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

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Humans in complex systems

An case study

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

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Train driving

Is this a complex work? If so, why?

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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?

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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)

Humans in

Technical barries – 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?

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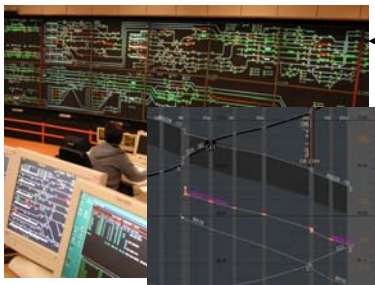
Information barrier



Does not show decision relevant info

Shows decision relevant information

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Train traffic control

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

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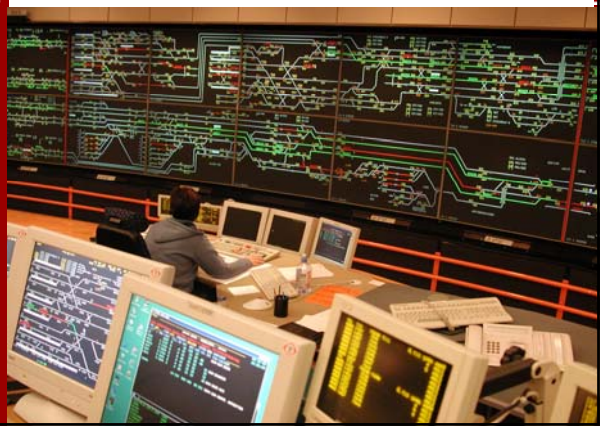
A traditional traffic control centre



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The time-distance graph

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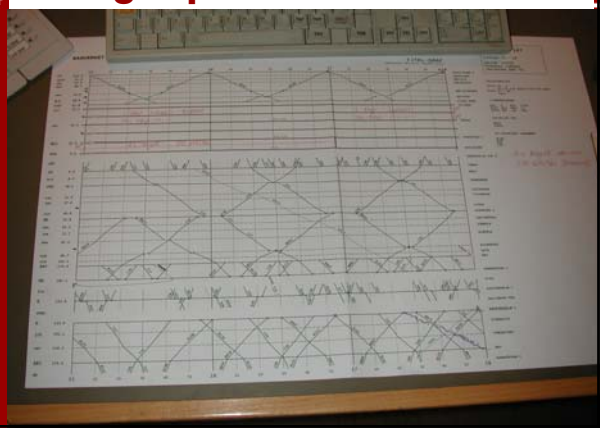
The graph



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Communication and cooperation

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A complex organisation

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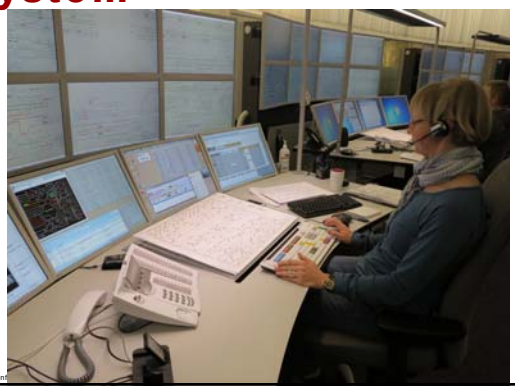
New workplace, same system



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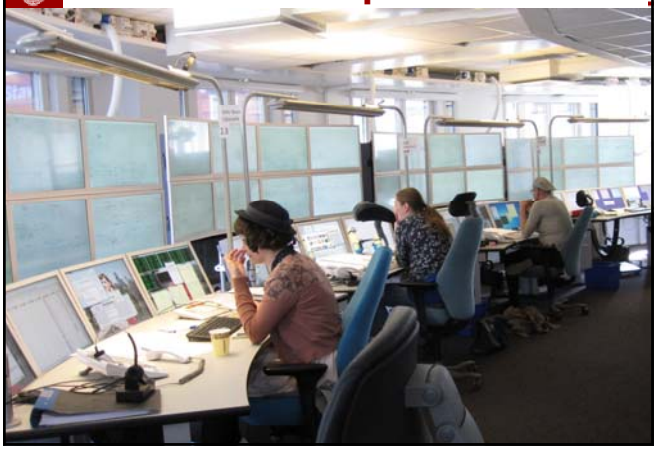
The new workplace



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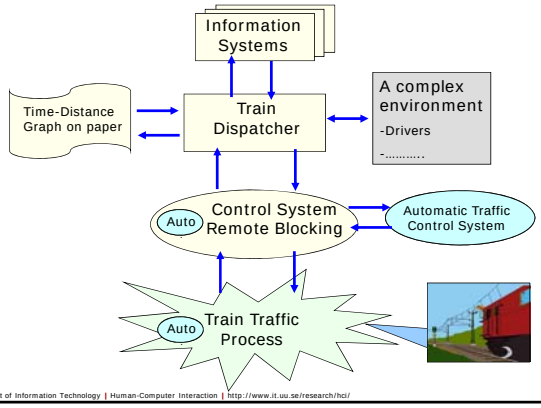
Today's control system



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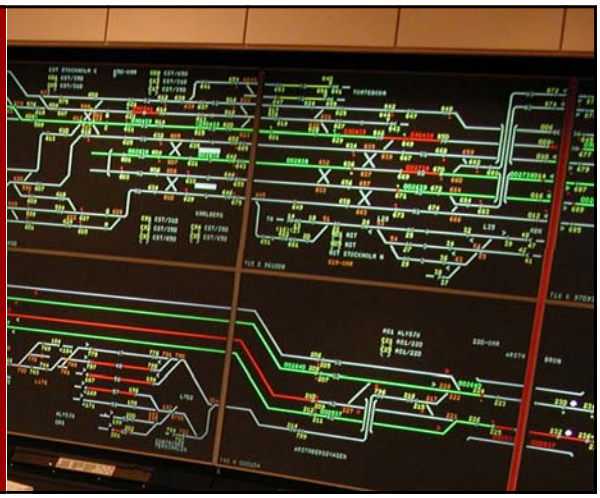

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GMOC analysis

- Goals…
- Models….
- Observability….
- Controllability….

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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!!*

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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.

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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

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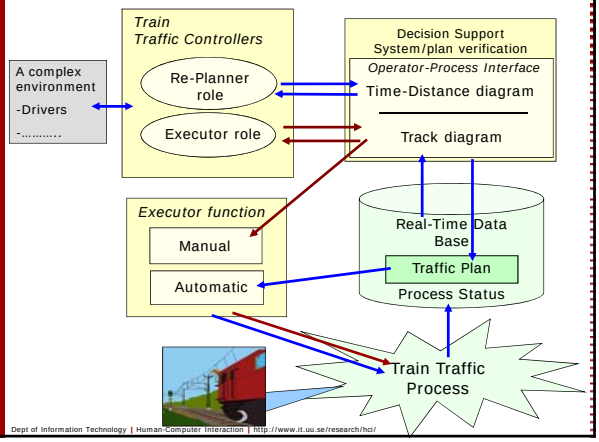
The new control strategy



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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!

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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.

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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

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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.

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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

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Future
Time
Present

Time-Distance diagram
(re-planning tool)
Actual Plan:
Time Table
Track Usage

Prediction
Deviation
Conflict detection
Plan verification and test

Linear distance scale, correlated graphics

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

Present
Time
Past

History, time distance graph

Train information

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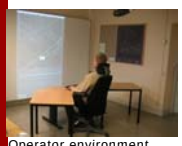
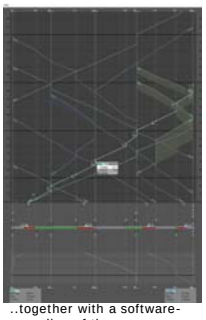
Prototype environment at Uppsala University


Operator environment


The interface is generated by projectors


..together with a software-recording of the user interface interaction.

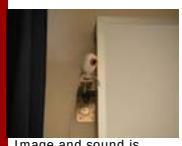
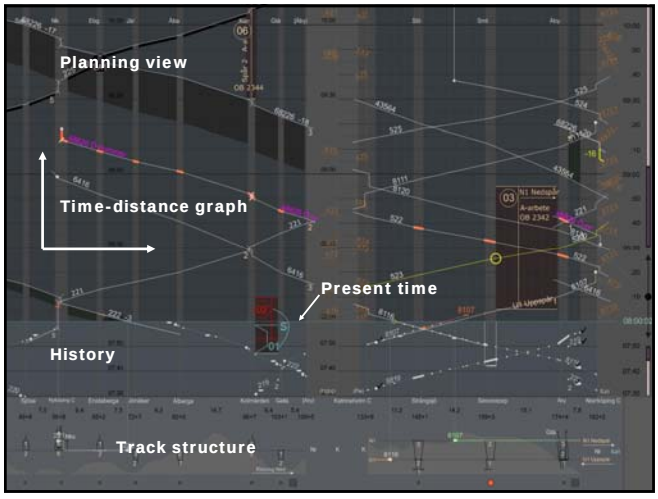


Image and sound is recorded during experiments...


..for later analysis..

Dept of Information Technology | Human-Computer Interaction | http://www.it.uu.se/research/hci/



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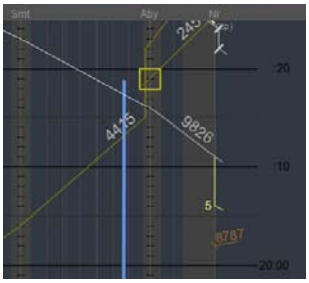
Detection of conflicts

Station track conflict



Line track conflict

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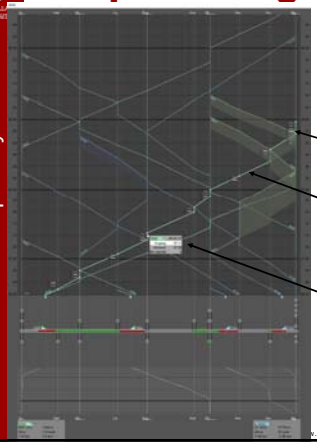
Re-planning in the graph



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

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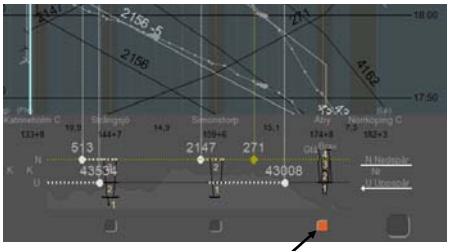
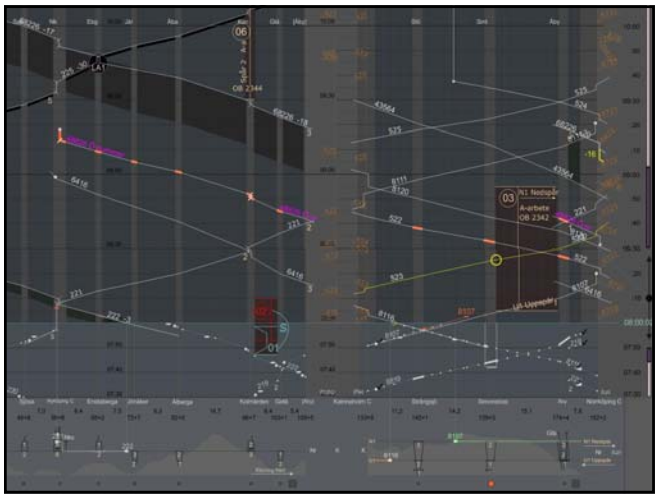
Display of automation aspects



- Atomatic execution turned off at one station



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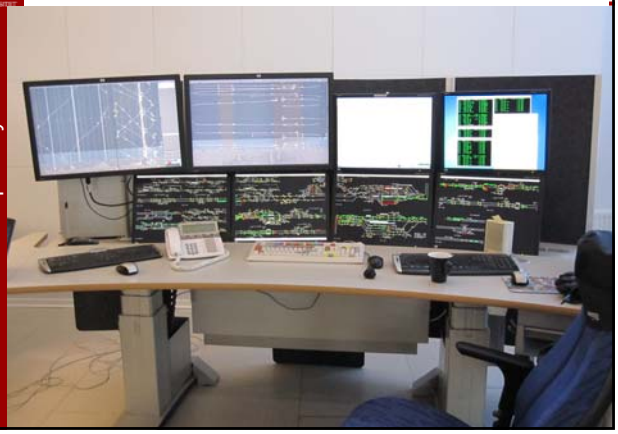
STEG
An operational system

- 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



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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

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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

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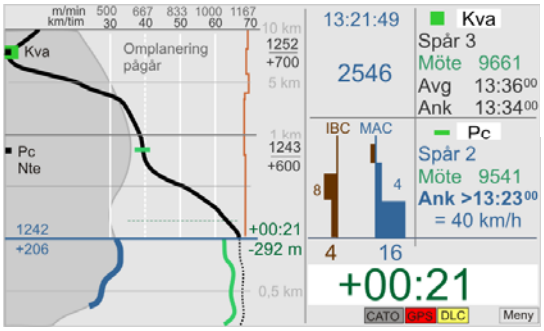
The CATO system



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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