Development for train traffic control, based on a usability approach

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An example
- Train traffic control
- Today’s systems and interfaces
- A new control strategy
- Future operator interfaces
- Implementation of a new system

Today’s traffic control
The graph

Train traffic control

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The complex information environment
Communication

Today’s control system

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.
The GMOC model

Control a dynamic system requires:

- Goal (G)
- Model (M)
- Observability (O)
- Controllability (C)

The problems.....

- Lack of overview.
- Separated information systems.
- Focus on control of the technical infrastructure, not on the traffic.
- Lacking observability.
- Lack of precision in data.
- Complexity caused by autonomous automatic functions.
- Difficulties to identify disturbances.
- Time consuming communication with train drivers.
- Dispatchers lack efficient support when this is most needed!!

A new control strategy

- From control tasks to real-time re-planning of a traffic plan
- Automatic execution of the continuously updated traffic plan
- Manual execution when needed
- Automatic functions are made predictable
  - does not autonomously change track usage or train order
- Continuous information exchange between train and control centre
The new control strategy

Problems with automation

Situation awareness requires that the operator can
- Observe (past/present status)
- Comprehend (past/present status)
- Project (future status)

Automated functions can reduce situation awareness and cause automation surprises.

Problems with automation

- In order to be in-the-loop and have full control, the human operator often turns the automated functions off.
- This is common in disturbed and problematic situations, i.e. when help is most needed.

"The irony of automation"
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.
- Minimal cognitive load.
- Design structure:

<table>
<thead>
<tr>
<th>Future</th>
<th>Time</th>
<th>History, time distance graph</th>
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<td></td>
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<td>Time-Distance diagram</td>
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<td>(re-planning tool)</td>
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<td>Actual Plan:</td>
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<td>Time Table</td>
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<td>Track Usage</td>
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<td>Conflict detection</td>
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<td>Plan verification and test</td>
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<td>Present</td>
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<td>Linear distance scale, correlated graphics</td>
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<td>Track Diagram</td>
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<td>line, station, track, train; track usage, train routes, actual position; track work</td>
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Planning view
- Track maintenance
- Time-distance graph
- Present time

Track structure

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

History, time distance graph

Train information
Conflicts are identified

Different types of conflicts are identified and visualized.

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
Laboratory tests

STEG - Background

STEGBackground

STEG – control by planning in a computerized time-distance graph.

- A “sharp” implementation in order to test the concepts in a real traffic control centre.
- The complexity of the real work situation can not be generated in a laboratory.
- A completely new role as “real-time replanner” is introduced.

STEG - Objectives

STEGojectives

- To obtain knowledge for future decisions about new national control systems.
- To evaluate
  - Work procedures and control principles
  - Functionality and algorithms
  - User interface and interaction
  - Technical requirements and specifications
  - Risks
  - Cost benefit analysis
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

The test traffic area
**The test workplace**

**User centered development – a “must”**
- The users are experts on their own work.
- In process control the operators have skills developed over many years.
- Many skills are “tacit”
- An iterative process in the design of systems and interfaces is a necessity.

**Evaluation of STEG**
- Work procedures and control principles
- Functionality and algorithms
- User interface and interaction
- Subjective experiences
Evaluation results

- Test persons very positive
- Better overview
- Better accuracy in traffic plans
- Earlier detection of potential conflict
- Better understanding of trains’ dynamic movements and positions
- Efficient support from the new automatic systems

- Ergonomic problems
- Too small presentation area
- Some integration problems