IT-systems and Human Factors
A case – Train Traffic Systems

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An case study
- Train driving – safety barriers
- Train traffic control
  - From today’s system to something new and better
  - How are human factors considered?

Train driving

Is this a complex work? If so, why?
**Human error (reliability)**

- Human errors:
  - Slips (e.g. wrong action)
  - Mistakes (e.g. wrong interpretation of information)
  - Violations (e.g. breaking of rules)

- If it is possible to make an error, it will happen – sooner or later!

- If somebody makes an error – who is to blame?

**Barriers**

- Two different approaches
  - Prevent the operator from doing wrong
  - Support the operator to act correctly (e.g. “resilience engineering”)

- Technical
  - Informational
  - Competencies
  - Organisation (Culture)

**Technical barriers – train protection (ATP)**

- Balises in the track gives information about position, signals and max speed.
- The driver manually enters train parameters.
- ATP-computer calculates break curve.
- ATP-computer “takes over” if the driver do not break in time.
- The driver can not (?) drive against red or drive too fast.

---- Where are the safety risks?
Information barrier

- Shows decision relevant information
- Does not show decision relevant info

Train traffic control

- Today’s systems and interfaces
- A new control strategy
- Automation – how?
- Future operator interfaces
- Implementation of a new system

A traditional traffic control centre

- A traditional traffic control centre
The time-distance graph

Humans in complex systems

The graph

Communication and cooperation
A complex organisation

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New workplace, same system

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The new workplace
Today’s control system

Train Dispatcher

Information Systems

Time-Distance Graph on paper

A complex environment

- Drivers

Control System Remote Blocking

Automatic Traffic Control System

Train Traffic Process

Goal...

Models....

Observability....

Controllability....
The problems.....

- Lack of overview
- Many separated information systems
- Focus on control of the technical infrastructure, not on the traffic
- Conflicts and disturbances are detected too late
- Lack of precision in data
- Observability problems, data missing
- Controllability problems, timing of actions
- Complexity induced by autonomous automatic functions
- Time consuming communication with train drivers
- Dispatchers lack efficient support when this is most needed!!

Domain and user analysis

- The analysis was based on many observations and interviews
- The GMOC model was used to describe, analyse and design
- Active work groups of skilled professionals supported the work
- Ideas and prototypes were developed iteratively.

A new control strategy

- Traffic control through real-time re-planning of a traffic plan
- Automatic execution of the continuously updated traffic plan
- A complete plan from start to stop
- Possibilities to optimize better
- Manual execution when necessary
- Automatic functions are made predictable
  - Can not change track usage or train order
- Improved communication between trains and control centres, train drivers are made aware of the plan
- Better information to passengers
The new control strategy

Automation in traffic control
- Today’s automation causes several problems
- “Automation surprises”
- Reduced situation awareness
- “Irony of automation” - “Turn it off syndrom”
- We need another type of automation!

The new system
- Non-autonomous automation
  - Only executes – is not allowed to change the plan!
  - The traffic controller is always “in the loop”
- Supports situation awareness
  - Tells the traffic controller exactly what is does and when.
The new user interface

- Presents dynamic traffic data
  - the operator is always “in full control”
  - supports “situation awareness”
- Supports planning tasks
- Supports early detection of conflicts
- Shows possible solutions
- Integrated information presentation

Design of systems and interfaces in process control

- Control systems and operator interfaces must support efficiency, safety, a good work environment etc.
- I.e. they must have a high usability for the operators.

Interface design principles

- Interface design can not be separated from design of control strategies
- Design for skilled users and high efficiency
- Support control by awareness
  - Show dynamic information
  - Support understanding of the process
  - Support development of mental models
- Efficient visualisation and interaction
  - Support overview
  - Show information simultaneously
  - Show much information!
  - Efficient information coding
  - Minimize input activities
- Make the design complete, minimize manipulation
- Make it error tolerant, allow experiments
- Supportive alarms
Time-Distance diagram
(re-planning tool)
Actual Plan:
Time Table
Track Usage
Prediction
Deviation
Conflict detection
Plan verification and test

Track Diagram
line, station, track, train;
track usage, train routes,
actual position; track work

History, time distance graph
Train information

Prototype environment at
Uppsala University

Operator environment
The interface is generated by projectors
Image and sound is recorded during experiments...
...for later analysis...
Recording of the user interface interaction.

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Time-Distance diagram
Track structure
Planning view
Time-distance graph
Present time
History
Track structure
Detection of conflicts

Station track conflict

Line track conflict

Re-planning in the graph

Re-planning directly in the planning view

Available tracks and track usage

Planned graph for selected train

Departure time, track usage etc can easily be changed here

Display of automation aspects

Automatic execution turned off at one station
STEG

An operational system

- A full implementation in order to test and evaluate the concepts in a real traffic control centre.
- To obtain knowledge for decisions about future national control systems
- Developed in close collaboration between researchers, the rail administration and developers.
- Deployed, tested and evaluated in Norrköping and Boden.
The Iron Ore Line

Iron Ore Line:
Trains up to 8 600 ton,
750 m long
Kiruna – Narvik: 160 km

The STEG workplace
From research to implementation

- The importance of a solid knowledge base
- The close collaboration between researchers and the rail administration
- The user centred approach
- Collaboration in all phases (research, specifications, development, deployment, evaluation)
- Focus on efficiency and work environment

Driver Advisory Systems

Driver advisory systems (DAS)

- The new control strategy requires:
  - Information to and from the train driver
  - Support for the driver to follow the traffic plan
  - Keep the driver in-the-loop
  - Support driving skills
  - The driver must have situation awareness and possibilities to drive with precision and efficiency
The CATO system

CATO
- Recommended speed to save energy and reach arrival points
- Arrival points are set by traffic control
  - Train should reach a certain point before/after a certain time
  - Should guarantee e.g. smooth meetings or fixed time windows for infrastructure maintenance
- Technical development by Transrail