

INDVIELSE AF RAILTECH DTU

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$$f(x+\Delta x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$$

$$\int_a^b \epsilon \Theta + \Omega \int \delta e^{i\pi} = [2.7182818284]$$

$$\sqrt{17}$$

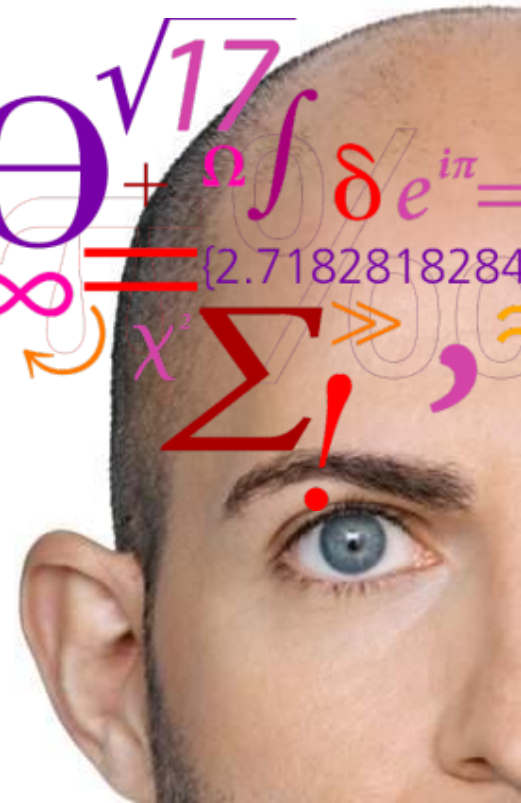
$$\infty$$

$$\chi^2$$

$$\Sigma$$

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DTU Management

The research at the Department contributes to new knowledge about **planning, production** and **management** and hereby contributes to the development of innovative **decision support systems** and **optimisation** of products and production in both the public and the private sector.



RobustRailS, Robustness in Railway Operations

Vision

Trains provide an environmentally friendly way of transportation.

If we want more people to use the trains, then the transportation system must be more timely, reliable, high-frequent, and comfortable.

- January 2012 – July 2016
- DTU Management, DTU Transport, DTU Compute, DTU Fotonik
- 6 PhD projects, 3 PostDoc's



Robustness in Railway Operations

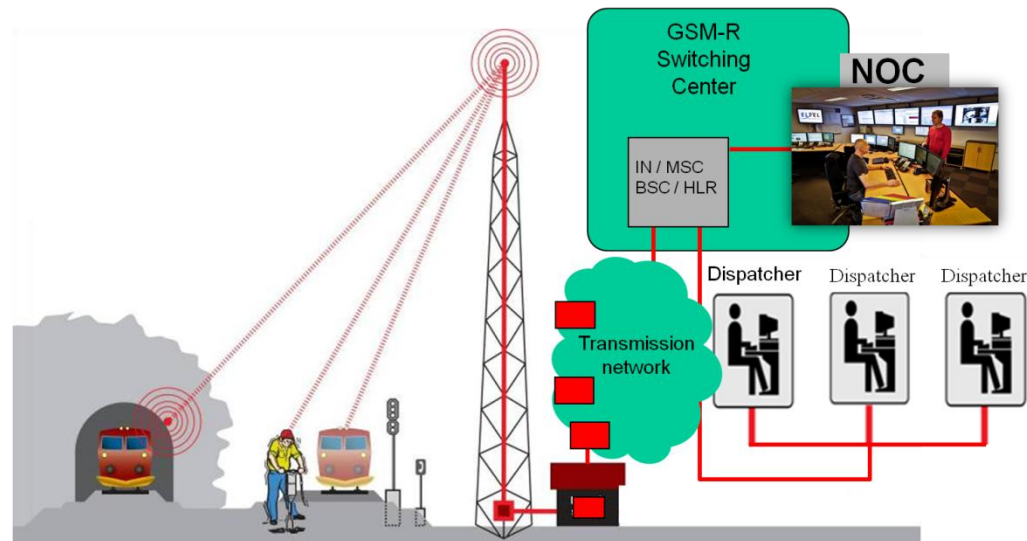
- A robust system can
 - absorb small disruptions
 - quickly recover from larger disruptions
- Robust infrastructure
- Robust communication
- Robust timetables
- Robust recovery



Projects in RobustRails

Infrastructure robustness

- Verification of railway control systems
- Communication technologies support



Projects in RobustRails

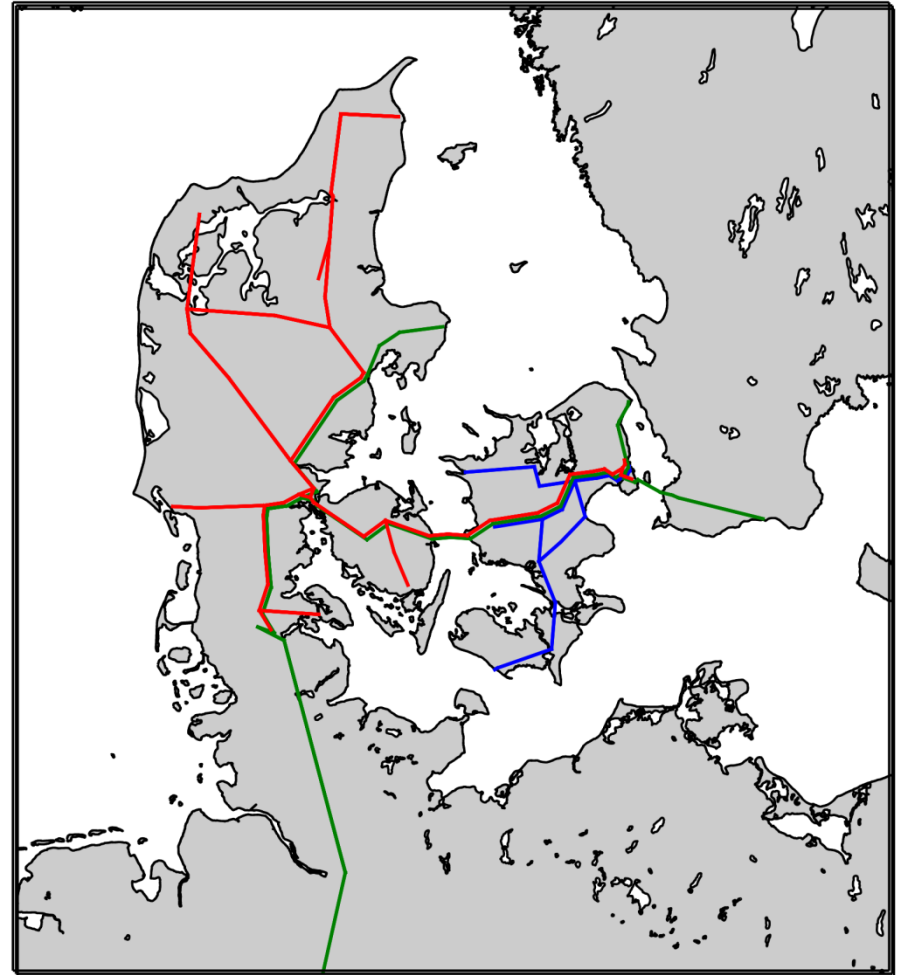
Robustness in rail operational process

- Operations planning to prevent delays (proactive robustness)
- Recovery planning (reactive robustness)



Independant subsystems

- Working with DSB to investigate independent train subsystems in Danish train networks.
- Disruptions from one subsystem does not propagate to other subsystem
- 18 unit types
- 17 trip types
- Benefits/costs of partitioning lines and units into independent pools



Integrated Disruption Management of Passenger Railway Transport

How does one optimally recover the timetable, rolling stock, and depot schedules in a disrupted environment?

Results

- Prototype model for S-tog developed
- Tested on historic disruptions
- Fast solution time (30sec to 5 min)
- In most cases better recovery plan than manually found



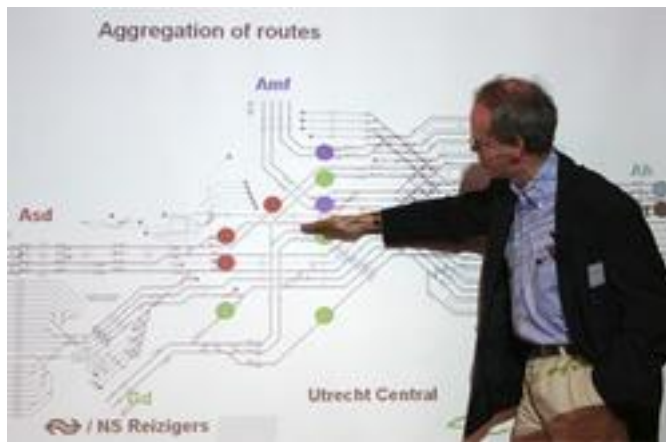
Projects in RobustRails

Passenger viewpoint



International collaborators

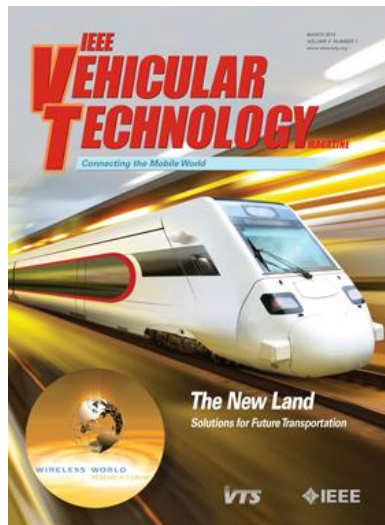
- Leo Kroon, professor at the Rotterdam School of Management of *Erasmus University* and *logistic consultant at the Dutch railways*.
- Jan Peleska, professor at *Bremen University* and *founder of Verified Systems International*. He has strong experience in industrial development and validation of safety-critical railway and avionics systems.
- Marion Berbineau. LEOST-IFSTTAR in France.



Publications

www.robustrails.man.dtu.dk/Publications

More than 40 publications since 2012



RobustRailS Prizes

- Linh Hong Vu, Jan Peleska, Anne Haxthausen "A Domain-specific Language for Railway Interlocking Systems" **Best paper award** FORMS/FORMAT 2014

FORMS/FORMAT 2014
10th Symposium on Formal Methods



- Jørgen Haahr, Richard Lusby, **first prize**, RAS Competition, Railway Application Section, INFORMS, 2014



- Jørgen Haahr, Simon Bull, **second prize**, ROADEF/EURO Challenge 2014, junior.



Other activities at DTU Management

- Master thesis projects with DSB, Metro
- PhD project: PhD project on algorithms for integrated time table and rolling stock planning (part of IPTOP project)
- PostDoc with Metro: Timetabling in urban networks with time-dependent frequencies



Railways leading role in big data revolution

- Lyndon (2013)
"leading role that rail public transportation has been playing — actually for a number of decades — in the Analytics and Big Data revolution that has been sweeping through both the private and public sector of global economies."



"I know it's yesterday's ticket! That's when I got on this bloody train!"



Man on the moon project in this century



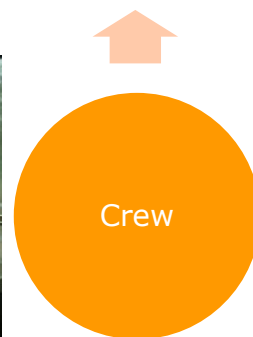
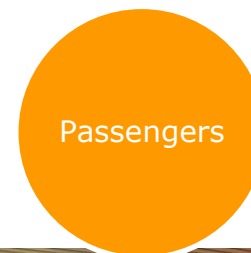
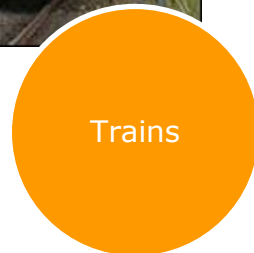
Thank you



RobustRails PhD Projects, and affiliated PhD

Title	PhD student	Department
Disruptions management	Jørgen Haahr	DTU Management Engineering
Defining, measuring and implementing robustness	Simon Bull	DTU Management Engineering
Formal development and verification of railway control systems	Linh Hu Vong	DTU Compute
Communication technologies support	Aleksander Sniady	DTU Fotonik
Optimization of Railway Operations with regard to Passenger Benefits	Jens Parbo	DTU Transport
Network effects within railways	Lars wittrup Jensen	DTU Transport
Omløbsplanlægning af rullende materiel for DSB s-tog	(Per Thorlacius) ErhvervsPhD S-tog	DTU Management Engineering
Scheduling of maintenance work on tracks	(Shahrzad Pour) Banedanmark	DTU Management Engineering

Holistic approach



International projects on robust railways

