To implement technology in some specific work domains

- What is needed?
- What must be avoided?
- Some important examples
  - Process control (human control)
  - Health care
  - Administrative work

Agenda

- A model of human control
- Work environment problems
- Human error and barriers
- Situation awareness
- Alarms
- Design of operator interfaces
- An example
  - Train traffic control
- Assignment 4 specification
**ISO 9241:**

Remember the definition of usability:

"The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"

This means:

- To successfully design, develop and deploy an information system (IT, computers, technology) we must know and understand:
  - The work domain (context...)
  - The users (situation, needs, competencies...)
  - The goals (of users, organisation...)

Some examples of complex dynamic control situations
Train drivers

HSC bridge design

IT and process control

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

Paper mills
Also health care....

Are there problems?
- Processes are complex and dynamic.
- Control is indirect, via a control system and an interface.
- Demands are high (speed, accuracy, quality, safety, ...)
- Control systems and operator interfaces sometimes provide inadequate support.
- Operator performance not always satisfying (optimality, errors...).
- Work environment problems.
- More....

A model of 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 feedback.

**Work environment**
- Physical
  - Ergonomics
- Psychosocial
  - Support
  - Group
  - Leadership
- Cognitive
  - Support operators work
  - Provide prerequisites for efficient work
- We must provide a good work environment for the operators.
A good and healthy work

Karasek & Theorell:

Here control is especially important. Control over: process, work situation, work environment, work planning, work processes, systems and tools etc.

Demands are almost always high. Support must be strong.

A bad and dangerous work

Some important concepts

- Human error
  - See e.g. Reason, J., 1990
  - See e.g. S Dekker, 2006
- Barriers
- Situation awareness
  - See e.g. Endsley, M.R., 1999
- Automation problems
  - See e.g. Bainbridge, L., 1987
- Alarm systems
- User centred development
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
  - Help the operator to act correctly

  - Technical
  - Informational
  - Competencies
  - Organisation (Culture)

Technical barries – train protection

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

- Situation awareness – to always be “in control”, “in the loop”.
- Three levels:
  - Perception (observation)
  - Comprehension (understanding the significance of the information)
  - Projection (prediction, evaluation of actions)
- Two different approaches to control:
  - Control by exception
  - Control by awareness

Example

- Temperature
  - Static vs dynamic presentation

Temp (°C): +85
Automation problems

- Automation surprises
  - Difficulties to predict
  - Not transparent
- The irony of automation
  - No help when it is most needed...
- E.g. the problems with autonomous automatic systems (autopilots)
- The “turn off” effect

Alarms and alarm problems

- Alarm – warning for something important
- Explain the situation – support adequate actions
- Often one alarm results in many other secondary alarms
- Large disturbances occur seldom
- Many alarms during a short time period
  - 800,000 alarms during the first 2 h after the Harrisburg incident.
  - The operators could not understand the situation
- How to design supportive and “intelligent” alarm systems?

Alarms...

- Cause -> effects not clear
- Many causes are possible
- Mix of many different alarms and sounds
- The alarm list unusable
- Difficult to restore the situation
- Stress
Alarm list

HSC Sleipner before.....

....and after!
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.

ISO 9241:

Definition of usability:

"The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"
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 building 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

An example

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

- 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:
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
- The user centred approach
- Collaboration in all phases (research, specifications, development, deployment, evaluation)
- Focus on efficiency and work environment
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.
Assignment 4

- Assignment 4: Developing for usability in some special domains
  - Process control
  - Health care
  - Administrative work
- Optional assignments – choose one domain.

Assignment 4

- Option 1: Process control, operator systems and interfaces
- Write a summary of a relevant theory and describe/analyse an application, e.g.:
  - situation awareness, human error, barriers, automation etc.
- Analyse an incident or accident in process control and analyse it with regard to HCI aspects. Problems and solutions? E.g.
  - Train accidents
  - Flight disasters
  - Nuclear power plant incidents (Harrisburg, Tjernobyl, Forsmark)