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SIMLAB—a training simulator for emergency preparedness decisions

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The paper describes an EDP-simulation program package SIMLAB (Simulation Laboratory) which is under development for Esso Norge A/S by A/S Quasar Consultants. SIMLAB is a simulation training course for personnel involved in safety and contingency planning and/or personnel who have operative responsibility for such matters. In order to perform a simulation an offshore platform is modeled with respect to accident development, escapeways etc. Also its surrounding fields and platforms with their rescue resources are included. SIMLAB contains the following program modules:

ADS	– Accident Development Simulation
EVADE	– Simulation of the mustering phase of an evacuation
PTRACK	– Personnel tracking of every individual involved in the evacuation process
LBL	– Simulation of the launching phase of the lifeboats
HEVAC	– Simulation of helicopter evacuation
ORS	– Simulation of an SAR operation offshore

The purpose of using these simulation programs in training, is to enlighten the effects of decisions that might influence the development of an offshore emergency situation. By such a simulation it is possible to include extreme scenarios, which are difficult to test out in real life. In addition to being a training tool, the programs also represent a valuable planning tool concerning safety and contingency matters offshore.

1. Introduction

Contingency training may be divided into two separate categories. The first category deals with practical handling of an emergency, in the form of fire drills, etc., whilst the second category contains training of the staff who are supposed to lead and coordinate contingency operations. The simulation package SIMLAB is being developed for the last of these purposes. It will be part of a training programme that will concern decision making in an emergency. Important factors in such training will be gathering of information necessary for decision making, and transforming this into actions. A successful handling of an emergency depends on the efforts of the personnel both as individuals and as groups. It is therefore important that the training gives the opportunity of training the skills of the individual as well as the group. The SIMLAB development is therefore trying to meet both these requirements.

Contingency training is normally based upon simulation of an accident scenario. The objective is to establish a realistic scenario, without passing the danger threshold which distinguish the real accident from the simulated one. EDP is today in extensive

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use in training of personnel in simulators for aircraft pilots, ship masters, etc., where the operator is trained in a control room situation similar to the one he meets in real life. The SIMLAB project uses EDP in training of personnel in a management coordination operation in order to handle an emergency situation and is therefore different to the existing available EDP-simulation tools. A computer program simulates an accident development, and the management team acts upon this emergency with decisions which are aimed to minimize the consequences of the accident. The SIMLAB is being developed for Esso Norge A/S for their Odin Platform located in block 30.10 on the Norwegian Continential Shelf.

2. The SIMLAB concept

The SIMLAB training concept is intended to be used in the training of groups or individuals.

In the group exercise, the contingency staff (trainees) are supposed to meet in the emergency room/control room as soon as possible when an emergency occurs, and from there manage the emergency operation. Each individual is supposed to play the role he would have if a real emergency was to occur. By use of different types of communication tools, like PA-system, telephones etc., the contingency staff has to act upon these data, in order to bring the emergency under control, or minimize the losses.

The information fed to the contingency staff will be given by a simulation staff (instructors), taking on the roles of personnel outside the control room. A situation as sketched in Fig. 1 is established.

SIMLAB is primarily intended to be a tool for the simulation staff, to keep track of the simulated emergency situation onboard. This will help them to act realistically when 'playing' their roles into the emergency room. In addition SIMLAB also logs events and the time history of the emergency simulation, in order to facilitate evaluation of the performance of the trainees during debriefing. After the training has been performed, a debriefing and exercise session follows. In this session the instructors may re-run the simulation in order to demonstrate the trainees' decisions on crucial occasions, and demonstrate alternative decisions and their outcome. The purpose of

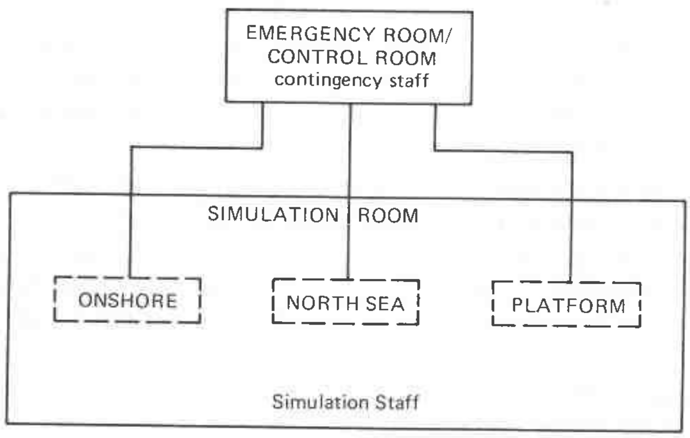

Figure 1. The SIMLAB training concept.

using SIMLAB in the debriefing exercise is to improve the trainees' ability to making correct decisions.

In the debriefing session the trainees are not faced with the same complex situation as during the accident simulation, nor do they face the same time pressure. The trainees therefore receive feedback on their performance and have time for reflection without added stress. Individuals may also use SIMLAB, and can 'play' their own scenarios and test out the results of their choices. Moreover, before starting the simulation, a thorough briefing session must clarify the issues for the trainees, and the goal of the training.

3. The SIMLAB computer programs

The intention of the SIMLAB computer programs is to simulate the development of an emergency scenario offshore. The simulation comprises the following

—Accident development
—Evacuation and personnel tracking
—Rescue

performed by the following computer programs illustrated in Fig. 2 and described in the following.

3.1. *ADS (Accident Development Simulation)*

The ADS program will contain a library of several types of accident scenarios. The accident scenarios are built up by using the event tree methodology.

For each event, the YES or NO branches are given a probability. In addition, a figure is given with respect to the probability of further accident development during a time step. The way through the tree is then a result of a probabilistic selection of branches and also interfering decisions taken by the emergency staff (manual input to the system) in their effort to control the emergency. The accident development is therefore stochastic (different ways through the event tree) and will vary for each time of use.

ADS contains two modules:

—Event tree constructing module
—Simulation module

In the constructing module, the user can construct his own accident scenarios which can be saved in ADS library and called up for changes or simulation on request.

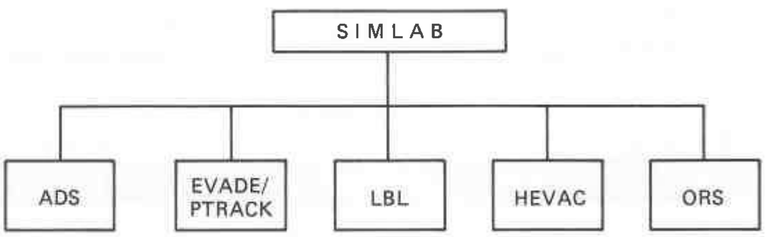

Figure 2. The SIMLAB computer system.

In the simulation module, the accident development is simulated including the users decisions. Figure 3 shows a screen output of a simulation of Hydrocarbone Topside Release accident scenario.

3.2. *EVADE/PTRACK (Evacuation/Personnel tracking)*

The EVADE program is modeling the evacuation of a building. The program can be applied to several types of structures, which will be referred to as 'buildings' in the following. Alternative personnel distributions can be assumed. The program gives an indication of the time needed to evacuate the building, as well as identifying escape route bottlenecks. For a ship or an offshore platform, the program will show the time between the alarm onset and the completed mustering at the lifeboat stations.

The user models the escape route of the building to be evacuated through a description of escape-way elements, building topology and the people present in the building. Each escape-way element describes a part of the escape route like a corridor, room or stair. All these elements are described through their length and average width as well as their smallest width. These data are then used by the program to calculate passage of queues through the escape routes.

During the evacuation process the smallest width of an element may initiate queueing. The program will identify and report queues that may appear. The topology of the building is described by a set of nodes which knits the elements together and makes up the complete map of the building. Distribution of people within a building at the alarm onset is given by specifying the number of people within an element. The time of the first and last departure from an element can also be given. This gives the possibility to test the effects of different types of reaction time. The movement of people is decided by their walking speed, the specified ability to pass through doors and other

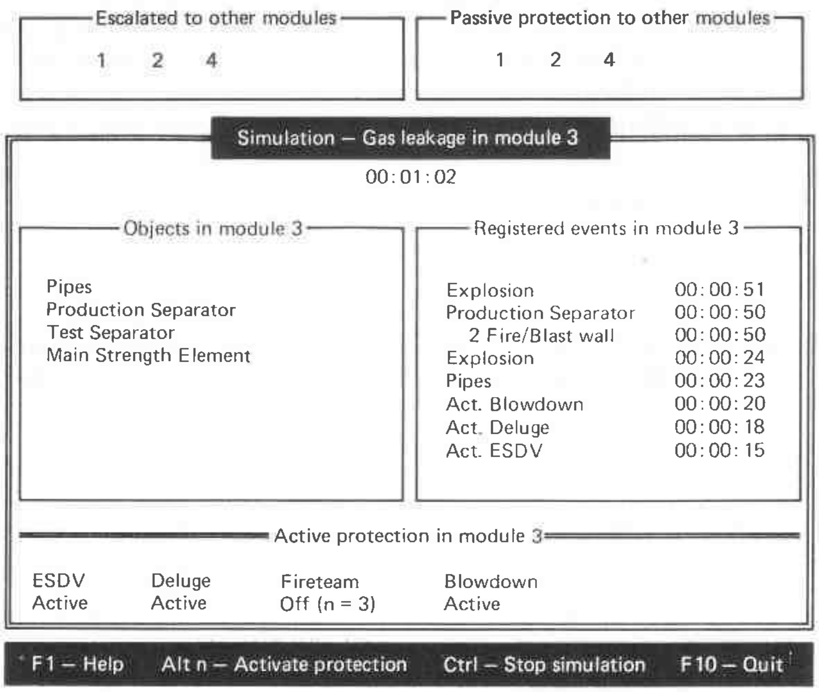

Figure 3. Simulation screen output.

constrictions in the structure, and the limiting number of people per square metre. These parameters are given as default values, but may also be changed by the user. The program shows the evacuation through pre-defined escape routes disregarding dysfunctional behaviour. The evacuation time is thus a function of the number of people in the building and the layout of the building itself. Used this way, the program will give an estimate of the minimum time needed to evacuate the building, given certain personnel distributions. The program does, however, have more possibilities than the plain testing of a 'normal evacuation'. This can be done by applying a list condition as for ships or floating structures, in which the program adjusts element parameters according to the chosen list. Furthermore, it is possible to simulate different accident scenarios by 'closing' elements that may be unavailable due to the accident, or reduce walking speed of personnel because of smoke, etc. Simulation of extreme accident scenarios also requires a change in the concept of evacuee behaviour. From studies on panic and other types of dysfunctional behaviour which appeared during accidents, knowledge of what kind of behaviour to expect under different accident scenarios is gained. Applying this knowledge to the model, the effect of such behaviour can be included by changing parameters as walking speed, maximum density, and by narrowing critical elements.

Figure 4 shows an example of the output, and Fig. 5 shows the results from a calibration exercise on board the flotel POLYCROWN. As can be seen there is good coherence between the model and observed data. PTRACK is an extension of EVADE, addressing individuals rather than queues. Each individual is recorded with position, duties, human factors and other data necessary to perform an individual tracking. By establishing human factors on each person, it is possible to model the individuals with different reactions towards danger and different ability to choose favourable routes in an emergency situation. PTRACK is therefore able to perform a fairly realistic simulation.

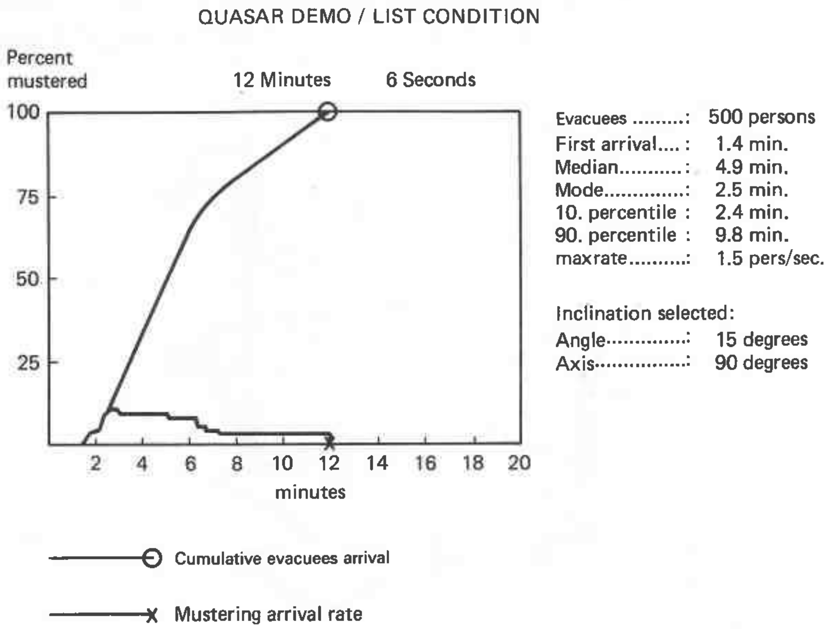

Figure 4. Example of EVADE output.

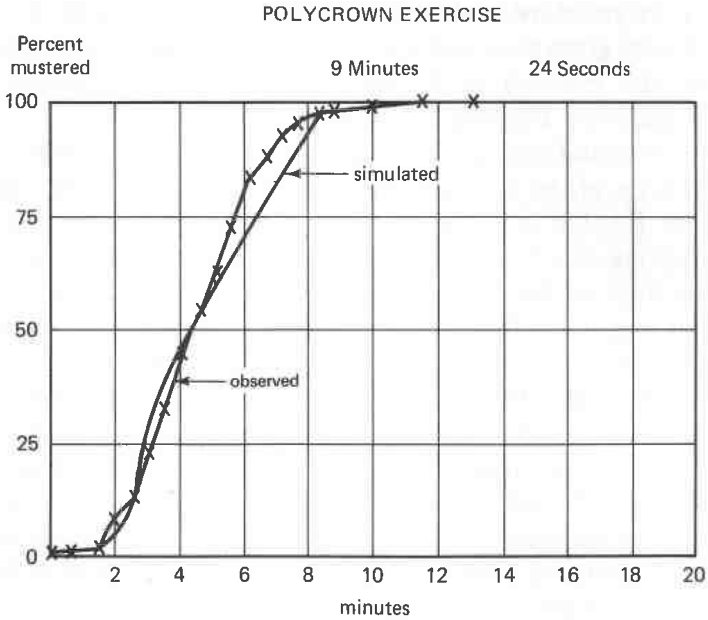

Figure 5. Calibration exercise on board POLYCROWN.

The user is given a display view by a 3-D colour picture of the escapeway system with individuals in their positions marked with numbers, which can be used to identify them. The escapeway system picture can be looked at from different angles and different distances, such that the user may choose the best view during the simulation. The lifeboats/rafts and helideck are clearly indicated on the picture. The updating frequency can be chosen by the user. Fig. 6 shows an example from the Odin platform.

When starting to track individuals, they are given a position in the system dependent on time of day. At accident initiation or when an alarm signal is given, delays occur probabilistically before persons start to move. Persons with special duties

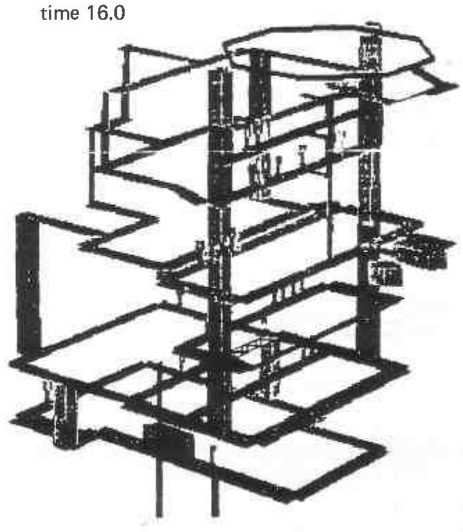

Figure 6. An example of PTRACK screen output.

move towards their pre-decided positions. PTRACK will calculate the movement of each individual dependent on human factors and accident scenario and show their positions in the escapeway system on the screen.

The following operations are possible in PTRACK:

—Position the personnel at different locations
—Simulate mustering of the personnel
—Give order to personnel to move to a given position
—Simulate wounded or killed personnel as a result of accident impact
—Simulate a rescue-team for transportation of wounded personnel
—Simulate a fire-fighting team
—Simulate a search team
—Simulate panic and apathy occurrence
—Show accident impact result for the escapeway system

PTRACK and ADS will be the main programs in the SIMLAB-package, and the screen output can change between the PTRACK and the ADS picture.

3.3. *LBL(Lifeboat Launching)*

LBL simulates the launching of a lifeboat or raft from an offshore structure. The present version of the program handles conventional lifeboats with two fallwires. Further development for simulation of free fall lifeboats is in progress.

The program simulates the motion of the boat with respect to the collision hazard until the boat is at a safe distance away from the platform. Both fixed and floating platforms can be evaluated. In doing so, the program is handling both the launching operation to the sea and the manoeuvering of the boat when it is seaborne. To perform the simulation, data about wind and waves, the course of the boat to avoid a collision with the structure, the distance to the structure, the initial location of the boat and lifeboat particulars are required. A probability distribution with respect to time required for release of the boat when seaborne is also needed as well as the motion characteristics of floating platforms. During descent the twist and pendulum motions are calculated, as well as the distance to the rig structure to identify collisions. The motions are also of importance as to where the boat will reach the sea. When the boat is seaborne the initial speed, impact from waves, thrust and manoeuvering affect the escape operation. If the displacement is always less than the distance to the structure, the launching is considered successful. Otherwise collision speed is calculated.

The program is based on a stochastic model as wave and wind component phase angles are drawn at random when simulation starts. Wave component amplitude data are obtained from a Newmann wave energy spectrum, and correspondingly a Davenport spectrum is applied with respect to wind component amplitudes. A Monte Carlo simulation technique is applied. One to five hundred simulations for a given set of input data are required. Given a scenario, the probability of collision and statistics with respect to collision speed, slamming etc. are presented. The approach fully demonstrates the efficiency of Monte Carlo simulations on this type of problem. The impact of several parameters with respect to the collision probability can be calculated. Even by giving conservative data for uncertain parameters like time to release, it can be identified whether such parameters have impact on the collision probability. The results may also efficiently be used to decide location of the lifeboat on the rig and possible need for additional boats in case of unfavourable weather conditions. The evaluation process can be shown graphically on the computer screen. Thereby problems with respect to such operations are highlighted. As interactive input with respect to launching and release can be given, the program is very appropriate for training situations. Figure 7 shows a simulated launching operation from Odin.

3.4. *HEVAC* (*Helicopter Evacuation*)

Based on the accident development and mustering process a number of persons may need to be evacuated from the platform. The HEVAC program will cover the evacuation performed by helicopters. The scenario needs to be described by various personnel status:

—The total number of persons to be evacuated.

—The number of persons to be evacuated by the means of stretchers.

—The number of persons who need medical assistance during the transport.

These factors influence the passenger capacity of the helicopters and time to bring the persons in distress aboard (time from the helicopter landing to take off).

The accident scenario will influence the different ways of carrying out the helicopter evacuation. This leads to three different forms of helicopter evacuation.

—Evacuation by landing on the helideck.

—If the helideck is not accessible, evacuation may be done by using a rescue lift and lifting from the platform.

—If the evacuation cannot be performed from any place at the platform, there is a possibility to use helicopters' carrying rescue lifts and the evacuation is performed via rafts and lifeboats brought to sea level.

These factors can influence which type of helicopters that can be used, bearing in mind that helicopters' capacity and access time will depend on whether a rescue lift has to be

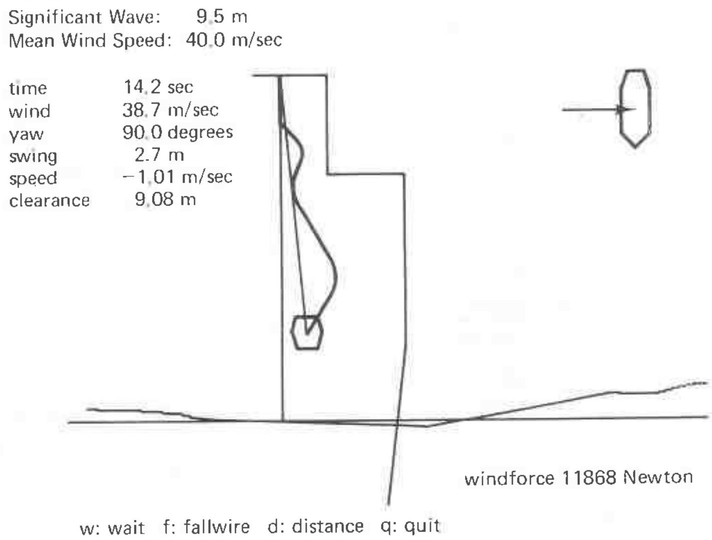

Figure 7. Lifeboat/raft launching simulation.

mounted or not. The above mentioned scenarios lead to the following parameters that are given as an input to the program:

—Number of evacuees to be evacuated from helideck.

—Number of evacuees to be evacuated by rescue lift from the platform.

—Number of evacuees on stretchers.

—Number of evacuees to be recovered by rescue lift from lifeboats and rafts.

—The types of helicopters available.

—The different helicopters' access and emptying times.

—The weather conditions.

3.5. *ORS (Offshore Rescue Simulation)*

The present version of the program is limited to the simulation of the rescue of people actually in the sea, but further ongoing development will also simulate the rescue of people in lifeboats and liferafts and from the installation. The program is based on a theoretical model of the main features of a rescue operation. Details concerning operational limitations and capabilities of different means of rescue related to environmental conditions, have been obtained by systematic collection of expert judgements. The information is collected in a database directly accessed by the program. It is possible to choose survival functions different from the default values implemented in the database of the program. The kind of helicopter, pickup-boat etc. and the number of available rescue teams must be specified, together with their expected time of arrival at the scene of rescue. The kind of helicopter, etc. may be chosen from a menu, implying that certain default parameter values concerning loading capacity, detection ability and boarding times are involved. Furthermore, shuttle times must be specified for rescue means of limited loading capacity.

The program will then simulate the rescue operation and the results will be displayed. One graph shows the number of people picked up as a function of time, another shows the number of people rescued alive. A comparison of the two graphs will then indicate whether the operation should be considered 'successful'. Figure 8 shows a typical ORS output.

4. SIMLAB application

The described computer programs were all developed for solving specific problems within the field of safety and contingency, and the use of them in a simulation package for real-time training purposes is a later development. This has required further development of the programs and has introduced a real-time on-line application. Figure 9 shows the application sequence of these programs in SIMLAB.

4.1. *The briefing phase*

In the briefing phase the trainees will be introduced to how the simulation will be performed and the simulation environment. It is assumed that the trainees are familiar

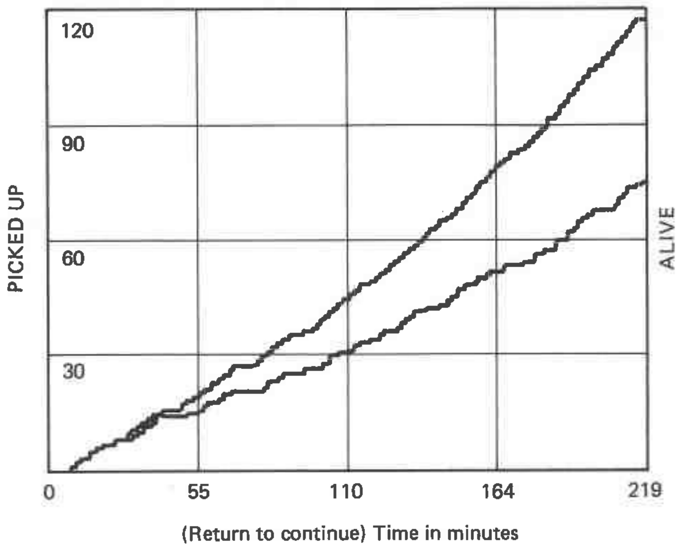

Figure 8. ORS rescue history.

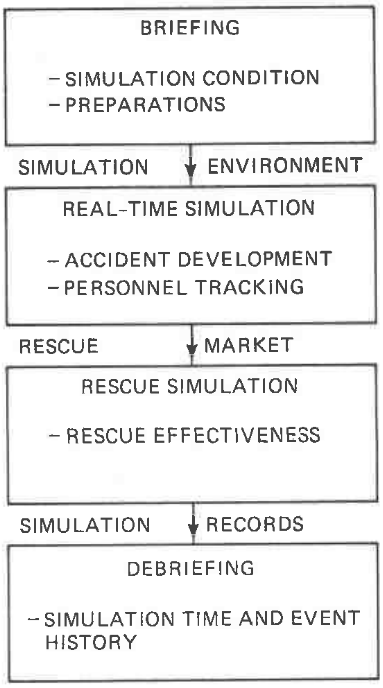

Figure 9. SIMLAB application sequence.

with the platform in question. If not, a platform layout demonstration also has to be performed. The conditions to be defined are as follows.

Environmental conditions
—sea state
—wind state
—time of day

Personnel situation
—location of personnel
—personnel behaviour
—personnel duties

Field rescue resources (not platform based)
—standby boats
—helicopters
—ships in the area

Repair status
—Status on equipment onboard which may have influence on the accident development like deluge systems, lifeboat motors, etc.

Accident scenarios
—A brief gothrough of the scenario (event-trees) will be performed.

Parameters assumptions
—These are estimated parameters, influencing the accident development, or rescue operation, like time to survive with survival suit, time to observe a person in the sea, etc. All these parameters can be changed.

The trainees are now supposed to be familiar with the simulation environment, and a demonstration of the lifeboat launching program will be performed. The intention is to demonstrate the effect of launching boats or rafts during the given environment. The program will calculate the probable success rate for all lifeboats and rafts, and this will be available information for the trainees when the simulation starts.

The trainees are now ready for the simulation and leave for the emergency/control room, and the instructors start the real-time simulation.

4.2. *The real time simulation*

The real-time simulation performed by SIMLAB is illustrated in Fig. 10. The main program in this sequence is EVADE/PTRACK which gives the instructor an updated picture of the situation on the platform. The instructor may choose the updating frequency. PTRACK gives status of platform internal situation concerning personnel, where they are and their condition, and the status of escapeways and platform based rescue means. Due to the stochastic feature of the program and decisions taken by the trainees, the outcome of the simulation will vary. The instructors have to feed the computer with the trainees decisions, and may introduce into the simulation scenario different equipment failures etc. in order to put a strain on the trainees in the emergency situation. The trainees themselves only communicate with ordinary communication means with the instructors. ADS (Accident Development Simulation) gives information to EVADE/PTRACK on accident effects, and EVADE/PTRACK calculates the consequencies with respect to personnel, for example if an explosion should occur, which personnel is within the danger zone and probabilistic selection of the consequences to them.

The response from the trainees will also have impact on the accident development, i.e. use of fire fighting equipment, activating manual deluge, etc. If the trainees decide to start lifeboat/raft launching or helicopter evacuation the programs LBL or HEVAC will be initiated. Based on the outcome of the launching or helicopter evacuation EVADE/PTRACK will summarize the consequences with respect to personnel. When the outcome of the simulation is clear, either the accident is brought under control or

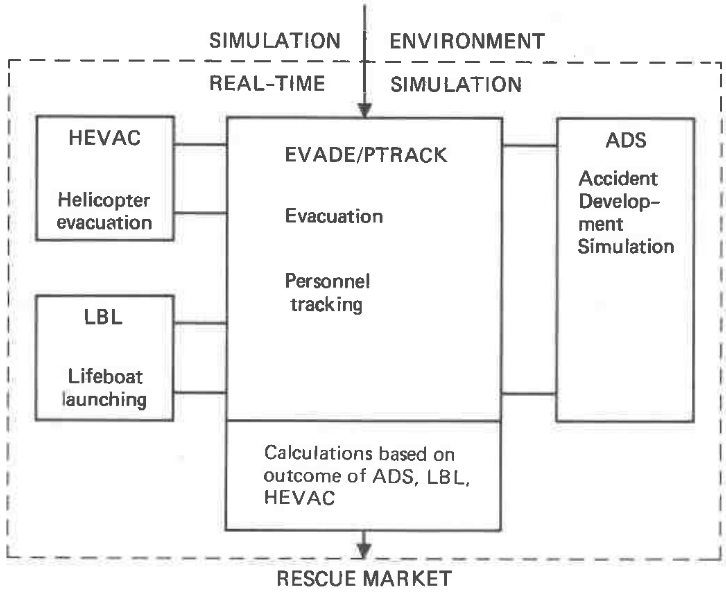

Figure 10. Real-time simulation.

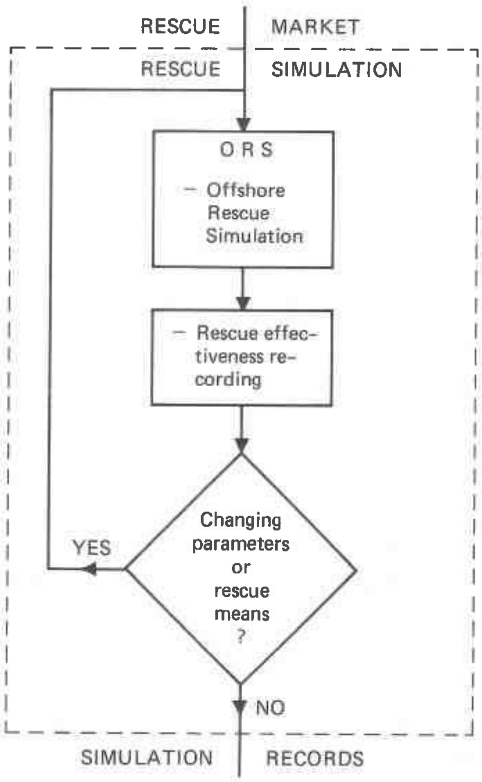

Figure 11. The rescue simulation phase.

the platform have to be evacuated, the simulation ends, with a potential rescue market. The rescue market is the number of the persons that have to be saved either from the sea or lifeboat/rafts. The real-time simulation stops here, and the instructors and trainees meet to run a rescue simulation of the potential rescue operation.

4.3. *The Rescue Simulation*

This is joint session between instructors and trainees, and SIMLAB is used to calculate the probable outcome of a rescue operation after the accident, given the non-platform-based rescue means available. Figure 11 illustrates the sequence. Based on the non-platform-based rescue means available, and the rescue market, the ORP program will calculate the rescue effectiveness, or probable survival rate of personnel. It is now possible to vary the assumed parameters and rescue means, used during a potential rescue operation, in order to find a right match of rescue means to achieve the best probable outcome. All records from the simulation runs are saved by SIMLAB, to be used during the debriefing session.

4.4. *The debriefing*

During simulation, time and event history is recorded such that it is possible to re-run the simulation in order to evaluate the decisions made by the trainees, and judge if an alternative decision could lead to better handling of the emergency. The SIMLAB system should be very well suited in the debriefing phase in teaching the trainees to take the right decisions in order to arrive at the best handling of an emergency situation.

5. Simulation equipment requirements

The first version of the SIMLAB system is developed for a single computer system with the following equipment:

—Micro Computer with hard-disk and EGA-graphics

—Colour display

—Keyboard

—Printer

—(Video transview overhead)

The last one can be replaced with more colour displays. The objective is to use equipment which makes it easy to communicate with the trainees. The operative system used is OS/2. Additional equipment necessary for the training concept is two rooms, where one can act as an emergency room and the other as an instructor's room, with necessary communication equipment between the two rooms to fulfill requirement of a control room/emergency room. Also very necessary are qualified instructors who can run the 'show' so that the trainees have the feeling of how to handle a real emergency. However, SIMLAB may also be a one-man training tool. The SIMLAB now being developed is the first system to be delivered, and the experience of use will first be available within the last half of 1989. This experience will be the basis for further development of the system. However, already there exist ideas of further development using a multicomputer system where the trainees also have access to the SIMLAB during the training simulation. It is the intention to let the trainees have available the PTRACK picture showing the platform internal status. The reason for this is that personnel tracking is crucial during an emergency, and SIMLAB may also, to a limited extent, be a tool to be used in an operative situation in a real emergency.

Combined with a hardware tracking or position system, PTRACK could give a live picture of the activity on the platform. Every time personnel passes a detector, their real position could be updated, and PTRACK could perform the simulation of movement of personnel between real position fixes.

6. Conclusions

SIMLAB is a training tool under development and no experience is gained yet with SIMLAB in use. However, there are several advantages with SIMLAB as a training tool, which can hardly be met by today's manual systems.

—Repetitive possibility
- The simulation runs can be exactly repeated at any time

—Easy to change
- Any changes can be easily implemented

—Accumulation of knowledge
- The simulation system can be updated continuously with gained experience, and thus be updated to represent state of the art at any time.

—Training of groups and individuals
- Both individuals and groups can use the system without alterations, and achieve the same level of training

—Recording advantages
- Every communication with the system can be recorded and thus be exactly repeated.

—Debriefing advantages
- With an exact recording, the debriefing analysis will be even more valuable.

—Easy implementation both offshore and onshore
- The system requires only a microcomputer system which is easy to transport, and quickly mounted anywhere.

Moreover, EDP has not been used in contingency training, and represents innovation and a challenge in this field. Esso Norge A/S has been willing to take this challenge, and thus made the development of SIMLAB possible.

Finally, all the programs which make up the SIMLAB package have been developed for safety and contingency planning and evaluation purposes, and have by the development of SIMLAB become more valuable as such tools. SIMLAB also introduces the possibility that the companies can model all their platforms with potential accident situations, personnel and surroundings, and thus have easy access to a live picture of the platform when safety and contingency matters are to be discussed.

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