C4R

Capacity for Rail

Simulation and models

FFE (Madrid, Spain) – 21 September 2017

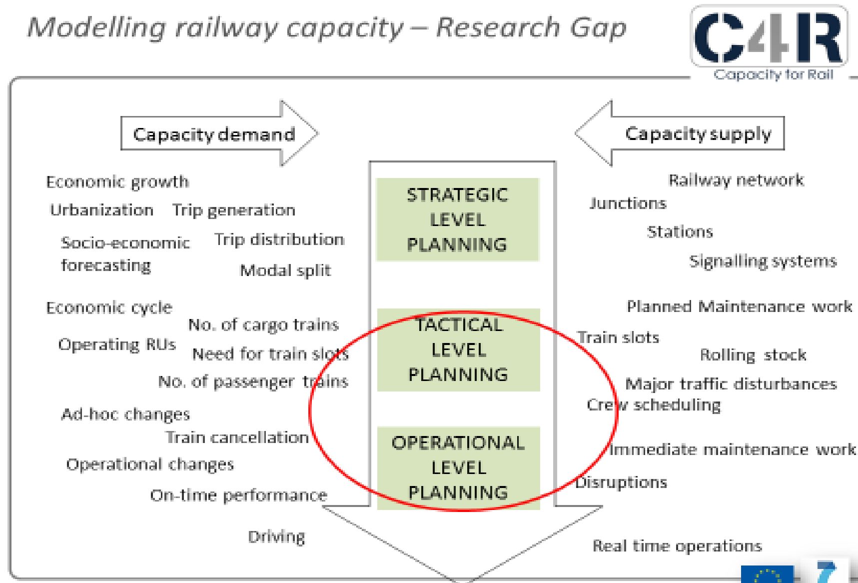
Magnus Wahlborg
SP 3.2 WP leader

TRAFIKVERKET

SEVENTH FRAMEWORK PROGRAMME

WP 3.2 Simulations and models

- Main focus research GAP tactical planning and operational traffic (digitalisation)



- Main partners
  - Infrastructure manager Trafikverket
  - System supplier Oltis – Traffic management systems
  - Research institute Linköping U - optimisation

Capacity for Rail

Digitalisation and increased automation of tactical planning and operational process

- Ongoing trend tactical timetable planning process and operational traffic process is merging

- The limit between planning and operational traffic is 3 days to 8 hours before traffic starts

- A third process is to carry out maintenance and monotoring (status of infrastructure and vehicles)

SEVENTH FRAMEWORK PROGRAMME

Digitalisation and Automation – timetable planning/traffic management

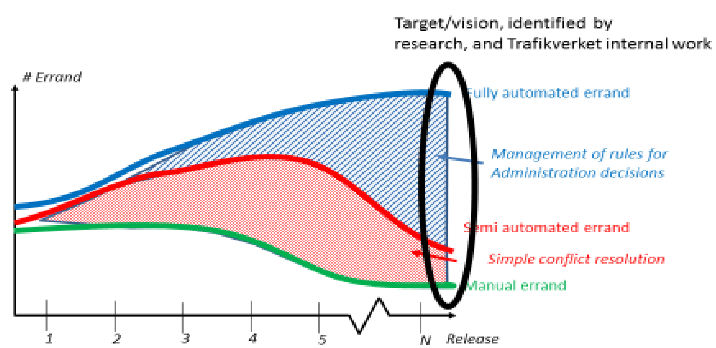
Capacity for Rail

Film new methods timetable planning Trafikverket
https://www.youtube.com/watch?v=-AAiTASw7fs

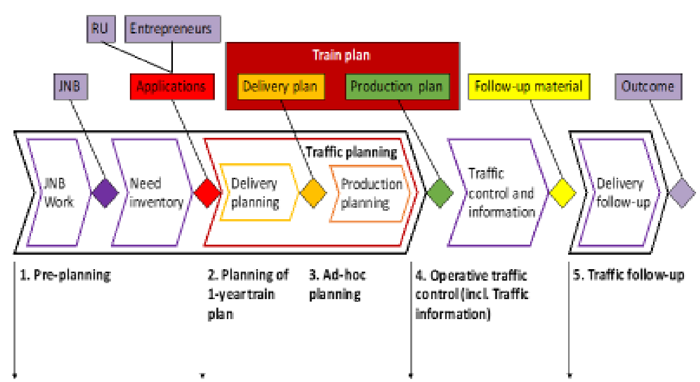
RNE TTR project Redesign of the international timetabling process (TTR)
http://www.rne.eu/sales-timetabling/ttr/

Shift2Rail
- 2016 start
- CCA Plasa
- IP5 ARCC WP2, WP3 (workshop IP2)
- 2017 start
- IP5 FR8Hub, OC Optiyard
- X2Rail-2

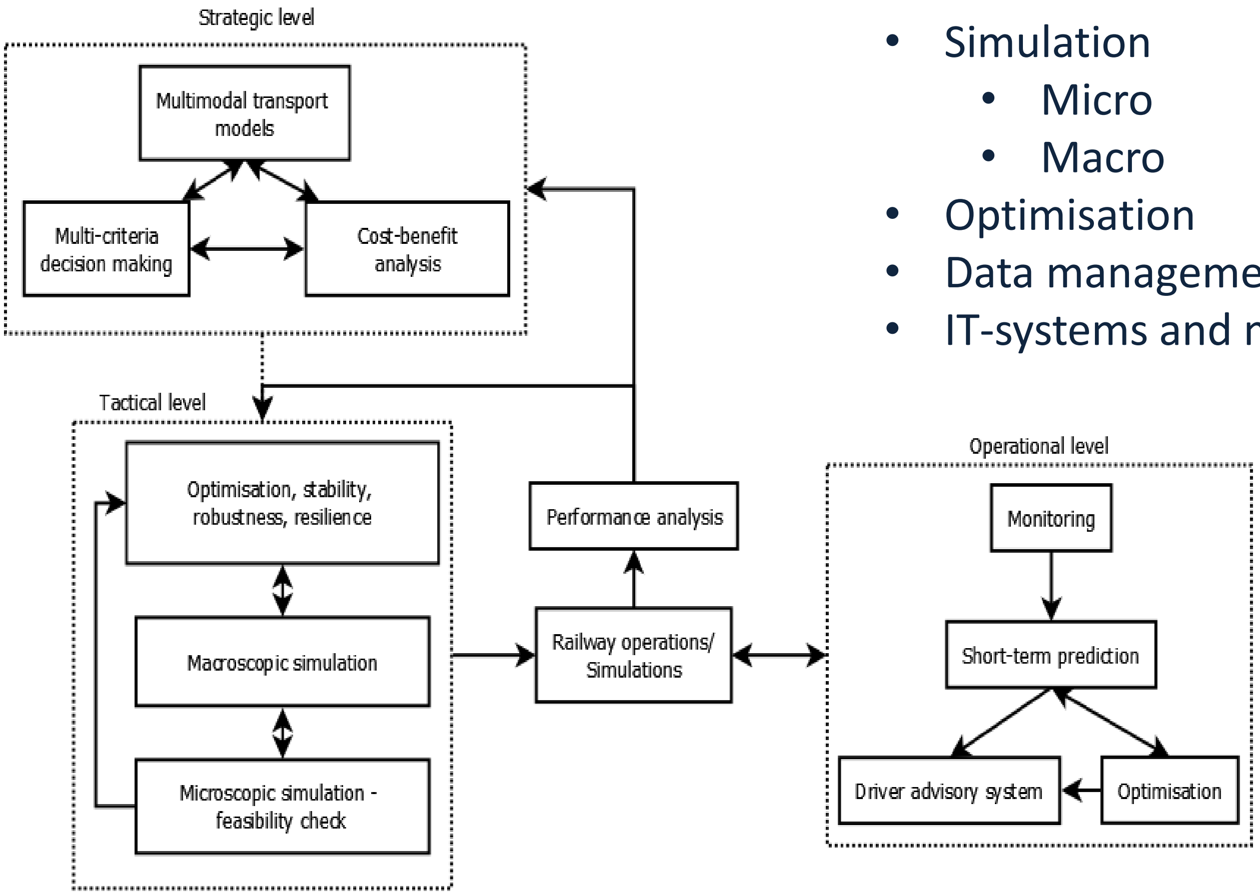
Development of automation in timetable planning process Trafikverket



Capacity planning follow up – 1,5 years ahead



Capacity4Rail – framework modelling and simulation



- Simulation
  - Micro
  - Macro
- Optimisation
- Data management (analysis…)
- IT-systems and modules

The CAIN - LiU:

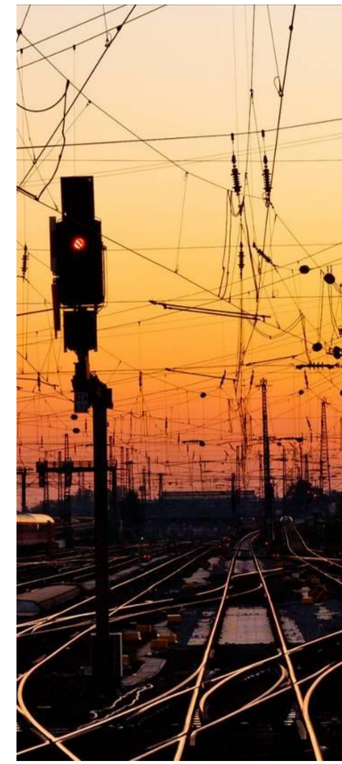
Demonstrator

*CAIN – **CA**pacity of the **IN**frastructure*

Capacity for Rail

CAIN – Demonstrator

- IT tool developed by OLTIS Group
- Based on KADR (CZ & SK infra-managers)
- Real time software for:
  - input of ad-hoc train paths into the real timetable
  - optimisation of the timetable
  - simulation of different scenarios
- CAIN interacts with the model from Linköping University



TRAFIKVERKET oltis group LINKÖPING UNIVERSITY

SEVENTH FRAMEWORK PROGRAMME

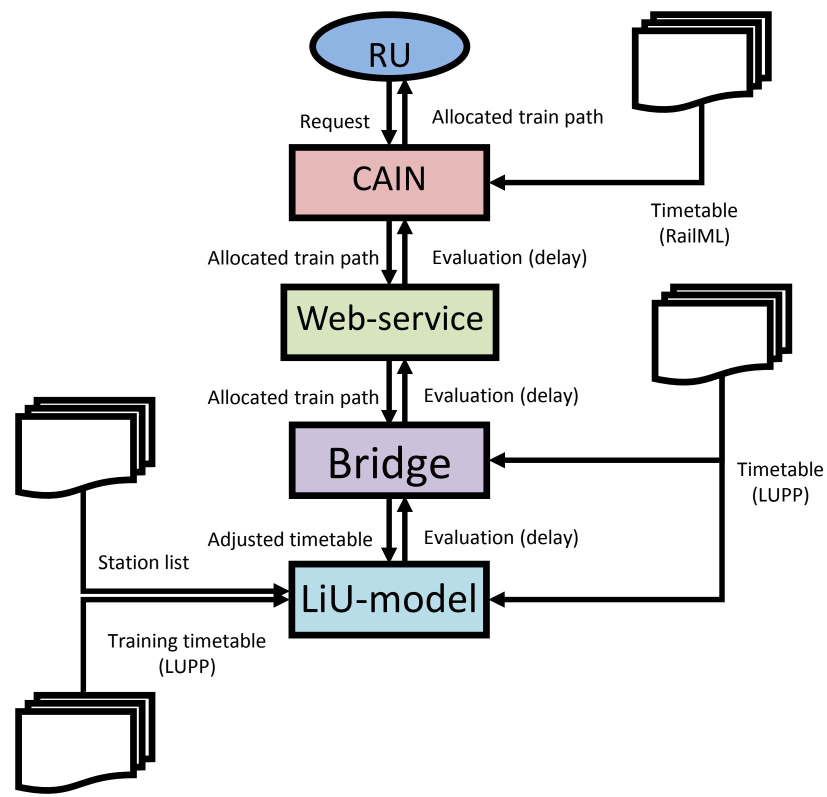
CAIN – **CA**pacity of the **IN**frastructure

CAIN – part I

- **Import** static data of Sweden:
  - **Railway infrastructure**
  - **Timetable**
  - **Vehicles**
- **Corridor Malmö – Hallsberg**
- Data in RailSys/railML format
- **Process** the data
- **Create** a virtual network
- **Display** the railway network

The LiU model – Interaction with CAIN

1. A request for an new train path sends to CAIN. (blue)
2. CAIN creates an allocated train path. (red)
3. An application (Bridge) fetches the allocated train path from CAIN via an Web-service. (green)
4. The bridge inserts the allocated train path into an adjusted timetable. (purple)
5. The LiU-model evaluates the adjusted timetable. (teal)
6. The Bridge sends the evaluation back to CAIN via the web-service



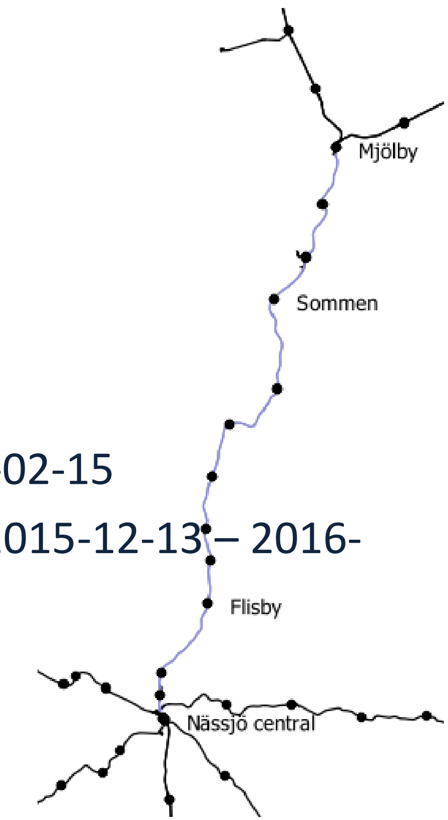
Numerical results - Specifications

Train path specification

- Type of train: Freight train
- Maximum speed: 90 Km/h
- Desired route: Mjölby – Nässjö
- Desired arrival time: 10:00

Simulation parameters

- Calibration dates for Bayesian network: 2016-02-11 – 2016-02-15
- Calibration dates for random deviation of departure time: 2015-12-13 – 2016-03-12
- Number of simulations: 200



Numerical results - Cases

Case 0 – Unchanged timetable

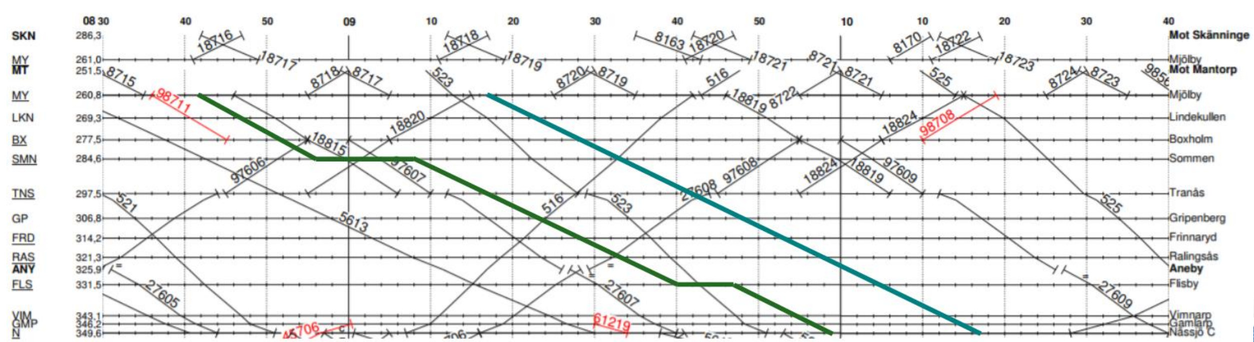
- Used as a benchmark for the different cases

Case 1 – Ad hoc train **(green)**

- Departing from Mjölby at 08:40
- Waits at Sommen and Flisby for passing passenger trains
- Arrives at Nässjö at 09:59

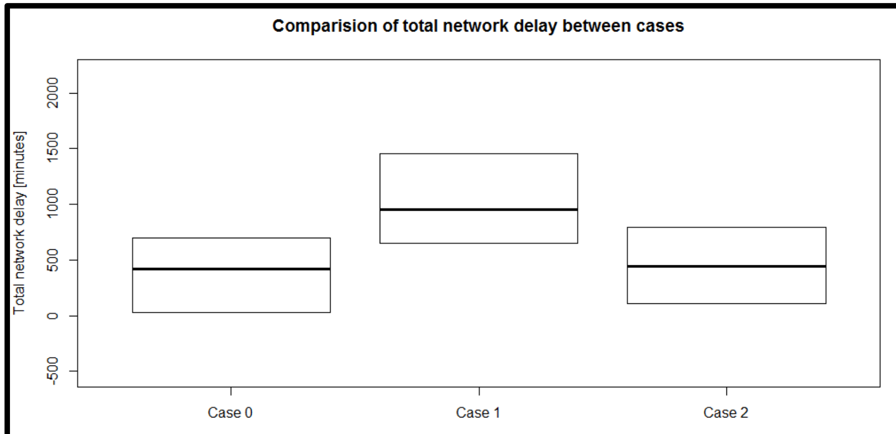
Case 2 – Ad hoc train alternative slot **(teal)**

- Departing from Mjölby at 09:17
- Arrives at Nässjö 10:17



Numerical results - Comparison

- Using the desired train path in case 1 more than double the estimated delay in the railroad network.
- Using the alternative train path in case 2 increases the estimated delay in the railroad network with 5 %.
- The best choice from a robust time schedule point of view is case 2.



Case	Arithmetic mean	Median	Difference to case 0
0	357.23	421.87	-
1	993.21	949.6	+ 125.09 %
2	429.7	444.14	+ 5.28 %

Main results

1. To define a framework strategic – tactical planning – operational traffic with micro-simulation, macro-simulation, data analysis , optimisation and IT system modules. By combining these methods tactical planning and operational traffic can be improved.

2. The LiU model have given us knowledge about a data analytic model to predict punctuality, when parameters in the timetable are changed.

3. The CAIN – LiU model interaction have given us new knowledge about interaction between IM timetable system and optimisation/data analysis model to predict timetable robustness and punctuality in the network due to changes in the timetable.

4. The CAIN demonstrator has given us knowledge about TAF/TSI, how to transfer data in Railsys/Rail ML standards and to interact between different data exchange standards. CAIN - Process the data, Create a virtual network and Display the network.

Publications and dissemination

D 32.1 Evaluation measures and selected scenarios, 2014-12-18
D32.2 Capacity impacts of innovations, 2017-03-31

Leaflet WP3.2 simulations and models, Innotrans 2017-09-20
Workshop Digital operations enhanced performance Olomuc 2017-04-27

Scientific publications arisen from the work in C4R, WP3.2:

- Jovanović, P., Kecman, P., Bojovića, N. and D. Mandića (2017) “Optimal allocation of buffer times to increase train schedule robustness”, *European Journal of Operations Research* 256, pp. 44-54.
- Kecman, P., Corman, F. and L. Meng (2015) “Train delay evolution as a stochastic process”, in: *6th International Seminar on Railway Operations Modelling and Analysis RailTokyo 2015*, Tokyo, Japan, March 23–26, 2015.
- Kecman, P., Corman, F., Peterson, A. and M. Joborn (2015) “Stochastic prediction of train delays in real-time using Bayesian networks”, in: *CASPT 15: Conference on Advanced Systems for Public Transport*, Rotterdam, The Netherlands, July 19–23, 2015.
- Solinen, E., Nicholson, G. and A. Peterson (2017) “A microscopic evaluation of robustness in critical points”, accepted for publication in: *7th International Seminar on Railway Operations Modelling and Analysis RailLille 2017*, Lille, France, April 4–7, 2017.

Capacity for Rail

Thank you for your kind attention

Magnus Wahlborg

Leader WP 3.2

Trafikverket

Magnus.Wahlborg@Trafikverket.se