INTEGRATING PLANT-INTERNAL AND PLANT-EXTERNAL INFORMATION SYSTEMS FOR OPTIMAL HANDLING OF NUCLEAR EMERGENCIES

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ABSTRACT

The handling of nuclear emergencies is a complex task, which may involve rescue personnel at the emergency site as well as personnel residing at significant distance from the disaster area. This paper will focus on integration of support systems for use in emergencies arising from nuclear power plant accidents and will cover both plant-internal and plant-external aspects.

The different decision centres being involved in management of nuclear accidents, the plant control room, the technical support centre and the regional and national emergency centres, are briefly described and focus is placed on the utilisation of a common information base, containing basic information being presented at an inter-centre level. The utilisation of advanced information systems for decision support as well as national emergency management systems is discussed in an attempt to optimise their use in an integrated information network.

1. INTRODUCTION

The accident at the Chernobyl Nuclear Power Plant in the USSR in 1986 clearly showed that nuclear emergencies may constitute a severe threat to modern society. It became obvious that such accidents not only would have impact on the plant itself and its local surrounding area, but could influence territories on a national as well as an international scale. This paper will not focus on the security aspects of different kinds of Nuclear Power Plants, NPP, or discuss relative probabilities for accidents to happen within specific plants. However, we know that accidents do happen and in this paper we will try to identify how management of serious nuclear emergencies may be made more efficient by integrating support systems.

The handling of major nuclear emergencies is an extremely complex task and will involve personnel located at the different decision centres, both within the NPP facility and on a regional and national basis. The involved personnel at each centre will have their own information base available as support for their decisions and mitigation strategies. Problems arise when the basis for decision at one decision centre is incompatible with that of another, therefore it is essential that the information base provides consistent and up-to-date information.

The heterogeneity of information needed at the different decision centres is obvious, however, some key information is required at all centres in order to present a complete overview of the situation. The required level of detailed information varies, especially regarding power plant operation parameters. Such parameters are widely available in the NPP control room, while other decision centres could utilise a condensed set of such parameters. To be able to utilise this information as part of their information base, it is important that the parameters are continuously updated via specific network facilities. One can also anticipate that off-plant decision centres could derive considerable benefit from high-level expert knowledge generated on-line by advanced expert systems, as well as key results from predictive simulations based on the current situation.

This paper will concentrate upon describing the different decision centres being involved in managing serious nuclear accidents and try to identify how information can be shared between the different centres in an optimal way. Nuclear power plant operator support systems for advanced information integration and accident management will be identified as potential systems for managing the required information exchange and being the source for intelligent information generation. A national emergency management system for handling nuclear emergencies, being developed under the Eureka umbrella, will also be presented as one source of information in the total nuclear emergency management information network.

In some countries the integration of information is well under way. This is, however, not the case for other countries, where there is a lot to achieve by introducing a common information network.

2. EMERGENCY MANAGEMENT DECISION CENTRES

NPP Control Room

Two categories of staff work in the control room: operators and shift leaders. Their responsibility is to handle the plant in normal situations, in situations with disturbances, and in situations which may turn into an accident. In more serious situations they will have to ask assistance from people in the Technical Support Centre, which will then be manned. The more serious the situation, the more of the responsibility is transferred to the Technical Support Centre.

There are large amounts of information available in the control room, typically thousands of readings from instruments in the plant: temperatures, pressures, water levels, valve positions etc. Some of the most important physical quantities may be measured by several instruments.

Based on a complex information pattern the staff shall try to form a mental picture of what is going on in the plant. This is no easy task, especially in an abnormal situation. For example, it is not easy to see the difference between a fault in a component like a valve or a tank and an instrument error. And if the present state is correctly understood, what will now happen? Will the trouble calm down, or will it develop from bad to worse? What counteractions should I do?

The control room staff may benefit from several types of assistance :

- signal validation
- status identification
- diagnosis
- presentation of higher-level information than just measured quantities
- prediction of what will happen if nothing is done, or if a proposed counteraction is carried out
- generation of strategies
- implementation of strategies

The immediate concern of the control room staff is the situation within the plant, external conditions should influence its work only if there is a direct cause-consequence relationship.

NPP Technical Support Centre

A nuclear power plant usually has several reactors, each with its own control room. In addition, there is a technical support centre that is common to all reactors of the plant. The technical support centre is usually located in an underground bunker, and it is not manned under normal circumstances. In an emergency situation the centre is manned, its staff comes from the plant management and from the staff of those reactors that are not in trouble. The staff of the technical support centre will make an independent assessment of the plant situation and give advice to the control room of the impaired plant. In this function they will concentrate on the broad lines and leave the details to the control room. Moreover, the technical support centre will coordinate the fire brigade, will take decisions (in cooperation with the police and other local authorities) on whether to evacuate the local population or not, and similar questions. It will also furnish the press centre with information.

To function, the technical support centre will need plant-internal as well as plant-external data. The centre will also need to communicate with the staff at other centres, like the control room, the police, the press centre, the fire brigade (of the plant as well as that of the local community), the hospital, and the regional emergency centre.

In addition to plant-internal data (pressures, temperatures, radioactive release, or the risk of radioactive release) the technical support centre will also need plant-external data like information about meteorological conditions, the measurements of local radiation monitors, static demographical information, and dynamic demographical information (for instance, is there a football match at the stadium in the wind direction).

Regional Emergency Centre

In the event of an accident with emission of radioactive materials outside the plant perimetry, the regional authorities are in most cases responsible for initiating the required measures. To protect the public from adverse health effects and secondly minimize the economic impact of the accident, the county commissioner's staff must have access to information that covers most aspects of crisis management. Information on the source or installation causing the pollution is naturally of prime importance, and direct contact to the supervisory system at the plant would be useful. However, the county authorities are not in need of any detailed technical information, but rather an easily understandable picture of the present situation at the source, the amount of radioactive materials released and the projected releases. To obtain this knowledge at the earliest possible moment is essential for efficient handling of a nuclear emergency. Decisions on countermeasures such as intake of iodine, sheltering or evacuation has to be taken early on in the course of an accident, and even though the time saved may be counted in hours or less, the dose averted may be considerable. Thus there should be a direct line of contact between the technical support centre and the regional centre, with transmission from the installation to the centre of select information on plant status, measures initiated or planned and projected development. From the centre to the scene of the accident there is a counterflow of information on the authorities' handling of the situation and the impact this has on the actions taken at the site.

The complex interplay between accident site or utility, the regional emergency operating centre, police, civil defence and the public is difficult to handle even with the aid of an efficient communication and information presentation system. The flow of technical data, messages and commands demands a large capacity network, but equally important is the ability of the computer system to select, condense and present information to the decision makers [Kvalem, 1994]. A unified approach to all these activities is necessary to ensure that all staff involved in emergency handling are presented with a correlated and comprehensive view of the course of the accident, mitigating measures and the cooperation with the public.

National Emergency Centre

A large release of radioactive materials may have serious consequences far outside the site of origin, and to protect life and property in such cases is a national responsibility. The tasks of a national emergency centre are determined by considerations that are partly different from those that dominate the in-plant and local activities. Knowledge of technical matters or local conditions is not essential, what matters is existing and predicted releases, how much is expected to reach national territory, if the accident takes place in a neighbouring nation, and what will be the probable radiological impact. This information is necessary input for the actual decision process which has to take several other conditions and constraints into account. The overall effectiveness of measures is not a simple question of comparing doses to the population with, versus without sheltering, evacuation etc., and then try to maximise averted dose. Any mitigating measure involves a set of actions that disrupt normal life and has its economical and psychological costs. To arrive at a balanced view the decision makers at the national emergency centre require access to a broad information spectrum :

- present and predicted status at the source
- updated global meteorological charts with air currents and precipitation patterns
- weather forecasts on a national level and predicted concentration of radioactivity
- population affected and dose distribution without countermeasures
- dose averted by various countermeasures related to their practical execution
- short and long term health effects
- economical consequences and environmental impact

In addition there should be continuous monitoring of progress in accident mitigation and resource allocations, not to mention the need for timely and precise information to the public and media. Many problems arising during and after an accident could have been avoided by keeping the public well informed and suppress the speculations and psychological strain that are fairly certain to follow in the wake of a major nuclear accident.

3. INFORMATION NEEDS

As described in the previous chapter the decision centres have different needs for information, based on their specific work tasks. To get a comprehensive overview of the situation each decision centre needs data originating from other cooperative decision centres. Figure 1 tries to illustrate the integrational aspects being addressed in this paper, by identifying the four relevant decision centres and their requirements for data and information. The thickness of arrows in the figure depicts the volume of information flow.

The data requirements indicated in Figure 1 are described below.

Plant Data

All plant-internal data (measurement data as well as data derived from measurements) are available in the control room. A selection of plant data are needed in the technical support centre. A regional emergency centre will need a narrower selection, and a national emergency centre quite few plant data.

Local Data

All relevant local plant-external data (demographical, meteorological, radiological, etc.) available in the technical support centre, less in the regional emergency centre, even less in the national emergency centre.

Regional Data

All relevant regional plant-external data (demographical, meteorological, radiological, etc.) available in the regional emergency centre, less in the national emergency centre and in the technical support centre.

National Data

All relevant national plant-external data (demographical, meteorological, radiological, etc.) available in the national emergency centre, less in the regional emergency centre.

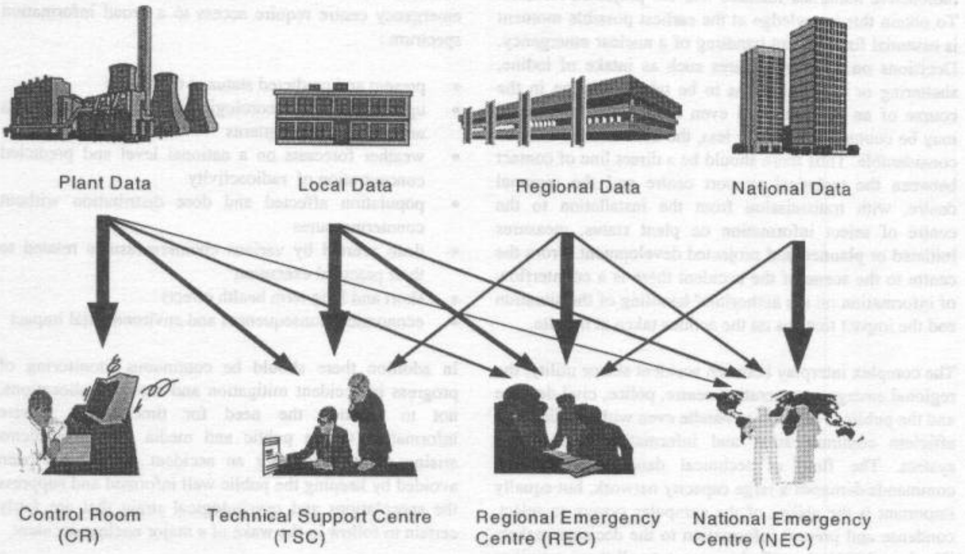

Figure 1 : Information flow

4. COMMON INFORMATION PLATFORM

In a previous chapter the decision centres involved in handling nuclear emergencies have been described. The information required at the centres differ according to their personnel's specific work tasks, however, the need for a common information platform seems obvious. Computerised information systems aiding personnel in their specific work tasks should exist as parts of the information basis at all centres involved in emergency management. Several decision supports systems are even integrated at specific centres to obtain a comprehensive overview of the situation. However, the inter-centre integration of information is normally not operating the same way, resulting in lack of a common information basis for sound decisions to be taken across decision centres. How should one then obtain such an inter-centre integration? One way is to take advantage of already existing support systems residing at the different centres and see whether it is possible to extend their scope to operate on an inter-centre basis. Several decision support systems for accident management and information integration have been and are currently being developed within the Halden Reactor Project and principles applied in their design may be used as basis for integration.

CAMS

The Computerized Accident Management Support, CAMS, is a system that will provide support concerning the plant operation in normal states as well as in accident states [Fantoni, 1994]. Support is offered in identification of the plant state, in assessment of the future development of plant conditions, and in planning of mitigation strategies. The system picks up information from the plant and transforms it into a more digestible form before presenting it to the users. The transformation process can be controlled by the user. CAMS is restricted to plant-internal parameters and plant-internal operations. It consists of a signal-validation module, a tracking simulator, a predictive simulator, a strategy generator and a critical function monitor. At the present time, CAMS exists as a prototype to test out the possibilities of the chosen design, and is still under development.

ISACS

The Integrated Surveillance And Control System, ISACS, is a general concept for advanced control rooms, in which emphasis is put on efficient use of modern computer technology to help solve problems in many of today's control rooms. Major points are the need for a careful integration of a number of specific operator support systems, with respect to information integration, software and hardware aspects and the design of the man-machine interface [Haugset, 1992]. The "heart" of the ISACS concept is the Intelligent Coordinator, which continuously supervises information coming from the different operator support systems. The information is used for analysis of the status of the plant and the Intelligent Coordinator can activate support systems for acquiring additional diagnosis or prognosis. The Intelligent Coordinator then generates high-level information for the operator and presents the information through a fully unified man-machine interface. A first prototype of ISACS is currently in operation in the research laboratory at the Halden Project.

MEMbrain

The Eureka project MEMbrain (MEM: Major Emergency Management) is centred around the development of modules tailored to applications in MEM systems, included handling of nuclear disasters [Drager, 1994]. It aims at providing the information acquisition and processing functions together with communication modules that are needed in emergency management. It is mainly directed towards use in the handling of accidents on the national or regional scale, but may at a later stage encompass all levels involved in a nuclear emergency, integrating the in-plant information system with external systems that are designed for national or regional emergency centres.

Personnel being involved in major emergency management on an extended geographical scale will require meteorological information, access to short and long distance dispersion models, geographical information systems including detailed demographical information for the threatened area, and extensive communication facilities for contact with supporting institutions as well as local and global preparedness organisations. All these aspects are being covered as part of the MEMbrain concept currently under development.

Aspects Of System Integration

The decision support systems described above have their traditional origin as indicated in Figure 2. However, they can most probably meet the requirements indicated by the thin lines of Figure 1, by extending their ability to supply the decision centres with data originating in another centre. CAMS and ISACS will typically provide information from left to right in Figure 1, based on their origin as control room systems. MEMbrain, however,

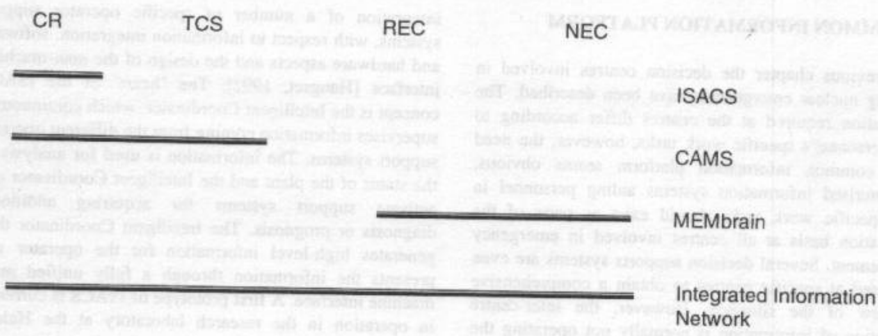

Figure 2: Distribution of systems across centres

with its main functionality directed towards national emergency management, should typically be extended to act as an information provider from right to left in Figure 1.

To introduce several free standing support systems, although they are partially integrated, does not produce a complete information network. An overall coordinating system is required, collecting and distributing relevant information to and from several sources, refer Figure 2. The ideas behind the ISACS Intelligent Coordinator concept, which until now has been implemented on a local scale, i.e. for the control room, may possibly be utilised to meet requirements of a totally integrated information network on a broader scale :

- collection of relevant information, provided for instance by single systems like ISACS, CAMS and MEMbrain
- condensation of collected information
- prioritisation of information relevant for each specific centre
- intelligent decision making
- generation of high-level information
- proposal of actions/mitigation strategies
- intelligent person-to-person communication facilities
- intelligent distribution of information

The functional requirements described above will put severe demands to the technical solution for such a computerised system. An efficient data communication network, with the utilisation of wide area networking and satellite communication facilities, is one of the key factors for such a system to function properly. Efficient database and expert system management are other factors which will require careful consideration before implementation.

However, we believe that there exist mature information technology solutions today, which can make it possible to build an integrated information network for managing nuclear emergencies. Such an information network can be based upon existing support systems already implemented and utilisation of ideas that have already proved their worth in smaller scale environments.

5. CONCLUSIONS

The goal of the ideas presented within this paper is to provide decision makers handling nuclear emergencies with the best possible information basis for making their decisions. Computerised information systems exist and although they have been developed for different purposes and different tasks, an extension of their scope making them serve additional purposes is definitely possible. In such a way it should be possible to integrate different support systems across decision centres providing personnel with an extended and common information basis, which could assist them in functioning even better in executing the complex tasks of nuclear emergency management.

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