GIS answers „**who**", „**what**", „**where**", and „**when**" questions but **NOT** „**how**" questions
- End-user can derive **knowledge** based on presented information and analysis results
- GIS captures, visualises and analyses spatial features
  - vectorised (OCG standard **WFS**)
  - rasterised (OCG standard **WMS**)
- Crisis Management: GIS provides a holistic view of status report
- Two ways of presenting **Information**:
  - **base** layers (background)
  - **reference** (or **thematic**) layers



»what if« analysis for exploring different courses of action

- Action graph (n-dimensional tree)
  - each node of the n-dimensional tree refers to an action
  - rollback capability creates an additional branch (**dim Action Graph = n+1**)
  - final actions are marked as green nodes
  - root node corresponds to the initial state o the scenario



»what if« analysis for exploring different courses of action

- CA results are presented three-fold:
  - **table** (static)
  - 2-dim **diagrams** (sortable)
  - **GIS maps** showing results with spatial context

TOTAL COSTS AND DAMAGES

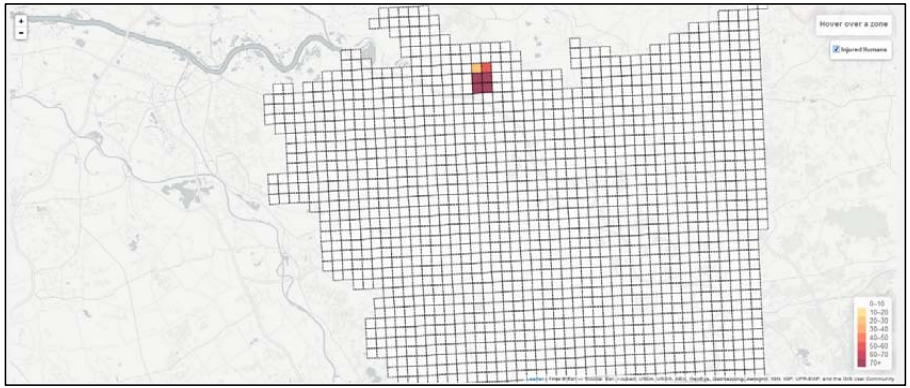
Category	Value (EUR/Amount)
Reconstruction Cost Residential Building	0
Reconstruction Cost Business Building	0 EUR
Reconstruction Cost Infrastructure	0 EUR
Value of Lost Loads Households	0
Emergency Forces Cost	0
Number of Injured Humans	2572
Number of Dead Humans	0

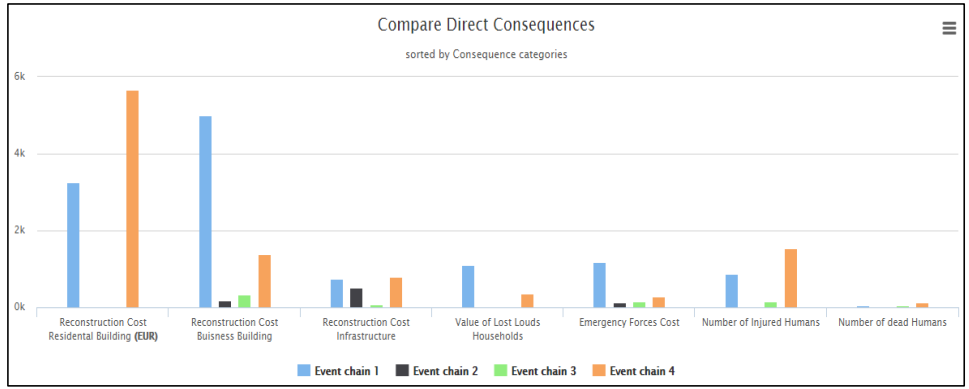
Page 1 of 1 5 View 1 - 7 of 7

ACTIONS

Action Cost (EUR)	Action Hours (h)	Number of Forces

Page 1 of 0 5 No records to view





CIPRTrainer hands-on – the basics

Conclusion

- CIPRTrainer incorporates GIS functionalities which provide **data** & **information** but NOT **knowledge**
- Knowledge can be derived by conducting analysis (CA, expertise of crisis manager)
- CIPRTrainer **enables training** with **complex scenarios** considering different roles in **crisis management teams**
- Different **trainees** have **different privileges**
- CIPRTrainer presents complex CA results in **three different ways**: table, 2-dim diagrams, GIS map
- CIPRTrainer enables **comparing** different sets of training results

Disclaimer
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Thank you for your attention!

project website: ciprnet.eu

online glossary: cipedia.eu

Acknowledgements: CIPRNet team

CIPR Net

Fraunhofer IAIS

CIPRNet

Critical Infrastructure Preparedness and Resilience Research Network

CIPRTrainer demonstration and hands-on experience – preparation

Erich Rome, Betim Sojeva

Fraunhofer IAIS (Sankt Augustin, Germany)

3rd CIPRNet Course on Modelling, Simulation and Analysis of Critical Infrastructures

UCBM – Rome (Italy) – 14-15 July 2016

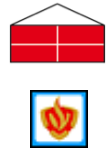
Agenda

- **Crisis Management (CM) Icons Primer**
- **Trainee roles in CIPRTrainer**
- **Performing role-specific actions**
- **Acting as a CM team**

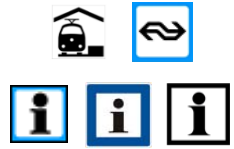
CIPRtrainer – CM icons primer

CIPRTrainer uses different icon sets

- (National) standard crisis management icons
  - German icons (full set)
  - Dutch icons (partial set)

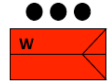


- Terrain symbols, incl. road signs (partly internationally standardised)

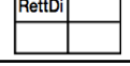


- Icons for CI elements (not all standardised, partly own depictions)

CIPRtrainer – CM icons primer

Icon (Dutch)	Name (Dutch)	Name (English)	Name (German)	Icon (German)
	gevaar	Threat (general)	Gefahr (allgemein)	
	Gevaar acuut	Threat (urgent)	Gefahr (akut)	
		Event	Anlass, Ereignis	
		damage	Angeschlagen, beschädigt	
		Initial fire	Entstehungsbrand	
	watertransport	Company for Water Supply	Löschzug Wasserversorgung	
	Gevaar explosieve atmosfeer	Warning Explosion danger	Explosionsgefahr	
	Geneeskundige aanwezigheid	Deployment Unit of a NGO (aid organisations)	Einsatzeinheit der Hilfsorganisationen	
	Ziekenhuis	Hospital	Krankenhaus	

CIPRtrainer – CM icons primer

Icon (Dutch)	Name (Dutch)	Name (English)	Name (German)	Icon (German)
	Ambulance post	Ambulance station	Rettungsdienst	
	Brandweerkazerne	Fire station	Feuerwehr	
		Technical relief station	Technisches Hilfswerk	
	Meldkamer; alarmcentrale	Emergency call center; dispatch room; command room	Notrufzentrale / Leitstelle	
	Politiebureau	Police station	Polizieistation	
	Treinstation	Train station	Bahnhof	

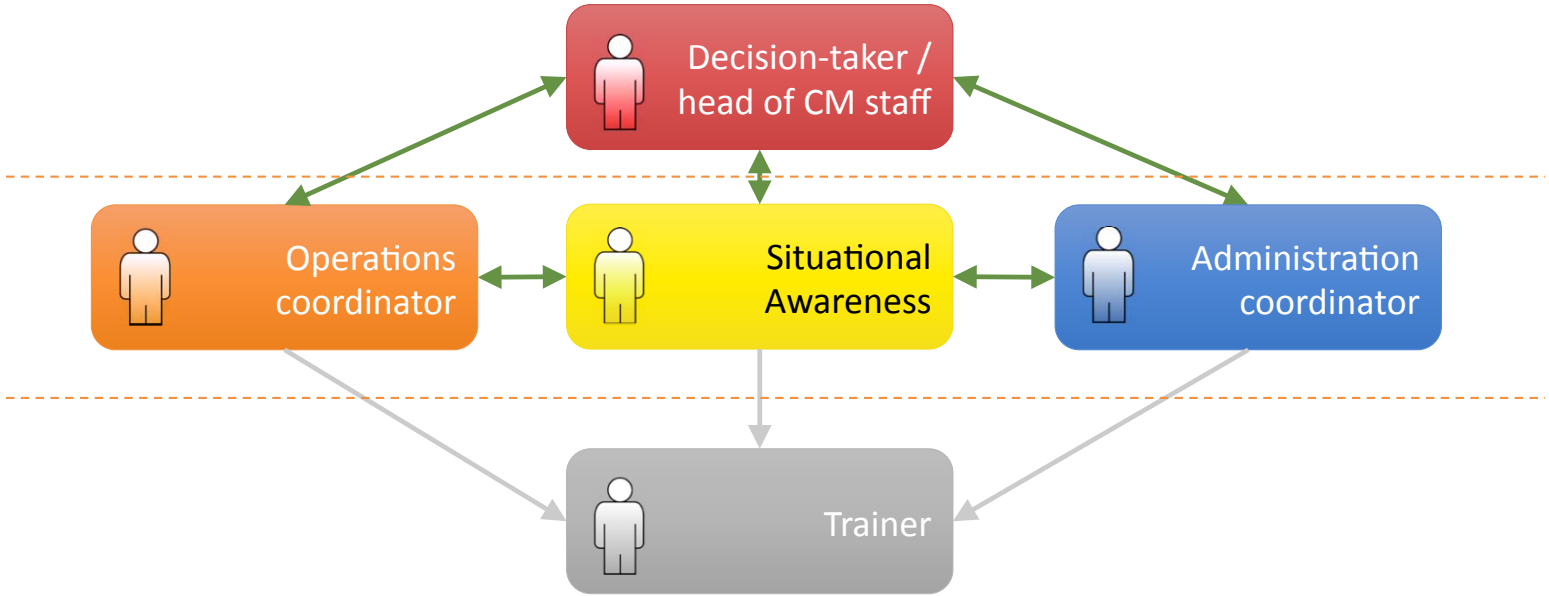
CIPRtrainer – Trainee roles

- Trainer 
  - starts, monitors and stops training sessions
  - can download and view training log files

- Trainees    
  - can assume four roles: decision taker, situational awareness, operations and administration coordinator
  - all but decision-taker can work simultaneously with the system
  - have different action menus depending on their roles

»What-if« analysis as a new capability for Crisis Management

Generic Crisis Management roles for CIPRTrainer



CIPRtrainer – Trainee roles

Decision-taker / Commander

- Leads the CM team
- Does not operate CIPRTrainer
- Gets informed by Situation Awareness, Response Coordinator and Administration Coordinator about the current situation and decision options
- Takes decision(s)

CIPRtrainer – Trainee roles

Decision-taker / Commander can take one of the following decisions:

- Initiate evacuation (OPERATIONS)
- Request electricity outage / power cut-off from electricity supplier in <place> (S.A.)
- Request locking the railroad track from train authorities
- Inform companies in the area that work with dangerous goods
- Contact european emergency response capacity
- Contact chief administrative officer of the district
- Request more emergency forces from other districts
- Inform the public by media (press, radio, television) (ADMINISTRATION)
- Request support from municipal transport services for evacuation

CIPRtrainer – Trainee roles

Operations Coordinator

- Leads the responders (virtually)
- Informs Decision-taker / Commander about the taken response actions, remaining resources etc.
- Executes decisions regarding response force activities
- Responders include:
  - Law forces (like police)
  - Rescue forces (like firefighters)
  - Action forces (like technical relief forces)

CIPRtrainer – Trainee roles

Operations coordinator can take one of the following actions:

- Inform action forces / rescue forces / law forces to prepare for operation
- Send action forces / rescue forces / law forces from <location> to <location>
- Inform the public by sending action forces with speakers and sirens
- Cordon off the scene of accident
- Recover affected victims / humans
- Evacuate the accident site (initiate evacuation)
- Evacuate population from <location> to <location> (initiate evacuation)
- Request special forces
- Block all critical bypass roads like tunnel and bridges
- Warn the public by using air raid sirens

CIPRtrainer – Trainee roles

Administration Coordinator

- Leads the administration departments (virtually)
- Informs Decision-taker / Commander about the taken administrative actions, remaining resources etc.
- Executes decisions regarding administration activities

CIPRtrainer – Trainee roles

Administration coordinator can take one of the following actions:

- Inform hospitals to prepare for casualties
- Prepare evacuation
- Support evacuation
- Inform the public by media (press, radio, television)
- Request support from municipal transport services for evacuation
- Block all critical bypass roads like tunnel and bridges

CIPRtrainer – Trainee roles

Situational Awareness

- Gathers all information on the current situation
- Informs Decision-taker / Commander about the current situation
- Monitors the progress of the response and administration actions
- Initiates the next decision-taking cycle by pausing the simulation and convening the CM team around the decision-taker / commander

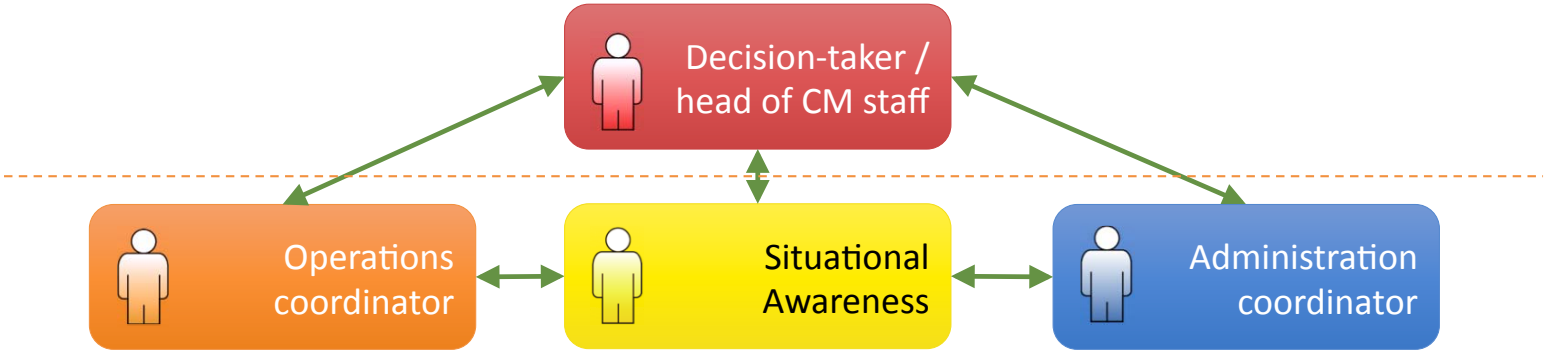
CIPRtrainer – Trainee roles

Situational awareness can take one of the following actions:

- Request electricity outage / power cut-off from electricity supplier in <place>
- Request locking the railroad track from train authorities
- Inform companies in the area that work with dangerous goods
- Contact european emergency response capacity
- Contact chief administrative officer of the district
- Request more emergency forces from other districts

CIPRtrainer – Acting as a CM team

- Simulate the cycle of situation update, decision-taking, and action
- Situational awareness pauses and resumes the simulation



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