Systems Safety
— Human Factors (2) —

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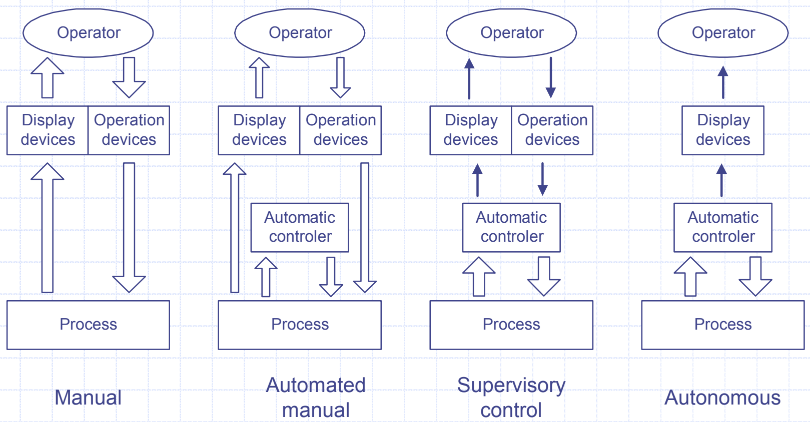
Progress of automation



Degree of automation

1. The computer offers no assistance, human must do it all.
2. The computer offers a complete set of action alternatives, and
3. narrows the selection down to a few, or
4. suggests one, and
5. execute that suggestion, if the human approves, or
6. allows the human a restricted time to veto before automatic execution, or
7. executes automatically, then necessarily informs the human, or
8. informs him after execution only if he asks, or
9. informs him after execution, if the computer decides to.
10. The computer decides everything and acts automatically, ignoring the human.

T. Sheridan

Function allocation principle

- Mechanize whatever functions that machines can do.
- Mechanize functions with which machines are better in abilities, leave others to humans with which humans are better.
- Share functions between humans and machines in a proper manner.

Fitts list

Humans are better	Machines are better
• Sense low levels of certain kinds of stimuli. • Detect stimuli against high noise level background. • Recognize patterns of complex stimuli. • Sense unusual and unexpected events. …	• Sense stimuli outside of the human sensitivity. • Deductive reasoning such as classification of stimuli. • Monitor prespecified (infrequent) events. • Store coded information quickly and accurately. …

Drawbacks of Fitts list

- Now there are overlaps of functions that both humans and machines can do well.
- Humans are flexible but inconsistent, while machines are consistent but inflexible. The both are complementary rather than substitutive.

— H. Jordan

New principle of allocation

- We can mechanize a function when
  - The function can be mechanized well enough with the current technologies.
  - The reliability of machines is better than humans in terms of the function.
  - The reliability of the total human-machine system is better if the function has been mechanized.

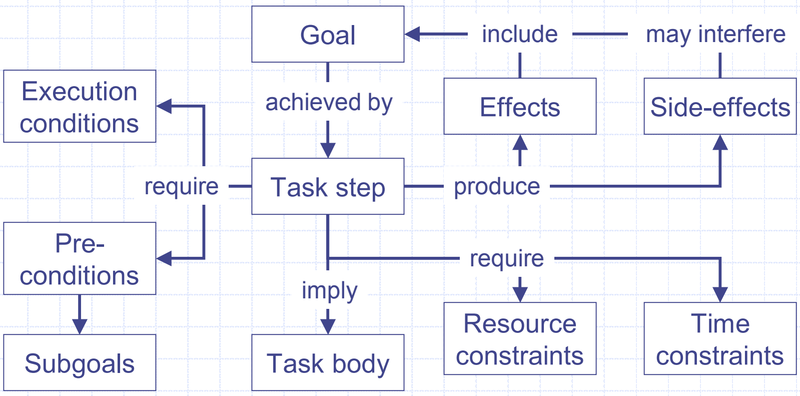
Task analysis

- Work to identify what human operators or users should do and in what manner to achieve the designated goal of the system.
- Very basis for function allocation, design of human interface, and staff management.

Task and task step

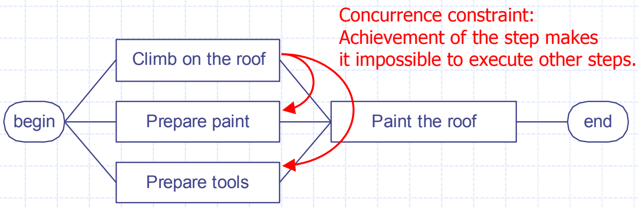
- Task
  - A set of well-structured actions that is expected to achieve a designated goal.
- Task step
  - A group of actions that can be thought of as an elementary unit of a task.
- Function
  - Behavior of the system that is implemented to achieve a designated goal.

Description of task step



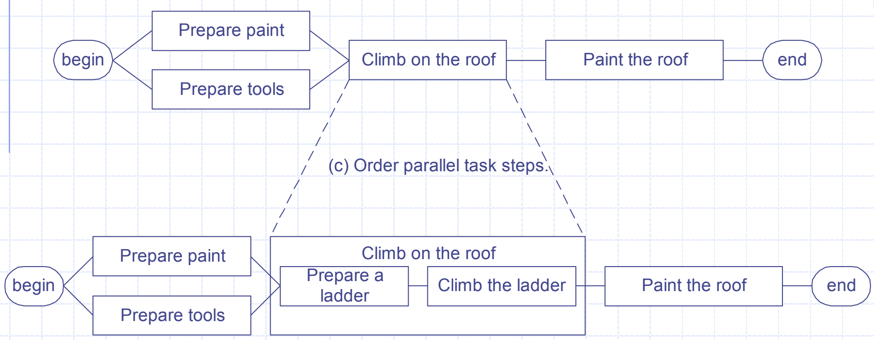
Goals-Means Task Analysis (1)

(a) Generation of the main task.



(b) Expansion of subtasks.

Goals-Means Task Analysis (2)



(d) Embody task step.

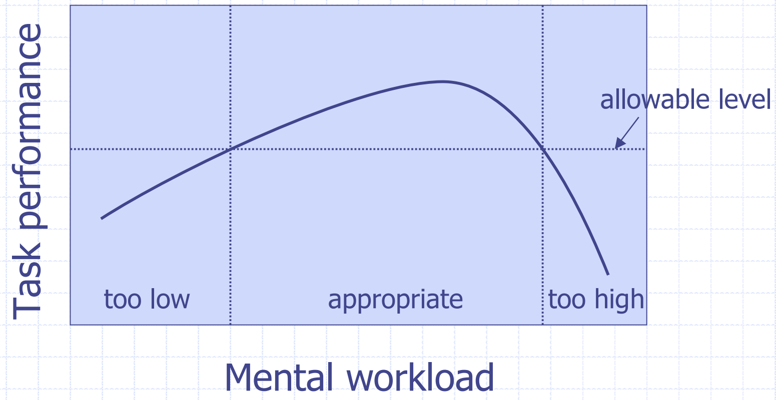
What should be assessed?

- Number of concurrent goals
  - Goals that should be pursued in parallel.
- Available time
  - How long will it take to finish the task.
- Workload
  - Level of physical and mental activities of humans.
- Cooperative relations
  - Points that require task cooperation and communication between individuals.

Workload

- Physical workload
  - Level of physical-mechanical activities of the skeletal-muscular system.
  - Measured by metabolism, oxygen consumption.
- Mental workload
  - Level of mental-cognitive activities of the central nervous system.
  - Objective measure VS subjective measure

Yerkes-Dodson's law



Assessment of MWL

	Subjective	Dual task	Physiological	Task analysis	Observation
Selectivity	○	◎	△	○	×
Reliability	○	○	×	?	◎
Sensitivity	○	△	○	?	?
Theoretical	△	○	×	○	○
Interference	◎	×	○	◎	◎
Real time	×	○	◎	×	○
Easiness	◎	○	△	×	△

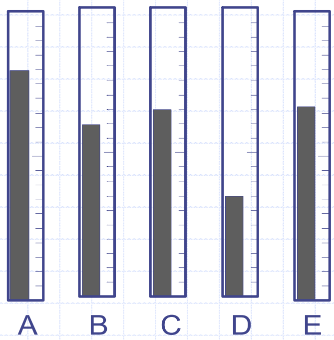
Optimization of MWL (1)

- Automation
- Cognitive support tools
  - Procedure manuals, check-lists, and various computer based support tools.
- Training
  - Change the mode of behavior from knowledge-based or rule-based to skill-based.

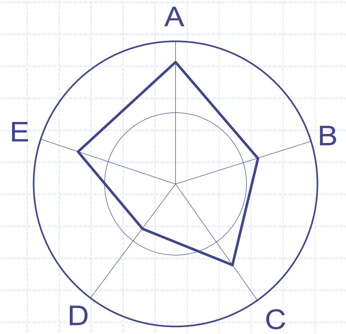
Optimization of MWL (2)

- Restricting the amount of information
  - Only important information is to be displayed.
  - Prioritization of information.
- Changing the style of presentation
  - Massive information can be delivered in a few chunks of stimuli.
  - Multi-modal presentation.

Example of display style



Convensional SSSI (5 chunks)

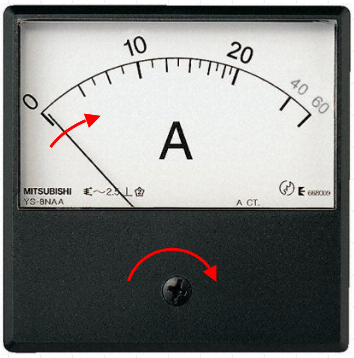


Plygon display (1 chunk)

Types of S-R compatibility

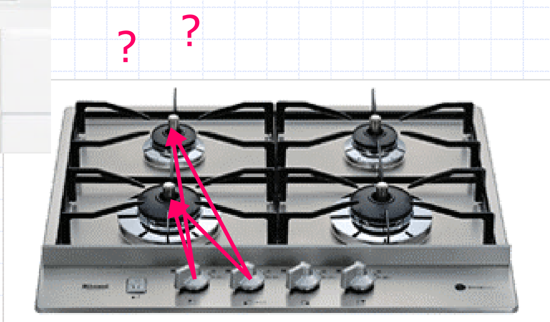
- Degree of correspondence between stimulus (S) and response (R)
  - Movement compatibility
  - Spatial compatibility
  - Modality compatibility
  - Conceptual compatibility

Movement compatibility



Spatial compatibility

- Gas range -



Spatial compatibility

- Switch panel -

Prioritization of information

- Display of unimportant information should be suppressed or done by request.
- Important information should be displayed in the central position to draw attention.
- The color, size, or form of display should be changed depending on the importance.
- In CRT, information should be ordered in accordance with the importance.

Alarm suppression

- Alarm avalanche
  - Too many alarms may annunciate at the same time so that a human cannot recognize what actually has happened.
- Alarm suppression rules
  - Suppression by mode
  - Suppression by propagation
  - Suppression by level

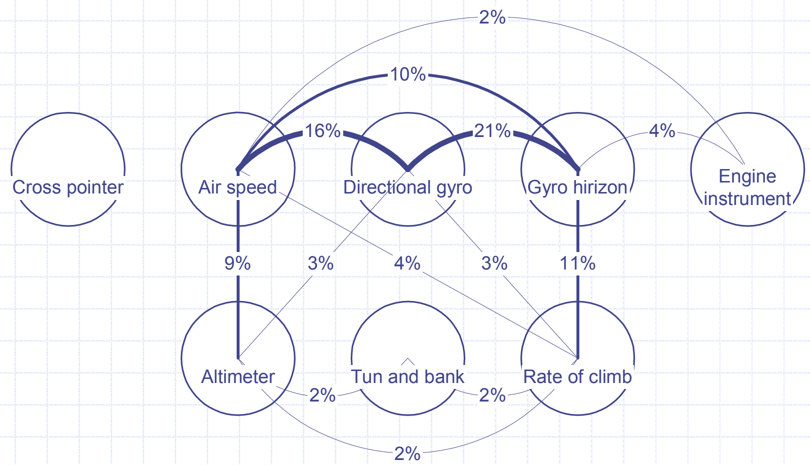
Layout design

- Physical-perceptual features of a human
- Environmental factors
- Task related characteristics
  - Individual characteristics
    - Important or frequently used elements should be located at the central and accessible position.
  - Relations between different items
    - Related elements should be located close together.

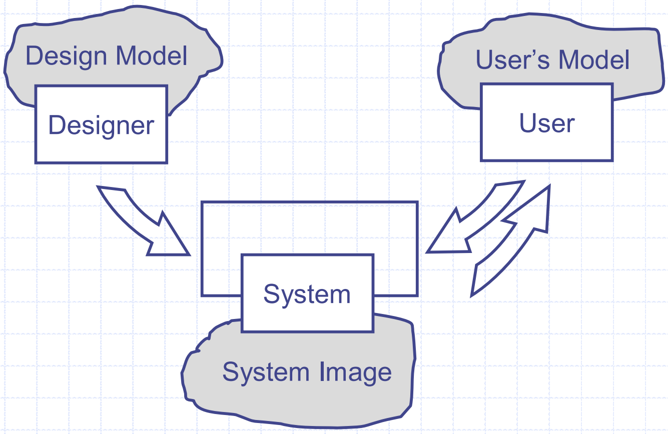
Link analysis

- Assessment of affinity among interface elements.
  - Temporal affinity
  - Topological or positional affinity
  - Structural affinity
  - Etiological affinity
  - Teleological affinity
- Mapping the conceptual space of affinity on an Euclidian space.
  - Manual operation of a link graph.
  - Analytical methods of systems engineering.

Eye-movement link between aircraft instruments



Consistency of mental models



Example of model mismatch