SEVENTH FRAMEWORK PROGRAMME

IFSTTAR

[Optimal Networks for Train Integration Management across Europe]

Collaborative Project

7th Framework Programme

ON-TIME research major disturbances (WP5)

Trafikverket seminar

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Borlange, 16 th October 2014

Research aims and objectives

WP5 : Operation management of large scale disruptions

- To **specify** the integration of the real-time traffic and asset management **procedures**, optimization **models** and **tools**;
- To **develop algorithms** for resource management in the case of a large disruption;
- To **design and validate** effective intelligent decision support strategies and tools

Research aims and objectives

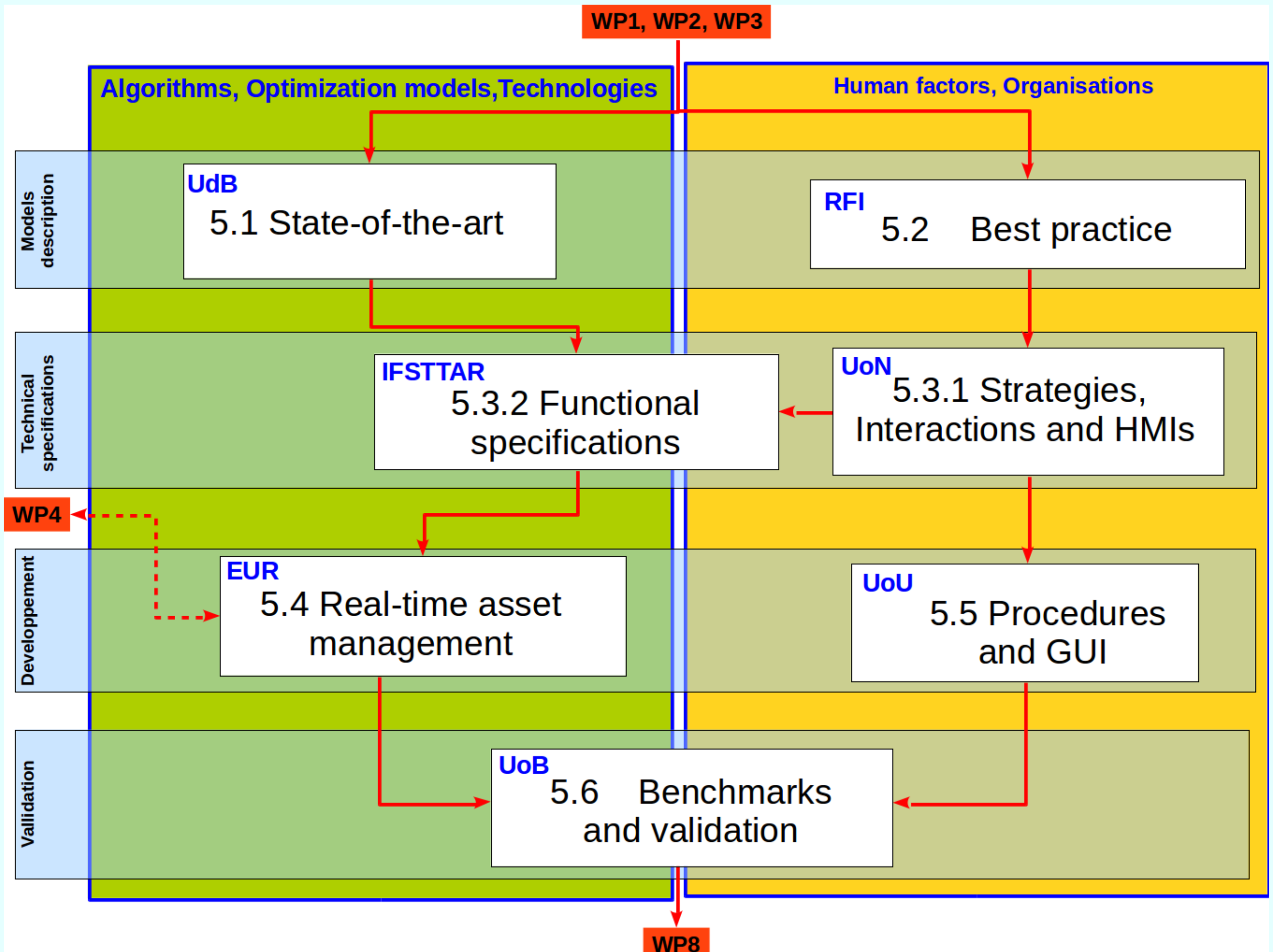
Large perturbations: perturbations that need a change to the way in which resources were originally planned will be managed by IM and RU controllers.

"Resources" :
- Infrastructure capacity;
- Rolling stock;
- Crew.

Examples:
- Broken catenaries
- Accidents with other traffic

Consequences : One or more tracks blocked for a certain period of time

WP5 structure



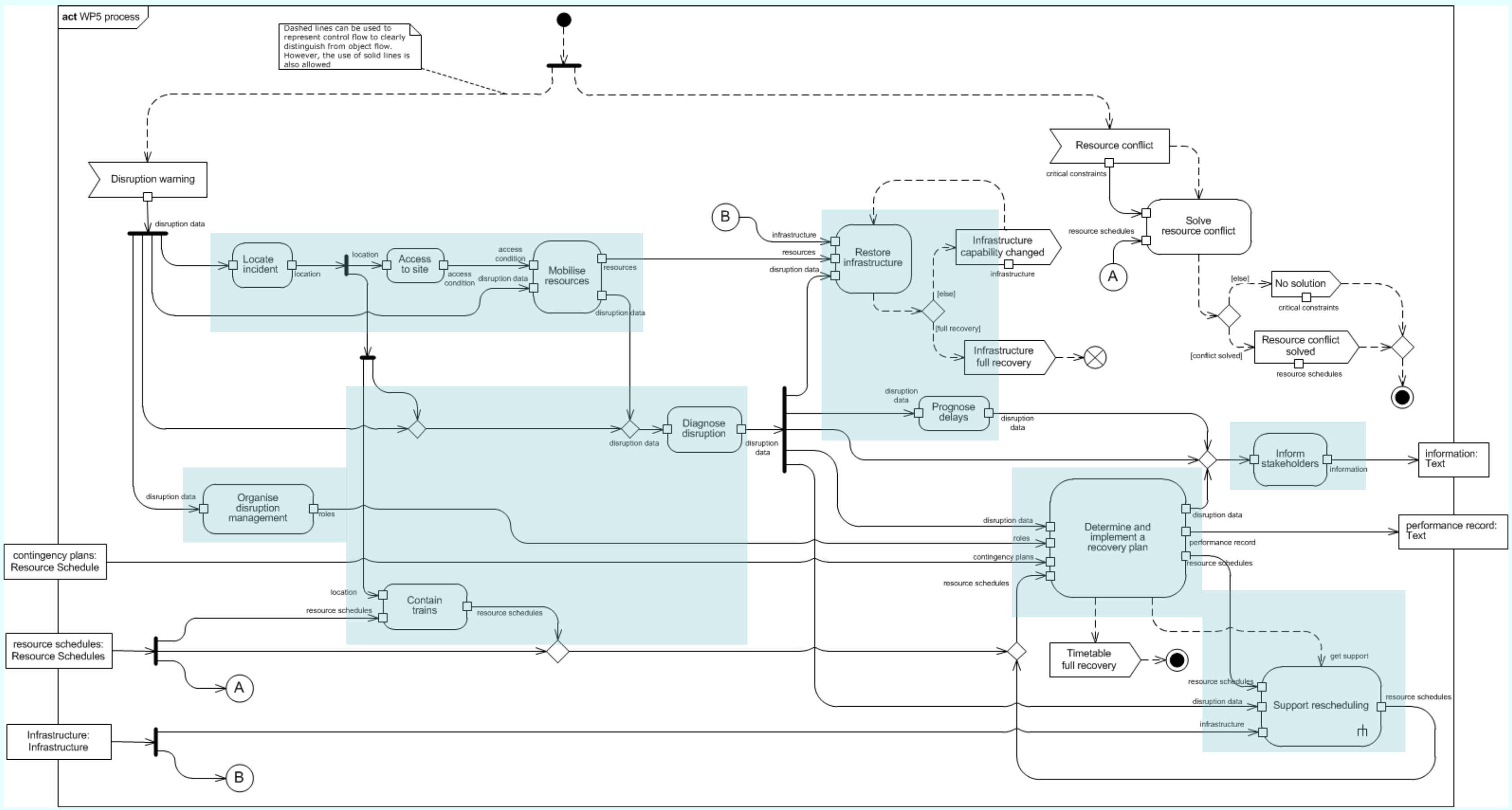
Research outputs

Human Factor / HMI

- Questionnaire on best practices
- Structured interviews method
  - → Set of representative incidents
- Analysis of real incidents
  - → Stages of incident management
- Critical Decision Method
  - → A list of key criteria for decision making
  - → Typical decisions of operators
  - → Information needs
- Repertory grid technique
  - → key characteristics of incident management.

Research outputs

Workflow of the recovery process specified by SysML activity diagrams



Research outputs

State-of-the-art of Recovery Algorithms in Railway Optimization

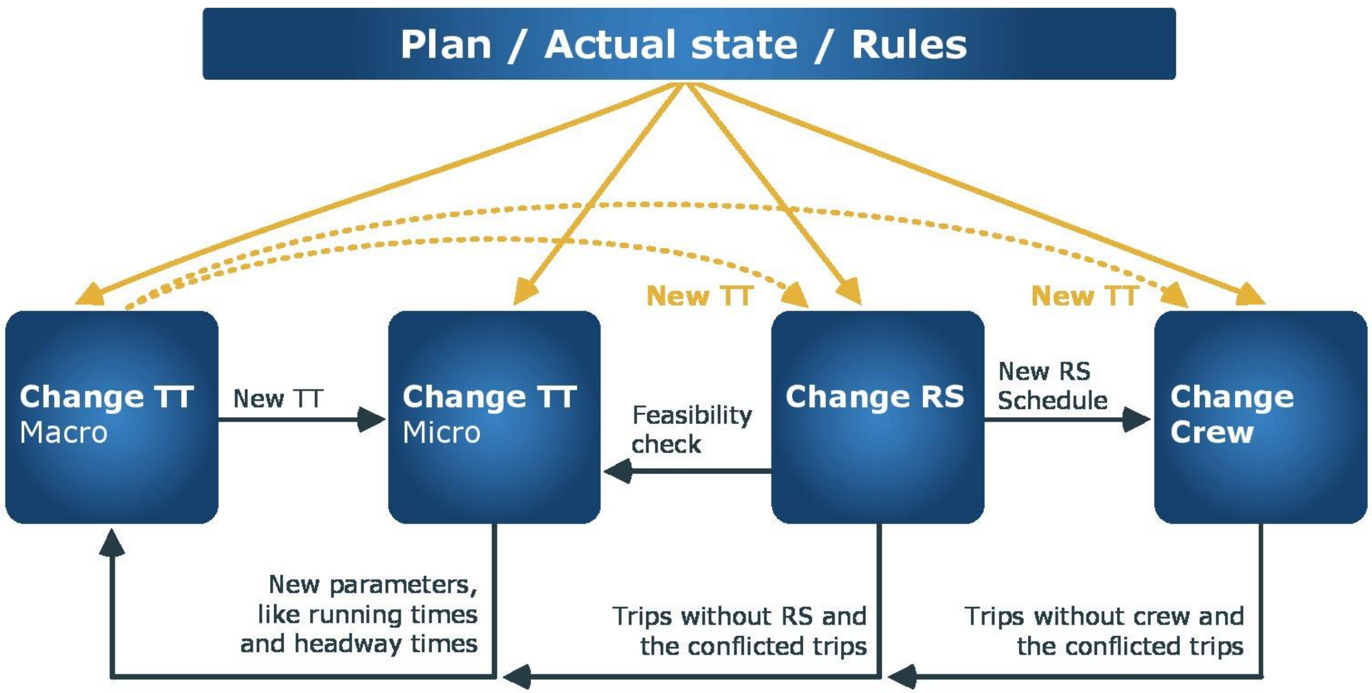
- Algorithms for rolling stock rescheduling
- Algorithms for crew rescheduling
- First approaches for timetabling
- Resources are always considered independently.
- Combining the individual models has never been tested in literature nor in simulation!

Practice

- 'De solver' at NS for crew rescheduling

Research outputs

Framework of closed loop for integration of the rescheduling phases



For each of the three resources, any rescheduling algorithm can be inserted

Macroscopic timetabling

- Objectives
  - Minimize number of cancelled trains
  - Minimize delays
  - Ensure feasible rolling stock schedule

- Measures
  - Retiming arrivals and departures
  - Short-turning trains
  - Reordering trains

- Input
  - Running and headway times

[Veelenturf et al. 2014]

Microscopic timetabling

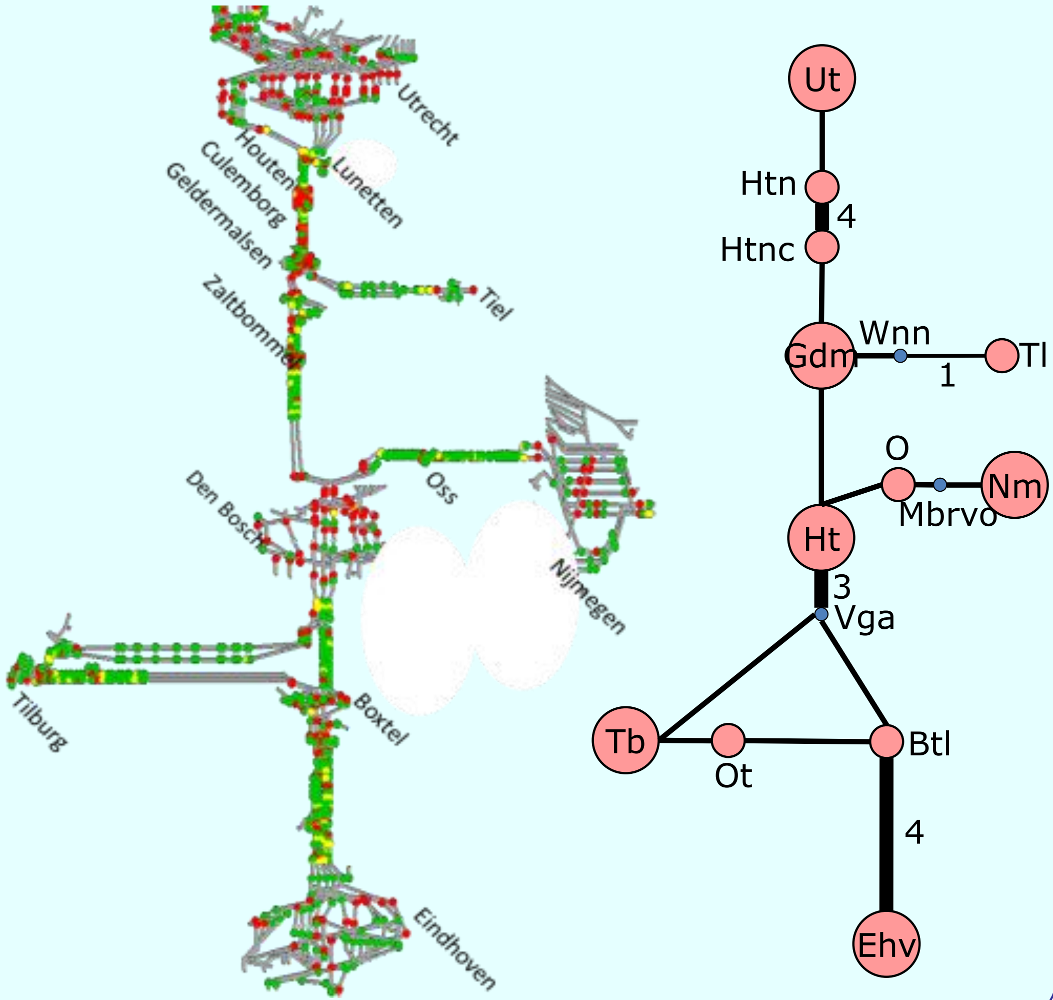
- Objectives
  - Compute headway and process times
  - Compute a feasible platform assignment
- Approach
  - Blocking time theory
  - Headway and running times based on speed profiles
- Input
  - Macroscopic timetable
  - Local train routes
  - Alternative train routes

[Besinovic et al. 2013]

Macro and Micro network

Models

- Microscopic network
  - 1500 nodes
- Macroscopic network
  - 15 nodes



Rolling stock rescheduling

- Objectives
  - Minimize number of trains without rolling stock
  - Minimize deviations from original schedule
- Measures
  - Assigning rolling stock compositions to trains
  - Adding / cancelling shunting operations
- Input
  - Macroscopic timetable
  - Original rolling stock circulation

[Maróti and Kroon, 2005; Fioole et al. 2006; Nielsen et al. 2012]

Crew rescheduling

- Objectives
  - Minimize the number of tasks without crew
  - Minimize deviations from the original schedule
- Measures
  - Assign a (new) duty to all crew members
- Input
  - Macroscopic timetable
  - New rolling stock schedule
  - Original crew schedule

[Potthoff et al. 2010, known at NS as `De solver']

Iterative framework

Input: Disruption, planned resource schedules

1. Compute timetable on macro and micro level
2. Reschedule rolling stock
   - If there are trips that are not covered
     1. cancel these these trips in the timetable
3. Reschedule the crew
   - If there are trips that are not covered
     1. Cancel these trips in the timetable
     2. Go back to step 2

Output: Timetable, rolling stock schedule, crew schedule

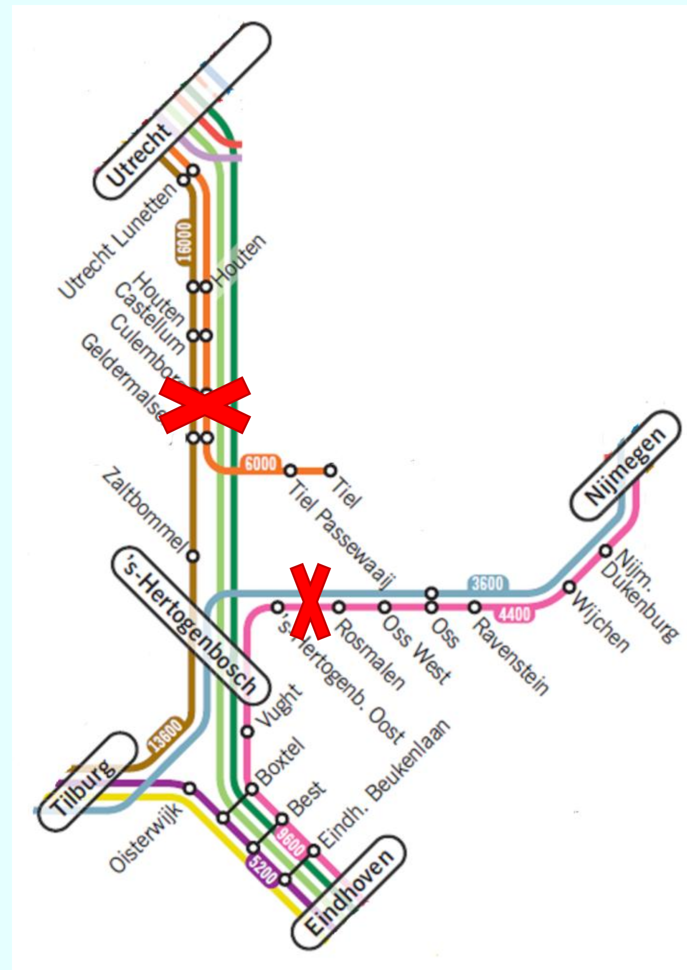
Case study

Disruption scenarios

- Resource schedules for a complete day (June 2012) from Netherlands Railways
- Timetable rescheduling on part of the network
- Rolling stock and crew rescheduling on the full network

- 2 locations
  - 's-Hertogenbosch – Oss
  - Utrecht – Geldermalsen
- 2 types
  - Partial blockage
  - Complete blockage
- 4 durations
  - 60 / 80 / 100 / 120 minutes
- 61 start times
  - between 7:00 and 17:00

976 disruptions



Computational results

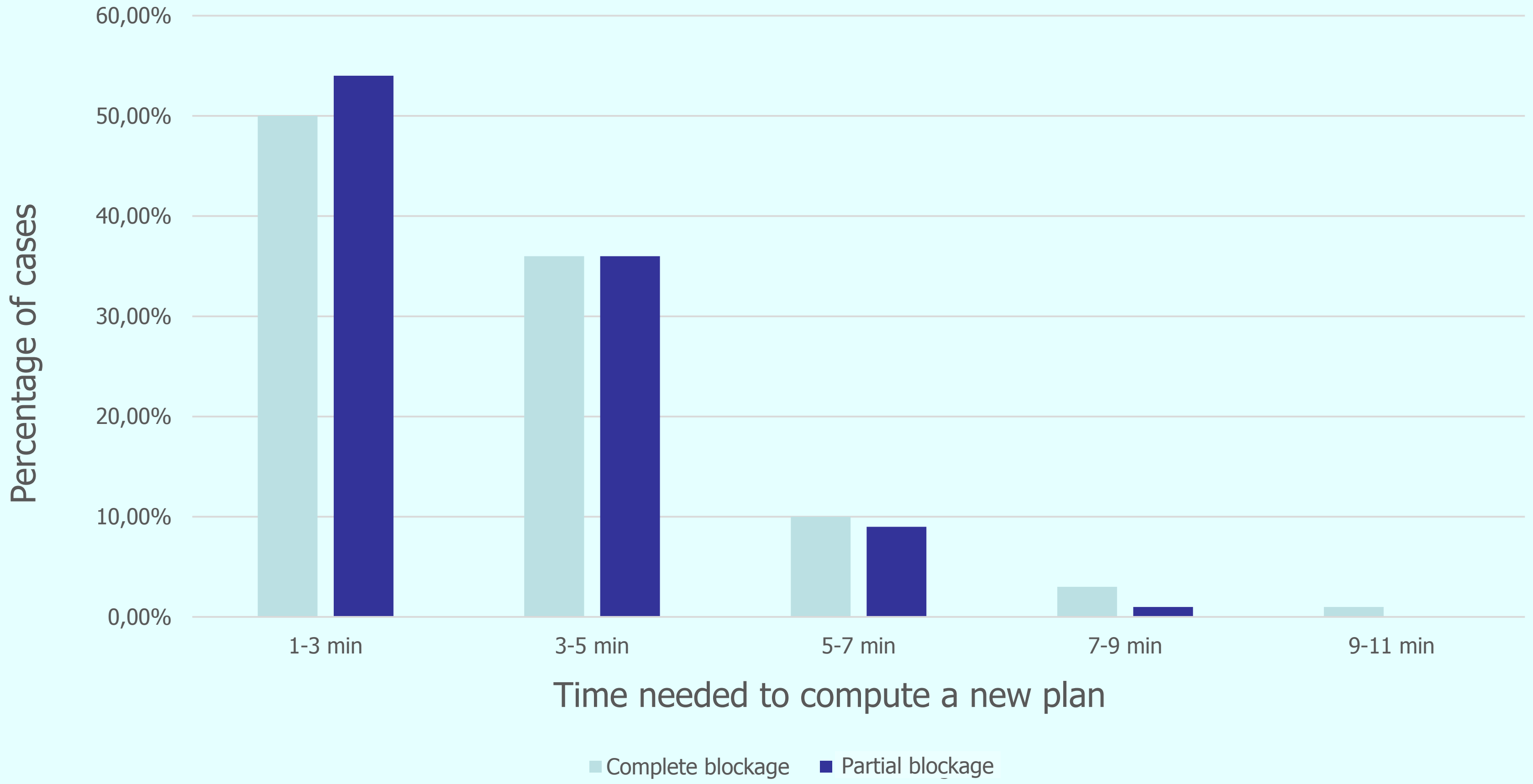
Complete blockage between Ht and O

- On average, 12.6 trips are cancelled.
  - Timetabling: 12.2 trips (204 minutes)
  - Rolling stock rescheduling: 0 trips
  - Crew rescheduling: 0.4 trips (14 minutes)

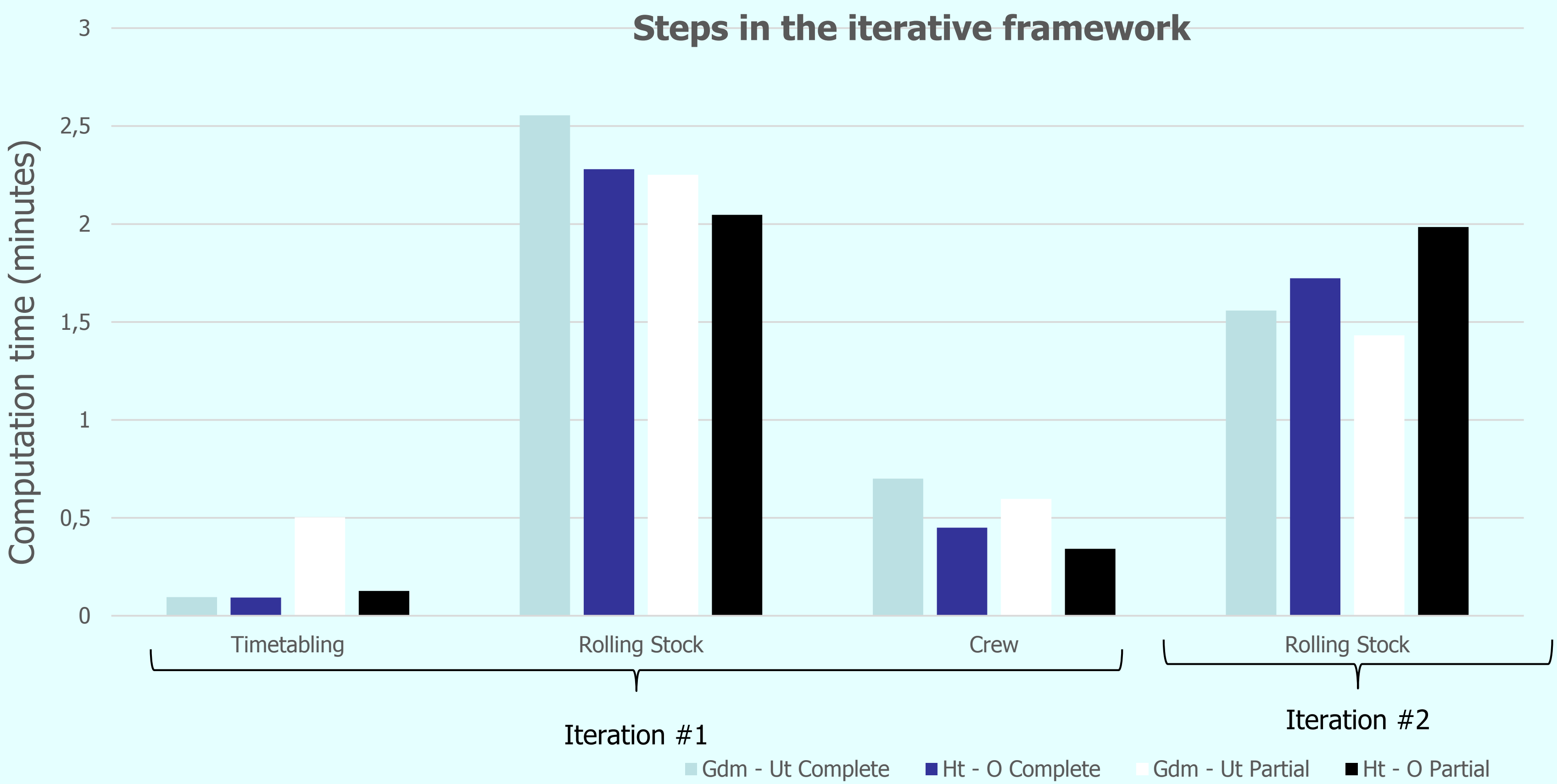
- The maximum number of cancelled trips equals 18.

- Only in 24% of the cases, a second iteration is required.

Computational results



Computational results



Summary of results

1. For a large set of disruptions, we can reschedule the timetable, rolling stock, and crew within minutes.
2. In our tests, at most two iterations were needed, because rolling stock rescheduling never cancelled additional trips.

Conclusions / Lessons Learnt

1. We developed an algorithm for timetable rescheduling.
2. We introduced an iterative framework for disruption management that sequentially solves timetable, rolling stock, and crew rescheduling.
3. We show that the algorithms individually and combined can be used to solve practical disruptions in a few minutes. This shows that a modular approach works.
4. Evaluation in a simulation model turns out to be complex and may not be necessary to show that this concept works.

Deliverables

D5.1 : Functional and technical requirements specification for large scale perturbation management

D5.2 : Decision support tools for the optimal human supervisory control of the recovery processes

D5.3 : Analysis of the benchmarking