

**The Halden Man-Machine Laboratory,
an Advanced Facility for Performing
Emergency Management Studies**

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ABSTRACT

The paper focuses on important aspects related to emergency management such as training, post-training analysis and the use of computerised systems as support in emergency management. The requirements for proper training of staff being responsible for handling major emergency management are obvious, since, luckily, major emergencies rarely occur. The training itself is of little value if not followed up with detailed debriefing sessions, discussing what went wrong and what was handled in an acceptable manner. The need for an advanced facility for performing controlled training and post-training analysis becomes evident, and the Halden Man-Machine Laboratory is such a facility. With its experienced staff and necessary infrastructure, emergency management studies of different sorts may easily be performed in this laboratory.

1. INTRODUCTION

The management of major emergencies is an extremely complex task, including a wide range of activities, and the outcome of decisions being made can have severe impact on humans and economy. Emergencies may range from incidents having local implications and involves decision making on a local scale, to major emergencies affecting large regions or the nation as a whole, involving inter-regional or international decision making and cooperation. The type of emergency may be either man-made, e.g. explosions of different kinds, nuclear accidents or chemical spills, or natural disasters, e.g. earthquakes, landslides or floods. The

management issue, however, does not necessarily differ that much whether the emergency is man-made or caused by nature.

Major emergencies involving inter-regional or international cooperation occurs fairly seldom, although the frequency differs between countries and regions. Due to this, the need for training of emergency personnel is obvious since operational experience is rarely obtained through real-life accidents. Personnel involved in accident management range from personnel operating at the emergency site, dealing directly with the large effects of the accident, to personnel residing in coordination centres, directing on-site personnel and planning efficient countermeasures to minimize the effect of the emergencies from a regional or global perspective. Human-to-human communication is of vital importance for optimal emergency management and in this paper this is a key issue.

Training of emergency managers and supporting personnel is an absolute requirement to prepare them for optimal performance in real situations. The establishment of training programmes is important and the creation of relevant scenarios for training must be treated seriously (1). The analysis of the training sessions is of particular value, analyzing every action being taken, every order being given, all communications taking place between personnel, to prevent that wrong decisions made in training sessions are repeated in real-life situations. The availability of an advanced human-machine laboratory and availability of staff with experience in conducting training and analysis of human performance could enhance the quality of major emergency management training.

2. HUMAN-TO-HUMAN COMMUNICATION IN EMERGENCY MANAGEMENT

In the management of major emergencies with nationwide implications one normally have staff located in a central emergency centre being in charge of coordinating the emergency. Their defined task is manifold, e.g.

- determining the scope of the emergency
- assess possible implications for humans, agricultural areas, industry etc.
- initiate and coordinate actions at the site
- decide upon more long term countermeasures
- analyze the emergency and how it proceeds
- alert institutions both at county and national level
- handle contact with and information to media
- analyze consequences in the aftermath of the emergency
- propose actions for avoiding or reducing implications of future emergencies.

As is seen from the above list of tasks most of them require verbal or written communication between humans, and it becomes quite obvious that unless this communication functions in the best way, the management and coordination of the emergency becomes difficult. The emergency management training should focus on this aspect as being one of the most important for a successful outcome of the work related to managing emergencies in the best way. Staffing of emergency control centres, i.e. how many people should be present, the organization within the personnel located at the centres, and division of responsibilities between the control centre and the site managers are key questions which may be answered by performing advanced studies in training and testing environments.

3. COMPUTERISED SUPPORT IN EMERGENCY MANAGEMENT

The experts normally being part of the emergency management team located at the emergency centre have deep knowledge of the emergency having occurred or is about to take place. However, to make decisions based on their expert knowledge requires that they have a sound basis of information upon which their conclusion can be drawn. With use of today's advanced computer technology, computerised support systems are available to emergency managers providing baseline information and direct support in managing emergencies. These support systems range from simple PC-based systems focusing on specific items to advanced systems claiming to support emergency managers at all levels in following the development of the emergency. MEMbrain and CAMS are two examples of advanced support systems, MEMbrain of a general character, CAMS focusing on support for a specific accident regime (2,3).

Although the commercial market is not inundated by emergency management support systems in 1996, one may anticipate that emergency management is an area where IT providers can see a potential growth in the coming years. When this happens it is important to select the correct support system for its own emergency organization. Such a choice is not easy to make just by examining the systems, thorough testing is definitely required. The best testing is to test the support in a realistic environment and see how the support system acts in a realistic situation. Does the introduction of computerised support enhance the decision making, or maybe a performance degradation is discovered? How is the usability of the support system in a realistic environment with stressed operators forced to make quick decisions?

4. EMERGENCY MANAGEMENT TRAINING AND POST-TRAINING ANALYSIS

Which are the most important aspects to think of in training and analysis of emergency situations? This is a key question which must be answered in order to ensure optimal training and post-training analysis. It should be clear that training without sufficient debriefing and detailed analysis of the training session is almost worthless. Below are described some points of relevance when designing realistic training and debriefing.

For optimal training:

- create a realistic scenario
- the emergency control centre should be realistically manned
- support should be made available as in real situations
- all communication channels should be open or simulated
- the time span should resemble that of a real situation.

For optimal post-training analysis:

- audio/video taping of sufficient quality should be made
- all communication must be taped
- all usage of computerised support should be logged
- debriefing sessions where the personnel explain specific choices being made in the training session is mandatory.

It is obvious that the requirements set to post-training analysis requires extensive facilities not normally present in real-life emergency control centres, pointing to the need for using well-equipped laboratories for such real-life training and analysis.

5. THE HALDEN MAN-MACHINE LABORATORY

The Halden Man-Machine Laboratory (HAMMLAB) is a research laboratory operated by the OECD Halden Reactor Project. This laboratory is the nucleus for the research within the man-machine systems area and the experiments and studies have mainly been human factors related, e.g. the measuring of human performance in different situations, and testing and evaluation of operator support systems before possible installation in commercial plants.

5.1 Infrastructure

HAMMLAB consists of a fully screen-based cockpit control room and an experimenter's gallery for running experimental studies, see figures 1 and 2. Since HAMMLAB primarily is focusing on studies related to safe operation of complex industrial processes, a PWR simulator is the basis for most of the activities taking place in the laboratory. The software systems of HAMMLAB executes on numerous high-resolution graphics workstations and several number-crunching server computers.

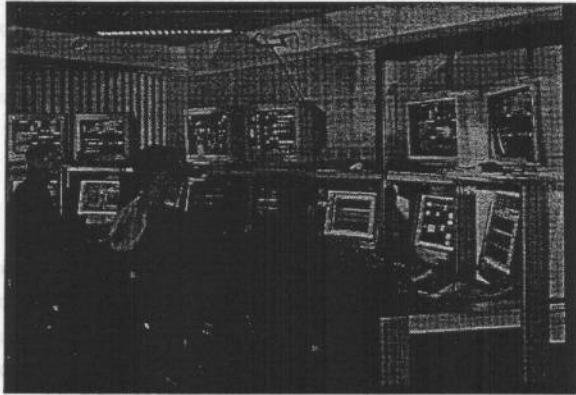


Fig. 1 HAMMLAB cockpit control room



Fig. 2 HAMMLAB experimenter's gallery

The software systems are developed using modern software tools and development technology ensuring full modularity and openness in a complete distributed client/server environment. Such a solution ensures the possibility of including new sub-systems and exchanging systems without too much effort.

5.2 Experienced Staff

The organization of staff around the HAMMLAB advanced facility is one of the real assets, making HAMMLAB one of the few places world-wide for performing man-machine interaction studies of this kind. A mixture of human factors experts, process experts, experienced operators and computer specialists working closely together, makes it possible to perform experiments and studies of extreme complexity in a successful manner.

5.3 Experimental Facilities

In order to perform comprehensive studies it is important to record data for later analysis of experimental sessions. HAMMLAB is therefore equipped with advanced audio/video recording equipment. The audio system is able to record the voice of individual operators as well as the crew communication, in separate channels. In the data analysis phase the channels can be mixed according to the needs of the personnel analyzing the data. Video facilities include possibilities for monitoring all the activity from different angles, zoomed in or on a more overview basis.

HAMMLAB is in addition to audio/video logging equipped with software logs containing all actions being made by the operators, e.g. process control actions, switching of process displays, all relevant process events, and all actions performed by experimentalists, e.g. the introduction of malfunctions into the simulation.

6. USING HAMMLAB FOR EMERGENCY MANAGEMENT STUDIES

The HAMMLAB has since its construction in 1982 primarily been used for conducting studies related to how operators perform in control rooms and how introduction of new information systems influence the operators' work. The studies have primarily been related to nuclear power plants operation, however, plans are underway for offering similar studies related to operation of other processes, and also human factors studies focusing on other activities than strict process operation scenarios. In this context studies of different activities related to emergency management becomes possible. Fig. 3 illustrates how HAMMLAB may

be utilised for emergency management studies, both related to evaluation of emergency management support systems and studies of crew communication within and between simulated emergency control centres.

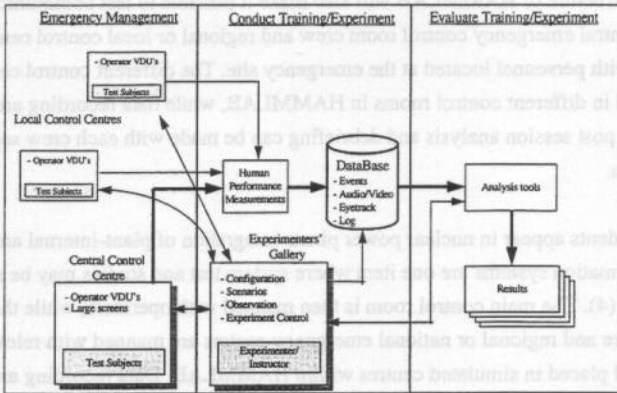


Fig. 3 The role of HAMMLAB in performing emergency management studies

As can be seen from fig. 3 the data collection and analysis is a major part of the "sequential" activity being outlined, both regarding systems evaluation and communication studies. Regarding evaluation of emergency management support systems, such an evaluation in HAMMLAB could typically answer questions like

- will the system enhance the users overall understanding of the situation?
- will the system assist users in decision making?
- is the presentation of information made according to accepted guidelines?

Conducting such evaluations by comparing different systems with similar functionality or comparing user performance with and without the assistance of a support systems, are activities which have been made at several occasions in HAMMLAB, and the staff are very experienced and utilize several well-proven methods for such evaluations.

Regarding studies tied to communication aspects, this is an activity which can be closely coupled to training. By defining realistic emergency scenarios and continuously introducing incidents requiring actions by the emergency management crew, realistic training may be made in HAMMLAB. In addition by utilising the advanced recording facilities, analysis of

and video recording are being available, the crew have the possibility to see for themselves what actually happened during debriefing of the training session.

The infrastructure of HAMMLAB will also make it possible to test communication between a central emergency control room crew and regional or local control centres, and of course also with personnel located at the emergency site. The different control centre crews can be placed in different control rooms in HAMMLAB, while data recording are made centrally and post session analysis and debriefing can be made with each crew separately or in a joint session.

When incidents appear in nuclear power plants integration of plant-internal and plant-external information systems are one item where system test and studies may be made in HAMMLAB (4). The main control room is then manned with operators, while the Technical Support Centre and regional or national emergency centres are manned with relevant personnel and placed in simulated centres within HAMMLAB. Data recording are made simultaneously of all "centres".

The MTO (Man, Technology, Organization) concept, which focus upon managing the complexity of technological systems and organisations, is important in emergency management situations since it emphasizes the interaction between organizational aspects and technology, as opposed to a technology-only centered view. HAMMLAB is very well suited to cope with MTO-related studies, because of its infrastructure of systems and staff.

6.1 Methods For Studying Human Performance

There are several techniques and methods available for studying human performance. At the Institute for Energy Technology (IFE) studying how operators behave in control room situations is a major research item. Although the research at Halden is directed towards control room operators and optimal operation of industrial processes, the methods and techniques being applied could very well be used for measuring human performance in related environments.

At IFE a method called the Situation Awareness Global Assessment Technique has been utilised for measuring operator's situation awareness in process control environments (5). This method has proven to be valuable in such an environment and could very well be usable in studies of emergency management. In addition several other methods have been utilised at

IFE for studying user-system interaction, crew communication and teamwork aspects (6). These methods should also be suitable for utilisation in emergency management studies.

7. EXPERIENCE AT IFE IN EMERGENCY MANAGEMENT

IFE has for some years been working in the area of accident/emergency management, mainly within the nuclear field. In the following three examples are given, illustrating typical projects which have provided the staff with experience in this field.

As part of a joint Nordic programme on application of advanced information technology in emergency management, a prototype was developed focusing on communication paths connecting on-site and off-site centres in a total emergency organization (7).

IFE is currently participating in the EUREKA project MEMbrain providing framework technology for implementing emergency management systems. A pilot application of MEMbrain is being made for the Norwegian Radiation Protection Authority, supporting the organization in managing the threat to Norwegian territory due to nuclear emergencies (2).

Another related activity currently taking place at the Institute is the development of the Computerised Accident Management Support, CAMS, system. This system is supposed to provide support concerning nuclear power plant operation in normal states as well as in accident situations (3). An exercise with the first CAMS prototype was made in cooperation with the Swedish Nuclear Power Inspectorate and some preliminary experience with the system was gained (8).

8. CONCLUSION

The key tasks of the staff manning emergency control centres are, to collect information, evaluate and prioritize information and present relevant and condensed information to humans being located outside the emergency control centres. These tasks resemble very much those being the responsibility of control room operators, implying that there are distinct similarities in the tasks of operating industrial processes and handling major emergencies.

The Halden Man-Machine laboratory has proved to be an excellent facility for performing human factors research related to operation of nuclear power plants. Based upon the experienced staff and the infrastructure of hardware, software and experimental equipment, a clear indication is seen in that HAMMLAB should be an optimal place for doing training and studies around emergency management issues. Such studies could include both evaluation of

communication between humans and tests for applicability of computerised support systems dedicated to emergency management.

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