Introduction to assignment 3

Human control of complex dynamic systems

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Implementing technology in domain-specific contexts

- What is needed?
- What must be avoided?
- Different perspectives mean several different research questions
- Your contribution?

Agenda

- 1 A short introduction
- 2 A model of human control
- 3 Different perspectives
  - Human error and barriers
  - Resilience engineering
  - Situation awareness
  - Automation issues
  - Alarms
  - Design of operator interfaces
- 4 Assignment 3 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 information systems we must know and understand:
  - The work domain (contexts, situations)
  - The users (needs, competencies)
  - The goals (of users, organisations)
- Some application contexts require special considerations

Complex dynamic control situations – some examples

They are complex – but what is complexity?
They are dynamic – but what does dynamic mean?
They are intransparent or opaque – but what do we mean with intransparency?
Health care

Are there problems?
- Processes are complex, dynamic and intransparent
- 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)
- 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 and ill-defined
- Contains conflicts
- Goals are:
  - 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 ill-structured 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

Problem formulation following GMOC-model
- The general purpose of the analyses is to reveal:
  - How do operators and teams of users transform goals and develop models as function of the available observability and controllability of the current system?
  - How can observability and controllability be enhanced and augmented so that users and operators can explore and learn about the system?
Different perspectives

- Human error
- Barriers
- Resilience engineering
- Situation awareness
- Automation problems
- Alarm systems
- Operator interface design
- Socio-technical systems

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 barriers – 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.

Information barrier

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

Engineering traditions

Classical approach
- Well-designed and scrupulously maintained systems
- Complete and correct procedures
- People behave as expected, and as they are trained to
- Designers can foresee all contingencies and provide appropriate responses

Resilience engineering
- Humans can learn to overcome design flaws and functional glitches
- Humans can adjust their performance in order to meet actual demands
- Humans can interpret procedures and apply them to meet actual conditions
- Humans can detect and correct when things fail
**Human Factors and Resilience Engineering**

- Management by awareness, not management by exception
- Situation awareness
- Design for unexpected and unusual situations and tasks
- The operator “in the loop”
- Resilience engineering

**Organizations & Safety cultures**

**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

![Temperature Graph]

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

27 December 1991
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 hours 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
Design of systems and interfaces in process control

- Control systems and operator interfaces must support efficiency, safety, a good work environment
- 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
Assignment 3

- Choose a domain of interest for further analysis and research
  - Previous courses or lectures
- Choose a perspective (topic) from the list
  - Human error
  - Barriers
  - Resilience engineering
  - Situation awareness
  - Automation problems
  - Alarm systems
  - Operator interface design

Assignment 3 cont.

- Search and identify relevant literature
- Write a summary with relevant theory and empirical findings in relation to domain and topic
  - Identify problems and issues within the domain and topic
  - Review empirical findings
  - Demonstrate solutions etc.
  - Examine critically the progress so far
Remember the purpose

- To provide usable systems and successful design of information in a specific domain
- How is usability related to goals as productivity, safety, efficiency, health, good work environment etc.