Modelling Decisions In Emergency Situations

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Abstract

This paper describes a methodology and supporting software tool that has been developed at AIAI for helping to model the decisions that people take in emergency situations offshore. We believe that this is the first time that people's decision-making has been incorporated into egress and evacuation models. Our work is therefore an important first step in the introduction of improved approaches to the evaluation of platform layout, facilities and emergency procedures.

We have worked with our collaborators to integrate our model of people's decisions with their model of people's movement. The result is that people's movement is modified by factors such as their reactions to alarms, their reactions to hazards, their familiarity with the installation, their training and their role. Our program has a generic architecture for modelling decisions. We have used "scripts" to define typical actions or procedures associated with particular conditions: people in the computer simulation adopt particular scripts according to the situations in which they find themselves.

In future developments, we would like to improve the decision model by incorporating communication between individuals as a scenario proceeds. This would be particularly useful in: scenarios which go beyond muster to evacuation; scenarios where there is significant structural damage; scenarios where there are casualties; and scenarios that cannot be simulated realistically in exercises.

The software runs on a 486 PC under Windows 3.1. Safety analysts can build floor plans and set up scenarios with different facilities, populations or hazards, to determine their various effects.

1 Introduction

The motive behind the EGRESS project was to provide a methodology and supporting tool to help safety analysts model the mustering and evacuation of personnel on offshore installations.

Most egress and evacuation models, e.g. EXITT [7] & EVACNET [9], concentrate on modelling how people move, individually or in crowds, along various floor layouts. The effect of initial wait time and negotiating obstacles have been dealt with but the subsequent decisions made have not been modelled. Modelling these decisions, particularly those made immediately after the occurrence of a hazard, is critical to the validity of a simulation exercise. This is particularly true in the offshore environment where the population are well trained and many have unique duties to carry out in an emergency. They do not behave as a single group moving towards a specific location. The number of possible routes to any location may be very large and personnel do not simply take the nearest exit or the shortest route.

It is sometimes argued that modelling decision making in emergency situations is too difficult or simply not worthwhile. It is often assumed that people panic and that their subsequent behaviour is irrational. However, studies have shown [11] that people do not panic in emergency situations and that the decision making is in fact rational and amenable to modelling. From studies, carried out as part of this project, of various incidents on offshore installations there is evidence to show that even in extreme situations people are capable of and do make rational decisions and remember their training. There are reports of personnel monitoring wind direction before embarking on a route, or laying down on the ground before opening doors to hazardous modules. The Offshore Installation Manager on the Piper Alpha [2] was reported as showing signs of panic, but this had probably more to do with a reduction of his decision making capacity, as a result of the initial confusion.

We have found it very hard to find empirical data to support our decision model: much of our data were based on individual experience and on studies in environments other than offshore. In an effort to gather such data for ourselves we monitored a muster exercise with a simulated incident on Texaco's Tartan Alpha platform. We used the data to help validate our software but much more data are needed before we can have confidence that our model will extend to other scenarios.

This paper describes an overview of the methodology that was developed to provide a framework for safety analysts carry out safety assessments. The architecture of the EGRESS tool that was developed to support this methodology is introduced and the way that MOBEDIC models the decision making behaviour of people in emergency situations is described in more detail. Finally, we discuss the results of a simulation, using the EGRESS tool, of an incident on an actual offshore installation.

2 The EGRESS Safety Assessment Methodology

We have developed a methodology from our reviews of the literature on human behaviour in emergencies, existing expertise within AEA Technology Consultancy Services and discussions with personnel from within the project sponsor companies, particularly Shell and Texaco. The methodology defines the steps that a safety analyst should take in assessing the overall safety of an installation. The methodology focuses on those issues which relate to the safety of personnel when an incident has occurred, e.g. escape route plans and safety procedures. The methodology does not make any assessment of the inherent safety of the installation or the operating procedures. A step-by-step guide in the form of a flowchart is shown in Figure 1.

Offshore Environment This is the environment within which the safety analyst operates and it includes the offshore installation, its personnel, operating procedures, safety procedures, etc. This also includes information such as the likelihood of particular hazards occurring and possible escalation scenarios.

Describe Structure This involves describing the layout and contents of the offshore installation to be analysed. The layout should include escape routes, location of muster points, temporary safe refuges (TSR) etc. The contents and function of the various modules, offices, etc. determine the type of incidents that can occur and influence how they escalate. A person's knowledge of the structure plays a major part in assessing their behaviour in the event of an incident.

Describe Hazard Scenario A safety study should identify potential hazardous situations that can occur on an installation. The description of a hazardous incident should include the type of hazard, e.g. fire, and the rate and extent of escalation. The effects of the hazard on the structure, e.g. making walkways and modules untenable, and the direct effect of the incident on the population must also be assessed, e.g. will it injure of kill any personnel.

Describe Population Factors The behaviour of the population is the primary focus of this methodology and thereore population factors are very important. The emergency team structure, platform emergency procedures and training must be described. Emergency role, current (ongoing) activity, training and many other attributes must be described for *all* personnel.

Forecast Behaviour And Movement Using information about the structure, population factors and the hazard scenario the safety analyst now attempts to predict how personnel would behave. The decisions that personnel would make in response to the various stimuli arising from the incident must be analysed. This can be very difficult to do for a large population with different emergency duties, engaged in varying activities and receiving different information. Analysing the likely exits and routes that personnel would choose can be very time consuming even for one scenario and a small number of people. Finally, the movement of personnel along corridors, stairs, around obstacles, etc. must be analysed.

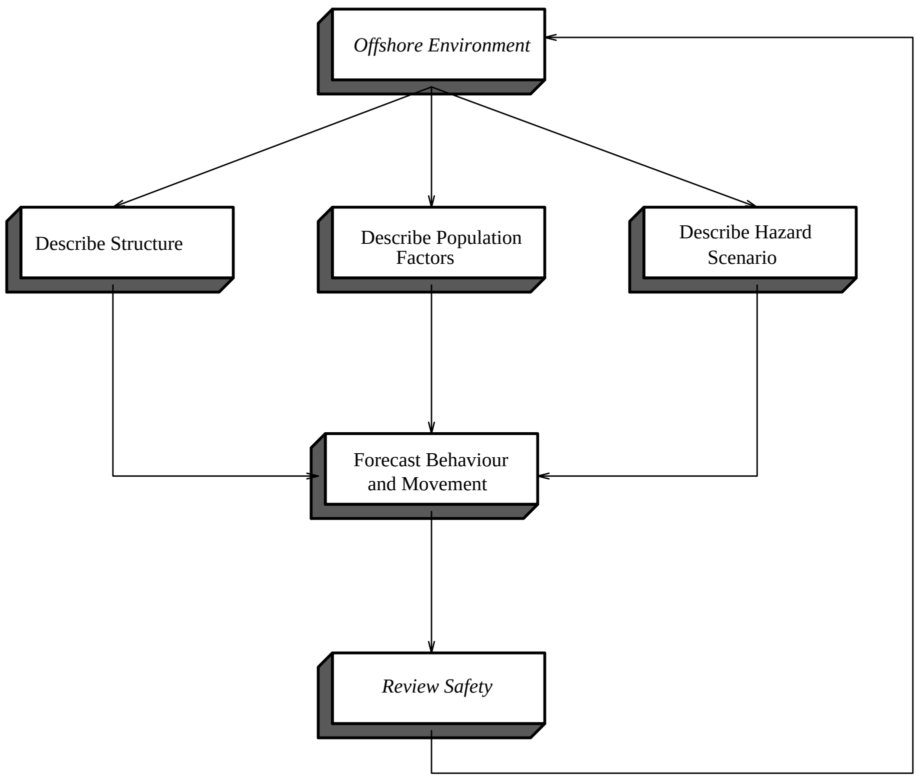

Figure 1: The EGRESS Safety Assessment Methodology

Review Safety The results of the *behaviour forecast* must be analysed to see if the *environment* could be improved in any way. The analysis should identify ways in which the location and number of muster points, TSRs, etc. could be improved. Ways in which the emergency procedures and training could be modified should also be identified. The effects of these modifications can be analysed by repeating the steps as described above.

The methodology can be followed independently of the use of specific tools but the existence of the EGRESS tool speeds up the application of the methodology and ensures its consistency. Analysing the decisions that personnel could and do make is very difficult and time consuming. There are a number of factors that influence any one decision and the changing nature of the environment can result in any individual making a large number of decisions before mustering or evacuating. Peoples' movement depends on a number of factors that include the topology of environment and their interaction with obstacles and the people around them. Predicting the rate and path of movement of an individual or group of people involves performing numerous time-dependent calculations.

The EGRESS tool allows the analyst to describe the structure, the hazard scenario and the population. The mechanisms for predicting the decision making and subsequent movement of the personnel are also encoded in the tool and facilitate the analyst in reviewing the safety of the environment. The EGRESS tool is described in more detail in the following section.

3 The EGRESS Computer Tool

Figure 2 shows a conceptual view of the EGRESS system. The system comprises two separate models; MOBEDIC which models peoples' decision making and the movement model which models the subsequent movement of people throughout the platform. The two models have been designed and implemented separately but they interface with each other and share the same User Interface (UI). This section contains a brief overview of the Movement Model and a more detailed description of MOBEDIC.

3.1 Movement Model

In the Movement Model the physical structure of the offshore installation is represented using a hexagonal cellular grid. A *Plan Editor* allows the user to define physical structures, such as walls, equipment, etc., using different types of cells.

The Movement Model also represents information about the hazardous incident. A *Scenario Editor* allows the user to specify the hazard, its escalation and effects on the structure over time. For example the location of and intensity of smoke can be specified at a number of time steps.

Personnel are represented using *cellular automata* which can move about the plan from cell to cell. The automata are created using a *Population Editor*. An individual automaton cannot, of course, occupy cells representing walls, etc. or cells occupied by other automata. The movement and interaction of the automata on the cellular grid simulate the movement and physical interaction of people on a platform.

More detailed information about the Movement Model is contained in [3].

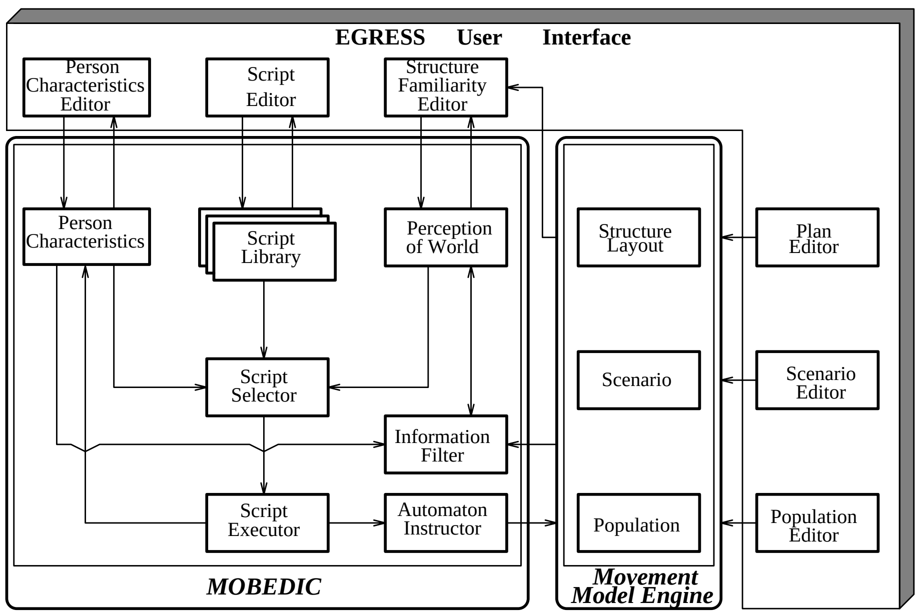

Figure 2: The EGRESS Tool

3.2 MOBEDIC

MOBEDIC represents the "brain" of the automata in the Movement Model. It explicitly models a person's decision making knowledge which enables it to respond to a changing environment and instruct its automaton to carry out some action.

In the field of cognitive science much research has been done in modelling the human thought processes. The more relevant examples include mental models [5], frames [8], scripts [10] and models of decision making [4]. More recent work includes that of Kaemph [6] who has developed a Recognition Primed Decision model of how experts make decisions in emergency situations.

The model used in MOBEDIC is based on frames and scripts. A frame represents knowledge of a person's characteristics and perception of a situation. This knowledge is continually being modified as a situation progresses. A script defines a goal for a person in a particular situation and the high level actions required to carry out this goal. This model is explained in the context of the architecture of MOBEDIC in the following sections.

3.3 A Person's Knowledge

A *person's characteristics*, e.g emergency role and current activity, are defined using the *Person Characteristics Editor*. In this manner a population can be specified which reflects the different duties and characteristics of personnel on board an offshore installation.

A *Script Library* is used to define peoples goals and actions for specific situations. A script consists of a *header*, which defines the relevant situation and a *body* which describes the goal and the high-level actions required to carry out the goal. Scripts are organised into sets; each member of a set has the same *header*. A set of scripts therefore applies to a specific situation. Each member of the set has a probability rating which determines the probability of this script being selected from the set. In this manner the non-deterministic behaviour of people can be modelled.

A *Script Editor* is provided which allows the user to create and browse through a library of scripts which are relevant for a simulation. The script editor provides a pseudo-English interface to the scripts which makes them easy to edit and understand. The script representation has many advantages:

- It is a natural formalism.
- It can be easily inspected by the user of the software.
- It can be easily modified by the safety analyst to reflect different roles, conditions or procedures.
- It is easy to relate inputs for the decision model to conditions in scripts.

The *Familiarity Editor* allows the user to specify a person's level of familiarity with various parts of the structure, i.e. *Perception of World*. Different people will be familiar with different parts of the structure, depending on their day to day duties and training, and this familiarity is critical when choosing exits and routes.

3.4 Response To A Changing Environment

In the same way that people are bombarded with information from their environment, the Movement Model broadcasts information to MOBEDIC; information such as presence of smoke or fire, alarms and an automaton's current location. Just as humans have to "filter out" or "block out" irrelevant information MOBEDIC *filters* this information before analysing it and modifying the *Perception Of World*.

The process of *filtering* information is dependent of the person's current knowledge of the environment and on their personal characteristics. A person's current knowledge results in an expectation about what the world is like and whether new information constitutes a significant change in this expectation, e.g. the presence of smoke is something which would be unexpected in a normal workplace and would result in some kind of decision being made.

Making a decision is a two stage process that involves *selecting* a script and then *executing* it. There may be more than one script set defined for a given situation and each possible script set is put into a conflict set. All competing script sets are evaluated to check their applicability to the current situation. The most suitable script set is selected; a script is then selected from this set based on its probability rating.

Executing a script involves expanding the actions defined in the body of the script and executing them in sequence. Actions typically include modifying the person's own characteristics or issuing instructions to the automaton to carry out some action. The person therefore can actively change the real world which can result in new information being broadcast to self or to other "personnel".

4 Simulation Of An Incident

A literature review carried out at the start of the project highlighted the fact that there are very little data available to construct or validate the Decision Model. Some data exist on evacuations of public buildings and shopping malls [1] but these data are of limited use for the offshore environment. This lack of real data became increasingly evident as the project progressed and it was decided to gather some additional data by carrying out a mustering exercise offshore.

The exercise was carried out on Texaco's Tartan Alpha platform during February 1993. The exercise simulated a torch fire in one of the production modules, which eventually resulted in part of the platform becoming untenable. Data on movement and response times during the exercise was collected in addition to information about the routes taken.

The "incident" was then simulated using the EGRESS model. The following personnel were modelled:

1. personnel with emergency roles and personnel with non-essential roles;
2. personnel who were asleep, relaxing, on work break and working;
3. personnel in close proximity to hazard;
4. personnel encountering a hazard *en-route*.

The model simulated the response of the above personnel with reference to the following:

1. initial alarm/PA announcement;
2. selection of routes;
3. PA instructions to avoid specific part of the platform.

The results of the simulation were encouraging. People did respond to alarms and their response times varied with their activities. Personnel reacted differently depending on their specific characteristics and on the environment and their overall behaviour was similar to what would be expected in a real situation. The routes selected reflected what would be expected in an emergency situation; personnel chose familiar routes, avoided crossing production modules and took external walkways where possible.

However, although these results are encouraging we are not interpreting them as verification of EGRESS. Verification, particularly of MOBEDIC, will require gathering much more data and simulating a greater number of different scenarios.

5 Concluding Remarks

EGRESS demonstrates that it is possible to model the behaviour of people in hazardous situations. The results of simulations, while they cannot be interpreted as verification of the model, are very encouraging.

In the future, we would like to improve MOBEDIC by incorporating communication between individuals as a scenario proceeds. This would be particularly useful in: scenarios which go beyond muster to evacuation; scenarios where there is significant structural damage; scenarios where there are casualties; and scenarios that cannot be simulated realistically in exercises.

EGRESS can simulate scenarios in different platform layouts and help in the design of safer installations or in the improvement of existing ones. By varying the scripts to model different emergency procedures EGRESS can be used to evaluate the effectiveness of existing procedures and to help in improving training.

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