The International Emergency Management Society
10th Annual Conference Proceedings, June 3-6, 2003
Sophia-Antipolis, Provence, France

ECOLOGICAL USER INTERFACE FOR EMERGENCY MANAGEMENT DECISION SUPPORT SYSTEMS

Verner Andersen

Risø National Laboratory[1]

Keywords: Emergency management, ecological interface design, abstraction hierarchy

Abstract

The user interface for decision support systems is normally structured for presenting relevant data for the skilled user in order to allow fast assessment and action of the hazardous situation, or for more complex situations to present the relevant rules and procedures to be followed in order to deal most efficiently with the situation. For situations not foreseen, however, no rules exist, and no support may be given to the user by suggested actions to be fulfilled. The idea of ecological user interface is to present to the user the complete situation at various interrelated levels of abstraction supporting the situation assessment and remedial actions based on the domain knowledge of the user.

Introduction

Decision support systems for emergency management are all based on experiences from and analysis of previous emergencies and drills which indicate need of further training and support. Based on this input decision support for most hazardous situations are covered by updated preparedness plans and what-if scenarios revealing the best counter action to all known situations. However, even though this is sufficient in most situations the drawback of these systems is exactly that they rest on foreseen hazardous situations and therefore are not capable of supporting or handling unanticipated situations. Situations may be unanticipated because these situations have not previously been experienced, and because nobody has had the fantasy to dream them up. Often hazardous situations arise from a sequence of events that not even the most creative fantasy could imagine. Each of these events may be more or less harmless on their own, but a specific succession not even realised could happen, and perhaps even in aggravating environments, may result in a hazardous situation of huge dimensions.

The idea of the ecological user interface is to support or handle not only the well known situations, but also to support decision makers in actions related to completely new and complex situations.

Decision support systems are normally based on presenting the preparedness plans, the agreed procedures, and the location and status of all rescuing equipment. The ecological user interface must present the same very important issues including the prescribed procedures if possible due to the type of hazardous situation. But furthermore, the hazardous situation or the symptoms hereof should be presented on a variety of abstraction levels in order to give the decision-maker an overview from various points of view. This overview, which could include presentation of potentially risky or vulnerable objects, may hopefully expose the intentions and goals to be pursued supporting the decision-makers to act based on their personal knowledge of the present domain.

[1] Systems Analysis Department, DK 4000 Roskilde, Denmark,
e-mail: verner.andersen@risoe.dk.

The means-end hierarchy

The task analysis of the situation will be based on the means-end hierarchy, a tool well suited for analysis of specific domains, see figure 1.

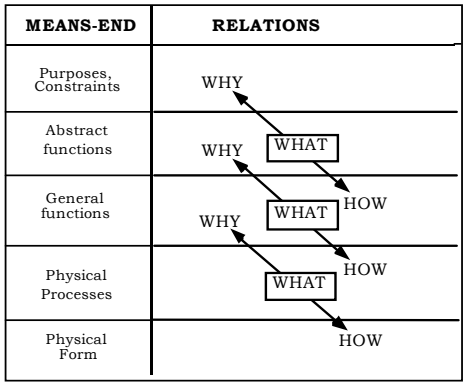

Figure 1, The means-end hierarchical structure

The Means – Ends hierarchy was developed as a domain representation describing the various levels of abstraction in a working situation (Rasmussen, Pejtersen, and Goodstein). The framework has been utilised previously, however, for analysis and design of decision support systems (Andersen ad Rasmussen, 1987ghest level corresponds to the system objectives, the middle levels to functional descriptions and procedures of the working situation at various levels of abstraction, and the lowest level corresponds to the physical form of the domain. The functional connection between the levels are expressed in the relational column indicating that for each level, the next upper level will give the reason for the task to be performed, and the next lower level give the answer to how to perform this task.

The use of this hierarchical analysis for the emergency management domain is given in figure 2 indicating - as the purpose of the overall goal of the emergency management - the protection of human beings, their property, and the environment. Going from the more abstract level to less abstract levels, the overall goal may be pursued by striving for preventing accidents from developing or at least diminish the consequences of unavoidable accidents. This level will likewise be supported by the available preparedness plans, which again is built on knowledge and experiences from previous events about how to handle various emergency situations. At the end all potential interaction with the hazardous situation will built on available human and technical resources.

In the abstraction hierarchy the specific task situation must be described completely at each level. The skilled person exposed to familiar situations will be able – based on the lowest levels – to deal with such situations by implementing actions directly. For less skilled persons exposed to situations unfamiliar to them, but anyway anticipated by domain experts, the higher levels – indicating specific functions to be fulfilled - will be needed. Finally, for situations not anticipated even by domain experts, the highest levels will point to the end-goal to be fulfilled, and the combined input from all levels may stimulate the experts – based on their domain knowledge – to cope in the best possible way with the hazardous situation.

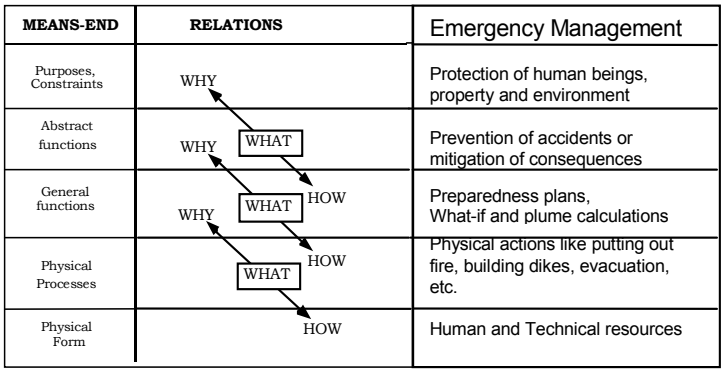

Figure 2, The means-end relations adapted to emergency management

The various conditions are reflected in figure 3, the decision ladder (Rasmussen, Pejtersen, and Goodstein) giving possible shortcuts on the complete process from the incoming alarm to the final execution of diminishing and rescuing actions. The shortcuts are directly related to the skill and familiarisation of the decision-maker in relation to the specific situation.
A more detailed analysis of tasks to be fulfilled at various levels is specified in figure 4.

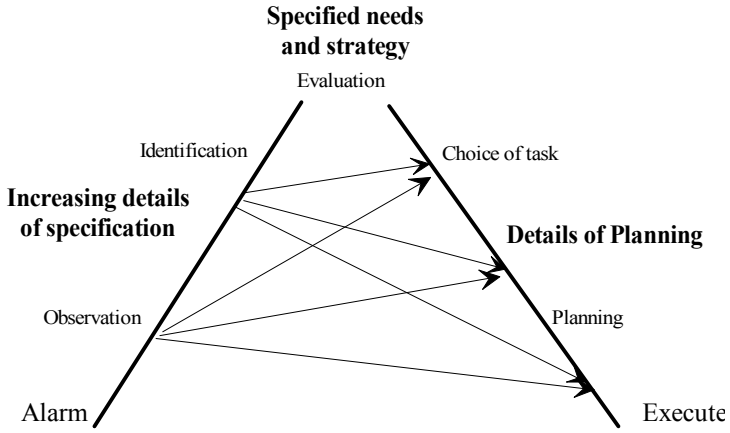

Figure 3, Sequence of actions in a decision/action model

Applications for ecological interface design

As mentioned above the idea of ecological interface design, EID, is to support decision makers when exposed to unanticipated events contradicting existing system normally built on experience from events related to previous incidents or accidents, or problems revealed from drills or other kind of exercises. The foundation of the EID is the hierarchical work domain analysis as sketched above and the various degrees of skills and expertise, which is reflected in the decision ladder.

The theoretical foundation of EID has been dealt with in detail by Vicente and Rasmussen (Vicente and Rasmussen, 1990; Vicente and Rasmussen, 1992) and recent demonstrations in various domains by, e.g., Vicente (Vicente, 2002) and Reising and Sanderson (Reising and Sanderson, 2002).

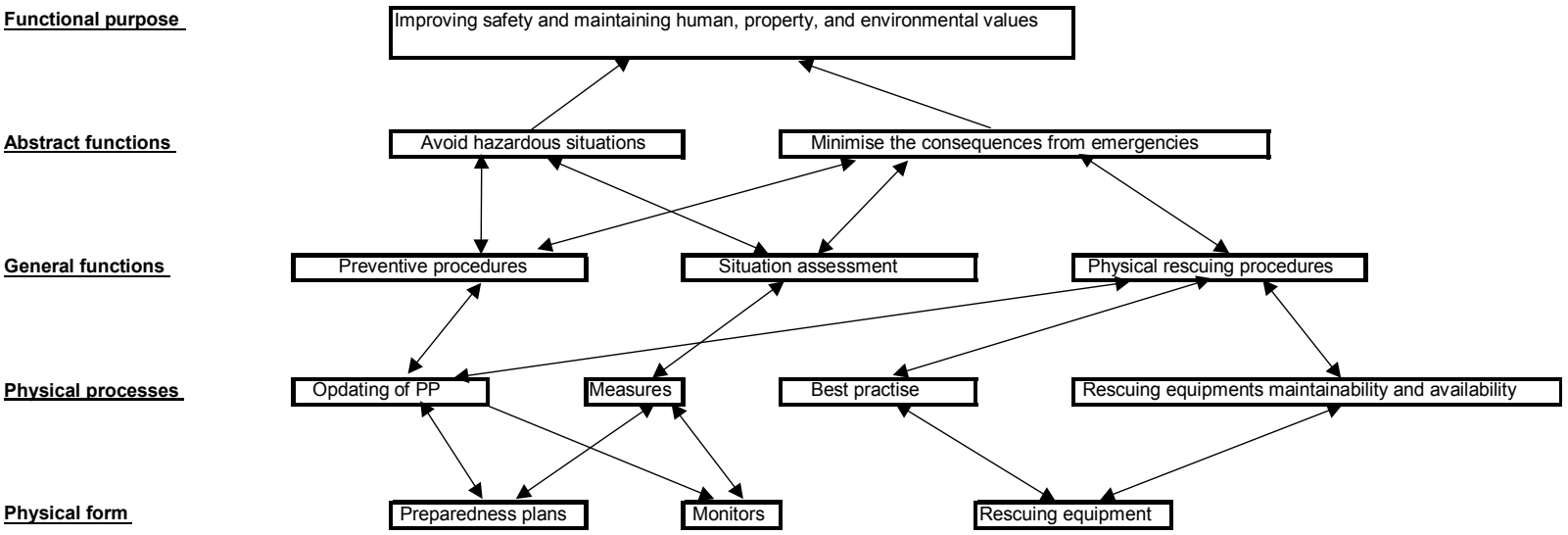

Figure 4, Abstraction hierarchy of a work domain analysis related to decision support for emergency management

Figure 5 gives a suggestion for the necessary contents of presentation at the various levels of an EID for emergency management. The skill or expertise of the decision-makers has been related to the 'skill, rule, knowledge' philosophy presented by Rasmussen (Rasmussen, Pejtersen, and Goodstein). Similarly, the user interface has been chosen for supporting these three levels of skill. All three levels must fully present the hazardous situation in relation to the related levels of abstraction. The lowest level – the skill based one - will give the decision-maker all the needed information concerning the alarm and available measures, the resources – human as well as technical – and their availability. For familiar events and skilled decision-makers this information may be sufficient for starting immediately the necessary operations for handling the emergency. Less skilled decision-makers may prefer to go the next higher level of presentation – the rule based - presenting preparedness plans, what-if scenarios, and best practices. For unfamiliar events the decision-maker may – due to shortcomings in the preparedness plans or lack of best practice – go to the highest level – the knowledge based - to get an overall impression of the symptoms and consequences of the situation.

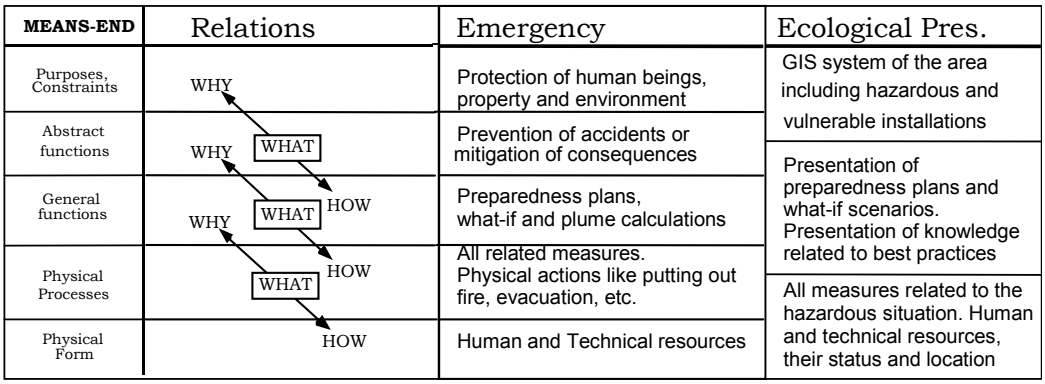

Figure 5, the three levels of EID for emergency management for covering all aspects of decision support for the emergency manager

However, the various levels, individually, are not sufficient for having an EID. The levels need to have well specified mutual constraints to be fulfilled when going from one level to another. Clicking an object, say a vulnerable one, on the high level may open the preparedness plans, what-if scenarios and best practise - if possible - on the next lower level directly related to this object. Likewise, the resources to be presented on the lower level must be related – once again – to the object considered.

For all anticipated events the path among levels will be complete. For unanticipated events this will not be possible. However, a detailed presentation of the actual event on the highest level may create a mental model for the decision maker that combined with his domain knowledge and experience from similar events may support his ability for managing the actual hazard.

Conclusion

The motivation for this paper is the lack of support from existing emergency management decision support systems concerning complex unforeseen events. The EID concept has been tested in a variety of other domains, like process control, aviation, and medicine (see Vicente 2002), but not in the area of decision support for emergency management. The concept, however, looks very promising for including valuable support for coping with unexpected hazardous events. The real test and evaluation of this type of system for emergency management remain to be seen following a design and implementation of such a system including all the aspects related to the field of cognitive systems engineering.

Biography

Verner Andersen got his Ph.D. in Physics in 1969. He is a Senior Research Scientist since 1992 at Risø National Laboratory. He has since 1986 been responsible as project manager and co-ordinator of various international projects related to decision support and training related to emergency management. His research topics include man-machine interactions and human factors.

References

Rasmussen, J., Pejtersen, A.M., Goodstein, L.P., 'Cognitive Systems Engineering', New York: John Wiley & Sons. (Wiley series in systems engineering).

Andersen, V. and Rasmussen, J., 'Decision support systems for emergency management', in Emergency Planning for Industrial Hazards, edited by H.B.F. Gow and R.W. Kay, Elsevier Applied Science 1987.

Vicente, K.J., and Rasmussen, J., 'The ecology of human-machine systems II: mediating "direct perception" in complex work domains', Ecological Psychology, **2**, 1990, pp. 207-249.

Vicente, K.J., and Rasmussen, J., 'Ecological interface design: theoretical foundation, IEEE Transactions on Systems, Man and Cybernetics, 22, 1992, pp. 589-606.

Vicente, K.J., 'Ecological Interface Design: Progress and Challenges, Human Factors and Ergonomics', vol. 44, no 1, Spring 2002, pp. 62-78.

Reising, D.V.C., and Sanderson, P.M., 'Work domain analysis and sensors I: principles and simple examples', Int. J. Human-Computer Studies (2002) 56, pp. 569-596.