Integrated User Interface for MEM Decision Support

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ABSTRACT

Decision support systems for Major Emergency Management (MEM) must provide efficient information collection, processing and presentation for a variety of accident scenarios and for end users with different backgrounds. Regardless of changing conditions during an accident, the MEM decision support system should give a consistent and dependable presentation of relevant information that can be adapted to the situation at hand.
The design of user interface for Major Emergency Management systems must reflect the needs of the end users and enhance their ability to extract information, combine data from different sources and present a comprehensive picture of the situation at all stages in accident progression. To do this successfully, there must be a systematic and structured approach to user interface design, encompassing information hierarchy, navigation principles, display design and the communication between operator and MEM system. In a MEM situation the operations centre has to cope with an avalanche of messages, requests and commands, it is the task of the user interface to provide the means for compiling and presenting an ordered overview of this complex situation.

1. INTRODUCTION

The aim of Major Emergency Management (MEM) systems is to support the emergency organisations in their efforts to protect the public and the environment. An efficient MEM system can become a decisive factor in time critical situations, provided it measures up to the demands emergency organisations have to reliable information collection, communication and information presentation. It is very much a question of structured information flow, not only within the MEM system itself but, equally important, between the MEM system and the user.

It is the latter which will be the focus of this paper. Given that a comprehensive software and hardware system has been established containing all information needed for handling a major accident, it becomes a question of how to make it accessible to the decision makers. That translates into a demand that the end user must be given the means for extracting the information he or she needs, combining it to suit the task at hand and then present the best possible overview of the situation as basis for decision. The user interface of a MEM system shall be able to fulfill these requirements for a variety of accident situations, and in addition cater to the needs of decision makers with quite different backgrounds and responsibilities.

To establish principles for MEM interface design one should first try to identify all common factors in accident handling, regardless of the type of event. The basic functions to be fulfilled by the MEM system are all motivated by the desire to establish the best possible basis for correct decisions. The first step in providing an ordered transfer of information from sensor to decision maker is to establish principles for user interface design. A structured interface design process is a prerequisite for an efficient transfer of information to the end user.

2. MEM SCENARIOS AND INFORMATION NEEDS

Hopefully a major emergency will be a rather shortlived affair, and generally one would tailor a MEM system to support short term emergency management, meaning the time from the initiating event until the threat to the public is reduced to an acceptable level. But for many scenarios one can actually not draw a clear dividing line where accident mangement ends and the handling of the

aftermath begins. An explosion or an aircrash requires intense but generally short periods of MEM system activation, and the system, including the interface, has to be designed for adaption to such situations. But there are other emergencies which have a quite different time evolution and may require situation monitoring and initiation of measures over a prolonged period. Examples are spread of dangerous chemicals and radioactive materials, such as happened in the course of the Chernobyl disaster. In the immediate vicinity of the power plant it was necessary to implement drastic measures, from the firefighting immediately following the explosion to the evacuation of tens of thousands in the first days, thereafter long term actions with relocation of even larger population groups. Although the Chernobyl scenario may remain the only one of its kind, the MEM system shall in principle be designed to handle emergencies of a very wide class. This has an impact on the design of the user interface, and one should be aware of the demands placed on system information processing under changing circumstances.

In short term accident handling one has to concentrate on time critical events, and preparation and forethought saves precious time when an accident situation arises. The question is actually how one should prepare for the unexpected, and that is generally difficult. But there are some principles that can be applied which may provide the user with the right information at the right time. To do that one has to figure out on beforehand what are the expected information needs and structure the user interface accordingly. One way of doing this is to make the user interface, or part of it, function oriented. This is appropriate for the user which requires information to perform a specific function or task. Another possibility is to use scenario based structuring with the user interface tailored to the information needs as the accident scenario evolves. In many cases, particularly for handling of large accidents, it may be advantageous to use a combination of the two approaches as there will be persons assigned to cover part tasks concurrently with the coordinated handling of the different accident stages.

In Norway a MEM system for assisting the nuclear preparedness organisation in handling nuclear emergencies is being developed [1]. The user interface design principles being described in this paper will be applied for this Norwegian MEM system.

3. BASIS FOR USER INTERFACE DESIGN

Since MEM systems are often developed as a combination of several free standing tools, the integrational aspects of the user interface becomes even more important than in normal system development. The overall goal must always be that the user should interpret the system as one and not as several systems arbitrarily put together. This integration feeling can be achieved by establishing communication facilities "behind the scene", allowing different tools to freely communicate. However, from the user's point of view the most important integration work should be concentrated on the user interface itself, both with respect to presentation and interaction.

When designing a user interface there are some crucial questions which have to be answered on beforehand [2]. Typically, questions like

- how many screens will be available for operation ?
- how many users will access the system in parallell ?
- can certain information be tied to specific screens ?
- does one allow the system to create new displays on-line ?

are important to clarify. However, since MEM systems normally will operate in many different environments, from simple one screen PC systems to multi-screen computer network solutions, flexibility of the user interface is one keyword. One also has to keep in mind that one MEM system can be operated upon from different sites, typically one may have an operations centre with a high resolution multi-screen setup, while personnel at the emergency site may have low

resolution hand-held devices for communication with the operations centre. This means that presentation of information must be made in such a way that the utilisation level become optimal for all users.

3.1 Structuring of the Information Displays

The structuring of the user interface is perhaps the most important item for the user. When he/she is to make use of the system, a natural information structure is a major factor for optimal utilisation. One way of structuring the user interface in a MEM system is to divide the interface into several information layers, typically

- entry level displays
- information overview displays
- medium level displays
- low level detailed information displays.

These displays are of a typical hierarchical nature and the user must have an easy way to navigate within this information hierarchy. The structuring of the medium and low level displays must be done in such a way that it is logical for the user. The structure could be functional based or scenario based, in many cases one would choose a combination of the two.

3.1.1 Functionally based Structuring

Functionally based structuring means that displays are tied together on a functional basis and that display groups are built up of pictures with logically coherent information content. In this way the user can navigate within a functional subsystem of displays for addressing information belonging to one logical area.

3.1.2 Scenario based Structuring

A scenario based information structure is based upon the natural development sequence of an emergency. The information is structured so that the user can address display groups describing each stage of a development of the emergency. A scenario based information structure, related to the Norwegian MEM application, is illustrated in figure 1.

Accident progression phases →	Event	Impact (site vicinity)	Impact (distance)	Source control	Final stage
	Emerg. org. (alert)	Situation assessment	Predicted effects	Consequences, mitigation	Final assessment, rehabilitation
System functions	Source info. (library)	Severity (site info.)	Dispersion (calculation, meas.)	Model vs. measurements	Known /pred. effects
	Meteorology (library, dynamic)	Contamination (library/pred.)	Contamination (pred./measured)	Contamination monitoring	Overview, measured contamination

Figure 1: Scenario based information structure

3.1.3 Navigation Aspects

Navigation between the different information levels, and inbetween displays at the same level, should be made as self-explanatory as possible. The following guidelines are suggested :

- any picture should be accessible without numerous selections in the hierarchy
- softkeys may be used for frequent operations (e.g. return to top level picture, return to previous picture etc.)
- there must be a consistent approach for sideways navigation in the hierarchy
- operation of windows (re-scaling, moving within the screen , closing, iconising etc.) should be made using standard window handling, for instance MOTIF
- the use of icons should be possible, however, it should be carefully considered what to do with icons when the user is moving within the information hierarchy.

The possibility for creation of an overloaded screen exists and it should be considered whether to perform automatic system cleanup in certain situations. However, non-user started operations must only be performed with great care.

3.2 Information Presentation.

The presentation of information on the screen should be made in an uniform way throughout the application. The same type of information should always pop up at the same place on the screen. It is common to organise pictures in fixed and temporary fields :

- fixed fields (e.g. picture field, dialogue field, message field) and fields for common information has always the same relative placement on the screen whenever shown (refer figure 2)

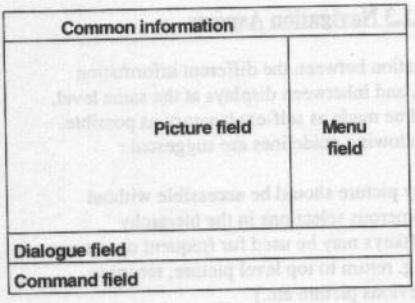

Figure 2. Placement of fields on the screen

- the information within the picutre field is the different main information types of the application (e.g. geographical information)
- the information in the fixed fields (e.g. lead text) accords with the main information within the picture field, similar content has same relative placement within fields
- the size of fixed fields as dialogue and message fields is according to the information content
- temporary fields (windows) are shown and deleted on request by the user
- temporary fields can either be shown initially in a fixed positiion within the screen or according to default criteria for how or from where they are requested (e.g. when a window is requested by addressing within a map the window should not overlay the addressing point)
- temporary fields may also be placed at specific positions requested by the user
- the information in temporary fields is strictly context sensitive

The density of information is dependant upon different criteria, but some guidelines may be given:

- the information density should be chosen according to how well known the picture is to the user (how often is it used)
- in pictures well known to the user the information density is only limited by the need for visual separation, however, consistency in information placement is required
- in pictures seldom used one should be more restrictive with loading much information into the pictures

Experience from industrial applications clearly shows that high information density is preferable to frequent need for picture changes. It is important to design the user interface in such a way that work operations and the request for specific information requires a minimum of picture changes.

3.2.1 The use of Colours

The use of colours is an important factor in information systems, since colours can be used for enhancing the user's perception of the system [3]. However, wrong use of colours may greatly reduce the information content of pictures and hence reduce the system's overall effect. The following can give some ideas on how to use colours in the most efficient way :

- combination of colours, e.g. fore-ground/background colours on the screen, should be chosen according to visual laws for contrast colours and coloured light
- the use of colours must be uniform and consistent, i.e. one colour must only have one meaning in a specific context

- alarms and warnings should have carefully selected colours, these are not to be used for any other purpose
- especially important information within pictures may be given high intensity colours, less important information could be displayed in low intensity colours
- the use of colours in combination with symbols should be carefully considered, bright colours and big symbols may give an unintended dominance

3.2.2 The use of Symbols.

The human brain perceives much easier symbols and graphics than loads of textual information. Symbols should be used when they will ease the user's perception of the information being presented. Some general guidelines for use of symbols in information presentation :

- use of symbols must be uniform and consistent, i.e. one dedicated symbol shall have only one meaning
- graphic symbols should, to the extent possible, be selected from national or international standards
- symbols illustrating specific installations or components should have a profile resembling the physical reference
- the size of symbols must be adjusted to their context
- relative symbol size need not reflect physical size of installation or component
- symbols may have dynamic statuses associated (e.g. different shape or colour whether or not the installation is in operation or not)
- all information related to symbols must be shown at fixed places relative to the symbol

3.3 Automatic Picture Generation.

An important way of presenting the most relevant information to the user at any time would be to let the MEM decision support system provide basic functions for presenting and structuring information on-line. This means that the system itself will have possibilities for re-structuring pictures, as well as generating new pictures, which the system "feels" will provide the user with valuable information [4].

However, such automatic re-arranging of pictures or generation of new pictures should be performed with great care, since it may confuse the user more than assisting him/her. Especially if the user is addressing specific pictures to gain information and the system has re-arranged them, it will mainly be irritating to the user. In most cases the system re-arrangement of pictures should be possibly only on a limited number of specific pictures, of which the user is aware. In such cases automatic generation of pictures with the most relevant information can give a considerable effect of the user's understanding of the situation he/she is to supervise and control.

3.4 User Alerting

When supervisory tasks are included in the MEM system, e.g. measurements of air or water contamination, a valuable addition to the system could be to include some on-line limit checking of measurements. Such checking would result in alarms when certain limits are exceeded. These alarms would be of great interest to the user and should be presented to him/her as soon as they are detected. The alerting mechanism could be solved in different ways. One possibility is to use a dedicated alarm screen, showing all relevant alarms at any time. Another way could be to make an alert on the user's screen, e.g as a blinking icon in one of the screen's corners, no matter in what context the user is working.

4. MAN-MACHINE COMMUNICATION

Man-machine communication describes how the user is interacting with the computer, e.g. choosing what to be presented and , partly, how it is to be presented. This communication takes place through dialogues, where the user requests information and the computer supplies information. Proposed criteria for dialogues are :

- a given command/menu choice/symbol adressing must always be responded, the user should never wonder whether or not his/her action has been accepted or rejected
- faulty user action should not be accepted by the system
- if a command consists of several parts, only the faulty part should have to be repeated
- the user should have the possibility of changing any parameter of a multi-parameter based command
- a regret/undo function should be available and command confirmation should be considered
- one pointing device should be selected (e.g. mouse, trackerball, light pen)
- all messages from the system should pop up in the fixed message field

In applications with a multi-screen setup, the system must be able to handle simultaneous communication from several screens. This may imply that the same dialogue can take place from several screens. It is important that users can work independently at their own screen no matter what is happening on the other screens.

5. GEOGRAPHICAL INFORMATION SYSTEMS

Most MEM applications , including nuclear emergency MEMs, [5] will as a major part of their user interface include a Geographical Information System (GIS). It is mandatory that in those applications where the user interface encompasses a combination of a GIS and other user interface builders, the user should see an integrated approach when operating the system. This means that the GIS has to adapt to the following demands :

- the display within the screen must be adjustable to cope with the overall screen layout definition
- it must be able to meet the selected ways of addressing
- the use of menus must conform with selected standards (e.g. MOTIF) or the GIS should be able to utilise external menu systems
- it must be able to share the screen with other applications, either as windows or in a split screen environment
- since the total requirements to the user interface most probably is not met by a GIS alone, it must be able to communicate and possibly act as a subordinate to other systems

6. TOOL CONFORMANCE TO USER INTERFACE LAYOUT AND DESIGN

To present the appearance of an integrated system it is of major importance that all tools conform to the same principles for information presentation. That is, they should

- conform to the chosen style guide
- use standardised graphical symbols
- use standardised colours
- use the same man-machine communication principles.

These restrictions put definite requirements to all tools which are supposed to be a combined part of an integrated MEM. The user interface handling of such tools must be done in a flexible way to allow for definite adjustments, which may become necessary in specific applications. To achieve optimum flexibility all tools aiming for MEM integration should have a very loose coupling to the user interface management, allowing for easy adaption to the chosen User Interface Management System (UIMS) and the chosen way of presenting information [6].

7. FUTURE EXTENSIONS OF MEM SYSTEMS

A MEM system is basically intended for use during a major accident, where there is a pronounced need for handling a complex information and message flow, and resource utilization and actions have to be coordinated. However, having constructed the foundation for a MEM system one has also generated a framework

for computer based systems of a much larger class. Among these are general surveillance and monitoring systems for rescue organisations, police and civil defence, large transport networks and resource distribution in general. Basic requirements common to all are knowledge of or means for: Resource information (data storage), resource distribution (GIS), communication (internal and external), coordination (operations centre), control (control station).
The user interface, although concentrated in the operations centre, plays an essential part in all these functions and determines to a large extent the efficiency of the system as a whole.

The demands that MEM systems put on user interface can be fulfilled by an integrated UIMS - GIS combination. But there are certain functions that may not be generally available or has to be improved in future MEM systems. One particular function is automatic tracking of moving objects and plotting of position. This is a standard facility in military command centrals, and there is probably much to be learned in MEM system development from military systems. The problem is usually how to gain access to such information and make it available for commercial utilisation.

For handling of nuclear emergencies ther exist systems at different stages of completion in many countries. Although they tend to be notion or plant specific they offer valuable input to the structuring of support systems aimed at accident scenarios affecting several nations.

8. REFERENCES

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