Accident and Emergency Management. The Nordic Programme

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Risø National Laboratory, DK-4000 Roskilde, Denmark
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ABSTRACT

There is an increasing potential for severe accidents as the industrial development tends towards large, centralised production units. In several industries this has led to the formation of large organisations which are prepared for accidents fighting and for emergency management. The functioning of these organisations critically depends upon efficient decision making and exchange of information.

This project is aimed at securing and possibly improving the functionality and efficiency of the accident and emergency management by verifying, demonstrating, and validating the possible use of advanced information technology in the organisations mentioned above. With the nuclear industry in focus the project consists of five main activities:

1) The study and detailed analysis of accident and emergency scenarios based on records from incidents and drills in nuclear installations.

2) Development of a conceptual understanding of accident and emergency management with emphasis on distributed decision making, information flow, and control structures that are involved.

3) Development of a general experimental methodology for evaluating the effects of different kinds of decision aids and forms of organisation for emergency management systems with distributed decision making.

4) Development and test of a prototype system for a limited part of an accident and emergency organisation to demonstrate the potential use of computer and communication systems, data-base and knowledge base technology, and applications of expert systems and methods used in artificial intelligence.

5) Production of guidelines for the introduction of advanced information technology in the organisations based on evaluation and validation of the prototype system.

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INTRODUCTION

The basis for the study of the potential use of advanced information technology for accident and emergency management was established in a pilot project undertaken in 1985. The subjects addressed in this project led to a preliminary description of accident and emergency scenarios, a state-of-the-art review of models and methods available for construction of a conceptual system, and a review of available tools from Artificial Intelligence, e.g. expert systems.

The pilot project suggested three main activities in the first phase of the main project:

1) Detailed descriptions and analysis of accident and emergency scenarios.

Some information is available from detailed records from incidents and accidents and emergency drills in the nuclear industry. The analysis must lead to identification of observable weaknesses in the organisations.

2) Comprehensive conceptual work.

A general framework for a functional analysis of the accident and emergency management organisations has been suggested, but not thoroughly tested. In particular it is important to verify the applicability of this problem domain description model with respect to an understanding of the distributed and hierarchical decision processes, the mental strategies and the cognitive control domains.

3) Development of a prototype system.

As the project aims at an evaluation of the potential use of advanced information technology in the application domain chosen, it is very important to develop a technological test bed for main features, e.g. in data-base

and knowledge-base technology, communication systems, and tools from advanced information processing.

In an early stage of the project a limited target area must be defined. Based on the scenario descriptions in 1), a "vertical slice" is identified dependent primarily on two criteria: it must (a) be able to display the major features of the conceptual system, and (b) be limited to the extent where the prototype development is possible using the available resources.

In the later phases of the project the scenario descriptions will gradually change to data and knowledge acquisition, the conceptual work will be followed by development of a general experimental methodology, and by experimental work using the prototype as test bed. The prototype system will experience a dynamical development throughout the major part of the project. The keyword for the project is system studies with emphasis on system integration. This will be reflected in the recommendations and guidelines developed in the final phase of the project.

As the project described here receives limited funding it is of the utmost importance to choose a realistic scope and milestones to be reached in the project.

STATUS OF THE PROGRAMME

Conceptual Work

The general point of departure for the conceptual work has been to design a framework for analyzing different kinds of emergencies.

In the first stage, we have been concerned with the problems of hierarchical command and control systems in emergency management. Such systems were found to be of

limited use in this context because

- all kinds of emergencies cannot be foreseen, and this may create a need for a more flexible structure with the capacity to reconfigure itself;

- information delays would make it hard to exercise control by means of a hierarchical system that would be too slow;

- some aspects of emergency management cannot be modelled hierarchically but require a different control structure; and

- hierarchical command and control systems are not needed for all kind of emergencies.

In the second stage, we have tried to create a general framework for analyzing emergency management based on the view of emergency management as a control system. This

- provides a clear specification of the goals of an emergency management system;

- provides a specification of what the components of such a system should be;

- specifies the information needs; and

- specifies what can, and what cannot, be controlled in emergency management.

Further work is now directed towards solving two problems:

1. To develop a conceptual framework for those aspects of emergency management that cannot be controlled hierarchically. The problems here are those of co-ordination in a system characterised by distributed

decision making.

2. Using the time-area diagrams developed as part of the analysis of emergency management as a control system to analyse a variety of emergencies. This is done in an attempt to test the general usefulness of these diagrams as an analytical tool for analyzing information needs in emergency management.

In addition, some first thoughts on how the decision support system should be evaluated have been looked into. Here a distinction between two forms of evaluation has been discussed: analytical evaluation and empirical evaluation. It is recommended that an analytical evaluation be performed first. This comprises two steps:

- mapping the decision support system on to a set of general decision tasks, and

- assessing the extent to which these tasks are supported by analyzing (a) the nature of the situation, (b) the kind of displays that are provided, and (c) the knowledge required for understanding these displays.

It is also recommended that the empirical evaluation be directed towards limited and well-defined functions of the decision support system. DESSY-D, a general interactive program for simulating dynamic systems, is being developed for this purpose in Uppsala.

The methodological problems in using this system for the evaluation of a decision support system are now being analysed.

<u>Data Acquisition and Specification of Data and Knowledge Base</u>

The analysis of information requirements both on-site and off-site is almost finished. A detailed description of

the information flow has been completed for four different Emergency Organisation Centres (EOC): the County EOC, the EOC at the National Institute of Radiation Protection, the EOC at the Swedish Nuclear Power Inspectorate (SKI), and at the Technical Support Centre within the on-site EOC. Furthermore, the analysis will concentrate on the Plant Emergency Manager, the Radiation Protection Manager and the Plant Operation Manager. Experience from previous incidents and preparedness drills has revealed that many difficulties can be traced back to information management problems. This has been addressed in the emergency preparedness planning in setting-up of formal status departments, that are key departments in the information management activities. A detailed list has been completed identifying the basic information types needed within the status departments of the different EOCs.

Prototype Implementation

The work has concentrated on choosing a suitable implementation strategy for the prototype system. A common data structure has been defined for process data, rules and message passing. Frame structures and object-oriented programming techniques Flavors on Symbolic computers are utilised.

The implementation of a program that interprets the on-site classification rules for emergency situations is in progress. One can edit new rules, and then apply the rules on process data. The user can interact with the system when additional information is needed or if explanations are requested. The intention is to create a general inference mechanism that can be applied in other parts of the system where the rules have the same structure.

A basic message structure has been established supporting information exchange in the organisation. Functions for manipulating various kinds of messages have been specified. The implementation must handle both fixed and free format messages and the possibilities of automatic

distribution of information.

A first proposal for the off-site man-machine interface has been implemented. This interface is based on the complete item list from the SKI status department. The further development will be based on this framework.

The work on the user-interface for the on-site part has been continued. More specifically it is intended for use by the Plant Emergency Manager. The basic window-frame with its panes has been established and the technique for menu-handling as well as mouse-tracking has been utilised.

The trend- and bar-chart displays have been implemented. The functions for information concerning the manning of the preparedness organisation have been developed and are working satisfactorily. Also some basic functions for displaying and producing maps have been implemented.

The work with the items described above will continue to establish a prototype where the functions are implemented incrementally for both on-site and off-site parts of the organisation.

FUTURE PLANS

Having the first proposal of a prototype system, a test scenario for a limited part of an emergency situation will be designed to make experiments to evaluate empirically the combined effect of the database, the implementation strategy, and the conceptual model for the developed part of the expert system. Through these experiments the prototype system will be optimised by an iterative procedure, and the final product will be used for recommendations and guidelines for a possible further development into an expert system capable of coping with emergency situations in risky industrial plants.

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