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Project 6.4.4, Task 46

MASSTER

(Maritime Standardised Simulator Training Exercises Register)

Final Report

MASSTER - Maritime Standardised Simulator Training Exercises Register

MASSTER

Final Report

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1. Executive Summary

Title

Preparation of a list specifying ship's manoeuvres and operations exercised in simulators to be used for harmonisation of maritime education. Simulation of research results originating from new advanced technologies and procedures.

"MAritime Standardised Simulator Training Exercises Register" (MASSTER).

MASSTER is concerned with the harmonisation of maritime education and the standardisation of simulator exercises in particular. The project is sponsored by the European Commission's Directorate General for Transport (DGVII) within the Fourth Framework Programme.

Objectives

1. Description of the types of integrated, full-mission manoeuvring simulators, part task simulators i.e. manoeuvring, shiphandling, radar/ARPA usage simulators (and VTS simulators) and CBT/CAI systems available in Europe for training/education purposes, including their technical capabilities. Investigate the feasibility of implementing new emerging technologies in the area of simulation with a view to the covered training areas.
2. Categorisation of a complete catalogue of tasks based on maritime experience, rules of the road, new opportunities, including the ISM code (IMO), new navigation technologies, required education levels.
3. Inventory and summary of the simulation scenarios for the different types of simulators used by maritime facilities for training purposes, including the identification of the underlying education levels, tasks and training aims.
4. Determination of gaps and shortcomings based on the comparison of existing scenarios and their respective aims of training with the developed catalogue of tasks. Set-up of (a) methodology(ies) for the development of the lacking scenarios.
5. A basic catalogue of scenarios meeting the earlier set aims of training for the determined tasks and meeting the technical capabilities of most simulators. Provide the methodologies for the development of scenarios.
6. Assessment tools going along with the evaluation of the different training aims as reached through the different type of scenarios.
7. Provision of the final catalogue.

Technical Description

The overview of types of simulators created a first basis for a common approach towards the European simulator institutes. Agreement on the level of technology enabled the participants to come up with a common standard for training objectives and scenario/exercise description. The overall results based on these standards could be identified as follows:

- List of simulator capabilities and their future developments;
- List of training objectives deduced from the STCW'95 guidelines;
- List of simulator training exercises covering most training objectives suitable for simulator use;
- List of training exercises covering extra, in addition to STCW'95, training objectives on high speed vessels, management aspects, ECDIS and others;

- Scenario and exercise development methodology;
- Examples of assessment tools development added to the assessment criteria connected to training objectives which were identified and reported at the beginning of the project.

The MASSTER Project commenced in 1996. Different simulators were used to achieve common training objectives, at first it was necessary to provide an overview of types and use of simulators in Europe and their application of training scenarios. Special attention was paid to the STCW 95 regulations and the need for additional human factors training (e.g. situational awareness, team communication).

Based on an assessment of gaps and shortcomings in existing training scenarios, new scenarios were developed and documented. The resulting catalogue of scenarios serves as a basis for harmonising training in existing simulation facilities.

Scenarios for the assessment of training were demonstrated on a full-mission simulator.

Results

STCW'95

Since 1st February 1998 this year the IMO issued STCW'95 regulations came into force. The new regulations are generally seen as an important step forward to a worldwide introduction of simulator technology into the education and training of seafarers. Although the regulations do not oblige the use of full-mission simulators, their further explanation to the implementation clearly advocates the use of simulators in a wide range of areas.

The need for simulator training as stated by STCW'95 is well recognised as can be concluded from the outspoken worries of many seafarers supplying countries, the set-up of courses for understanding the new STCW'95 and the attention within the European Commission for the subject of harmonisation of simulator training exercises as within this task and on a higher level, governmental level for the maritime educational curricula.

Simulator technology; availability and developments

Availability

The MASSTER project started in 1996 with the assessment in concept of the availability of simulators around Europe and their status as far as their suitability for training according to the STCW regulations. However, due to the character of the STCW requirements which are basically written on a curricula level with some statements added on simulator requirements, the assessment was finalised at the end of the project. This included the findings of the project itself and the latest simulator buildings around Europe. The concept report is available at the MASSTER project administration. See address below.

Developments

Simulation Technology is a rapidly developing area with consequences in costs and technology application. The technology is also embedded within the ever increasing communication capabilities. Both of these issues will enable in the future to reach an important aim of this and other EC projects. Hence the use of cost-effective simulators based on emerging simulator technologies for maritime education within Europe and the related distribution of the standardised training scenarios was designed, updated and provided through a maritime knowledge institute. It requires cheaper simulation technologies and the definition of a framework (hardware and courseware) for the distribution of training scenarios.

The first report on these items was issued and will be available at the project administration.

Simulator Training Exercises

Training objectives

The first activity within this project in order to reach the ultimate aim of a register of exercises was to collect all the training objectives relevant for the maritime (navigation) area. The project team decided to follow initially the categorisation of STCW'95, who distinguishes between a Management level (Masters and first officers) and an Operational level (junior rankings). The tasks for each of these are described with a number of Functions further subdivided into Competencies. Within this frame work training objectives were defined.

It was recognised that in addition to these STCW related training objectives further training objectives should be established, covering the typical "Human Factor" related training objectives e.g. attitude, situational awareness, team communication, cognitive tunnel vision etc.

The project has delivered a concept report on the STCW'95 related training objectives as well as a report on Human Factor related training objectives. Within a later stage of the project the training objectives and their use in training scenario building were defined.

Training scenarios

The existing libraries of training scenarios around Europe are collected through a questionnaire and presented in a report. They are given in a general form. The participants of the project provided a more detailed set of existing scenarios which partly cover the earlier defined set of STCW'95 training objectives. The concept reports on these collections are. This report was followed by a further delivery of extensively described scenarios following the conclusion on scenarios who covered the missing training objectives, both STCW'95 based as well as the Human Factor related. The remainder of the project focused on scenario development methodology, additional scenarios and training assessment scenarios. The latter was demonstrated on a full-mission simulator.

Exploitation and Dissemination Plan

Significance of results

The results of MASSTER have five major dimensions which are worth further exploring:

- Status of the distribution of (advanced) simulators within Europe, which are suitable for the proposed levels of (simulator) training;
- Catalogue of STCW'95 based training objectives;
- Catalogue of STCW'95 based simulator exercises covering the training objectives;
- Methodologies for further, future scenario/exercise development, including non-STCW based training scenarios;
- Methodology of assessment tool development, including a number of examples.

Three are directly related to the possible implications of STCW'95 for the European situation of maritime education and training. The first reveals if European wide implementation of above STCW standards of training through the use of advanced simulators is feasible in the current situation. The second and third are a concrete implementation of the STCW standard within the assumed simulator infrastructure context. All three make perfectly clear what is required in order to give the STCW its follow up step of interpretation. Direct distribution of this information will make aware schools and institutions around Europe what is the shape of things to come in terms of harmonised, European standard of education and training. The METHAR concerted action could promote this information and refer to it as the appropriate level of STCW implementation (see further below).

The fourth dimension is merely an instrument to take the scenario developments further and allow schools and institutes to follow their own course of actions appropriate for their national, educational and tentative simulator infrastructures. The added above STCW training scenarios of HSC, ECDIS, integrated bridge etc. certainly fulfil a general need.

The fifth dimension on assessment tools development shapes the contours of a final, ideal situation in which the ultimate harmonisation is reached through a harmonisation of proficiency levels. A first step should be the individual development of these tools and gathering experience with their use(fullness) (see further below).

METHAR

After and during the METHAR final meetings a decision has to be taken on the relevance of the MASSTER results within the METHAR context. MSCN preferably together with ISSUS can and will play a role in the further integration within then METHAR project and is willing to come up with further proposals. Important points within such an integration and continuation proposal would be the greater detail required for implementation with respect to specific education programmes, education of instructors, which will largely be responsible for the implementation and the set-up of a library and methodology description of assessment tools on a number of levels.

A consequence a further set up of a dissemination/distribution/implementation plan.

Dissemination of results of MASSTER

The dissemination of MASSTER already started when working on the project for example by presenting the project at the CAMET meetings / METHAR.

Within 1997 the project was demonstrated and the first results were used in a one-week-training of students of the World Maritime University (WMU) in the seminar „Training for Trainer“ at SUSAN.

In 1998 the results of MASSTER were forming again the basic for the „Training for Trainer“ of the WMU-students at SUSAN.

During the International Maritime Simulator Forum Meeting in Australia, 28.Sept.-2.Oct.1998, the results of MASSTER were presented.

Internet:

The MASSTER project is accessible in the internet via

http://www.issus.fh-hamburg.de

or directly via

http://www.issus.fh-hamburg.de/iss_web/projekte/masster/

A workshop was held at MSR on 29 and 30 June 1998 which was attended by about 25 representatives from schools and government representatives.

The database of scenarios is distributed to a large number of schools in the UK, the Netherlands and a school in Belgium.

2. Introduction

At present within the EU there is no harmonised standard set of ship manoeuvres, operations and scenarios to be exercised in simulators for the harmonisation of maritime education.

The overall objective of this project is the collection of existing scenarios and the development and documentation of new scenarios, based on the assessment of gaps and shortcomings in the currently existing scenarios. The resulting final catalogue of scenarios will then serve as a basis for the harmonisation of maritime education and training for existing simulation facilities.

The inventory and development of scenarios for future harmonisation of maritime education and training within the EC countries requires the inventory of the existing levels of education and the documentation of the appropriate 'catalogue of tasks' for each level of education, where each task sets the existing aims of training and their resulting scenarios.

As different simulators are used to reach the aims of training, a proper overview of types and use of simulators will be given, in order to inventory the different training tools and their possibilities with regard to scenarios to be applied. The feasibility of new emerging technologies in the area of simulation will be looked at with a view to the covered training areas.

The new ISM code, and more in particular the STCW’95 guidelines [1], advanced technologies in navigation and maritime experience as brought in from different relevant bodies, are used as a basis for the determination and successive development of the catalogue of the scenarios. Scenario development takes place in the framework of curricula building techniques. The use of scenarios and exercises will never be a static set of scenarios but a dynamically varying set of scenarios changing through:

- national influences;
- covered sailing areas;
- types of vessels;
- education level;
- developments in shipping;
- developments in technology.

In order to enable people to maintain and create their own database of exercises it was recognised that the definition of exercise standards and a development methodology is very important. Along with the development of scenarios assessment tools are developed to prove the viability of the scenarios for the training. The first step in the assessment issue is the definition of assessment criteria on training objectives level.

The final catalogue of results, exercises and training objectives, are to be taken further through dissemination and incorporation in the EC project METHAR on harmonisation of curricula.

3. Objectives of the Project

The following objectives are identified within the project and stated in the proposal document [2]:

1. Description of the types of integrated, full-mission manoeuvring simulators, part task simulators i.e. manoeuvring, shiphandling, radar/ARPA usage simulators (and VTS simulators) and CBT/CAI systems available in Europe for training/education purposes, including their technical capabilities. To investigate the feasibility of implementing new emerging technologies in the area of simulation with a view to the covered training areas.
2. Categorisation of a complete catalogue of tasks based on maritime experience, rules of the road, new opportunities, including the ISM code (IMO, STCW'95), new navigation technologies and required education levels.
3. Inventarisation and summary of the simulation scenarios for the different types of simulators used by maritime facilities for training purposes and including the identification of the underlying education levels, tasks and training aims.
4. Determination of gaps and shortcomings based on the comparison of existing scenarios and their respective aims of training with the developed catalogue of tasks. Setup of (a) methodology(ies) for the development of the lacking scenarios.
5. A basic catalogue of scenarios meeting the earlier set aims of training for the determined tasks and meeting the technical capabilities of most simulators. Provide the methodologies for the development of scenarios.
6. Assessment tools going along with the evaluation of the different training aims as reached through the different type of scenarios.
7. Provision of the final catalogue.

4. Means used to achieve the project

4.1. Introduction

As simulators are more and more applied to increase the efficiency of maritime education the harmonisation of the education becomes desirable.

Training institutes and related nautical schools together form an important representation of the national resources of simulator training scenario, which are based on the actual national and partly on international requirements in maritime education.

To serve the harmonisation process the definition of a list of common scenarios is a goal to be pursued. Preceding to reach this goal the basic set of common tasks to be trained on a simulator are to be identified as a results of national and international education requirements, acquaintance with new technologies in navigation and the actual and emerging capabilities of simulators.

Existing simulator facilities, task descriptions, training aims and scenarios

To this end the capabilities of simulators in the navigation training area are to be known, including both the existing simulators as well as future simulators and simulation techniques, with a view to their usage in training. In parallel the nationally and internationally defined tasks to be trained on the different levels of education and translated into training aims are to be inventoried and formatted . After categorising the tasks and the related training aims, the available training aims elaborated into scenarios are scrutinised for further admittance in the list of scenarios.

As a follow-up of scrutinising the existing scenarios the gaps are identified for the selection of tasks and training aims to be elaborated into scenarios. The selection will not go without a close look into the training elements as to be present in the different scenarios.

Scenario development

The required development of additional scenarios is preceded by the development of a number of methodologies for the development of the scenarios. The development of these methodologies helps to standardise the setup of scenarios within this project as well for future scenario development. The total set of scenarios are listed in a final report.

Scenario validation

Scenarios need to be evaluated as to their effectiveness of training the required task. This is done indirectly by assessing the scenarios through their application by trainees. To this end assessment tools are to be developed for the different types of training aims. The tools measure the performance of the trainee with respect to the training aim. The tools and the scenarios are demonstrated through a short simulator training programme.

4.2. Project participants and work breakdown

Within the project five out of eight participants operate a large simulator facility at the time of the project, whereas the others operate smaller manoeuvring, radar and VTS simulators or are otherwise active in the maritime education world.

The project was separated into 7 work packages (WP), each headed by a work package leader. The work packages are listed below and are further discussed within the next chapter.

WP number	Title	WP leader
1	Capability description of (future) simulators	VTT
2	Determination of a complete catalogue of training objectives	ISSUS
3	Collection and examination of existing scenarios	WMC
4	Determination of Gaps and shortcomings	DMI
5	Provision of scenario development methodologies and scenarios	MSCN
6	Development of training assessment tools to be used in proving scenarios	MSR
7	Provision of a final catalogue of scenarios	WMC

The work was performed in a relative simple structure. Only one sub work package meeting was held around WP 4 in order to set half way the project the direction to go for the remaining scenarios to be developed within WP 5. All other meetings were held together with all the participants in an almost constant group composition, which dealt with the WP's in a roughly sequential order. Overlaps in activities exist within WP 1, which came along with updates throughout the project. The scenario development part within WP 5 had an overlap with the WP's 1-4.

4.3. Working Meetings

Following the kick-off meeting, in total 12 meetings were held at various locations. During these meetings results were presented and work plans discussed. The first set of meetings was used to settle a great number of details regarding standards and definitions on training issues. Boundaries were set to limit the extent of the workfield to the available simulators within the participants group e.g. manoeuvring-, vessel traffic services-, GMDSS- and engine room simulators. Also the area of instructor training was only partly addressed.

Two meetings were held on WP level. WP 4 was an important milestone during the project because of the decisions to be taken on the further realisation of training scenarios in the remainder of the program.Within WP 4 information was gathered of highly relevant training issue in the current shipping industry. In addition training objectives were collected relevant from a governmental point of view coping with keeping the manning standards. They addressed in particular the human factor related issues. These issues were the result of a separate study within the project on the role of human error in shipping accidents performed by the sub-contractor University of Leiden. Also the two participants WMC and MSCN performed a small simulator study on the confirmation of the idea that mariners develop personal styles of collision avoidance leading to accident repeaters.

The WP2&3 meeting focussed on the definition of a number of issues within the training objectives presentation and the scenario/exercise presentation. On this meeting the results, on didactical and educational aspects, from the second subcontractor, EMC, are presented.

The final meeting was organised as a demo around the manoeuvring simulator and a table top simulator in order to show a scenario on a simulator being used for an assessment of a captain. It showed the capabilities of the simulator for training and assessing.

4.4. Use of various simulators from the participants

Throughout the project full-mission simulator facilities were used at MSCN, MSR, WMC, DMI and ISSUS, and smaller facilities at the other participants to test and try out some of the new built scenarios. In particular the preparation and validation of the assessment tools required simulator time to detail and test them initially and to show them in a later stage during the demonstration session in Rotterdam.

During WP 5 simulator time was used at MSCN in order to perform a simulator experiment by WMC together with MSCN, which used experienced captains to research a type of 'human error' behaviour. The hypothesis assumed that certain reckless type of behaviour during collision avoidance situations is repetitive in connection to individuals and was verified.

5. Scientific and technical description of the project

The following sections give a description of the project per work package completed with the frame work description which links all the WP's together. The frame work is preceding every WP description.

5.1. Capability Description of (Future) Simulators / Literature Review

The objective of WP1.1 was to create a list of maritime training simulators, including a systematic description of their technical capabilities. The objective of WP1.2 was to evaluate emerging technologies in simulation technology with a view to the consequences for costs and compatibility.

WP1.1 contains a list of Ship simulators including description of their technical and operational capabilities. The catalogue is based on a questionnaire sent to simulator operators around Europe.

WP1.2: Capability description of (Future) simulators, evaluation of emerging technologies in simulation, summarising the ongoing developments in simulator technology and their possible consequences for wider use in maritime education. Volume II is based on questionnaires sent to simulator knowledge centres, maritime colleges and maritime authorities in Europe. Volume III is based on a questionnaire sent to the maritime simulator suppliers.

In a communication from the Commission to the Council, the European Parliament, the Economic and Social Committee of the Regions titled: "Towards a new Maritime Strategy" [1] a new approach of the Commission to maritime strategy is discussed. The communication re-assesses the maritime policy and sets further goals towards establishing a common maritime objective. Emphasis is given on the competitiveness of EC shipping in this document.

Training and Employment

A problem is expected in the supply of officers and ratings in the near future. Parallel to this the average age of the European work force is increasing. The "wastage percentage" of officers leaving the sea is also very high. In some of the European countries only 25 % of the need for cadets is covered. Such a shortage will have adverse implications for the safe operation of European vessels and related industries.

Liner shipping is developing a job pattern which includes some years of experience on a ship before being placed on shore to work in logistics or marketing.

The commission is also concerned about the impact of the present trend on the educational infrastructure in Europe. A lack of students implies a decrease in teachers jobs and also loss of knowledge and research capabilities since educational and research facilities may have to close down.

In line with the relevant Treaty provisions and (where appropriate) with existing financial instruments, such as subsidies, the Commission is encouraging training schemes and incentives to increase employment in the Member States.

Long term actions will be taken to safeguard the existing maritime expertise in the EC and the competitiveness of EC maritime industries. Extensive research and development efforts are necessary, focusing on quality, productivity, safety and environmental protection.

Research and Development

Different simulators and the lack of co-ordination in using simulators may jeopardise the achievement of a homogeneous quality of the maritime officers in each country.

The communication of the commission to which has been referred to above does not discuss the desirability of a European Maritime officer. Such an officer might be bilingual and should have the right to sail on all European waters in all ranks. This would promote the safety of European ships and the harmonisation of maritime education in the member states. It would also be the logical result of the Rome treaty which states that a European citizen has the right to work and to reside wherever in the community without any obstacle. This goal may be far reaching from the present point of view, but the present project provides a start to achieve these goals in the not too distant future.

To get a more detailed and up-to-date information about the status, use of the systems and future plans of the simulation providers and users of simulators and simulation technology, questionnaires were sent to European policy makers, possible (anticipated) simulation knowledge centres, nautical colleges and simulator suppliers. As the results were considered to be also useful for task 15 INCARNATION and task 16 RINAC of the 4th framework programme (as there is also interest in training and available simulation facilities for inland navigation), questions were made applicable for both seagoing as well as inland navigation vessels.

Another questionnaire about the present technical status of the European simulators was made by the World Maritime University within the 4th Framework task of Concerted action on Maritime Education and Training (MET). This questionnaire was made in co-operation with the MASSTER project and the results have been shared by both projects.

The questionnaires were set up to have an inventory of any change in the present training/simulation system as a result of applications of information technology.

The limitations of the use of present simulators

The use of simulators in the education process in many European countries has been limited. This is due to high amounts of money which were required to set up and maintain simulators. The tariffs for one simulator hour were prohibitive for the budgets allotted to nautical colleges. In the last decade some fundamental changes have taken place

The technology push

As a result of the breath taking development of chip technology and the massive scale on which these chips are being produced, PCs and workstations are becoming so cheap that practically speaking limits no longer exist. This is also due to the advanced state of networking technology, which enables each complex task to be shared among a number of PCs. In the end of the sixties it was nearly impossible to use a digital computer as mainframe for the total simulation process. Analogue computers were being used for the many differential equations which describe the motions of a vessel and to emulate the behaviour of many navigation instruments. At the end of the seventies analogue computers were no longer used and replaced by minicomputers. Computer generated imagery was introduced. The introduction of this technology was slow, since the resulting images were said to be similar to Mickey Mouse images. It took another large development in processing speeds and imaging techniques before realistic images could be generated which would be acceptable for the users. Prices remained still high and large investments were necessary to create a realistic environment.

The development of virtual reality is enabling the genesis of simulators which can be driven by a couple of PCs and to customise the database which is required for the visuals. The price of the software has gone down dramatically and the visuals of the ship’s environment in a port and port approaches can now be simulated realistically using off-the-shelve display techniques.

To examine how the supplier of simulation technology assess the present and future situation within the simulation industry, a questionnaire was drafted with the aim of retrieving information from, what might be seen as, one of the main sources of holders of information.

The questionnaire was distributed to 14 main suppliers of simulation technology. Contacts to suppliers were not restricted to EC or EEA based companies but enlarged to cover the western hemisphere.

The questionnaire is divided into two main sections. The first section is dealing with developments during recent years, while the second section is on future developments as anticipated by the individual respondents. Regarding the future respondents were asked to estimate developments in the coming five to ten years.

The detailed results of the questionnaires and the future technology assessment are given in [3].

5.2. Determination of a complete catalogue of tasks and training aims

Aim

The aim of this work package was to prepare a list of training objectives which may be used in every simulation facility for the design of scenarios and a training programme. This aim was developed before the STCW95 was published. When the working group started the MASSTER project and WP 2 the STCW95 was just issued. Therefore the working group decided to use the revised STCW-code as a guidance for the whole basic work. Those training objectives which can be a part in simulation were derived from the code and structured according to the functions and levels (management and operational level) defined in the STCW95-code.

The list of training objectives contains the

- general competence;
- detailed objectives which the trainee shall be able to perform;
- general assessment criteria.

For example:

Function: Navigation at the operational level / Function 1 Level 2 / shortened to FL1.2.

FL 1.2

Competence 1.2.1: Plan and conduct a passage and determine position

	Final Behaviour: the trainee is able to	Assessment criteria
1.2.1.1	Plot a position on the chart from simultaneous cross bearings and from bearing and distance off	Outcome: Accuracy (nm) Duration (time)
1.2.1.2	Plot a dead reckoning position on the chart	Outcome: Accuracy (nm) Duration (time)

The WP2 list contains training objectives for both the deck and engine room department.

These training objectives are made up in a very general manner. When the training objective will be installed in a scenario this will require more detail.

Within the development of the list of training objectives the working group noticed that STCW95 was prepared by human beings with a wide range of knowledge on one hand; on the other hand some parts were prepared by specialists who entered very detailed training objectives. This was leading to a different depth in details at certain competencies. Therefore every instructor should not follow strictly the list of WP 2 for developing scenarios. He shall take the list just as a guidance. He will have to establish the training objectives according to the training needs derived from the qualification of the trainees and the level to be reached. This has to be checked constantly within the complete training programme in order to achieve good training result.

Within the STCW95 there are some fields which are not clearly filled with defined training objectives, such as the human factor. But every simulation scenario which encloses human being is influenced by the human behaviour, by the attitude of the trainee as well as of the instructor. Therefore some general training objectives have to be developed and added such as planning, communication, team work, and safety culture as required by the ISM-Code.

During the remainder of the project the WP2 catalogue was taken as a reference for:

WP3 **Collection and Examination of Existing Scenario** which offers a generic approach to a great number of scenarios collected and

WP 4 **Determination of Gaps and Shortcomings** in which additional training objects are defined and

WP 5 **Provision of Scenario Methodologies and Scenarios** which offers scenarios for areas not covered by the STCW95.

It is important to notify that prior to this detailing of the training objectives following the lines of STCW'95 is was decided to add a scenario format description as to enable to relate the use of training objectives from STCW'95 to more concrete educational levels and the stage of education. Two levels are distinguished within this framework:

format gives a documented overview of the training scenarios that are used to achieve the training objectives from the catalogue of task 2.2. The level 1 format relates the (full-mission or part-task) scenarios to the training objectives and the education level. At level 2 the training objectives of each individual training scenario are linked with the events that must trigger the final behaviour that is being described in the objectives.

Learning Too

The training scenario is either used for a full-mission or a part-task simulator.

Objectives

Use the catalogue of training objectives from task 2.2. State only the main five objectives or groups of logically related objectives for each scenario.

Education Level

State for which education level this scenario is used.

Conditions

These are the conditions under which the trainee should be able to exhibit the final behaviour. For reasons of consistency, the conditions are categorised according to the list below :

1	Weather	4		7		10	
2	Equipment	5		8		11	
3	etc.	6		9		12	

Level 1 format

Scenario	Learning Tool	Objectives	Education Level	Conditions
X	Full mission	1: 1.1.1 - 1.1.8 2: 1.2.3 3: 1.4.4 4: 1.5.6	Cadet / Junior	Cadet: 1,3,6,14 Junior: 2,7,12,21
Y				
Z				

In the level 2 format each scenario listed at level 1 has to be described in more detail with the help of the description of the main events. The content of each scenario is determined by the events that take place. The choice of these events is determined by the training objectives you want to achieve with the scenario. This level 2 format relates the five main objectives to the main events of the scenario. For each training objective more than one event may be stated.

Level 2 format

	Event
1. : 1.1.1	Incoming NAVTEX message
2. : 1.2.3	Close encounter with another vessel
3. : 1.4.4	Engine room alarm
4. : 1.5.6	Auto pilot failure
5. : 1.8.4	Significant decrease of visibility

The full set of detailed information is given in [4]

5.3. Collection and Examination of Existing Scenario

5.3.1 Introduction

Currently, the training of seafarers using simulators is developed according to the guiding rationale of the state where the training is being conducted. Training of seafarers is therefore often nation specific. Moreover, training rationale and method are often specific to a single college or institution. Variation is evident between colleges within the same country, as well being evident between countries.

WP 3 of MASSTER was tasked with collecting information regarding the types of students that attend simulator training; the objective of the activities that the students undertake in a simulator; and the events that are presented to a student in the course of a time bounded training session. The objective was to collect information on existing scenarios used across the whole range of simulator resources available to colleges, from part-task to full-mission simulators. Consequently, the information collected has come to be known as simulator scenario descriptions. The responses documented in WP 3 give an indication of the most common simulators used, and the most frequent rationale for simulator-based training.

5.3.2 Work Package 3

The work that has been undertaken by the consortium members for WP 3 was the culmination of approximately 30 man months of work. The report itemises those scenarios and exercises currently used on simulators operating within the European Union. Three tasks were defined within WP 3:

Work Package 3.1 Selection of Scenarios

Provision of a main body of tasks and training aims for further usage in defining scenarios and selecting existing scenarios.

The deliverable was the selection of the principle tasks and training aims or learning outcomes to input into the final catalogue of scenarios. The selection and evaluation took place on the reported results of Task 2.2 of the preceding work package. Essentially the learning outcomes selected represented those that had relevance to simulator-based training.

Work Package 3.2 Acquisition of existing scenarios

Acquisition of scenarios fitting in the defined framework.

Detailed information was obtained from simulation centres regarding types of exercises (scenarios) used for training purposes. Each exercise collected specifies the underlying training aims (task coverage) and the appropriate education level. The exercises vary in complexity from basic equipment training scenarios to emergency scenarios, and represent those used on the whole range of simulator types available to simulation centres, including PC and low cost.

Scenarios were collected from other simulation operators within Europe, who were not members of the MASSTER consortium:

- The Netherlands
- Italy
- Greece
- Scandinavia
- France
- Portugal
- Spain
- Germany
- Finland
- United Kingdom

The format of the questionnaire and the results are given in [5].

Work Package 3.3 Systemisation of scenarios

The scenarios resulting from WP 3.2 are to be divided and categorised to ensure that the match is made between the required coverage of the training aims and the levels of education, with a view to the definition of further scenarios to be acquired.

The scenarios used by the simulator training establishments were examined and sub-divided into defined scenario categories by assessing their underlying education levels and aims of training. This section of the WP 3 report also contains an analysis of a number of accident scenarios for identifying opportunities for human error to emerge using the catalogue of human error types.

The scenarios gathered were categorised in the following manner:

Scenarios for full-mission simulators

Watchkeeping
Collision Avoidance
Bridge Team Management
Pilotage
Ship Handling
Emergency Procedures
Search and Rescue
Communications

Scenarios for part-task simulators: Radar/ARPA simulators

Watchkeeping
Collision Avoidance
Bridge Team Management
Ship Handling
Emergency Procedures
Search and Rescue

Scenarios for engine room simulators

Scenarios for fishing simulators

The document is complemented with a database (in Microsoft Access) containing all collated scenarios. This database allows cross-referencing through the tables in anyway required. For instance, if a selection is required for showing *masters* and *at night*, with a *full-mission simulator*, and with a *duration of more than 45 minutes* the database filter will quickly summarise all scenarios that suit this description. Thus the database is a very convenient tool for systematisation of the scenarios in any required way.

The format used for the scenarios is given below and completed with an example from the database:

A scenario description format was developed to collect detailed standard information from project participants. Information was sought regarding how the project participants use their simulators to achieve the training objectives developed in work package 2.

The scenario description format, described below, relates the (full-mission or part-task) scenarios to the training objectives and the education level. The training objectives of each individual training scenario are linked with the events that must trigger the final behaviour that is being described in the objectives. A full example is given below in Figure 5-1.

A scenario is defined by the elements that it contains as follows:

- identifying number
- training objective
- simulator tool
- standard of competence
- configuration
- traffic situation
- time of day
- current
- environment
- duration
- visibility
- area
- description of main events

All elements will be described in a generic way, thus enabling any maritime simulator institute to fill in, when applicable, these elements. This implies also that one scenario may have more than one exercise. An exercise is defined as the actual file to be started on a simulator, containing exact number and location of ships, exact wind and currents, specific area etc.

Hereafter the elements are further described where possible in accordance with the STCW Code definitions.

1) identifying number

2) training objective, maximum five training objectives or logically grouped training objectives of the catalogue on training objectives

3) simulator tool, one of the following:

- simulator for navigation and watchkeeping
- simulator for ship handling and manoeuvring
- simulator for cargo handling and stowage
- simulator for radio communications
- simulator for main and auxiliary operation

See STCW Code Section B-I/12.

Sufficient (more practicable) is also to state the use of a FULL MISSION SIMULATOR, a RADAR SIMULATOR, an ENGINE ROOM SIMULATOR or a PART TASK SIMULATOR.

4) standard of competence, the following levels are defined:

Master	
Chief mate	Chief engineer or 2nd engineer
Officer in charge of a navigational watch	Officer in charge of an engineering watch
Cadet	

See STCW Code Section A-I/1.

5) Configuration, description of main elements for the type of simulator. For instance specific class of own ship, or specific propulsion, or the status of specific elements.

6) traffic situation **if applicable**, from the following table:

NONE
SIMPLE, 1 per 10 minutes
MODERATE, 1-4 per 10 min
COMPLEX, 6 or more per 10 min

7) time of day **if applicable**, from the following table:

DAYLIGHT
DUSK or DAWN
NIGHT

8) current **if applicable**, from the following table:

NONE
REALISTIC (regarding AREA)
EXTREME

9) environment, as a description of wind, clouds, rain, snow, sea state, etc.

10) duration, from the following table:

SHORT, < 15 min
MEDIUM, 15-45 min
LONG, > 45 min

11) visibility **if applicable**, from the following table:

MORE THAN 8 nm
BETWEEN 2-8 nm
LESS THAN 2 nm
SUBJECT TO CHANGES (during scenario)

12) area, from the following table:

OPEN SEA
NEAR/IN TSS
COASTAL WATERS
CLOSE NAVIGABLE WATERS
NEAR/IN HARBOURS

13) description of main events during the scenario (max. of 100 words). The description should at least clarify the presence of sequential or coinciding of events and of failures and their kind.

Example: "For own ship A collision-possibilities have been programmed for minute 12 with target ship B from starboard and for minute 28 with target ship D from port while own ship A is then flanked on starboard by target ship C. At minute 9 a partial rudder failure will occur. At minute 21 a GPS failure will occur and the visibility will reduce to approximately 2 nm ultimately on minute 24".

Figure 5-1. ***A completed example of the scenario description format for project participants:***

identifying number	**COLLISION AVOIDANCE tp\polaroil\m\northsea\125.2**
training objective	1.2.1.1-1.2.1.3 (position plot, DR, EP) 1.2.2.1.11 (entering/leaving TSS) 1.2.2.1.19-1.2.2.1.23 (r15, give way, stand-on, four stages) 1.2.2.2.9 (call master when) 1.2.2.1.28 (determining risk of collision)
simulator tool	Full Mission Bridge
standard of competence	Officer in charge of navigational watch
configuration	Polar Oil tanker, 145m*23m*6.5m (draught) one propeller (no side thrusters) one Becker-rudder
traffic situation	Simple, 1 per 10 min
time of day	Daytime
current	Realistic, regarding area
environment	wind moderate, less than 6 BF, sea state 3
duration	Medium, 15-45 min
visibility	Subject to changes
area	Near/In Traffic Separation Scheme
event-description	For own ship A collision-possibilities have been programmed for minute 12 with target ship B from starboard and for minute 28 with target ship D from port while own ship A is then flanked on starboard by target ship C. At minute 9 a partial rudder failure will occur. At minute 21 a GPS failure will occur and the visibility will reduce to approximately 2 nm ultimately on minute 24

5.3.3 Results

Some 199 scenarios were acquired, covering part-task and full-mission simulators, appropriate for deck or engine disciplines. However, despite the standard scenario format, there was a predominance of scenarios acquired whose purpose is for the training of deck personnel. Furthermore, scenarios that have been collected to date are principally for full-mission bridge and part-task radar simulators and do not specifically address integrated bridge aspects of operations. It is also apparent that training objectives that expressly address the prevention of human factors related incidents need to be developed. Currently, training objectives designed to address skills based activities have been developed, but training objectives that address behaviour based activities are missing.

It is not surprising to see that every college responding has a radar simulator given that radar simulators were the first simulators to be developed. Furthermore, notwithstanding that the spread of the responses is patchy, it is apparent that there is a regional variation in simulator resources. We see that some member states apparently have a far more developed programme of simulator-based training, and a more comprehensive supply of simulator resources with which to effect this training. The Commission may wish to investigate these discrepancies further in order to bring about a complete harmonisation of simulator-based training.

5.3.4 Recommendations

The scenarios are presented as a reference guide for newly established simulator centres, or for centres that have acquired a new simulator that they did not previously have as part of their simulator resources.

Each scenario provides information regarding the appropriate competence level of the trainee for the events that are programmed into the scenario. The training objectives that the scenario is designed to test are also provided. However, the user of this guide is reminded that simulator exercises are dynamic. Whilst the essential components of the scenario are provided, elements that will enable an institution to develop a programme of simulator-based instruction, it will be the actions of the trainee that largely dictate the path the exercise will follow. This has implications for the ability of the instructor to manage and adapt to the situations that arise as a result of a trainee's actions. Moreover, critical to the value of any simulator-based training is the ability of the instructor to select the appropriate scenario for the level of competence of the trainees.

The Task 46 participants therefore recommend the following use of the scenario descriptions:

- The simulator-based training must form part and not the whole of the training undertaken by any trainee.
- The appropriate level of scenario difficulty must be chosen for the competence level of the trainee. The scenario difficulty is defined by:
    1. Speed of events
    2. Type and complexity of events
- Further usage of the currently available scenarios should not proceed without reading the work that follows in other work packages of this task, in particular WP 5. The translation of curricula into training programmes is a very important part of the process of developing a high quality education system and it is WP 5 that addresses the issue of instructional system design.

5.3.5 Human error in shipping

5.3.5.1 Human error

Introduction

In the paragraph above an overview is presented of the theoretical aspects of different forms of human error. In real life, accidents are the result of usually a multitude of events that were unforeseen. These can be of technical origin, uncontrollable events or caused by human errors or negligence. In 1987 a study of 100 shipping accidents (Wagenaar & Groeneweg, 1987) revealed that only 4 out of the 100 accidents had no preceding human error. The ratio of human error of these accidents to the total amount of causes underlying the accidents was 1: 6.5. This ratio should not be interpreted as an indication of a minor importance of human error in the causation scheme. On the contrary, the human errors were always crucial conditions. In 96 out of 100 cases the people involved could even have prevented the accident from happening all together. Another interesting finding was that the errors were made by one or two people. If one person is involved there is a possibility for correction. However if more than one person is involved on the other hand timely detection of possible consequences is often very difficult.

Classification of the human errors showed the relative importance of the different errors. Most important were errors on the cognitive level (70%), secondly errors as a result of situational stress (23%) and thirdly errors associated with the social system (7%).

The most frequent errors on the cognitive level were: 1) false hypothesis 2) habits 3) personality and training.

The most frequent errors on the situational level were 1) ergonomic aspects and 2) physical and environmental stress.

Errors on the social system level were almost exclusively linked to the social pressure placed upon people.

As a result of these findings, false hypothesis and habits were present in almost half of all accidents investigated. The overall category of cognitive problems accounted for 70% of the errors, and was present in 93% of the accidents. The data revealed that errors in the information processing and high situational stress are linked more frequently than expected by change. The other frequent combination was personality and social conditions on board.

Human error in recent shipping accidents

The study described above provided detailed information about the human error types in accidents and incidents in the shipping industry. It revealed the large contribution of human errors on the cognitive level to shipping accidents. The specific objective of the present study is, amongst others, to provide input for integrating human error elements in existing or new mission-based scenarios. For this reason it is essential that human errors are identified, classified and interpreted on a theoretical and abstract level, to ensure that the total variety of human error forms and levels is covered. Apart from this theoretical goal, the human error forms must eventually be translated in scenario elements to incorporate in scenarios and bridge resource management programs. It is therefore also of great importance to gain insight in specific events, circumstances and backgrounds of concrete behaviour and actions that people displayed in real-life accidents and incidents in the shipping industry. For this purpose a limited number of recent cases (1996) heard by the Dutch Shipping Council was supplementary examined. In this study the human error components in these cases were exclusively classified according to Reason's Generic Error Modelling System. Although the material provided by the council is public and relatively well documented, it has some limitations. It should be clear that not all incidents and accidents in Dutch coastal waters and/or with Dutch registered ships, are heard (and for this purpose documented). So, as a consequence this database is a sub-set of all accidents. The information available to the council is often provided by the people directly involved, and sometimes long time after the event took place. This could give way to undesirable memory and reconstruction effects and possible strategic presenting of circumstances and considerations, especially since the court decision could have far reaching consequences. This can result in opposing statements, without effective means to weigh them properly. Sometimes the people involved are not present at the hearing, sometimes there simply are no witnesses all together. The other complicating factor lies in the fact that sometimes the council has to rely on substantial amounts of additional information about the accidents provided by (external) experts on the basis of simulations and calculations afterwards. This procedure is perfectly well suited for use in the general reconstruction of course, speed, ship handling and or -manoeuvres, but not well-suited for gaining insight in the human error aspects of the events. These imperfections of the material with regard to human error are present in (almost) all available databases at present and cannot be easily overcome. Because of these limitations it is not always possible to ascertain to what extent errors or shortcomings contributed to the accident/incident. Because of this limitations and inconsistencies in the reports provided by the people directly involved, the emphasis of the limited study has been primarily on the contemplation and judging by the council. The main purpose was the identification an documentation of examples of human error and not to establish the causes and contribution to the accidents.

The data presented should therefore be regarded as the real life examples of human error forms on board ships. These examples will be essential and/or helpful in the process of translating the rather abstract human error forms in real life situations to be created in scenarios. Because of the fact that all three main error-levels can be present at the same time, the importance should be at the qualitative aspects of the examples and not at the absolute numbers encountered.

Results of the study

The study revealed that in the accidents analysed only 3 instances of clear Skill-based errors could be identified. In one occasion somebody forgot to switch back the mariphone to channel 16 after finishing a conversation with a colleague on a nearby ship (lapse). A skill-based slip was the result of an environmental capture by an incoming telex-message resulting in omitting an intended speed reduction and closely related to this omission, in a waypoint overshoot. Finally a slip was the result of being too preoccupied with manoeuvring the ship (overattention) and as a result ignoring all other relevant environmental information and in particular the radar information. This error could also be indicative of a training deficiency.

Mistakes on the Rule- and Knowledge-based level were present most often in the accidents. Mistakes on the Rule-based level consisted mainly of habitual behaviour as a result of applying strong and/or general rules. An example of this kind of mistakes is found in a collision between two fishing boats. Apart from other circumstances, one of the fisherman directly involved applied the (stereotype) rule that "fishermen never give way and always push through". This specific rule was used as the base for his action plan that eventually resulted in a collision. Although these rules do not necessary have to be held by all people, they were for the specific person rules to live by. Other Rule-based mistakes consisted of applying strong-but-wrong, bad or inadvisable rules. An example of an inadvisable rule was found also on a fishing boat. Common practice on board was that if anyone on the bridge needed to pee, they did not use the available toilet facility, but peed from a rail position on deck. This behaviour in combination with excessive alcohol intake resulted in the toppling over and drowning of the crew member. Mistakes more directly related to the nautical aspects of work were: deactivating watch-alarms and not using radar-alarms. Other examples of rule-based mistakes are: working according to unclear hoisting instructions, using advance data not suited for the specific speed and water depth, but also using a strong-but-wrong and inadvisable starting procedure for testing the engine with fuel instead of pressurised air.

Knowledge-based mistakes were also present in the sample of accidents. Especially errors as a result over overconfidence and selectivity/biased reviewing could be identified.

A clear example of overconfidence was found when a captain decided not to execute stability calculations because of his supposedly broad experience with the specific kind of deckload, cargo and consequences on the ship handling and stability. When the ship sailed into an area with extreme weather conditions (heavy seas and 10 Bft) this assumption proved to be wrong. The deckload was actually too high and too heavy resulting in a marginal dynamic and static stability of the ship. The result was that the ship was not stable enough to rise after banking as a result of wind or a slight displacement of the deckload (which actually happened). The ship became uncontrollable and eventually ran ashore. Another example of overconfidence was found on board a fishing boat. The crew member on watch did not considered it necessary to inform the captain of the rapidly decreasing visibility (< 1 mile). Although he was told by the captain to inform him immediately if something special came up, he felt (over)confident enough to handle the situation by himself because of the fact that he was the relieve master for that ship on a more or less regular base. When the captain came on the bridge the situation already was very confusing and complex. The ship was 3 miles from the harbour entrance, no visibility whatsoever, high sailing speed, communication problems with the harbour service, no accurate picture of the traffic flow ed.. The events eventually led to a collision with a dredger.

Apart from the slips, lapses and mistakes described above, the material also revealed that a number of *deliberate* and *conscious* rule-violation could be identified. In the overview of the accidents in the annex, the deliberate violations of rules are listed. This does not necessarily imply that *all* formal and informal law violations are mentioned in this annex. In retrospect, many of the wrong actions/errors can not only be catalogued as skill-, rule- or knowledge-based errors or violations, but often as formal rule violations as well. In this present study the emphasis have been on the *deliberate* and *conscious* rule violations. If the person was absolutely not aware of a formal rule or law to be applied in the particular situation, this is not listed as violation.

Many of these deliberate rule-violations involved some kind of corner-cutting behaviour or were closely linked to incompatible goals. Examples of corner-cutting behaviour are: sailing with overdraft, too much deck-load, no voyage planning or stability-calculations carried out, sailing too close to buoys, ships or other objects, not traversing traffic lanes squarely, ignoring sector lights, deliberately deactivating mariphone channel 16 ed. Violations can also be found in more organisational related rules. Delegation of responsibilities to unqualified personnel or the total absence or withdrawal of watchmen from the bridge all together were encountered.

In two instances excessive alcohol intake was closely related to the accident. Another form of organisational violations can be found in the absence of compulsory on-board training in for instance fire-fighting, and not executing the compulsory equipment tests or working with worn-out or outdated navigational charts to reduce costs.

The available information is unfortunately most of the times insufficient to draw any conclusions about the routine of exceptional nature of these violations. No single form of sabotage-behaviour (one of the violation-forms) was found.

Managing human error

As was described in Section 2.1 different error types have different psychological mechanisms. Some human error types are directly related to the limitations and specific functioning of the human memory, others are more related to mental models in use. The common factor in human error is that they all can be elicited by intrinsic and extrinsic factors. These range from memory and attentional limitations of persons to specific organisational, design and environmental aspects. Because of these differences in origin, each error type requires different methods of management. Unfortunately, although the error types are theoretically distinguishable, in real-life situations these types sometimes co-exist. In general the most structural and effective way of reducing human error is to limit the overall presence of general failures types that can provoke psychological precursors and substandard acts (pro-active). Limiting the general failure types can never entirely prevent all human error from happening. Therefore additional measures such as training people in optimising attentional checks and error detection strategies, increasing situational awareness, hypothesis testing and training in complex and ambiguous situations are always necessary to help further reduce the amount of human errors or else reduce the impact (re-active). In this study, the emphasis was particularly at identifying psychological and environmental aspects that should be incorporated in full-mission simulator scenarios to invoke and learn from different types of human error. Although the management of general failure types is the most successful pro-active strategy for limiting the number of human errors, this approach is not applicable to the relatively restricted simulator training situation and is therefore beyond the scope of this study. The main purpose in this study is to develop scenario elements with which people can be trained in identifying and coping with human error types and to increase the general level of realism of existing scenarios. Consequence of this is that the main accent will be primarily at (general) trainable aspects. Unfortunately not all error types or error aspects of human error are susceptible to training. It is not very fruitful to confront people with error types without some learning aspect or means of controlling them. Therefore only those elements that are to some extend manageable elements of human error, or those that raise the general attention level will be discussed. For some human error raising the level of training or knowledge will contribute to a moderation of human error, for others training cannot not prevent errors from occurring. For those errors limiting the potential damage by additional or special training in error recovery or early detection is the most feasible option.

Managing Skill-based slips and lapses

Basically slips and lapses are unintentional erroneous actions of people. People knew very well how to execute a specific action(sequence), but as a result of interruptions, strong habits, poor timing, omissions, the action failed to achieve its intended outcome. After completion of an action (sequence) or the use of an attentional check the error is easily detected. Performing the same action(sequence) for a second time is usually adequate. The action plan was all right but only the execution of the action went wrong as a result of preoccupations or distracters. These failures can result from under- as well as overattention. The characteristic cognitive processes of lapses and slips is that on the skill-based level the actions are performed parallel and without conscious effort or attentional checks. As a result of this, slips and lapses cannot easily be overcome or influenced by simply better training or by telling people to pay better attention next time. To prevent slips or lapses from happening all together will be relatively futile because the actions consists mostly of strong integrated and automatic actions (closed-loop) without many attentional checks. As a result of this characteristic there is no real sense in the additional training people in actions they know perfectly well how to perform. The action failures are the result of monitoring failures (in or overattention) caused by internal or external distracters or preoccupations. The existence of distracters are relatively hard to control. For this reason, instead of preventing lapses and slips from occurring, it will be more effective to limit the negative consequences if errors occur. In the case of slips and lapses this can mainly be achieved by providing additional structural (built-in) feedback on actions if something goes wrong (apart from tackling general failures on higher organisational levels). By providing this feedback, errors could be more easily and early detected. Once the error is detected, the correction is relatively straightforward.

The positive effect of specific individual training to prevent slips and lapses will be low, because the people know already how to act.

A simple solution for the prevention of slips might seem to be to 'de-routinise' all the day-to-day tasks. This would eliminate all the slips. If indeed a way could be found to do this, for instance by warning someone every 10 seconds that he should know what he is doing and realise the uniqueness of the situation, it remains doubtful if this option would be a beneficial one. The only reason why humans are able to perform a complicated task like driving a car and find their way through a city at the same time, is just because many of the programs involved in driving a car are automated. The Stroop task (Stroop, 1935) is an example of how two fully automated processes, reading and naming colours, can give way to slips if the two tasks have to be performed at the same time with conflicting information. The positive and the negative consequences of being able to perform such a complex task are the same: automation.

Managing Rule-based mistakes

Mistakes at the rule-based level can be characterised as *failure of expertise* errors. Actions are executed on a more or less conscious level and by open-loop processes. Environmental cues trigger the application of specific rules to a specific situation. Because of this expertise related aspect it is often relatively difficult for a person to detect a mistake. External feedback or intervention is often essential in detecting an error. The action can be executed perfectly according to plan, but the plan itself is wrong: applying bad rules, or misapplication of good rules. Rule-based mistakes can therefore mainly be influenced by enhancing the level of expertise and by increasing the number and quality of the attentional checks. If mistakes will occur another strategy is to limit the negative consequences. In Table 4 the characteristics of managing rule-based mistakes are summarised. In the first column, the characteristic of the problem area is prevented. The second column describes the tools for increasing the level of expertise. The third column presents the tools for limiting the negative consequences by optimisation of the error detection process.

Characteristic	**Training tools for increasing the level of expertise**	**Training tools for error-detection**
Knowing there is a rule	Training and education of the general professional basic skills	Training the rules (factual knowledge)
Knowing which rule is most suitable	Training in the selection and use of available rules	Training in given a situation, which rule is best applicable
Knowing how to apply the rule	Training in the optimal application of the person's expertise	Training in use of attentional checks on actions (self monitoring)
Knowing that the rule is not breached	Training the situational awareness	Training in active testing of alternative hypotheses Training in increasing the available information to reduce situational ambiguity

Table 4 *Managing Rule-based mistakes*

Managing Knowledge-based mistakes

Mistakes at the Knowledge-based level can be characterised as *failure of knowledge* errors. Actions are executed on a conscious level and controlled by the attentional mode. Mistakes at this level are made because the person has insufficient knowledge of the problem(area). This level of functioning is used for unique situations for which the person cannot use a suitable rule to apply. Mistakes at this level are difficult to detect The plan itself is not right, and based on a misconception of the problem, but the execution of actions proceed according to this wrong plan. If the action does not produce the anticipated results, the person has to diagnose the situation and/or action-effects again and to formulate alternative corrective actions. Often this is on trial and error base.

In Table 5 the characteristics, the tools for limiting the number of knowledge-based mistake and tools for limiting the negative consequences of knowledge-based mistakes are presented. The Table should be interpreted as 'building' on Table 4 some of the tools needed for reducing the number of rule-based mistakes can be used also to reduce the number of knowledge based mistakes. The training scenarios associated with the 'rule-based' reasoning involve familiar situations. In the knowledge-based training scenarios, new and unknown situations are presented without straightforward solutions. Rule-based reasoning will not provide solutions, as combination of rules and even inventing new rules is necessary. It is best to avoid knowledge-based reasoning at all. This can partly be done by reducing the number of new situations by presenting the crew with these 'new' situations in a simulator scenario and train them in the use of the available resources. Next time this situation is encountered, it is not 'new' anymore and rule-based reasoning can be applied.

Characteristic	**Training tools for increasing the level of expertise**	**Training tools for error-detection**
Knowing there is a rule	Training in infrequent or exceptional situations (develop suitable rules)	Reducing the number of infrequent situations by providing scenarios
Knowing which rule is most suitable	Training the situational awareness	Training and stimulation in the active testing of alternative hypotheses for the situation (optimal analyses of signs, countersigns and nonsigns);
Knowing how to apply the rule	Training the optimal application of the person's expertise	Training in the frequent use of attentional checks on actions (self-monitoring) Increase the amount and/or quality of relevant information at one's disposal to reduce the situational ambiguity
Knowing that the rule is not breached	Training in the handling of complex and ambiguous situations, increasing the abstract reasoning capabilities	Training in the use of external feedback on actions (bridge-resource-management) Optimising tasks and organisation (for example reducing stress, information overload)

Table 5 *Managing Knowledge-based mistakes*

Reducing errors at this level can be realised by for example better education, training, providing additional external feedback and control, better communication, better scheduling and planning of actions.

Although the cognitive processes underlying the human error forms are theoretically distinct, in real life situations they often are present simultaneously. The consequence of this fact is that no straightforward or simple solution is available to prevent specific human error forms from developing.

Conclusions

Human error is prevalent in almost all accidents, including accidents involving ships. Some of these human errors can be controlled most effectively by improving upon the individual, whereby others can maximally effective be controlled by changing the work environment.

This is illustrated in Figure 4.

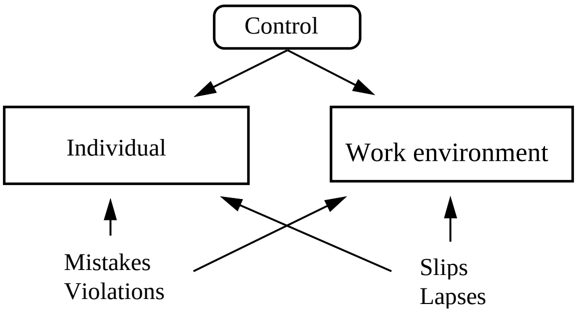

Figure 4 *The control of human error*

Changing the work environment falls outside the scope of this research project. This project aims at controlling the factors that can be improved with regard to the individual: the Mistakes and Violations. Controlling them involves more than only training in an simulator of practical technical skills: it should be aimed at the whole process of deviation control. A deviation of 'normal practice' must be detected, correctly diagnosed and appropriate action must be taken. Not in an individual setting, but each member of the crew as a part of a team.

To make the next leap in the control of human error, simulator training should be aimed at training the technical as well as the more social aspects of deviation control. How this can be achieved will be discussed in Chapter 4.

5.3.5.2 Training and simulators

Introduction

Chapters 2 and 3 introduced the three different levels of human error and how teach level can best be managed. Simulator based training should be aimed at the maximally effective controllable parts of human error: not at the work environment but at the individual level. A problem must adequately be diagnosed and appropriate action must be taken. The aim of training using simulators is therefore threefold:

1. Adequately diagnosing the situation, detection of a possible deviation;
2. Reduction of the occasions where knowledge-based decision reasoning is required;
3. Improvement of the knowledge-based reasoning process to allow for a more effective action execution.

The process from detecting a deviation given a situation to the response is illustrated in Figure 5.

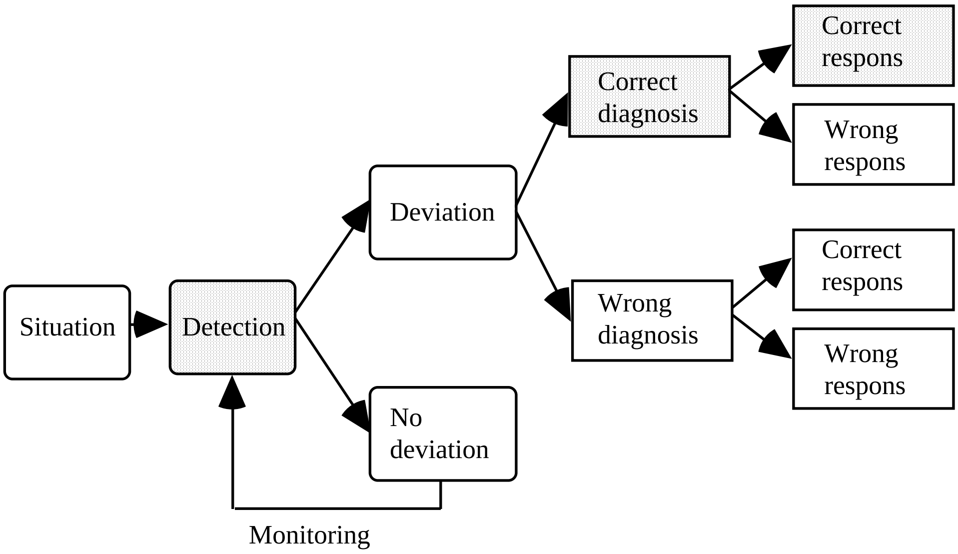

Figure 5 *The aim of simulator training*

The model describes the different stages of problem solving in a given situation. The aim is to arrive at the 'Correct response' by detecting a deviation, find out what the causes of that deviation are and generate the response. The boxes in the model represent either a situation or the outcomes of a process. The arrows refer to the distinct processes and involve the more 'organisational' side of simulator training. For example, to arrive at a correct diagnosis the crew must communicate effectively and have the right attitude, the captain must possess the necessary leadership qualities and information must be verified. The training objectives should involve the arrows, how can the process from getting from one box to another be most effectively managed. The effectiveness of simulator training however can only be verified at the 'box' level as these are the visible, recordable, observable and tangible outcomes of the processes.

Adequately diagnosing the situation.

A first requirement is a proper first diagnosis of the situation: the detection phase of a deviation. If someone does not know in which situation he/she is, it is impossible to take adequate measures. Essential is the concept of 'deviation'. Under 'normal' conditions, the crew can expect the ship to behave in a 'safe' way. The deviation from the 'normal' set of circumstances should be recognised and act upon. A first requirement is of course, that the crew knows what 'normal' is and how they can recognise a deviation. Simulator training can provide the crew with knowledge about 'normal' operations. This implies, that in simulators not only 'deviating' scenarios must be presented, but also scenarios in which nothing 'special' happen.

Reduction of the occasions where knowledge-based decision reasoning is required

The most preferable option is to avoid people having to think on a knowledge-based level at all. Numerous studies have shown, that even very experienced people suffer from a set of cognitive biases that prevent them from making proper inferences on the basis of the available information. The available 'thinking capacity' of people is limited. If someone is very busy solving a problem, it is almost impossible to solve another problem at the same time. The more tasks people perform 'automatically', the more 'thinking capacity' they have left for monitoring the navigation process, diagnosing the situation and for solving any problems that might occur. Knowledge-based reasoning uses more 'thinking capacity' than rule-based reasoning while skill-based reasoning requires almost none: behaviour is almost totally automated.

The difference between a very experienced person and a novice is the number of times thinking on a knowledge-based level is required. Compared with a inexperienced one, an experienced captain knows what to do in more situations because he/she knows they cannot only more adequately diagnose the situation they are in, but also know which rules to apply in the given situation. Some very complicated processes could even be trained to such an extent, that they become almost 'automated'. This will increase the 'thinking capacity' the captain has left for dealing with other problems. Simulators can help to increase the number of situations someone is familiar with and therefore help to reduce the number of occasions where someone has to resort to the much error prone knowledge-based reasoning.

More effective action planning

Not all possible situations can be simulated, either due to lack of imagination, knowledge of possible situations or time and resources available to extensively train the crew on the bridge. It is therefore essential that the crew on the bridge is made familiar with an extensive as possible set of rules that will allow them to reason more adequately. Simulator training should be aimed at increasing the number of rules available and improvement in diagnosing the situation.

Conclusion

The *main* aim of simulator training should not be the improvement of the knowledge-based reasoning process, but avoidance of this level of thinking at all. This might sound like a contradiction with what has been mentioned in previous Chapters. It was acknowledged, that people are not very good at knowledge-based thinking. Therefore, in the optimal situation it would not be necessary to act at that level. Given that this is not always possible, it is not possible to anticipate all possible deviations and it is not feasible to train a (applicant) navigating officer in handling all known deviations it is essential to optimise the knowledge based reasoning process.

The use of a simulator

A simulator can help the crew to achieve the two goals stated above on three levels:

1. Familiarise the crew with the situation on the bridge;
2. Familiarise the crew with possible scenarios they are likely to encounter;
3. Provide the crew with training in general rules of problem solving.

The situation on the bridge

This is the most fundamental advantage of using a simulator. The crew can familiarise themselves with all the equipment on the bridge an experience how they operate. In day-to-day operations, the crew should be able to work with all the equipment available without having to search for it or to wonder how to operate it. Simulator training should provide experience in:

- The use of the equipment under 'normal' conditions;
- The diagnosis of deviations, like breakdowns or malfunctioning;
- Continuing operations by repairing malfunctioning equipment, the use of back-up systems or improvisation in the use of other equipment.

Possible scenarios that are likely to be encountered

The crew should get experience in operating the ship under 'normal' situations. Ideally, a simulation of the critical stages, arrival in and departure from a port or docking station, should be rehearsed to the extent that it becomes almost routine. This will allow the crew to diagnose deviations from 'normal' more adequately: for an inexperienced person, almost everything could be a deviation.

Simulator training should provide experience in:

- The day-to-day routine of sailing the ship;
- Handling of the ship during critical stages;
- Familiarisation with the most frequently visited ports or docking stations;
- Diagnosing deviations from the 'desired' way of operating;

General rules of problem solving.

As the number of possible scenarios is infinite, it is not possible to simulate all possible deviations from 'normal'. Some of the accident scenarios are almost unbelievably complex and cannot be thought up in advance. There are however general rules of 'good seamanship' and they should be practised. Deviations are not dealt with properly, because the process is not managed properly: e.g. information is not communicated, external expertise is not used, necessary decisions are not taken or indications that the chose solution was not correct are ignored. Simulator training should provide experience in:

- The operating limits of the ship like: how fast can it go, how fast can it manoeuvre?
- Some well-known dangerous situations like adverse weather conditions or another ship in a collision course;
- Managing the deviation: leadership-skills, stress reduction techniques and communication skills.

In general, simulation training should not mainly be aimed at familiarising the crew with an extensive set of possible dangerous situations. Only the most 'common' ones should be practised. Training should be aimed at 'automatically' operating under 'normal' conditions, adequately diagnosing deviations and training in the management of these deviations. The skills profile of a person in charge during deviation control are listed in Table 6 (adapted from Flinn, 1996).

- Leadership ability
- Communication skills, especially briefing an listening
- Delegating
- Team management
- Decision making, under time pressure, and especially under stress
- Evaluating the situation (situation preparedness)
- Planning and implementing a course of action
- Remaining calm and managing stress in self and others
- Replanning to prepare for possible emergencies

Table 6 *Characteristics of a navigating officer during deviation control*

Table 6 shows, that deviation control is more than only diagnosing a situation adequately and take the appropriate actions. It involves a socially oriented process including consulting others and constant monitoring of the effectiveness of the chosen solution. If these processes are not adequately trained, there is little hope that people will effectively apply these skills in emergency situations.

Levels of training

There is an hierarchy in training needs. First skills must be trained and finally trainees have to be able to integrate all available knowledge to solve previous unknown problems. Each different acquired level of competence involves a different kind of training. It starts with obtaining factual knowledge and practical skills. It is not necessary that these skills are trained in a simulator environment. People can familiarise themselves with the learning material through reading, listening to 'experts' or by watching video films. The next level includes the study of practical examples. again not in a simulator environment but for instance in a class room. If people are not able to solve the problems in syndicate sessions with all relevant paperwork at hand, it is a waste of time to put these 'students' in an expensive simulator. Only after all these skills have been mastered and checked, it is appropriate to use simulators. This stage-approach is summarised in Table 7 (adapted version of Flinn, 1996):

Stage 1: Basic Training

Training method	Comments
Background reading	This can be a directed reading list, a specific text (e.g. Nautical Institute, 1986) or a specially prepared folder of course notes and supplementary articles
Lectures	These are given by experienced people from the organisation and guest lecturers from other agencies or academics
Video films	Specialist training films or footage of emergencies and disasters. Marine agencies should produce their own films.
Syndicate exercises	These are small group exercises, typically used to formulate a plan or to discuss a case study
Case studies	Very widely used and generally regarded as an essential component of deviation-control training

Stage 2: Practical but technically oriented training

Training method	Comments
Computer-based training	Used to provide individuals tuition, for example to develop ship training knowledge or learn relevant procedures. The systems can also be networked to provide an interactive exercise
Table-top exercises	This is a generic term covering a range of different types of low-fidelity exercises. They can involve ship plot plans, models and role playing. Paper-feed exercises include incoming information and status updates, often generated by a computer program
Floor-plan exercises	A version of the table-top exercise but with models laid out on a larger scale plan on the floor

Stage 3: Full integration of technical, and organisational skills in realistic settings

Training method	Comments
Simulators	Command training simulators can be high-fidelity technical simulators employed by realistic teams. The simulations include computer control and video projection
Exercises (on site)	Most organisations carry out in situ training and exercises on their premises. These exercises can also be assessed
Full scale inter-agency exercises	Designed for major incidents and disasters, typically involving high-hazards ships and multiple events in the scenario.

Table 7 *The different stages of training*

Each training stage adds to the optimisation of training requirements of people on board ships. Stage 1 provides training in the basic skills: individually or group wise trained. Scenarios are dealt with in a 'paper and pencil' very low fidelity environment. Stage 2 provides practical, but technically oriented training. Individuals are required to integrate their technical skills, but training is still in isolation. Stage 3 involves training in realistic high fidelity environment. The circumstances are 'real': the pilot may be on the bridge, the fleet owner might have decided to join on this trip and more than a single person is required to solve the problem at hand. Simulator scenarios will include new situations. Up to the Stage 3, the different kind of training fall outside the scope of this project. They are a 'prerequisite' for simulator training to be maximally effective. It must however be ensured that employees have the knowledge necessary to accomplish the basic tasks. A good training system will keep records of what people already know, or to test them to see whether extra 'knowledge training' is necessary (Redmill and Rajam, 1997). Written criteria for the performance of this knowledge should be in place.

Characteristics of simulator training

Simulator training should involve different aspects:

- Technical (skills, operating equipment);
- Personal (problem solving);
- Social (group processes).

Traditionally, simulator training is mainly aimed at the first two aspects. To be optimally effective, the social aspects should also be taken into account. Secondly it distinction must be made between diagnosing that there is a deviation and taking adequate action. The different options are presented in Figure 6.

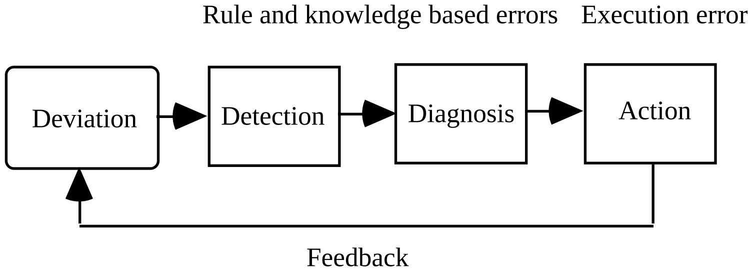

Figure 6 *The process deviation control*

People should be trained in detecting a deviation as well as diagnosing the cause of the problem. Simulator based training should not only include scenario's with an 'obvious' problem, but also more subtle scenarios. A small deviation can be the start of a serious problem. The sooner the crew has detected the problem, the smaller the problem usually is and the more time they have to remedy the situation. It is possible, that the deviation is such, that the situation becomes uncontrollable and the emergence response must be initiated. This is a different kind of training and not the subject of the present study. It is however very important that the (applicant) officer can diagnose whether a situation is 'out of control' or not. Simulator training should therefore include scenarios that can not be controlled by the crew and that require an 'abandon ship' course of action.

It is possible to test the detection and the diagnostic part of the process separately by presenting the crew with a 'given' situation and observe their reactions. In the 'easy' scenario the initiating event is completed while in a more difficult scenario the events are escalating. The number of people the necessary information is distributed, and therefore the number of people that must be consulted, can also change. There is a set of characteristics that influence the relative difficulty of a scenario. They are listed in Table 8.

Event Characteristic	**Relative easy scenario**	**Relative difficult scenario**
Speed of onset	Slow (hours, days)	Fast (seconds, minutes)
Warning	Prior indications	None
Preparation time	Long	None
Casualties	None	Many
Access	Good	Remote / awkward
Stage	Initiating event completed	Events escalating
Major risks	Single	Multiple
Decision demand	Routine, familiar	Complex, unfamiliar
Resources	Adequate	Insufficient
Knowledge of ship	Very familiar	Unfamiliar
Hierarchy	No hierarchical problems	Hierarchical problems
Social pressure	None	Severe
Time of onset	Day-time	Night-time

Table 8 *Event characteristics influencing the level of difficulty (Flinn, 1996)*

Simulator training should include some kind of 'building-up' of difficulty: starting with a relative easy scenarios the crew can practise for instance their communication and leadership skills as less effort is necessary in the detection and diagnostic area.

The scenarios should partly be based on problems identified in accident analysis (See Appendix A). For example, a captain interferes with the handling of affairs by the first officer. At night, the designated watchman should be on guard, but the captain decides that this person is needed elsewhere, for instance in a repair job. How does the first officer deal with this breach of the rules? Another example: the pilot makes an obvious blunder, but insists that he or she is correct. At what moment does the responsible person on the bridge decide that the pilot must be overruled? How can the crew detect a 'less than obvious' blunder, for instance in a harbour that has only very infrequently been visited?

Main advantages of using these relative easy scenarios are (Flinnn, Slaven and Stewart, 1996):

- Discovering how one responds and makes decisions under pressure;
- Practice in thinking of possible courses of action to deal with the deviation;
- Increase in self-confidence from having performed well;
- Opportunity to test the team structure and to identify strengths and weaknesses;
- An appreciation of the importance of communication during an incident.

In general, this kind of training provides the crew with insight into their own decision making process and leadership skills and into the reactions to stress that they are likely to experience in a real incident.

When these skills are mastered and have become 'routine', it is possible to advance to a more difficult level where all skills are trained and evaluated. It is best to use experienced people to generate the necessary scenario's or use 'real life' examples as the crew has an instinctive feel for scenarios that have little or no high fidelity with regard to the actual situations they are likely to encounter.

Evaluating performance

A set of criteria must be developed to evaluate trainees on. Feedback is an essential part of the learning process and should be carefully managed. It should be critical but constructive, designed to identify strengths as well as training needs within the required training framework. The Offshore Petroleum Industry Training Organisation (OPITO) provides standards of competence for handling the deviation (OPITO, 1992). The adapted version of the criteria is presented in Table 9.

Training objectives		**Performance criteria**
Evaluate situation and anticipate needs	a.	Information from all appropriate sources is obtained, evaluated and confirmed as quickly as possible
	b.	Valid interpretations of all evidence are made and valid decisions take throughout the deviation control process
	c.	Appropriate actions are ordered in the light of this evidence (this may include doing nothing)
	d.	Potential outcomes of the deviation are reviewed against consequences and probabilities
	e.	Resources to respond to the most appropriate outcomes are put in place as quickly as possible
	f.	Deviation-control teams are coordinated and directed in an effective manner
Maintain communications	a.	All essential people and organisations are immediately informed of the deviation
	b.	Reports of the situation as it develops are provided to staff at suitable intervals
	c.	Appropriate communications are maintained during the deviation-control process
	d.	An accurate record of all events and of key communications is maintained
	e.	Where possible, alternative means are put in place when necessary to maintain communications
Delegate authority to act	a.	Valid decisions are taken on which activities should be delegated in the light of the circumstances of the moment
	b.	Delegated activities are assigned to those most suited to deal with them in accordance with established procedures
	c.	Functions are clear and fully comprehended by those to whom are delegate (this must include the necessity to report back)
Deal with stress in self and others	a.	Symptoms of developing excessive stress in self and colleagues are recognised quickly
	b.	Appropriate action is take to ensure the continuance of the activities when stress is detected
	c.	Action is taken to reduce the stress in oneself and whenever possible in colleagues.

Table 9 *The OPITO standards*

At present there are no fixed criteria to evaluate the results obtained in a simulator training. The previous check-list can however form a basis to assess the competence of individuals in the training. The training objectives based on standards above are presented in Appendix B.

Conclusions

For simulator to be maximally effective, it is essential to train at four different levels. These levels are illustrated in Table 10.

Level of difficulty	Detection	Diagnosis	Remedial action
Very easy	Complete information	Complete information	Complete information
Easy	Complete information	Complete information	No information
Intermediate	Complete information	No information	No information
Difficult	No information	No information	No information

Table 10 *Four levels of difficulty*

In the 'Complete information' condition, the crew gets all necessary information, and no further reasoning, deduction, decision making or combination of information is required. In the 'No information' the crew has to make up their own mind about what is going on an what course of action will be taken.

In the easiest scenario, it is clear *that* there is a problem, *what* the problem is and *what* actions should be taken: a 'fixed' scenario. Only the quality of the executions of actions initiated can be assessed.

In the 'easy' scenario, the crew has top formulate an action plan, given that they know there is a deviation and what the cause of that diagnosis is. Assessment takes place on the level of action planning and execution.

In the 'intermediate' scenario the crew only knows that there is a deviation, but no clues are given to the nature of the problem or what the causes are. At this phase the diagnostic qualities of the crew can be assessed.

Finally, in the most difficult setting, the crew has to find out for themselves that there is a problem, what the causes are and which actions should be taken. This level of difficulty can be further refined by using the event characteristics listed in Table 6.

This Chapter has highlighted the requirements for training to make maximally effective use of simulators. These requirements are in the field of base-rate training requirements, the contents of the scenarios as well as with the assessment of the results.

5.3.5.3 Characteristics of scenario-based training

Introduction

In this Chapter an overview will be presented of general characteristics of effective scenario-based training. It must be emphasised, that no attempts are made to generate specific scenarios as it falls outside the scope of this report to do so. This list should serve as a guideline for building the scenarios and all aspects mentioned should be dealt with eventually. The list has four parts, distinction is made between the general characteristics, the detection, the diagnosing and remedial action planning and execution phase.

Phase	Characteristics of simulator training	Contents of scenarios
General	High fidelity	Real people involved (status, age, sex, position)
		Realistic scenario
		Realistic working environment (bridge and engine-room)
		New as well as familiar situations
		Successful completion of the scenario essential
Detection	Deviation detection	Small as well as large deviations
		No deviations at all
		Detection deviation outside the bridge
		Misreading due to malfunctioning equipment
		False alarms
Diagnose	Assessment of situation	Slowly escalating deviations
		Uncontrollable deviations (abandon ship)
		Real-time build-up, not 'jumping in the middle'
		Information only available outside the bridge
		External communication (on shore) required
	Social aspects	Status differences
		Social pressure introduced
		Obvious and not so obvious errors (blunders)
	Verification versus speculation	Ambiguous scenarios
		Feedback required on and outside the bridge
Action planning	Generating plans	Plans can only be executed in team
		Solution of problem outside the bridge
		Help from on shore is essential
	Executing plans	Failing equipment
		Insufficient means (e.g. personnel)

Table 11 *Characteristics of scenario-based training*

General characteristics

The scenarios must be 'high fidelity'. This means, that the scenarios must reflect the 'normal' situation as closely as possible. It is of no use to train people in situations they will not, at least in the foreseeable future, be placed in. If the coping with the possible negative effects of hierarchy are trained, role-playing for instance by applicant officers will not produce the desired effects. For the hierarchy effects to emerge the role of a senior navigating officer for instance should be played by a person who has the right experience and age for this. Denying those status differences will result in less than optimal training.

The scenarios must be realistic and involve new as well as familiar situations. The working environment should resemble the 'real situation' as closely as possible and should involve engine room monitoring (from the bridge) and internal and external communication as well.. It is of no use to present far fetched scenarios. These scenarios are best constructed by very experienced experts, with years of hands-on experience. People have a 'sixth sense' for artificially constructed scenarios and their first reaction to the scenario will be: 'this could not happen on my ship'. The result is, that they spent a substantial proportion of the scenario time discussing 'why this scenario is unrealistic'. Sometimes these inconsistencies with 'real' can be quite subtle to an 'outsider': the placement or availability of equipment, people who can or cannot be reached, or equipment (mal)functioning in an 'impossible way'. Only very experienced people can judge the scenarios on 'realism'. It is strongly recommended that any scenario will tested in a pilot-study before being issued.

Detection

In the detection phase, the crew must be trained to detect a problem as soon as possible. Often a scenario presents the crew with a complex situation. To train the detection process, it is necessary to present subtle as well as more obvious deviations. In some cases, no deviation at all should be presented. This enhances the perception of the crew of how important a quick detection is. By waiting for 'something to happen' the crew realises that in 'normal life' they consider the 'no deviation' situation as 'normal'. In a scenario training this is however very much against their expectations. The aim is to let the crew realise that under 'normal conditions' they should also be expecting something to happen and not become complacent.

Small deviations are introduced to let the crew realise that little things can have big consequences. This can be a failing meter or a short power surge. False alarms have to be introduced: scenarios where failings have indeed almost no consequences. The aim is again to fight complacency: the crew must realise that any deviation is worth to be detected. Whether these deviations are the symptoms of larger problems is something that will be dealt with in the diagnose stage.

Diagnose

A correct assessment of the situation is essential to be able to generate correct action plans. After a deviation has been detected, an active search for the causes of this deviation must be initiated. Essential is, that any individual must realise that only in a minority of cases they are able to diagnose a situation correctly on their own. Social interactions are introduced, by forcing for example the (applicant) officer to ask others what is going on because the necessary information is scattered over different people. Sometimes the necessary information is not even 'on board', contact must be established with on shore authorities.

The scenarios should not be too obvious, sometimes even ambiguous. They should not escalate too fast: a slow build-up of the problems, with a delayed influx of information will force the crew to reassess their diagnosis during the process. By teaching them that verification is an essential step it is possible to avoid speculation.

Disturbing factors must be introduced, like social pressure and hierarchical problems. If a superior makes an obvious blunder during the diagnosing by stating very firmly that 'this is the problem', how does someone lower in rank react? Status is not always a predictor for the ability to diagnose a problem correctly: everybody on board is a specialist in their own field. The crew must be trained to accept that superiors can fail and that 'lower status' people can be correct in assessing the situation. The (applicant) officer should be judged on how well the information obtaining process is managed.

Sometimes, the diagnosis should include the conclusion 'abandon ship' as the inevitable outcome of the reasoning process. Some deviations are not controllable and damage control is all the crew can do. At what time does the (applicant) officer consider the situation hopeless and is that too late or too soon? How much, sometimes implicit, pressure does the (applicant) officer feel from the company on shore when the decision has to be made to abandon ship. Communication with on shore authorities must be established and the emergency response must be managed. Simulator training is not intended to make hero's of crew members: it is intended to reduce the number of cases where abandon ship is necessary, but the illusion should not be stimulated that all problems can be handled.

Action planning

The action planning stage involves the planning an executing of plans. This stage should be judged independently from the previous stages. It is very well possible that the crew has diagnosed the problem completely wrong but, given this assessment, they make the right action plan.

In the scenarios a mix should be presented of plans that require only an individual to take action and scenarios that require more members of the crew to be involved. How well does the captain manages to delegate responsibilities to people on and outside the bridge? The solution of the problem can be locate outside the bridge, the responsible crew member should direct someone to that place to solve the problem and provide feedback on the situation. Sometimes the expertise is only available on shore.

During the execution phase, things can go wrong too, like: equipment can fail, equipment can turn out to be damaged beyond repair or back-up systems can fail. It is also possible that the action plan requires more personnel than is available on the ship. The assumed number of people available may not match reality: people can be killed, wounded, stressed out or lost on the ship and nobody can reach them.

Conclusions

In this Chapter, the characteristics of simulator-based training have been discussed and how these characteristics can be operationalised into training scenarios. Essential point from a 'general' point of view is 'realism'. Only realistic scenarios in a realistic setting will enhance knowledge based reasoning and allow for a fair assessment of the performance of the crew.

The crew should go through the whole scenario from start to finish: the feedback on how well they have performed should involve all three phases. It is realised that the number of different characteristics does not allow for a 'quick and dirty' scenario-based training program. The number of factors involved is large and the number of possible different scenarios is vast. It is inevitable that compromises must be made and that some characteristics will not be tested or only tested indirectly. It is not possible to give general rules of thumb on which characteristics are to be left in the training program and which can be left out. However, scenario-based training should always include the 'not so catastrophic' scenarios in which it is not so obvious that there is a problem and that it is not so crystal clear what the cause of the problem can be. Furthermore, it is essential that the social interactions on board are included in the scenarios.

5.3.5.4 General Conclusions on human error in shipping

Almost all accidents have a human error component and shipping accidents are no exception. One way to improve on the safety record of ships is to tackle the human error component in accidents. Chapter 2 indicated, that not all kinds of human error can be eliminated using simulator based training. An inventory was made of error types and how they can best be managed.

The Tripod theory was used to describe the limitations of simulator training. Some kinds of human failure can only be eliminated changing the work environment. Changing this work environment is not within the scope of this project. So, simulator training can only be partly effective. The message is therefore positive as well as less optimistic. Given the restrictions, it is possible to make a major leap in performance by using simulator based training. All organisation employing simulators for training and assessment appreciate that performance in a simulator will not predict with 100% accuracy performance in 'real life' situations. It is acknowledged, that at least some skills can be trained more effectively in a simulator than 'on board'. Simulator training can help to reduce the human error component in accidents. A general guideline for requirements for such a training are described in Chapter 4.

To make the training optimally effective, not only the technical and personal aspects of responding to a deviation should be taken into account but also the social aspects. The organisation of the process of detection, diagnosis and initiating the response to eliminate the deviation is as important as the more 'technical' aspects of for example being able to handle the equipment appropriately. It is absolutely essential that the situation during the simulator training reflects the 'true state of affairs' as closely as possible. When training applicant officers, an experienced captain should be the captain in the scenario and not someone who has never been a captain at all. The hierarchy on board should be reflected in the scenarios.

The crew should operate as a team and not as a set of individuals. Group processes can markedly improve the quality of decisions made. 'If these processes are not managed properly, the results can be very negative. The introduction of group processes in simulator training does not interfere with the authority structure on board at all. It is the Captain who has to take the final decision, but in order to take the best decision, he should communicate his diagnosis with others, test his hypotheses and ask for advice of local experts. The Captain should safeguard that the process of deviation control is handled optimally and the only way to achieve this goal is by providing the captain as well as the crew with realistic simulator based training in which these group processes are taken into account.

5.4. Determination of Gaps and Shortcomings

This work package formed the hinge of the project. The initial definition of training objectives and collection of existing training scenarios lead to gaps between the STCW based covered training objectives and the non-covered STCW training objectives.

The shortcomings refer to the extra. Non-STCW but important training areas, where simulator could play an important role e.g.:

- ECDIS
- HSC
- Integrated bridge
- Human Factor related.

The gaps and shortcomings are summarised in a report and used to define the follow-up actions for WP 5, where additional training scenarios were set up.

5.5. Provision of Scenario Methodologies and Scenarios

Within MASSTER, WP 5 has two main objectives. The first is to provide scenario methodologies and the second is to provide scenarios for the areas marked as gaps, resulting from the previous work package, WP 4.

5.5.1 Introduction

WP 5 provides guidelines for the development of scenarios for use on maritime simulators. In addition WP 5 gives a number of (new) scenarios that, in addition to those collated from European Institutes in WP 3, will cover the areas of particular interest. The elements of which a scenario consists are all described in a generic way, thus enabling any maritime simulator centre to use and adhere to the scenario-definition.

The development of scenarios can be considered to be part of the development of training programmes or training courses. According to the STCW training and assessment of seafarers must be *structured* in accordance with *written programmes*, and conducted, monitored, *evaluated* and supported by qualified persons.

Furthermore STCW prescribes that the education and *training objectives* and related *standards of competence* to be achieved must be *clearly defined* and identify the levels of knowledge, understanding and skills.

When it comes to using simulators for training purposes STCW requires that the *aims and objectives* of simulator-based training are *defined within an overall training programme* and also that simulator exercises are *designed and tested so as to ensure their suitability for the specified training objectives*.

The above mentioned STCW requirements are all derived from Part A, which is the mandatory part. Within these requirements and assuming the existence of an overall training programme the development of scenarios will be further operationalised in WP 5.

Within WP 5 three methodologies are described. The 1st methodology follows a top down educational approach, starting by a clear definition of the training aim and from thereon descending via certain steps to the level of the scenario-elements and the scenario itself. The 2nd methodology is about computer supported generation of scenarios via links between scenario-elements and themes or training aims. This methodology still has to be further developed. The 3rd methodology is based on collision avoidance settings. Finally, albeit not a methodology as such, some interesting work on the phenomenon of ‘personal styles’ is being reported on.

The following subjects, derived from the final report of WP 5, will be part of this extended summary:

1. 1st methodology
2. 3rd methodology in combination with the personal styles

5.5.2 1st Methodology, Educational Approach

The simulator training must clearly identify the education and training objectives, the standards of competence and the levels of knowledge, understanding and skill. This means that simulator training should be comprising the following:

- one or more scenarios (in accordance with [2]); and
- an assessment standard, stating the assessment criteria by which the performance of the trainee can be appraised.

Both the scenarios and the assessment standard have to be developed, prior to the training. The following figure shows schematically the processes involved.

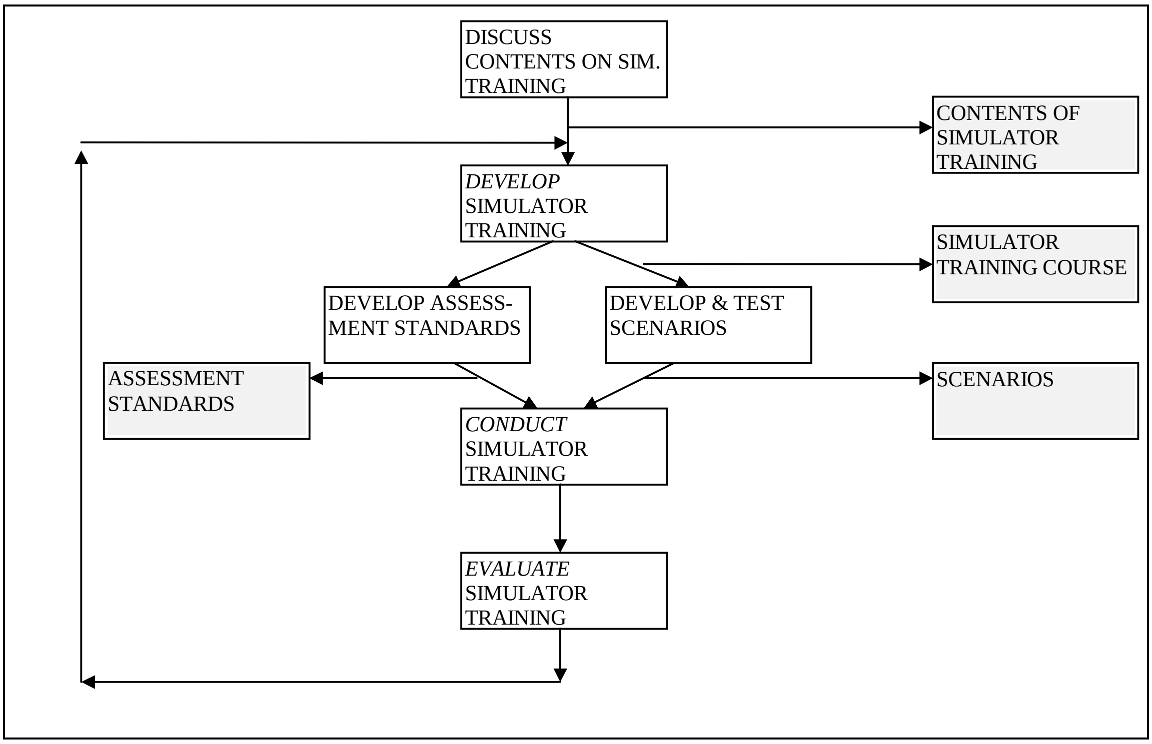

Figure 2 Simulator training development

In this figure the shaded boxes contain documents or written results. The other boxes are about a certain process. The three main processes are the *development* of simulator training, the *conducting* of the simulator training (including briefing and debriefing) and the *evaluation* of the simulator training.

The development process itself can be split further in developing the *scenarios* and in developing *assessment standards*. The methodology for both processes is discussed in WP 5.

Choosing the objectives

As mentioned before the definition of the objectives of any training is very important. It forms the starting point for the development process. WP 5 gives a helpful overview of main themes that can serve as the framework within which the objectives are defined. The following figure shows these themes.

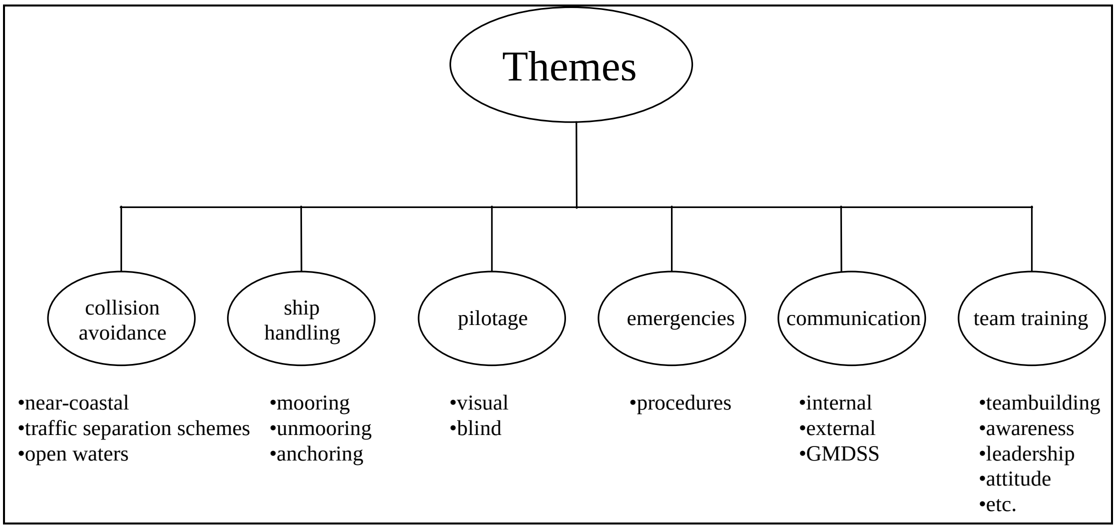

Figure 3 Themes for simulator training

During the process of developing the scenario and during the process of developing the assessment standard, it is useful to realise which of the themes will be emphasised in the simulator training. The themes can be considered as a division of the main tasks that the trainee has to deal with.

Consequently this means that depending on the theme, different scenarios and most likely different assessment standards may have to be developed. A scenario for training ship handling will differ from a scenario on collision avoidance in open waters. On the other hand, a scenario used for collision avoidance in close navigable waters may perhaps suit the purpose of team training as well, be it with a different bridge manning and perhaps a change in the (type or sequence of) events.

When it comes to choosing the relevant (set of) training objectives within the overall objective of the training, the catalogue on training objectives developed in WP 2 will be extremely helpful. The catalogue contains approximately 1000 objectives and is a straightforward elaboration of the objectives mentioned in STCW. These are all categorised by the function (STCW defines 7 functions) and the level of responsibility (STCW defines 3 levels here).

The objectives form a precise statement of intent, stating systematically:

- what the trainee should be able to do at the end of the training scenario (final behaviour), specifying what you are going to observe;
- the conditions under which the trainee should be able to exhibit the final behaviour, so you can be sure that 'under-performance' is not due to causes other than 'under-learning';
- the assessment criteria by which the performance can be measured

To enable easy references, a number identifies a training objective.

Completing the scenario

The following steps of the scenario development process are about the establishment of all relevant scenario elements. This is very much an iterative process. During this part of the process, the division into main training themes can once again be useful in making the decisions about the scenario elements.

A scenario contains the following elements:

- simulator tool
- standard of competence
- own ship's configuration
- traffic situation, if applicable
- time of day, if applicable
- current, if applicable

- environment, if applicable
- duration
- visibility, if applicable
- area
- description of sequence of events

Special attention is drawn to the description of the events and the sequence these are in. This element is very closely related to the training objectives and the standard of competence. Most probably there will be more than one description of sequence of events suitable for the same training objectives with the same standard of competence.

Assessment

Although the Assessment Criteria are not a separate scenario-element, they are **linked directly** to each of the training objectives. For each training objective there is at least one assessment parameter and sometimes more. This link is particularly important for the actual training.

A complete overview of the Assessment Criteria that may be used for any training objective is given in the WP 5 report (Appendix B).

The following figure shows the steps in the scenario-development process.

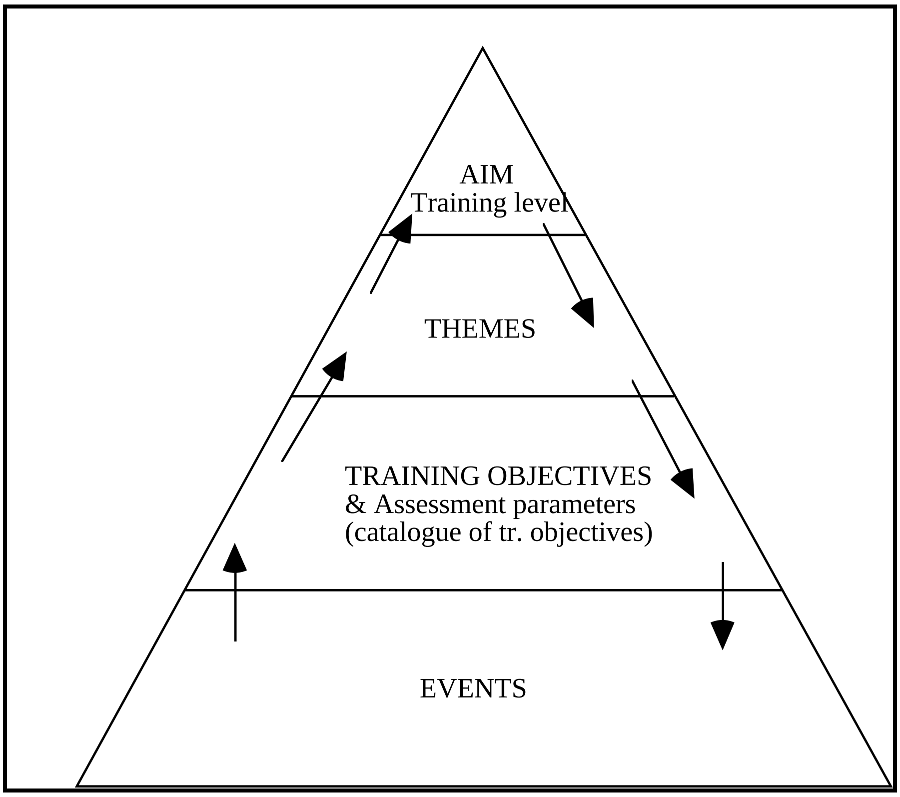

Figure 4 Steps in scenario development

The feedback arrows represent the confirmation-checks, which are needed between each step of the process. As mentioned before, the definition of the scenario elements is an interactive process. Different sequences of events can be used to reach the same set of training objectives.

5.5.3 3rd Methodology, Collision Avoidance and Personal Styles

Collision avoidance is a task that is carried out by all ranks of deck watchkeeper, whether the most junior of bridge officers or by the ship's Master, sometimes after a panic call from the bridge and consequently "in extremis". It is often the main function of a single watchkeeper especially when out of sight of land or coasting. Manoeuvres taken to avoid collision are based on a thorough understanding of the "International Regulations for the Prevention of Collision at Sea (IRPCS)", which comprise 38 rules divided into five parts with a further four annexes.

Collision avoidance exercises, coupled with a comprehensive assessment programme, using a ship simulator provide excellent training and assessment for bridge watchkeepers and Masters.

It is by now well established that simulated collision avoidance exercises provide effective training for watchkeepers. The main objectives of the training are to provide opportunities for instruction in situation handling, and feedback on performance under monitored conditions. There are, however, other possibilities for using simulator training, which recent research are beginning to reveal.

It has been observed that there are few in-service opportunities for situational learning available to working watchkeepers other than those provided by their own experiences. Working with simulators can provide accelerated experience of relatively infrequent situations, in which watchkeepers can monitor and reflect on their own performance. It is also important that the members of bridge teams get to know how others react to particular situations, which assists in forming a "collision avoidance culture" in the team; this can also be easily accomplished with simulators if the results of exercises are compared amongst team members.

Finally, recent work suggests that individual watchkeepers may develop identifiable patterns of behaviour in certain circumstances (e.g. turning to port to avoid another ship) which if manifested in simulator runs is likely to predict their performance at sea. Some of these "styles" of collision avoidance may be less safe than others and the simulator environment may be a desirable way of identifying and remedying them. Further work on these topics is to be reported in the next paragraph.

Research on Personal Styles

It was noted in a research study which used qualified seagoing watchkeeping officers and cadets undertaking their watchkeeping task in a ship simulator that the most important source of uncertainty in collision avoidance manoeuvres is the alter course distance. Analysing these results, it was noted that a large proportion (66%) of this was due to consistent differences between mariners. A smaller proportion (12%) of these differences is traceable to "historical" factors such as mariners' trading type and qualification. *However, this leaves a considerable part of the inter-mariner difference untraced; i.e. mariners have typical "idiosyncratic" habits of collision avoidance*, which do not apparently relate to any known or predictable characteristics. It was also noted that the inexperienced cadets did not show idiosyncratic behaviour and their performance, although more formal in intention is more variable in execution.

This suggests that mariners develop habitual and typical collision avoidance behaviours mainly as a result of their own experience. One of the possible implications from this research study is that if individual styles include rule violations, the individuals showing these styles are likely to violate the rules more often than others, and so become potential "accident repeaters". Identification and remediation of these individuals would thus have a greater influence on overall safety than more general measures of control.

The normal practice of watchkeeping officers in avoiding collision, when the Closest Point of Approach (CPA) is zero by altering course to port or starboard or slowing down is underpinned by the Collision regulations and by what is considered acceptable practice at sea. A series of collision avoidance scenarios with non-zero CPAs indicated that there are nodes of uncertainty for which there is no prescribed action and at various points in the encounter between two ships the alteration of one ship is likely to change in direction and amount. Simulator scenarios constructed to represent these particular situations cause considerable variations in watchkeeper response. At sea, this can cause considerable uncertainty in the minds of the watchkeepers on both ships.

This research study used a considerable number of practising watchkeepers and cadets and the researchers undertook other studies to ensure that the use of a ship simulator was a reliable vehicle for indications of collision avoidance methods at sea. However, this initial study was carried out 9 years ago, using British watchkeepers and cadets in a ship simulator with a nocturnal visual scene only and non - ARPA facilities. .

Within the methodology of WP5.1, it was decided to find out if these findings could be repeated, albeit on a smaller scale, using practising Dutch watchkeeping officers, in a daylight/night-time ship simulator equipped with modern ARPA radars.

Methodology

10 Dutch watchkeeping officers performed the collision avoidance tasks during one day at on the simulator, and returning 9 weeks later for a further day.

It was necessary within the methodology for the watchkeeping officers to undertake three exercises, which geometry could be repeated unrecognised to the watchkeepers when they came the second time. This was to provide an indication of consistency in individual behaviour.

A series of collision avoidance scenarios were written, 3 of which could be repeated. In order for an exercise to be repeatable the watchkeeper was given the same situation twice; once during his first visit to the simulator and again on his return 9 weeks later. In order that this should not be recognised by the watchkeeper as such, the geometry of the interaction between the watchkeeper’s ship and a specified target vessel was rotated, clockwise or anticlockwise and other “distracter” ships added. This provided 6 exercises. A further 6 exercises were written which were designed to provide more information on modes of uncertainty.

The chosen design for the repeated trials involved balancing the order of the two versions of each exercise, and embedding them in the series of six exercises to be performed by the watchkeeper in each week in such a way as to balance as far as possible their position in the series (excluding the first and last trials), and the sequential order of the exercises.

The general hypothesis to be tested in the experiment was that mariners would exhibit some aspects of personal style in their approach to collision avoidance situations, which would show up as consistent differences between their actions. Translated in a scientifically testable hypothesis, this implies that on any given measure of performance there would be a significant variance component attributable to the inter-watchkeeper component in a general linear model of repeated trials of exercises on a population of watchkeepers.

Rather than choosing a specific performance measure for which to test this hypothesis, as had been done in the earlier study, it was decided to test a slightly different hypothesis: that if a panel of judges examined the track charts of repeated simulator exercises performed by the population of watchkeepers, and were asked to group them according to which individual had produced each track chart, that they would produce a better-than-chance grouping; i.e. that they would tend to group together runs performed by the same individual based only on their perception of the recorded behaviour. This method has the advantages of providing an easily testable null hypothesis (that the grouping is no better than chance), and also that no specific geometry of collision avoidance behaviour need be selected for analysis.

As an extra result, the numbers of correct matches achieved by four members of the experimental team, working without specific recall of the data collection procedures , were considerably higher than the above.

A less formal technique was used to investigate results from the "filler" trials, given to the mariners between the paired repeat exercises. At a qualitative level, it could be seen that certain collision-avoidance tendencies seemed to be used more often by some mariners, and not at all by others. These tendencies included turns to port (particularly to avoid ships approaching from the port side), slowing down, and standing on into very close-quarters situations.

Conclusions and Recommendations

The conclusions at this stage of the investigation can only be tentative, but do point to a *confirmation of the idea that mariners develop personal styles of collision avoidance*, which in some cases are recognisably their own. If this is so, there are important implications for training in collision avoidance. If an individual develops a style of avoidance, which is unusual or even dangerous, this may persist and eventually cause misunderstanding or mishap; this corresponds to the *'accident-repeater' notion* in theories of car driver behaviour. This implies that training or retraining of specific individuals with certain styles will have a greater-than-average impact on the general level of safety.

5.5.4 The provision of scenarios for particular or new areas

In the previous work-package, WP 4, a number of areas concerning the gaps and shortcomings have been identified. In order to complete the catalogue on scenarios, resulting from WP 3, new scenarios have been developed for the following areas:

1. Human Factor. Human factor is identified as being the largest contributing factor when analysing accidents or near misses. The abandoning of the idea of training mariners to become without any faults has led to a whole new category of courses and/or (team) training programmes, in which *human-error-control* is the central issue. To get a good understanding of the different types of human-error and the way to deal with them, a separate report on "Improving Human Error Control in Maritime Simulator-based Training" has been drawn up as part of WP ¾. It is this report, call it the grammar on Human Error Control, that forms the basis for the scenarios that were developed under this heading.
2. High Speed Craft. High Speed Craft are being used more and more, both on inland waterways and on the open sea or in straits. This development has caused much discussion whether the normal ship status applies also to these vessels. Nevertheless, an additional set of training objectives and assessment criteria as well as a number of scenarios using these objectives were developed for High Speed Craft.
3. ECDIS. It is expected that ECDIS will be used more and more in the years ahead. Being such a significant change to the conventional sailing with paper charts, an additional set of training objectives, assessment criteria and scenarios has been developed.
4. Integrated Bridge Systems (IBS). Even more so than with the ECDIS, a fully integrated bridge calls for additional training objectives, assessment criteria and scenarios. Compared to the conventional bridge, operating a ship with an IBS may do away with a number of fault-possibilities, however, a whole new category of fault-possibilities will come in place.
5. Emergencies. One of the gaps resulting from WP 4 was training for emergency situations. For a limited number of emergencies, like fire, grounding, SAR and collision, new scenarios have been developed for this category.

The scenarios reported in the above five groups mainly represent the developing trends. As these were not closely linked with or covered by the 95 STCW Convention additional scenarios were developed. It is expected that the above areas remain the focal points for maritime simulation for a number of years to come and that the number of scenarios will continue to grow.

5.6. Assessment development and demonstration

5.6.1 Introduction

As was mentioned in the project bible, the overall objective of Task 46 was the inventory of existing scenarios and the development and documentation of new scenarios based on the assessment of gaps and shortcomings in the currently existing scenarios.

This report describes the results of the efforts done within the framework of WP 6: “Development of training assessment tools to be used in improving scenarios”. This WP contains two sub work packages:

The objectives of SWP 6.1. were the “development and adjustment of tools for the assessment of training aims to be reached through finally catalogued scenarios on technically capable simulators”

The approach taken was to limit the number of necessary tools by categorising the training areas into measuring three kind of objectives (1) the levels of skills, (2) the correct application of procedures and (3) the attitude of the trainee.

It should be noted here that the attitudinal aspect of assessment, or the human factor aspect in general, has been gaining in importance during the last four years since the proposal was drafted.

In these three areas assessment tools were further developed and evaluated against the background of the earlier definition of tasks, training aims and scenarios and with a view to the newly brought in training elements focused on creating and stimulating awareness and other cognitive failure based training elements. In the next paragraph the BRM based assessment development is further elucidated. The two other assessment tools on collision avoidance and High Speed Surface craft are reported in [9].

5.6.2 The development of a Bridge Team Training Assessment scenario

Introduction

The STCW’95 regulations do not require any specific assessment of students based on the use of full-mission simulators, let alone an assessment on human factors related issues. However human factors do play an important role in navigation. In addition to the basic skills and knowledge of rules required for the normal navigation circumstances exceptional situations, often dealed with by teams rather than individuals, do require other capabilities. These capabilities are to some extend required for all members of the bridge team. The more and more accepted bridge team training programs do refer to these themes.

Full mission simulation is an exceptionally good tool to demonstrate, train and assess the navigators qualities related to human factors. Future definition of seafarers education requirements should incorporate these qualities, in particular in a more demanding working environment with lower manning levels, different nationalities and diminishing sea time experience. The further on described assessment scenario on human factors is a ‘bridge’ too far within the scope of STCW’95 but hopefully a guide for the further introduction of bridge team training and assessment.

It goes without saying that only through assessment the real added value of bridge team training can be valued. It is believed that the developed assessment scenario is an example for many future scenarios to be developed. The assessment itself can be made appropriate to any level of education through defining the weighing factors of the objectives under assessment and setting the criteria levels for the final assessment.

This assessment scenario is prepared for mariners who are on the edge of becoming a master.

Approach

The set-up of the assessment scenario and the successive development is embedded in a wider nautical setting. During the preparations intense discussion have been held with the participants within MASSTER who did prepare human factor training objectives as deduced from marine accidents [1]. Further discussions are held with the Dutch Pilot organisation who also have a lot of experience as co-owners and developers of one of the first Bridge Resource Management courses based on the SAS Flight safety courses [2] and last but not least the Dutch Ministry of Public Transport has been involved as current applicant of a range of assessment tools of which one was developed at MSCN together with RUL. The sub-contractor EMC has been involved as advisor on educational and training aspects

The co-ordinated contribution of these participants did lead to a balanced assessment scenario with set priorities on the earlier defined training objectives (WP 3&4) as to be addressed within this scenario. Their contribution has been of great value for guaranteeing a realistic, pragmatic and easy to control scenario in which the occurring events were logically developing, appropriate to the chosen assessment level and exposing the assessment candidate to a sufficient degree in order to evaluate the candidate.

Scenario

The scenario for the assessment test is developed to assess trainees at management level in the capacity as captain. During this test, the candidates will experience real-life situations.

The candidate will act as captain on board of a general cargo vessel on its way to Rotterdam Port. Weather conditions: wind W 4-5 Bft, current NNE 2 kn, waves 1.5 m, with a visibility of approx. 6 miles. It is 20.30, and it is not yet fully dark. The third mate has taken over the watch at 20.00 from the first mate, with the instruction to “call” the captain (candidate) as soon as the vessel is next to the MN4 buoy and will sail into the traffic separation scheme. The pilot is expected to embark at 21.00 at port. The time is now 20.30 (time 0).

The assessment test will start at 20.30 hrs, when the watch is handed over by the third mate in a position east of the MN4 buoy in the traffic separation scheme “Maas Noord”. The vessel is sailing on a southern course with a speed of approx. 15 knots. At the bridge the third mate and the helmsman are present. Close to the buoy Maas Center the pilot will embark, after which the vessel will sail into the Maasgeul.

The candidate will be faced with an incomplete hand-over of the watch, a boatswain asking questions about the anchors, an agent who needs information which must be given and verified, and at the same time an VHF call, a complicated traffic situation and the embarking of a (tired) pilot. As soon as the pilot has embarked and the vessel is gaining speed again, the purser will come to the bridge and ask the pilot what he would like to have for dinner. About the same time there is a problem in the engine room, as a result of which the engine is not immediately giving the requested power. The pilot does not notice this and fails to adjust for the current. If nobody takes action, the vessel will drift to the north and a dangerous situation with meeting vessels will occur. The test will end west of the port entrance after approx. 45 minutes, when it is almost dark.

Appendix A of [9] contains a more elaborated version of this scenario.

In addition the following roles have been further defined in a so-called briefing sheet:

- Instructor (overall control, all VHF communication and the role of boatswain)
- Third mate
- Pilot
- Shipping agent
- Purser

Methodology

This paragraph describes the methodology in setting up the scenario, which is described in the previous paragraph, and also in preparing the assessment-protocol. The assessment-protocol is the list of questions that the assessors will fill out during and directly after the execution of the scenario. Here, the method of using two assessors simultaneously has been applied. More on this is described in the next paragraph.

Target group

The assessment test is meant for management level. This means the level of responsibility associated with serving as a master or chief mate on board a seagoing ship, and ensuring that all functions within the designated area of responsibility are properly performed. The target group, therefore, will contain those mariners that are on the point of making the promotion to become a master or chief mate.

Criteria

STCW gives a specification of a minimum standard of competence for masters and chief mates. In table A-II/2, STCW gives a number of competencies, as well as the respective methods for demonstrating and criteria for evaluating that competence. Being minimum standards, these form a prior condition for the development of an assessment tool at management level.

In WP 3, more in particular, the report on *improving human error control in simulator based training*, guidelines are given for the use of maritime simulators. These guidelines also form a prior condition for the development of an assessment tool at management level.

Approach

Before the scenario can be developed a clear picture of the objectives is needed. What must a candidate do to prove that he or she has the capability to serve as a master or chief mate? What kind of skills and proficiencies are needed, and how can these be tested?

Within MASSTER a large number of training objectives have been identified. They result from the STCW (WP 2) as well as from the objectives that are being used by training institutes etc. (WP 3). For the assessment tool at management level the emphasis is laid on the human factors. Also for the human factors aspect, a number of training objectives have been formulated within MASSTER (WP 4). These will, to a large extent, also be used as the objectives of the assessment test.

Altogether 27 objectives are formulated, grouped in five main categories. The main categories are:

- Situational Awareness
- Communication
- Decision-making
- Delegating authority to act
- Deal with stress

The assessment of the candidates at management level will be based on the performance over all five main categories.

Quite important in the whole assessment is the so-called ‘deviation control-process’. This process starts with a given situation. By monitoring the situation, a deviation may be detected in time or perhaps too late. Inadequate monitoring may even lead to no detection at all, allowing a problem to develop and perhaps cause other, sometimes-bigger problems.

The next phase, after the detection of a deviation, is the diagnosing phase, which will be followed by the action phase. During the diagnosing various errors are possible, the same with the action phase. Being two different things it may be so that a person is quite good at diagnosing a problem but has problems in defining or ordering the appropriate action, or vice versa.

The situation, detection of deviation, diagnosing and action are all part of the deviation-control process.

In defining events for the scenario it is useful to keep the deviation-control process in mind at all times, as it is actually this process that is part of almost every type of event.

Objectives

The objectives within each main category are summarised in the following table:

Category	No.	The candidate is able to:
Situational Awareness	1	Take initiative to obtain information from all appropriate sources
	2	Confirm the information as quickly as possible
	3	Detect deviations from course or action plan
	4	Make valid interpretations of all evidence/information available Reassess and re-verify the diagnosis if required
	5	Review potential outcomes of the deviation, assess potential hazards
	6	Continue operations by repairing malfunctioning equipment, the use of back-up systems or improvisation in the use of other equipment
	7	Avoid being distracted by unimportant events
Communication	8	Inform all essential/relevant people and organisations immediately of the deviation
	9	Provide reports of the situation as it develops to staff at suitable intervals
	10	Maintain appropriate communications during the deviation-control process (onboard and external)
	11	Maintain an accurate record of all events and key communications.
	12	Put, where possible, alternative means in place when necessary to maintain communications
Decision-making	13	Take valid decisions throughout the deviation control process
	14	Order appropriate actions in the light of the evidence (this may include doing nothing)
	15	Formulate appropriate action plan(s)
	16	Put resources to respond to the most appropriate outcomes in place as quickly as possible
	17	Organise and direct on- and off-board expertise in an effective and consistent manner
	18	Take, if necessary, unpopular decisions
	19	Make an unambiguous choice in the event of conflicting interests
	20	Avoid decision-making based on impulses
Delegate authority to act	21	Take valid decisions on which activities should be delegated in the light of the circumstances of the moment
	22	Assign delegated activities to those most suited to deal with them in accordance with established procedures
	23	Assure that functions are clear and fully comprehended by those to whom are delegated (this must include the necessity to report back)
Deal with stress in oneself and others	24	Recognise the symptoms of developing excessive stress in oneself and colleagues
	25	Take appropriate action to ensure the continuity of the activities when stress is detected
	26	Take action to remove stressors for other team members
	27	Avoid actively stressful situations

Table 1 Objectives Human Factor

Events

The events for the scenario have been chosen with the purpose to be able to monitor and assess the candidates performance in relation to the main categories, and more in particular in relation to the actual objectives.

The following events, at the main level, have been implemented in the scenario:

- Handing over the watch; here, the candidate takes over the watch from the 3rd mate. The third mate is not able to give a clear and complete picture of the traffic in the vicinity and also uses the wrong chart for navigating at this particular point;
- The boatswain calls the bridge with questions about the anchors and informs the bridge of the fact that the pilot ladder is properly mounted;
- The shipping agent calls, information is needed about the injured seafarer, about the smallest hatch size and about the relief personnel; at the same time there is a VHF call for the candidate;
- The traffic situation requires action;
- The pilot has to be embarked;
- The purser comes to the bridge for the pilot, on completion the third mate starts to talk to the pilot. The pilot is being kept busy and meanwhile the candidate is confronted with the engine problem;
- During the attempt to speed up, the engine has problems, resulting in less power than requested.

Unless the candidate takes proper action the ship drifts into an unwanted position, hampering outbound vessels.

Events versus objectives

In the following table the relation between the events, as mentioned in the previous paragraph, and the objectives is shown. It gives an overview of the intended assessment objective per event. For practical reasons the last two columns have been added where interaction of the candidate towards the pilot and towards the third mate is part of the assessment for an event.

Category	No.	The candidate is able to:	Scenario events									
			Traffic and chart, with incomplete hand-over of the watch	Boatswain about the anchors and the pilot ladder	Agent with info and VHF-call	Traffic situation	Embarking pilot	Purser and 3rd mate talking to pilot	Engine problem	Drifting into a dangerous position	Towards pilot	Towards 3rd mate
Situational Awareness	1	Take initiative to obtain information from all appropriate sources	X				X				X	X
	2	Confirm the information as quickly as possible	X		X		X		X			
	3	Detect deviations from course or action plan		X					X			
	4	Make valid interpretations of all evidence/information available Reassess and re-verify the diagnosis if required		X	X				X	X		
	5	Review potential outcomes of the deviation, assess potential hazards				X			X	X		
	6	Continue operations by repairing malfunctioning equipment, the use of back-up systems or improvisation in the use of other equipment										
	7	Avoid being distracted by unimportant events		X	X			X				
Communication	8	Inform all essential/relevant people and organisations immediately of the deviation		X	X	X	X		X	X		
	9	Provide reports of the situation as it develops to staff at suitable intervals								X		
	10	Maintain appropriate communications during the deviation-control process (onboard and external)	X	X		X	X				X	X
	11	Maintain an accurate record of all events and key communications.										
	12	Put, where possible, alternative means in place when necessary to maintain communications										
Decision-making	13	Take valid decisions throughout the deviation control process		X	X				X	X		
	14	Order appropriate actions in the light of the evidence (this may include doing nothing)	X	X	X	X			X	X	X	X
	15	Formulate appropriate action plan(s)										
	16	Put resources to respond to the most appropriate outcomes in place as quickly as possible					X					
	17	Organise and direct on- and off-board expertise in an effective and consistent manner			X		X					
	18	Take, if necessary, unpopular decisions		X				X				
	19	Make an unambiguous choice in the event of conflicting interests			X							
	20	Avoid decision-making based on impulses	X	X	X	X			X	X		
Delegate authority to act	21	Take valid decisions on which activities should be delegated in the light of the circumstances of the moment								X		
	22	Assign delegated activities to those most suited to deal with them In accordance with established procedures					X					X
	23	Assure that functions are clear and fully comprehended By those to whom are delegated (this must include the necessity to report back)	X	X	X		X					X
Deal with stress in oneself and others	24	Recognise the symptoms of developing excessive stress in oneself and colleagues					X				X	
	25	Take appropriate action to ensure the continuity of the activities when stress is detected					X				X	X
	26	Take action to remove stressors for other team members			X	X	X	X	X	X	X	X
	27	Avoid actively stressful situations				X						

Table 2: Relation between events and objectives

Scoring Analysis

General

To determine the capability, an objective performance assessment of the candidates during the test run is necessary. The assessment is done by two members of the examining board (DGG, Ministry of Transport and Communications). In order to further objectify and standardise the assessment, an assessment list has been drawn up which is specially tuned to the test run. This list consists mainly of questions with regard to specific manifest behaviour of the candidates, only a few general closing questions are given, i.e. questions about the impressions of the assessors with regard to more general operational capabilities of the candidate. For example questions about the assessment of the candidate with respect to accuracy, general view, prioritising of tasks. In contradiction to the assessment of the performed behaviour of the candidate, the assessors do not have to reach a consensus on these general judgements, since these are not supplementary to the information already obtained. However, in case of doubt, these general judgements can be part of the final assessment of the capability of the candidate. The general questions are not structurally used for determining the final results. The procedures followed to set-up the scoring list, the successive scoring-, validating- and normalising procedures were largely taken from an earlier definition of an assessment scenario, prepared for watch officers duties on small coastal vessels [3].

Scoring list

The determination of the scoring list is done through discussions with governmental bodies and industry related parties. The people from the ministry of transport are involved in the current examination procedures. To the objective categories as mentioned in paragraph 6.2.4 on the methodology weighting factors are given for the final assessment. Within each category the evolving events within the assessment scenario resulting in candidate behaviour are given points which reflect the relative importance of this behaviour in the actual context of the scenario. In other words if the correct behaviour in that event is highly relevant for the immediate safety it is seriously counting. It is obvious that the final weighting of the categories is depending on the officers position in the bridge team.

Table 2 has to be used to select the scoring items as a function of the occurring events and can be directly deduced from this table. In real life testing the assessment scenarios have to be varied in order to avoid the spread of knowledge of the scenario and the scoring list.

Scoring procedure

During the practical test of each candidate, two assessors must be present at the bridge who individually do the assessment on the basis of the assessment list. Directly after the test, the lists of the assessors will be compared. Even though the resulting consensus table almost only reflects manifest behavioural aspects and thus easy detectable, incidentally lacking observations cannot be avoided (e.g. as a result of a bad observation position of one of the assessors). A candidate may also show behaviour in between two different assessments levels, which can result in (limited) assessment differences. After completion of the test run, a final results table is drawn up, based on the independent and individual scores. These results are used for determining the capability of the candidate. The incomplete judgements and the judgements that differ from the judgements of other assessors will be given another combined assessment. In case of doubt, computer registration systems can play an important role in relation to the assessments of e.g. distances to buoys, vessel waypoints, navigation courses, course deviation, and positions at course deviation.

Validity and normalising

Validity

The validity of the assessment test is checked through the requirement that a repeat of the assessment with other assessors should lead to the same final assessment. Due to practical reasons this was not possible to do during this development phase. Although this part of the validity test was not executed it became clear that possible problems could be faced in both scoring list validity as well as assessor capability. The emphasis on the human factors related issues requires a deliberate bias from the assessor to these aspects. By consequence this requires the evaluation of how people act rather then what the end result of their actions is on a navigational level. The assessors need to be instructed to assess aspects of human behaviour which they are probably not very well educated into. This requires extra attention and necessitates even more, a high validity and hence objectivity of the scoring list.

A second kind of validity called inter-rater validity could be checked through the comparison of the assessment results of the individual assessors per candidate for each of the candidates. During the development of this test five candidates were assessed on the simulator using this scenario upon which the inter-rater validity could be determined. The average inter-rater validity turned out to be close to 70 %, which is a sufficiently high score. The consensus inter-rater validity turned out to increase further significantly as during the consensus discussions often agreement was reached on a final judgement. In some cases these discussions did lead to a further refinement or differentiation of the assessment scale for certain questions.

Normalising

The assessment tool needs normalising to define the upper scoring limit using known, good captains who throughout their career proved to be all round capable captains (normalising candidates). Their performance needs to be measured and determined per assessment category (see paragraph 6.2.4. Methodology) and used for the final assessment and criteria setting per assessment category. The normalised scores per category are used together with the preliminary defined weighting factors to set the final success criteria. The comparison between the normalising candidates and the normal candidates per assessment category is also used to check whether the scenario is assessing at the right level. It is obvious that the extent into which candidates and normalised candidates could be taken through this assessment were too limited within the scope of this project. Based on the 5 candidates no final conclusions could be drawn on the correctness of the level of the scenario, although the face-validity on this aspect seemed to be correct.

Discriminating

Both assessors and candidates agreed that the test scenario was on the right level of complexity and capable of discriminating the differences between candidates. Assessors were asked at the end of the scoring list to give a general assessment of the candidate, which was later correlated with the outcomes of the objective scoring list. It certainly did support the discriminating capability of the scenario and associated scoring list, although the assessors were slightly positively biased as to their final judgement of the candidates capability of being in the captain’s position in comparison to their objective scores. As said earlier in the paragraph on validity the assessors lack of experience to judge human factor related issues plays an important role here.

Candidates were asked to give their judgement on the reality content of the scenario. All 5 candidates reacted positively on this item.

5.6.3 Validation of the training through demonstration

The objective of SWP 2 was the validation of the training through validation of a number of scenarios.

The approach taken was as follows. Using the available simulators within the consortium, a number of scenarios was tried out to determine whether they were viable for the training of mariners in the envisaged training areas and education levels. The demo session is further reported in [9].

5.7. Catalogue of scenarios

The catalogue of scenarios is the final link up of the databases of training objectives from WP2, existing training scenarios from WP 3 and the newly developed training scenarios from WP 5. The information is presented as an ACCESS database. This database allows all kinds of queries and listings to be produced, very useful for addressing training objectives, function levels, and competencies within STCW and their available training scenarios.

6. Conclusions

1. The project has produced a coherent set of training objectives (1000), the equivalent number of appropriate assessment criteria and training scenarios (300) based on the STCW'95 code.
2. To fulfil individual, national or future requirements for training scenarios several methodologies are developed for scenario development based upon task analysis and shipping accident analysis.
3. Two studies addressing the accident related training objectives within the MASSTER project do point to the relevance of these issues. Mariners do develop personal styles of collision avoidance which leads in some cases to 'accident repeater behaviour'. The implies that training or retraining of specific individuals with certain styles have a greater than average impact on the general level of safety.
4. The human error based training objective analysis does lead to a considerable set of training objectives which are worth training and do closely relate with the bridge resource management type of training objectives.
5. The development of assessment tools is the way ahead to ascertain the positive effects of training, the correct level of education and in the end the definition of the unamous criteria levels itself within the EC. Assessment on simulators is possible on important aspects like navigation, bridge resource management and others.
6. The total set of results of MASSTER are directly applicable by users of simulators around Europe for the STCW training programmes.
7. The development within the simulator technology will quickly increase the capabilities of the systems and hence the availability of simulators at schools. However full-mission simulator technology including outside view systems will stay an expensive tool which has to be applied as one of the partly required options within a range of simulation tools. Between users large differences of opinion exist on the necessity of the level of simulation.

Discussion on the harmonization

Within the member states

The results of MASSTER need to be presented against the background of the harmonisation of the European curricula as discussed and prepared within METHAR. The result of these discussions are summarised within WP 4.1 of METHAR, where the process of meeting the revised STCW convention is reported. The final conclusion points to the harmonisation of the STCW implementation rather than trying to reach a common maritime education and training system. The harmonised implementation of STCW can lead to the recognition of the certificates from other member states. The implementation itself must then guarantee the minimum mutually accepted level of training and education. A possible way ahead could be through the development of common guidelines through the auspices of IMO STCW sub-committee and processes.

It is specifically in that area of guidelines development on the different aspects of STCW 95 implementation that the results of MASSTER should be used. Implementation aspects are:

Quality Standards Systems

- Course of Education and Training; MASSTER can contribute here through its developed training objectives and assessment methods
- Instructor qualification and experience; some attention is aid to this subject within MASSTER.
- Training supervisors
- Simulator standards; MASSTER has investigated and categorised the existing simulators and their future developments.
- Simulator training; MASSTER has produced a large amount of simulator scenarios (exercises) directly linked to the STCW training objectives and a methodology to develop courses and additional scenarios
- On board training program
- Recognition of Certificates of Competency; Within MASSTER some examples are developed of assessment methods who could serve as examples for the development of an important hands on part of a common assessment procedure of member states training and education. Obviously in addition to procedures who cover the theoretical content side of the training and education.

Outside the member states

A trend to develop training programs in the so called ‘low wages’ countries is noticed. One of the problems which occur is loss of harmonization of training objectives, etc. How can we tackle these problems or how can we organize one similar system globally?

- work with certified organizations.
- try to establish one philosophy to create assessment goals.
- keep on track with the technical innovations on the bridge.
- create a standard frame-work and curriculum.

What are the most important differences between training centers

- total training hours
- hours per subject
- beginners level
- pre-knowledge required
- end level
- practical level

Approximately every training institute spends an equal percentage of time on developing different training assessments. Measured in hours there is a considerable difference between institutes.

7. References

[1] STCW 95	STCW Convention and STCW code
[2] EC Proposal No. 197	4th Framework 6.4.4, Task 46, Maritime Standardized Simulator, Training Exercises Register
[3] WP 1, Version 2	Capability Statement of (Future) Simulators / Literature Review
[4] WP 2 Final Version 3.0	Determination of a Complete Catalogue of Tasks and Training Aims
[5] WP 3, Task 3.1 & 3.2, Final Version (1.3)	Collection and Examination of Existing Scenarios
[6] WP 3, Task 3.3, Version 2.0	Improving Human Error Control in Maritime Simulator-based Training
[7] WP 4, Version 2.0	Determination of Gaps and Shortcomings
[8] WP 5, Final Version (1.0)	Provision of Scenario Methodologies and Scenarios
[9] WP 6, Version 1.0	Development of Training Assessment Tools to be Used in Proving Scenarios
[10] WP 7	Instructions for use of Database covering the complete sets of Training Objectives and Training Exercises.

Annex - Exploitation and Dissemination

Significance of results

The results of MASSTER has five major dimensions which are worth further exploring:

- Status of the distribution of (advanced) simulators within Europe, which are suitable for the proposed levels of (simulator) training;
- Catalogue of STCW'95 based training objectives;
- Catalogue of STCW'95 based simulator exercises covering the training objectives;
- Methodologies for further, future scenario/exercise development, including non-STCW based training scenarios;
- Methodology of assessment tool development, including a number of examples.

Three are directly related to the possible implications of STCW'95 for the European situation of maritime education and training. The first reveals if European wide implementation of above STCW standards of training through the use of advanced simulators is feasible in the current situation. The second and third are a concrete implementation of the STCW standard within the assumed simulator infrastructure context. All three make perfectly clear what is required in order to give the STCW its follow up step of interpretation. Direct distribution of this information will make aware schools and institutions around Europe what is the shape of things to come in terms of harmonised, European standard of education and training. The METHAR concerted action could promote this information and refer to it as the appropriate level of STCW implementation (see further below).

The fourth dimension is merely an instrument to take the scenario developments further and allow schools and institutes to follow their own course of actions appropriate for their national, educational and tentative simulator infrastructures. The added above STCW training scenarios of HSC, ECDIS, integrated bridge etc. certainly fulfil a general need.

The fifth dimension on assessment tools development shapes the contours of a final, ideal situation in which the ultimate harmonisation is reached through a harmonisation of proficiency levels. A first step should be the individual development of these tools and gathering experience with their use(fullness) (see further below).

METHAR

After and during the METHAR final meetings a decision has to be taken on the relevance of the MASSTER results within the METHAR context. MSCN preferably together with ISSUS can and will play a role in the further integration within then METHAR project and is willing to come up with further proposals. Important points within such an integration and continuation proposal would be the greater detail required for implementation with respect to specific education programmes, education of instructors, which will largely be responsible for the implementation and the setup of a library and methodology description of assessment tools on a number of levels.

A consequence a further set up of a dissemination/distribution/implementation plan.

Dissemination of results of MASSTER

The dissemination of MASSTER already started when working on the project for example by presenting the project at the CAMET meetings / METHAR.

Within 1997 the project was demonstrated and the first results were used in a one-week-training of students of the World Maritime University (WMU) in the seminar „Training for Trainer" at SUSAN.

In 1998 the results of MASSTER were forming again the basic for the „Training for Trainer“ of the WMU-students at SUSAN.

During the International Maritime Simulator Forum Meeting in Australia, 28.Sept.-2.Oct.1998, the results MASSTER were presented.

Internet:

The MASSTER project is accessible in the internet via

http://www.issus.fh-hamburg.de

or directly via

http://www.issus.fh-hamburg.de/iss_web/masster/

A workshop was held at MSR on 29 and 30 June 1998 which was attended by about 25 representatives from schools and government representatives.

The database of scenarios is distributed to a large number of schools in the UK, the Netherlands and a school a Belgium.