Usability in complex work domains
A train traffic control example

Bengt Sandblad

http://www.it.uu.se/research/hci
A model of human control

- We need a model that helps us to
  - describe,
  - analyse,
  - design,

control of a complex dynamic system
The GMOC model

To control a dynamic system requires:

• Goal (G)
• Model (M)
• Observability (O)
• Controllability (C)
Goals

- Goals are often complex
- Contains conflicts
- Goals are e.g.:
  - Formal - informal
  - Organisational - individual
- Operators have their own goals...

To relate design to the goals, we must understand the goals!
Models

- Models are *mental* models.
- Models are individual and subjective.
- Models are (mainly) developed during work. This takes time!
- Different operators often have (very) different models.
- Organisational development of models and control strategies can solve many problems.
Observability

- We can only observe what the interface shows.
- We often lack information and precision in information.
- Often observations require actions.
- We can overview (very) much but remember little.
- Difficulties to identify and understand complex patterns.
Controllability

- We can only control what the interface allows us to control.
- We can sometimes only control a process at certain times.
- Different control modes can cause confusion.
- Time delays make control complex.
- Problems with feed-back.
In a complex situation
To design the new...

- Organisation
- Work place
- Work processes
- Control system
- Operator user interface
- ....
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
The information environment
Today’s control system

- Train Traffic
- Process Control System
- Remote Blocking
- Train Dispatcher
- Information Systems
- Time-Distance Graph on paper
- A complex environment - Drivers
- Automatic Traffic Control System
- Control System
- Train Traffic Process
- Auto Remote Blocking
- Information Systems
- Auto
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
- A Vision Seminar Process was used
- Ideas and prototypes were developed iteratively.
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

Train Traffic Controllers

- Re-Planner role
- Executor role

Executor function

- Manual
- Automatic

Decision Support System/plan verification

Operator-Process Interface

Time-Distance diagram

Track diagram

Real-Time Data Base

Traffic Plan

Process Status

Train Traffic Process

A complex environment
- Drivers
- ..........
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:*
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

History, time distance graph
Conflicts are identified

Different types of conflicts are identified and visualized
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
STEG- Background

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 re-planner” is introduced.
STEG - Objectives

- 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
- A user centred approach in all phases
- Collaboration in all phases (research, specifications, development, deployment, evaluation)
- Focus on efficiency and work environment
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.
OLYCKSPLATS
BORLÄNGE BANGÅRD