Humans in Complex Systems
Analyses of strategies and domain-specific knowledge
Anders Jansson

Formative analyses

- Vicente presents a structure for how to conduct a formative analysis. It contains four steps
  1. Identify conceptual differences
  2. Develop a set of methods
  3. Model the intrinsic constraints
  4. Go from analysis to design

Conceptual differences

- The first step in the formative analysis of socio-technical systems identifies five different conceptual levels
  - Work domain
  - Control- and sub-tasks
  - Operators strategies
  - Work organization and team-work
  - General cognitive characteristics and domain-specific competence and expertise
Data and conceptual levels

- Data collecting methods
  - Video analyses
  - Verbal protocols
  - Logging of interaction & activities
  - Questionnaires and interviews
- Same data on different conceptual levels
  - Domain-, task-, & strategy analyses

Model tool AH-DH 1

- Abstraction-hierarchy (AH)
  - Five levels of means-ends relations
  - From overall purpose to physical form and characteristics
- Decomposition-hierarchy (DH)
  - From the complete system to small components

Model tool AH-DH 2

- The tool is a problem space onto which you can describe actions from verbal protocols
- The verbal protocols give us information about the operators cognitive states in different situations
- The problem space is a “map” onto which we can situate the cognitive states
AH in process surveillance

- Functional purpose
  - Purpose behind the system design
- Abstract functions
  - The causal structure of the process
- General functions
  - The main functions you are aiming for
- Physical functions
  - Components and couplings and their behavior
- Physical form
  - Design and form of components and couplings

AH-DH för Duress II

- DH
  - System
    - The whole Duress II
    - Sub-systems for
      - Storage
      - Heating
      - Transportation
    - Components such as
      - Pumps
      - Valves
      - Heating
      - Reservoirs

- AH
  - Functional purposes
    - Volume, temperature, quality etc.
  - Abstract functions
    - Mass, energy, value, information etc.
  - General functions
    - Flow/time unit, volume, capacity, speed etc.
  - Physical functions
    - Parameter values, configurable parts
  - Physical form
    - Place, wear & tear, size etc.

Decision ladder 1

- Rasmussen's decision ladder is a model tool for analyzing tasks
- The decision ladder identifies the types of actions that must be conducted
- The decision ladder means identification of flexible working styles
- The decision ladder is adapted to well known cognitive levels within humans
Decision ladder vs AH-DH

- AH-DH
  - Work domain analysis
  - The system that activities will be directed towards
  - Must handle all situations
  - Structural means-ends analyses

- Decision ladder
  - Task analysis
  - Activities that the system must handle
  - Goal-directed situations
  - Action-directed means-ends analyses

The order of the analyses

- Work domain design
- Control tasks and sub-tasks
- Strategies
- Organizational aspects
- Operators expertise

Consequences for design

- Work domain analyses
  - Sensors, models, databases
- Control task analyses
  - Procedures, instructions, (level of automation?)
- Analyses of strategies
  - Dialogues, process interfaces, large screen displays
- Organizational analyses
  - Roles and responsibility, flow of communication, level of automation
- Analyses of the operators expertise
  - Selection, training, some interface design
Strategies 1

- AH-DH is used to conduct analyses of a certain work domain, a map of the object
- Decision ladder is used to conduct analyses of control tasks, what to do within the domain
- The tools for analyses of operators strategies are information flow maps, how the control tasks are executed

Strategies 2

- An important result from studies of how operators work is that they use different strategies depending on the size of the work strain/overload
- Maps of information flows is used to identify different types of diagnostic search strategies

Search strategies 1

- Topographic search
  - The use of an idealized process representation to generate different types of trouble shooting alternatives
  - Is based on models of normal function and the physical process as such
Search strategies 2

- Symtomatic search
  - The point of departure here is the information content in different observation reports
  - Three different types of av symtomatic search strategies
    - Pattern recognition
    - Decision tables
    - Hypotheses-and-test

Search strategies 3

- Strategies are independent from the observer/actor
- Design that supports the operators
  - Realize that operators generate spontaneous strategies from case to case
  - Replace cognitive demanding strategies
  - Enhance and augment the use of adaptive strategies
  - Realize the fact that the operators must be in charge, be "in-the-loop", and have situation awareness
  - The operators must be able to switch between different strategies when the situation changes

Tool for strategies?

Pre-indicator Main indicator
Conclusions chpt. 9

- Maps of information flows are not descriptions of cognitive activities, but idealized categories of task procedures.
- Information flow maps are based on context-specific contents.
Rasmussens SRK-model

- Decision-making at two levels
  - General human characteristics in terms of abilities and limitations
    - Working memory limitations affect the ability to browse among process pictures
  - Domain-specific competence in terms of expertise within a certain domain
    - Train-drivers must have route-knowledge in order to stop smoothly at the platform

SRK: Knowledge

- Problem space = mental models
  - Whole-parts relations
  - Means-ends relations
  - Causal relations
- Process-rules in terms of:
  - Rules of thumb
  - Model development
  - Transformation of models
  - Matching between abstraction levels
  - Cognitive walk-throughs

SRK: Rules

- Problem space = implicit rules
  - Rules in terms of matching between impressions and actions
  - Action-response models (implicit)
- Process-rules in terms of:
  - Situation-based rules (if-then)
  - Actions directed toward physical or symbolic objects in the work context
SRK: Skills
- Problem space = internal dynamic models about closest surrounding
  - Closest surrounding and the own body
- Process-rules in terms of:
  - Not relevant here, behavior is controlled by fluctuations in the nervous system

SRK: Levels of signals
- Knowledge level – Symbols are the units on which knowledge-based behavior is based
- Rule level – Signs lead to rule-based behavior, if-then situations
- Skill-level – Signals lead to automated actions, pattern-matching

SRK: Supports expertise
- The advantage with the SRK-model is that it gives possibilities to design dialogues and process pictures with the level of expertise in mind
- This is especially important in contexts where domain-specific knowledge is a precondition for a decision adapted to the context and situation
The operators design

- Operators will always change and adjust the system interface in order to make it as efficient as possible
- Some changes are permanent, indicating bad design from the beginning
- Other changes will be temporary, the use of alarm systems is an example

Conclusions chpt. 11

- General human characteristics
- Domain-specific expertise
- Organize work after a process model
  - User-centred systems design
    - Analyzing representative work tasks
    - User participation in design and evaluation of interfaces and process pictures
    - Exploring possible ways to develop work together with users

Organization & Cooperation

- For this part, Vicente uses the same analyses once again, but the focus is now on identifying responsibility and roles