Use of Simulators in e-Navigation Training and Demonstration Report

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Executive Summary

This report describes the status quo of training requirements and use of maritime simulators generally and the specific use of simulators within the ACCSEAS project over the period of developing and evaluating the so called “candidate solutions”, introduced in the “ACCSEAS Baseline and Priorities Report”.

The report starts with the placement of the STCW 2010 training and assessment requirements for ship-side users of navigational systems. Furthermore it is clarified that the implementation of the e-Navigation concept requires a new training concept which includes the e-Navigation user ashore. The following highlighted issues:

a) Standardization,
b) Training for technology based systems and
c) Introducing new technology regarding the human element,

which should be considered for the training of seafarers when introducing new technology are relevant for shore-side users too. Three of the subsequently named and explained five prioritized “SIP solutions” addresses the use of equipment on board a ship and ashore, e.g. at a VTS station. At this point the report advises an IMO Model Course: “Operational use of VTS Services” as possible solution.
Section 3.3 presents the evolution of maritime simulators and their increasing part in maritime training with the aim to raise safety standards within different operational areas of a ship and for the shore-side part of VTS communication.

Chapter 4 introduces the 14 “candidate solutions” and groups them related to stage of their development in reference to training needs and use of simulators for training. The classification ended with the result that 11 solutions are ready for developing training arrangements.
Chapter 5 investigates the Human-Machine Interfaces (HMI) of the solutions referenced to the user groups. The 2nd part of this chapter describes and motivates the use of the e-Navigation Prototype Displays (EPD), an ECDIS like free programmable tool, in ACCSEAS. In ACCSEAS the EPDs were used for development, demonstration and evaluation of the solutions.
Chapter 6 clarifies the simulator requirements for different shipboard usages based on STCW regulations. Furthermore this section presents an up-to-date list of maritime simulators with different function areas and classes. At present time all maritime simulators are certified for only 1 function area. The 2nd part of chapter 6 describes the simulator requirements for training purposes, which can be used for training of more than one user group and different HMIs, e.g. VTS training: shore-ship / ship-shore communication. As an example for a possible solution the “European Maritime Simulation Network” is introduced. The mentioned key benefits and the given basic points demonstrate potential for further development.

Chapter 7 describes vessel and crew e-Navigation requirements. That covers: a) meeting the INS/IBS requirements by the shiphandling simulators and b) a basic knowledge of the e-Navigation concept by the trainees before they attend an e-Navigation simulator training course.
Chapter 8 reports in full all simulator referenced activities in ACCSEAS for each solution. All available Information relating to operational and technical characteristics of the solutions is incorporated. Some solutions provide a kind of user manual and Information related to their development Taken as a whole chapter 8 delivers a useable picture of the development status related to training needs and in particular simulator based training requirements.

Contents

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1 Introduction

The purpose of this report is to describe the use of maritime simulators during all development phases of the so called “candidate solutions” in ACCSEAS. Furthermore the report presents in the final chapter for some solutions simulator training recommendations.

2 ACCSEAS project activities

The North Sea Region (NSR) as a crossroads of regional and global shipping was extensively researched by Work Package 3 (WP 3) of the ACCSEAS project. This research related specifically to the development of shipping, installing of offshore wind farm areas and other installations e.g. oil platforms. All details and results of the investigations are registered and proved in the first two chapters of the “ACCSEAS Baseline and Priorities Report” [1].

The findings correspond in large with the assumptions stated in the project description of the approved ACCSEAS “Application” [2]. Based on this analysis of the present and future situation in the NSR, ACCSEAS identified candidate solutions framed in the IMO’s concept of e-Navigation to increase the efficient use of resources, provide better voyage planning and track-keeping. All ACCSEAS candidate solutions, presented in chapter 4 of the “Baseline Report” [1], should meet the attributes stated in the “Application” [2]:

> “This can be achieved by innovative Aids-to Navigation and Vessel Traffic Services with ship-shore and ship-ship communication of reliable navigation information providing situation awareness on a vessel’s position and intended routing” ([2], 4.1 Background and aim).

For demonstrating and testing the solutions ACCSEAS setup an e-Navigation test-bed in the NSR. The entire process of the implementation of prototype solutions in the e-Navigation test-bed was supported as far as possible by simulation in a virtual test-bed to cover the areas of training and demonstration.

3 Maritime education and training

Extensive and detailed requirements of training and assessment for the ship-side users of navigational systems, the seafarers, are determined in the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) 1978 [3]. In 2010 the Manila amendments were adopted (STCW 2010). The members of IMO recognized e.g.:

> “the need to allow for the timely amendment of such mandatory standards and provisions in order to effectively respond to changes in technology, operations, practices and procedures used on board ships” and
>
> “that a large percentage of maritime casualties and pollution incidents are caused by human error” [3], attachment 2.

Such changes generate new demands on training institutions and on instructors working within them. The implementation of the e-Navigation concept on board and ashore requires a further adaption related to new training concepts and new instructional media to changed standards. Complementary it must be ensured that instructors and assessors are appropriately trained and experienced. Trainers must be qualified in the task for which training is being conducted.

3.1 Training and assessment on-line introducing new technology

During the last decades a lot of new navigational systems were installed on ships' bridges. Responding to that development the Maritime Safety Committee (MSC) published already in June 2003 the MSC/Circ. 1091 "Issues to be considered when introducing new technology on board ship" [4]. The introduction describes the way of looking at the problem in summary:

> "The effectiveness of crews to use the technology safely and to best effect requires familiarity with the equipment and training as recognized in the STCW Convention. There are a number of aspects to be considered with respect to how seafarers interact with the technology and also some issues to be considered when assessing the training needs for the seafarers who use such technology" [4].

Furthermore MSC/Circ. 1091 stipulates issues to consider for the training of seafarers when introducing new technology:

a) **Standardization:**
Although performance standards exist, the controls and displays are not standardized. The result is an increase in the amount of training needed to make a seafarer familiar with and effective in the use of the equipment. There are some causes which make increased training impossible e.g. a seafarer joins the vessel just prior to departure or the system aboard the vessel is very different from those on which the seafarer has received training ashore.

"One solution is to familiarise seafarers with equipment by training them using simulators (either desktop or full mission) prior to them joining their ships. This is made far more efficient when manufacturer provide assistance in developing the training tools" [4].

This solution can be improved by developing a common interface with standard symbology for common operations. Seafarers should be trained to use the standard display whenever possible, preconditioned the "standard operation" includes all functionalities for safe navigation.

b) **Training for technology based systems:**
There are a lot of challenges to be managed when training seafarers for using technology-based systems on board. E.g. different cultural and practical behaviour patterns. It was ascertained that many young watchkeepers have a culture of using information technology (home computers, Internet, video games etc.) and that during times of stress revert to electronic displays for their primary decision support systems. "Inexperienced seafarer may seek more data and information in stressful situations, often confusing themselves further. Problems can also develop when novice navigators are trained on desktop simulators which do not have the advantage of a simulated 'window' for visual observation. This may reinforce the habit of constant reliance on a digital display for situational awareness during actual operations" [4]. One quintessence concluding this section is that only well-trained officers understand to manage and prioritise ECDIS and AIS information. The same information provided to an officer without ECDIS and AIS training can lead to information overload and poor decision making.

c) **Introducing new technology regarding the human element:**
The results of research referenced to automation are:
- automation has qualitative consequences for human work and safety,
- automation does not simply replace human work with machine work,
- automation changes the task it was meant to support,
- automation creates new error pathways,
- automation shifts the consequences of error further into the future and may delay opportunities for error detection and recovery,
- when automation is installed operators will monitor less effectively,
- automation creates new kinds of knowledge demands.

"Watchkeepers must have a working knowledge of the functions of the automation in different situations, and know how to co-ordinate their activities with the automated system's activities. This manifests itself in situations whereby officers do not understand weakness or limitations of systems they rely on. Training in this respect will become more important, as systems become more integrated and sophisticated" [4].

d) **Summary:**
New technology installed on board can improve the efficiency and effectiveness of watchkeeping and consequential improve the safety of operations. However, this technology brings with it the inherent training requirement needed to operate the new systems physically, and also the training need to use the system to make better decisions. The positive effects of new technology will increase with degree of standardization of designs.

3.2 e-Navigation specific training

The first proposal for the development of an e-Navigation strategy was submitted to the Committee in 2006. At MSC 85, (2008) the Committee approved the strategy for the development and implementation of e-Navigation, which contains the following definition:

"E-navigation is the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment" [5].

"Relevant background information relating to the development of the e-navigation strategy can be found in document NCSR 1/INF.5" [6].

The IMO document NCSR 1/9 (28 March 2014) with the annex: "Draft e-Navigation Strategy Implementation Plan (SIP)" describes the further development of e-Navigation and contains a plan for enhancing public awareness of e-Navigation [7]

"The SIP focuses on five prioritized solutions, as follows:

S1: improved, harmonized and user-friendly design;
S2: means for standardized and automated reporting;
S3: improved reliability, resilience and integrity of bridge equipment and navigation information;
S4: integration and presentation of available information in graphical displays received via communications equipment; and
S9: improved communication of VTS Service Portfolio"[7]

The implementation of all prioritized solutions require specific training referred to the used technical methods and new operational procedures to comply with the key messages for all stakeholders listed in the table "Examples of key messages to promote the benefits of e-navigation" [7], Annex 3. A detailed description and a table presenting the structure of the SIP are included in the "Baseline and Priorities Report" [1].

Scrutinizing the solutions in detail it becomes clear that the solutions S1and S4 address the equipment and its use on a ship only, while S2 and S9 address improved communications between ships, ship to shore and shore to ship. Solution S3 addresses both bridge equipment and e.g. shore-ship information as part of the PNT system

Consequently training courses which must developed for the solutions S2 and S9 must include new technical and operational competencies for both users groups, the seafarers and the shore side users. With regard to S9 the STCW requirements and the "IALA Model Course V-103/1 – Vessel Traffic Services Operator Training" [8] must be revised. A possible solution could be an IMO Model Course: "Operational use of VTS Services".

3.3 The evolution of using simulators in maritime education and training

By 1967 first ship simulators came into use for the maritime education of seafarers at merchant marine academies, not only in the USA but also in Europe. In the 1990ies, along with the increasing capabilities of computers the simulators developed from pure radar simulators to full mission simulators with more and more sophisticated visualisation.

The modern ship handling simulator provides the new students of the naval academies and universities with the opportunity to sample ship handling, without hazard. Simulators also allow working bridge personnel to learn the techniques of Bridge Team Management (BTM), working through a variety of potential problems that might never be encountered, but would be life-threatening should they occur.

The simulator allows mariners access to a real time simulation of the conditions aboard ship--on the bridge, in engineering spaces or in specialized spaces such as cargo handling at a lower cost than teaching classes aboard a training ship. Ship handling simulators are used to train mariners to handle ships in a variety of situations, from docking and undocking, to navigating various approaches in a variety of conditions using actual ship performance data in real time.

The key features to a ship simulator are real operational controls and a system that allows the instructors operating the simulator to put the simulator students into realistic situations. All simulators are designed to provide an experience as close as possible to the real world. Bridge simulators provide accurate visual representations through the "bridge windows" and some are even mounting on hydraulic platforms to mimic movement. The speed controls, steering, radar and charting systems are the same found on the bridge of modern ships.

Today marine simulators take over an increasing part in maritime training to raise safety standards. STCW 2010 [3], section A-I/12, contains the standards governing the use of simulators for maritime training of seafarer.

Part 1 deals with the general performance standards for simulators used for mandatory simulator-based training, assessment of competence and in accordance with their specific type (Radar simulation, ARPA simulation).

Part 2 deals with the training and assessment procedures. STCW 2010 [3] section B explains the “Recommended performance standards for non-mandatory types of simulation” “Such forms of simulation include, but are not limited to, the following types:

.1 navigation and watchkeeping;
.2 ship handling and manoeuvring;
.3 cargo handling and stowage;
.4 reporting and radiocommunications; and
.5 main and auxiliary machinery operation.

“Navigation and watchkeeping simulation equipment should, in addition to meeting all applicable performance standards set out in section A-I/12, be capable to

.4 realistic simulate VTS communication procedures between ship and shore”

For the shore side part of VTS communication the IALA Model course V, Part D – Guidelines for instructors, section 5, describes subjects and assessment criteria included in 100 hours simulated exercises.

4 The ACCSEAS candidate solutions

This section will now introduce the candidate solutions relating to education, training and using simulators. In total ACCSEAS identified 14 candidate solutions. All are described in the “Baseline Report” [1]. Some are portrayed in detail including technical specifications and user manuals. At the end of ACCSEAS project the solutions reached a different stage of development. For further work on training and use of simulators it is reasonable to group them as follows:

4.1 Thoroughly investigated solutions

The following 11 solutions are thoroughly investigated and ready for developing training arrangements.

1. Maritime Service Portfolios (MSPs) for the NSR (NSR-MSPs)
2. Route Topology Model (RTM)
3. “Maritime Cloud” as an underlying technical framework solution
4. Innovative Architecture for Ship Positioning:
   a) Multi Source Positioning Service;
   b) R-Mode at existing MF DGNSS and AIS Services
5. Maritime Safety Information / Notices to Mariners (MSI/NM) Service
6. No-Go-Area Service
7. Tactical Route Suggestion Service (shore-ship)
8. Tactical Exchange of Intended Route (ship-ship and ship-shore)
9. Vessel Operations Coordination Tool (VOCT)
10. Dynamic Predictor (for tug boat operations)
11. Augmented Reality / Head-Up-Displays (HUDs)

4.2 In principle recognized solutions

The following 3 solutions are in principle recognized but yet not ready for developing training arrangements.

12. Automated FAL Reporting
13. Harmonized Data Exchange – Employing the Inter-VTS Exchange Format (IVEF)
14. Real Time Vessel Traffic Pattern Analysis and Warning Functionality for VTS

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5 ACCSEAS candidate solutions – Challenges in training

5.1 Human-Machine Interfaces

“The ‘human element‘ features prominently for all ACCSEAS candidate solutions where there is a Human-Machine Interface (HMI). This applies in particular to several of the solutions which have a clearly identifiable potential future impact on ’future regulations and operational practices.’ Those solutions are:

- Innovative Architecture for Ship Positioning:
  a) Multi Source Positioning Service (MSPS);
  b) R-Mode at existing MF DGNSS and AIS Services
- Tactical Route Suggestion Service (shore-ship) (HMIs to shipboard and shore-based users)
- Tactical Exchange of Intended Route (ship-ship and ship-shore) (HMIs to shipboard and shore-based users)
- Maritime Safety Information/Notices to Mariner (MSI/NM) Service (HMI to shipboard and shore-based users)
- No-Go-Area Service (HMIs to shipboard and shore-based users)
- Route Topology Model (RTM) (HMIs to shipboard and shore-based users)
- Augmented Reality / Head-Up-Displays (HUDs) HMIs to shipboard users)
- Automated FAL Reporting (HMIs to shipboard and shore-based users)
- Vessel Operations Coordination Tool/(VOCT) (HMIs to shipboard and shore-based users)
- Dynamic Predictor (for tug boat operations) (HMI to shipboard users)” [9]

5.2 New technology and simulation - EPD

As carved out in the “ACCSEAS e-Navigation Architecture Report”, “all ACCSEAS candidate solutions are inherently innovative. Some use and demonstrate existing technology for new fields of application and/or in a novel way.” For showcasing, further development and testing of the solutions a simulator is required. Furthermore, to identify training needs the use of a simulator is one of the best practices.

At the present time it is not possible to integrate solutions directly in a commercial Simulator. To solve this problem the open source software “e-Navigation Prototype Displays (EPD)”was developed [10]. The EPD consists of two applications normally running on standard computer. The ship-side EPD simulates the onboard HMI of a solution and the shore-side EPD simulates the HMI ashore, e.g. a VTS station. For testing solutions and demonstrations both types can be connected back to back. But EPD is not only working on standard simulators. Within ACCSEAS it was possible to integrate an EPD into a bridge system and a shore-side EPD was linked to simulate a VTS station. Even solutions as “Multi Source Positioning Service” and the “Harmonized Data Exchange” may be successfully demonstrated in future

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6 ACCSEAS candidate solutions – Simulator requirements

All in section 5.1 listed candidate solutions have a HMI to shipboard user. Therefore the training and use of simulators is subject to the STCW convention. The shore based users are not affected by this regulation. STCW requires that simulators, when used:

a) for mandatory simulator based training,
b) as a mean to demonstrate competence (assessment) and/or
c) to demonstrate continued proficiency required by the same convention

shall be approved by the relevant maritime administration [3], A-I/12. The DNV▪GL for example determines in the document "Standard", version: DNVGL-ST-0033:2014-08 requirements for the performance of maritime simulator systems. Maritime simulators that comply with the requirements of the DNV▪GL-standard receive a product certificate for "Maritime Simulator". The simulator's function area and the class according to this standard are stated on the certificate.

6.1 Types and classes of current maritime simulator systems

With input from the "International Marine Simulators Forum" (IMSF), the classification society DNV▪GL e.g. has classed the simulators on functional (functional areas) basis. They further subdivided each class into four categories depending on the level of tasks it is capable of simulating. The function areas are:

- Bridge operation
- Machinery operation
- Radio communication
- Liquid cargo handling
- Dry cargo and ballast handling
- Dynamic positioning
- Safety and security
- VTS operation
- Survival craft and rescue boat operation
- Offshore crane operation
- Remotely operated vehicle operation

The following table shows the four simulator classes for the function area "Bridge operation"

Class A (NAV)	Full Mission Simulator	A full mission simulator capable of simulating a total shipboard bridge operation situation, including the capability for advanced manoeuvring in restricted waterways.
Class B (NAV)	Multi Task Simulator	A multi task simulator capable of simulating a total shipboard bridge operation situation, but excluding the capability for advanced manoeuvring in restricted waterways.
Class C (NAV)	Limited Task Simulator	A limited task simulator capable simulating a shipboard bridge operation situation for limited (instrumentation or blind) navigation and collision avoidance.
Class S (NAV)	Special Task Simulator	A special tasks simulator capable of simulating operation and/or maintenance of particular bridge instruments, and/or defined navigation manoeuvring scenarios.

> "With this classification the trainee can be gradually introduced to the simulator from a simple task to a full mission simulator, thereby making optimum use of the costly simulator facilities and instructor time to achieve desired proficiencies without overloading the trainee" [12].

6.2 e-Navigation simulator requirements and design

The existing maritime simulators are designed and approved for only one specific function area. For example a simulator certified for the function area "Bridge operation" should be used only to train nautical officers, captains and pilots. Referenced to the HMI a "Bridge operation" simulator is designed for nautical shipboard user. Looking at the ACCSEAS candidate solutions it becomes apparent that the majority of the solutions are operated on collaboration of shore-based and shipboard user. Relating to the simulator requirements for training, a new combined simulator including two function areas and two specific HMIs is essential. Potentially for installing this "two functional area" simulator extra space is required. The more effective and flexible way to design a "two or multi-function area" simulator is to create a simulation network. A network provides the chance to train different user, ship-side and shore-side) simultaneously.

6.3 European Maritime Simulation Network

The European Maritime Simulation Network (ESMN) was conceived in order to test the Sea Traffic Management (STM) concept and solutions under development within the MONALISA 2.0 project. Such a simulation network offers a huge potential for distributed simulations. For example test scenarios involving multiple vessels and a VTS-station in congested areas to test solutions like "Tactical Route Suggestion Service" or "Tactical Exchange of Intended Route".

> The Infrastructural Specification highlights: "The main goal of this specification is to achieve a technically and proven approach, which is easy and cost effective as well as fast to implement. – The Distributed Interaction Simulation (DIS) is chosen as underlying communication protocol to support the simulation data exchange between connected simulators" [13].

Key benefits are e.g.:

- International standard protocol for simulation networks (IEEE 1278)
- Open standard with no licence costs
- Very simple infrastructural requirements
- No need to open up existing proprietary simulator software to others

In addition of the transport of the simulation data, e.g. AIS data, the EMSN supports also voice communication. The EMSN is based on public internet resources protected by the tunnelling mechanism of Virtual Private Networks.

6.4 Simulator Network Topology

The simulator network within the MONALISA 2.0 project consists of Sea Traffic Control Centres (STCC) and several Ship Handling Simulators (SHS) spread across European locations.

For further testing and training purposes of candidate solutions, a simulator network of VTS stations and vessels could use the EMSN concept:

"In order to enable a sufficient realistic evaluation of MONALISA's capabilities a minimum set of services is established with the ESMN.

- Distribution of simulated exercise data which consists primarily of published entity data that represent the participating simulated ships.
- Voice Communication between SHSs among each other and between them and the STCCs emulating real world radio communication.

- Supply of network capacity for the MONALISA data communication.

The services are provided in IP (sub) networks and enable the EMSN participants to join in a corporate simulated exercise.

The service networks are realised as virtual private networks (VPN). For that purpose VPN tunnels are established between the EMSN participants they provide confidential and authenticated links with integrity over the public internet" [13].

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7 Vessel and crew e–Navigation requirements

The shipboard part of the e-Navigation concept is based from technical and operational consideration on the Integrated Bridge System (IBS) and the integrated Navigation Systems (INS). As pre-condition for successful use of simulation for e-Navigation training both the simulator and the trainees have to be prepared relating to IBS and INS.

7.1 Vessel e–Navigation requirements

> "An integrated bridge system (IBS) is a combination of systems which are interconnected in order to allow centralized access to sensor information or command/control from workstations, with the aim of increasing safe and efficient ship's management by suitably qualified personnel" [14].

IBS system requirement
Supporting systems performing two or more of the following operations:

- Passage execution
- Communications
- Machinery control
- Loading, discharging and cargo control
- Safety and security

At least all new full-mission simulators with the function area bridge operation should as far as possible comply with the requirements of regulation 15 of SOLAS chapter V, "Principles related to bridge design, design and arrangement of navigational systems and equipment and bridge procedures".

Although full-mission simulation can be ideal, some competences are possible to achieve using single screen classroom simulators properly configured with IMO's requirements for an IBS or INS.

7.2 Crew e-Navigation requirements

Before starting any practical training relating to e-Navigation all trainees must be inducted into the e-Navigation as a concept with large-scale changes. Looking at the definition, see section 3.2, it is rather difficult to describe e-Navigation in a concise way.

The following chapters are an attempt to explain that e-Navigation is different from simply meaning "electronic navigation".

> "Focussing on the words 'harmonized', 'information' and 'navigation' the general intent quickly becomes apparent. Navigation, safely carrying various cargoes from A to B via ship is a complex process and has a tremendous number of related services. All these services require or supply various amounts of information from or to the ship. Be they, for example, the port requesting ETA (estimated time of arrival), or a meteorological service supplying weather data. This 'web of information' slowly evolved each part individually with their own particular data requirements and information. The e-Navigation concept seeks to harmonize the entirety of this marine informational conglomerate. This is to be accomplished mostly by electronic means. As such the bulk of work to be done will lie in programming and developing the necessary infrastructure. The intent is to enhance navigation and related services. It is only to enhance not to replace or fundamentally change the navigational process or related services, always keeping in mind the overarching goals of higher safety, security and better protection of the marine environment" [15]

Building on the above entrance to e-Navigation the further parts of the definition must be explained in a short and demonstrative way. – For example:

> "**Collection of maritime information**:
> From traffic density, to port arrival times (ETA) through current vessel speed and reports of misplaced buoys, there are a great many different types of information going back and forth between ships and shore stations. Different parts of this bundle of information are of interest

to different parties. To be able to distribute it in a harmonized way it first needs to be collected and stored safely.

Integration of maritime information:
This collected mass of information shall be fit into a single standardized format. Enabling all existing and future devices in one way or the other to input their information and have it, easily read out by authorized parties and devices. The result is allowing a more harmonized integration and general use of maritime information.

Exchange of maritime information:
The aforementioned format is intended to allow for an unprecedentedly free and easy exchange of maritime information; harmonized to allow seamless, clear and effortless exchange.

Presentation:
With the development of ever more intricate and accurate information gathering systems in the last decades, the amount of raw data presented to the mariner has increased as well. Sadly most attempts to make this less confusing or complex have not been successful. When compared to the possibilities of modern technology, design and user-friendliness, current solutions simply fall short. It is proposed, that along with the overhaul and standardization of the data format, the presentation and display of the information improved as well. To this effect the human element must be the prime factor in developing layout, arrangement and type of information. A harmonization of necessary information volume, user friendliness and intuitiveness for the user has to be achieved.

Analysis:
With the data in the standardized and easily processable format it can be used for a variety of research and prediction purposes on a global scale. Scientific analysis of data on this scale can yield to an unforeseeable insight into the workings of ship transport, weather and climate situation and other factors" [15].

It must be proved that all users understand that harmonization is more than central to the e-Navigation concept. It is the pivotal point around which nearly all discussions and developments circle.

8 ACCSEAS candidate solutions - Use of simulators for training and demonstration

The previous chapters described the demands on education and training to understand the e-Navigation concept and the requirements to operate new navigation systems more in general. The following sections will carve out the use of simulators for training and demonstration the individual ACCSEAS candidate solutions in detail.

8.1 Maritime Service Portfolios (MSPs) for the North Sea Region (NSR-MSPs)

8.1.1 High level technical and operational description

NSR-MSPs will provide the knowledge, eventually in electronic format, on the variety of operational and technical services in the NSR. That includes all service features and quality levels to be expected by shipping. “The knowledge of available services along the fairways in the NSR, acquired in an efficient manner will influence maritime traffic to a degree yet unknown” [9]. The degree to which MSPs influence the maritime traffic depends on the degree of influence of the individual service’s referenced by the MSPs.

8.1.2 Nature of service and kind of Human-Machine Interface (HMI)

NSR-MSPs can be construed as “maritime traffic support system”.
Indication of: HMIs to shipboard and shore-based users

8.1.3 Function area(s) of required simulators

Indication of: Ship operation, Shore operation

8.1.4 Use of simulators for training and demonstration

Not yet investigated

8.2 Route Topology Model (RTM)

8.2.1 High level technical and operational description

“The RTM provides a theoretical model potentially underlying any and all future traffic support system as it describes the available routes (including their features and their connectivity) the maritime traffic can use in a given maritime situation” [9].

8.2.2 Nature of service and kind of Human-Machine Interface (HMI)

The Route Topology Model can be construed as “maritime traffic support system”

8.2.3 Function area(s) of required simulators

Not relevant

8.2.4 Use of simulators for training and demonstration

Not relevant, only simulation of portrayal

8.3 “Maritime Cloud” as an underlying technical framework solution

8.3.1 High level technical and operational description

The ACCSEAS candidate solution “Maritime Cloud” (MC) provides the technical basis for several other candidate solutions. The MC is “a proposed technical framework enabling efficient, secure, reliable and seamless electronic information exchange between all authorized maritime stakeholders across available communication systems, refining an instance of the overarching e-Navigation Architecture in the North Sea Region” [16].

Architectural elements are:

1. "**A shipboard technical infrastructure** – Shipboard communication, navigation and display equipment is integrated to exchange information seamlessly, using harmonized data formats.
2. **A shore based technical infrastructure** – Shore based information is made available through harmonized data/information services.
3. **Communications** – A concept of generic communication links providing the logical connections that allow data/information flow between the shipboard and the shore based systems" [16].

In detail the MC concept supports information transfer on board ship, ship–ship, ship-shore and services shore-shore. The used systems are operated by shipboard and shore based users. At the present time (2014) possible forms of governance and operation of the MC is ongoing work.

Summarized the MC is a possible contribution to the communication infrastructure as a key element of e-Navigation. – see Task "T15", Annex of SIP 2014 [7]:

> "Identify and draft guidelines on seamless integration of all currently available communications infrastructure and how they can be used (e.g. range, bandwidth etc.) and what systems are being developed (e.g. maritime cloud) and could be used for e-Navigation.
> The task should look at short range system such as VHF, 4G and 5G as well as HF and satellite systems taking into account the 6 areas defined for the MSPs."
>
> "Expected deliverables: Guidelines on seamless integration of all currently available communications infrastructure and how they can be used and what future systems are being developed along with the revised GMDSS."

8.3.2 Nature of service and kind of Human-Machine Interface (HMI)

The shipboard part of the MC is shipboard equipment which complies with e-Navigation requirements to deliver requested technical functionalities. This part of the MC contains a Human Machine Interface to control the "more" technical service.

8.3.3 Function area(s) of required simulators

Bridge operation, VTS operation, other shore-side operation
In accordance with the development of integrated communication systems, bridge operation simulators must be expanded with an integrated communication module too.

8.3.4 Use of simulators for training and demonstration

During period of ACCSEAS no simulation activities ware planned or carried out.

8.4 Innovative Architecture for Ship Positioning

a) Multi Source Positioning Service (MSPS)
b) R-Mode at existing MF DGNSS and AIS Services

8.4.1 High level technical and operational description

The Multi Source Positioning Service (MSPS) provides position, navigation and timing (PNT) information. The specified service level will assure the accuracy, integrity, availability and continuity-of-service of the PNT information. In addition the PNT will indicate the bounds of uncertainty associated with the estimated accuracy of the PNT solution. This will enable the robust and confident portrayal of position for mariners and shore based users. It will also ensure that the navigation risks inherent in technical navigation services are reduced through the recognition of the quality of PNT data and the use of dependable uncertainty and integrity information.

The primary source of PNT will be GPS. In parallel to this, the PNT data processor will monitor one or more complementary backup services, for example eLoran and/or R-Mode at existing MF, DGNSS and AIS services or radar absolute positioning.

Vessels will not only be provided with position information, but also an estimate of the error bounds of the position estimate to the level of integrity risk demanded by the e-Navigation services, and a PNT alert to indicate the source of the PNT information. Error bounds will feed forward to form part of the error budget of the performance of other monitored backup services. Upon detection of interferences with the primary source the PNT data processor will switch automatically and seamlessly to a backup source.

A comprehensive description explaining the structure, the design and ship side components, e.g.: Multi Source Receiver (MSRX), eRadar, PNT Data Processor is part of “ACCSEAS Test-Bed Service Description: Multi Source Positioning Service” [23].

8.4.2 Nature of service and kind of Human-Machine Interface (HMI)

The MSPS is characterized by innovative architecture for ship positioning. The service employs existing satellite systems and existing as well as novel terrestrial radio navigation systems for a novel and improved method for shipboard position fix in combination with an innovative HMI.

8.4.3 Function area(s) of required simulators

Bridge operation

8.4.4 Use of simulators for training and demonstration

The ACCSEAS project Application Form requests simulation for PNT demonstrations and scenarios for training needs analysis [2]. Over a period of 12 month the ACCSEAS partners General Lighthouse Authority (GLA) and Flensburg University of Applied Sciences (FUAS) developed a PNT jamming tool to simulate GPS jamming in the shiphandling simulator in Flensburg. Most of the investigation was realized by GLA. During the phase of development 3 versions were sent to FUAS and tested extensively. Version 1 had considerable problems with data acceptance and exporting generated GPS sentences. The version v2 ran stable and jamming the GPS signal of the own ship was possible and the integration in the shiphandling simulator also succeeded. But the so called “Random Walk” of the own ships position could hardly be observed because the time span of the jamming process was a fraction of a second. For demonstration purposes a “Random-Walk” over 30 seconds is required. Beside the problem of jamming the own ships position jamming of AIS data and target ships failed. The final version v3 had the ability to export eLoran sentences instead of GPS sentences. But both systems the EPD and the ECDIS in the simulator could not interpret the data. In summary GLA and FUAS developed a partly functioning jamming tool within lifetime of ACCSEAS but it was not usable for demonstrations and training purposes. During further development it must be achieved to jam the GPS signal of all ships within the area of a scenario and a duration of around 30 seconds.

However a prototype NMEA sentence has been developed within the project to convey resilient PNT information to the EPD. This was achieved by connecting the output of the MSPS receiver as a direct input to the EPD. The EPD uses this data, along with other inputs to display information to the mariner e.g. the current position error and the position source used [23, page 39]. In a similar procedure it was demonstrated in an EPD the effect of losing GPS signal.
Section 6 of the MSPS Description [23] outlines a structured regime for training stakeholders on the MSPS:

- “The rationale for providing Resilient PNT
- Options for sources of Resilient PNT
- An introduction to the Multi-Source Positioning Service
- Engineering officer training on how such systems work, their limitations and how to fault find with them.
- Navigating officer training
  -- Training for Navigating without GNSS

-- Training for using resilient PNT systems, what they can do and how to use them" [23]

During further development of the MSPS it is inevitable to implement simulated prototypes of resilient PNT system into Bridge operation simulators to review the impact on navigating officers and safe navigation.

8.5 Maritime Safety Information / Notices to Mariners (MSI/NM) Service

8.5.1 High level technical and operational description

Maritime Safety Information (MSI) is navigational and meteorological warnings, meteorological forecasts and other urgent safety-related messages. MSI today is actually broadcasted in text or voice via SafetyNET, NAVTEX, coastal radio stations and in some countries on the Internet.

Notices to Mariners (NMs) are promulgated particularly to keep nautical charts and publications up to date. Temporary and Preliminary NMs (T) and (P) advise mariners of important matters affecting navigational safety, including new hydrographic information (in advance of new editions or chart updates), changes to routing measures and aids to navigation. Chart corrections are corrections to paper and digital nautical charts which make it possible to keep the vessels charts up to date. NM T&Ps are distributed on paper, on the Internet and in addition Hydrographic Offices include NM T&Ps in their ENC updates.

Chart corrections and the way they are promulgated have evolved tremendously the past 10 years and are in many ways very different from MSI and other NM today. Chart corrections are georeferenced by nature. MSI and other NM are often georeferenced but not necessarily portrayable with text and symbols.

The essential difference between MSI and NM today is the way of promulgation and the speed of handling and thereby the quality assurance. The content of the two types of messages are nearly the same.

As part of the ACCSEAS project, a combined model for MSI and NM T&P has been devised and a web application has been developed in order to effectively test the combined model, the portrayal and the promulgation of the messages. – The "ACCSEAS MSI/NM (T&P) Service Description" [24] contains explanations of the most important features.

8.5.2 Nature of service and kind of Human-Machine Interface (HMI)

"The MSI/NM Service can be construed as "maritime traffic support system.

The maritime traffic may be directly influenced by maritime safety information sent to all vessels and No-Go-Area information sent to participating individual vessels.

The MSI/NM Service employs existing technologies of communication in existing and well understood fields of application in a novel way, i.e., by an optimal communication path selection in combination with an innovative HMI" [9].

8.5.3 Function area(s) of required simulators

Bridge operation, MSI/NM operation

8.5.4 Use of simulators for training and demonstration

During lifetime of ACCSEAS the development of the candidate solution MSI/NM (T&P) was strongly supported by EPD demonstrations, tests and evaluation using ship-side EPD and shore-side EPD stations, updated with an integrated MSI-NM System.

A shore-side user test was conducted in October 2014 with participation of relevant maritime authorities from Denmark, Sweden, Norway and the Netherlands. Participants tested in particular to create, edit, publish and manage the life cycle of MSI and NM messages. The user test was concluded with a workshop at the premises of the Danish Maritime Authority to discuss the feasibility of a combined MSI-NM model and the experiences obtained from using the MSI-NM test bench. “As general feedback it was concluded that there were indeed clear benefits of a combined MSI-NM model/system to the mariner/end user”, [24]. Furthermore it should be investigated, using the EPD simulation, how to present messages with no geographical information on graphical clients such as ECDIS and ensure that they are read by the officer on watch (OOW). Also it was debated if the OOW should be allowed to delete MSI-NM messages, and how to ensure that all relevant messages are available to the next OOW. As possible solution all OOWs are required to start their watch by reloading all MSI-NM messages. This should be tested and evaluated in future with active mariners by simulation. – The complete MSI-NM user test feedback and the conclusions are kept in the final subchapter of the MSI/NM (T&P) Service description [24].

For future use of MSI-NM they should be displayed as objects on the navigational (ECDIS) screen. That way the use of MSI-NM is incorporated in the IMO course 1.27 [21] in the Subject Area: “Watchkeeping with ECDIS”, Topic 16: “Chart Information”. This Subject includes a simulator exercise in coastal waters.

8.6 No-Go-Area Service

8.6.1 High level technical and operational description

At the present time vessels are sailing using charts with static depth curves. The safety contour can only be selected from the limited selection of contours contained in the electronic navigational chart (ENC) database, typically 2, 5, 10, 20, etc. meters. The depth information given is charted information related to a chart datum, a standard water level which can be different in different parts of the world. Normally a route is planned with a large under keel clearance (UKC) and the provided safety contours work well enough as an approximation of navigable waters. However in future with limited sea room, available space might need to be more efficiently used. In some countries in the NSR the required full bathymetrical database is publicly available for querying. Based on the provided database the ACCSEAS candidate solution “No-Go-Area Service” calculates the No-Go-Area.

The No-Go-Area Service is working by query. The OOW starts a “No-Go Request” on EPD. He selects the wanted area, the time interval and the current depth. The query is sent to a shore server that calculates the No-Go-Area for the vessel based on detailed bathymetry, tidal variation and weather. The No-Go-Area is returned and displayed as a polygon on the vessels EPD” [26].

8.6.2 Nature of service and kind of Human-Machine Interface (HMI)

“The No-Go-Area Service can be construed as “maritime traffic support system”
The No-Go-Area Service employs existing technologies of communication in existing and well understood fields of application in a novel way, i.e., by an optimal communication path selection in combination with an innovative HMI”

8.6.3 Function area(s) of required simulators

Bridge operation

8.6.4 Use of simulators for training and demonstration

During runtime of ACCSEAS project the ACCSEAS simulation workgroup (WGSim) developed 2 scenarios to test the operational features and the user acceptance of No-Go Area Service. All scenarios are taking part in the simulation test-bed area. The final tests were conducted using the “Bridge operation” simulators with amended EPD stations of Chalmers

University of Technology (Chalmers). The detailed scenarios are included in the "ACCSEAS Final Report" [19].

Introducing a new navigation service like the No-Go-Area Service needs additional dedicated basic training and familiarization of the new functions introduced in an electronic chart or ECDIS. This should, in the future, be part of for the basic course in tidal water and currents and a bridge management course.

This basic training needs to include the following parts, here introduced as training requirements:

- Measurement principle or service calculations in order to fully understands potential; data errors, pros and cons with the system or service;
- Data checking, how to perform integrity checking of the information;
- Familiarisation with functions and the display outline; and
- Operational methods and procedures used in the navigation process, hence taking into account all steps; appraisal, planning, execution, and monitoring.

Based on the training requirements listed above, a recommended solution is presented below. First, it is recommended that when a No-Go-Area Service is introduced, mariners that will use the service are attending an additional training module. For longer term, training of the service should also be introduced in the compulsory parts of the Master Mariner Program both on operational level and management level.

Training requirement	Recommended training solution
Measurement principle or service calculations	Lecture or high quality CBT
Errors and Pros and Cons	Lecture or high quality CBT
Data checking	Lecture or high quality CBT, Simulator exercise
Familiarisation with functions and display outline	High quality CBT, Ship simulator exercise
Operational methods and procedures	Ship simulator exercises

Recommended training solutions for the different training requirements.

Lectures where an instructor are explaining the theory, errors, data checking, introducing methods and procedures are very beneficial, especially if the class is rather small. The instructions can then be followed by interaction between the class and the instructor.

Computer Based Training (CBT) is a cost effective way of introducing new systems and services. It should be pointed out that the CBT tool needs to be of high quality appreciating pedagogic methods and means. However, this type of training will lack the interaction with an instructor.

Simulator exercise is used to train the practical and soft skills of using the service in a realistic context together with all other procedures etc.

For this type of simulations advanced ship simulators are recommended equipped with modern bridge equipment including the new service. The simulators are recommended to be of class A or B.
All No-Go-Area Service test-results are included in the "ACCSEAS Training Needs Analysis Report" [20].

8.7 Tactical Route Suggestion Service (shore-ship)

8.7.1 High level operational and technical description

Tactical Route Suggestion Service is a solution that may be used by VTS operators, shore based pilotage and SAR operation. The service provides a reliable method to transmit a route suggestion to vessels as a response to developing traffic situations in crowded and restricted areas. The targeted vessel receives the suggested route automatically e.g. via the AIS system and displays the route on the navigational information system; e.g. as a layer on an ECDIS. The service intends to substitute or supplement voice communication in case of communicating comprehensive and precise information. - All functionalities, a user manual and a description of the technical implementation are included in: “Tactical Route Suggestion Service Description” [17].

8.7.2 Nature of service and kind of Human-Machine Interface (HMI)

Tactical Route Suggestion service is a communication service using a shipboard HMI and, dependent on connected station (VTS, pilot station, MRCC) a shore side HMI. Over the AC-CSEAS period all steps of developing the service were carried out with an EPD ship station connected with an EPD shore station, VTS operation. In the same way the operational simulator tests and training needs analysis were conducted. To determine the training needs exactly ass possible the EPD ship stations were almost seamless integrated in the bridges of a siphandling simulator fulfilling the INS/IBS concept [18].

8.7.3 Function area(s) of required simulators

Bridge operation, VTS operation, future trend: Remote pilotage operation

8.7.4 Use of simulators for training and demonstration

During runtime of ACCSEAS project the WGSim developed 5 scenarios to test the operational features and the user acceptance of Tactical Route Suggestion Service. All scenarios are taking part in the simulation test-bed area. The final tests were conducted using the “Bridge operation” simulators with amended EPD stations of Chalmers University and Flensburg University of Applied Sciences (FUAS). The detailed scenarios are included in the “ACCSEAS Final Report” [19]. All test-results are part of the “ACCSEAS Training Needs Analysis Report” [20].
Based on the subject areas and topics described within section 4 “Description of developed service” [17] of the service description, it becomes apparent that the existing IMO Module Course 1.27 “Operational use of Electronic Chart Display and Information System (ECDIS)” [21] could be used as basis for Tactical Route Suggestion Service training. In particular the subject areas “ECDIS Route Planning and Monitoring” and “ECDIS Targets, Charts & System” of Model Course 1.27 containing subjects look very similar to subjects named in the manual like part of the service description.

Also the Model Course “Exercise 4 Simulator exercise – restricted waters (advanced integrated Navigation with ECDIS)” may easily be adapted by implementing operational objects of Tactical Route Suggestion. The use of simulators for Tactical Route Exchange Training should consider all STCW requirements determined in appendix 4 of Model Course 1.27 [21]. - In summary the observations during the simulation-tests and the gained experience with ECDIS 1.27 training courses max. 2.0 hours of additional simulator training is sufficient.
For this type of simulations advanced ship simulators are recommended equipped with modern bridge equipment including the Tactical Route Suggestion service. The simulators are recommended to be of class A or B.

In the future more effective training seems to be possible using a simulation network of one or more VTS simulators, manned with real VTS operators and a useful number of shiphandling simulators (Bridge operation), manned with BTM crew.

8.8 Tactical Exchange of Intended Route (ship-ship and ship-shore)

8.8.1 High level technical and operational description

Tactical Exchange of Intended Route provides the opportunity to transmit the own intended route to vessels in a specified area and to shore stations (VTS, MRCC, Pilot station). At the receiving stations the route is displayed on the ECDIS screen. By enabling vessels to send and receive each other's intended routes there is a chance to decrease the risk for conflicting situations, as dangerous close quarter situations up to collisions.

Further, VTS operators or pilots can assist vessels by sending a Tactical Route Suggestion to avoid dangerous situations (see section 8.7). "Tactical Exchange of Intended Route should be seen as a supplement of traditional VHF voice communication which is subject to misunderstandings due to language problems, lacking situation awareness, wrong interpretation of surroundings and human error" [22]. Using AIS as means of Exchange of Intended Route in practice has turned out to be too fragile. In the ACCSEAS project the Maritime Cloud MMS was used as the means of communication. - All functionalities, a user manual and a description of the technical implementation are included in the Description: "Tactical Exchange of Intended Route" [22].

8.8.2 Nature of solution and kind of Human-Machine Interface (HMI)

The Tactical Exchange of Intended Route can be construed as a "maritime traffic support system" [9]. The intended route exchange employs existing technologies of communication for a new field of application and in a novel way, i.e. by an optimal communication path selection (Maritime Cloud concept) in combination with an innovative HMI.

8.8.3 Function area(s) of required simulators

Bridge operation, VTS operation, future trend: Remote pilotage operation

8.8.4 Use of simulators for training and demonstration

During runtime of ACCSEAS project the WGSim developed 4 scenarios to test the operational features and the user acceptance of Tactical Route Suggestion Service. All scenarios are taking part in the simulation test-bed area with different environmental and traffic conditions. The final tests were conducted using the "Bridge operation" simulators with amended EPD stations of Flensburg University of Applied Sciences (FUAS). The detailed scenarios are included in the "ACCSEAS Final Report" [19]. All test-results are enclosed in the "ACCSEAS Training Needs Analysis Report" [20].

Studying the subject areas and topics described within section 4 "Description of developed service" [22] of the candidate solution description, it becomes apparent that the existing IMO Module Course 1.27 "Operational use of Electronic Chart Display and Information System (ECDIS)" [21] could be used as basis for Tactical Exchange of Intended Route training. In particular the subject areas "ECDIS Route Planning and Monitoring" and "ECDIS Targets, Charts & System" of Model Course 1.27 containing subjects look very similar to subjects named in the manual like part of the solution description. Also the Model Course "Exercise 4 Simulator exercise – restricted waters (advanced integrated Navigation with ECDIS)" may easily be adapted by implementing operational objects of Tactical Exchange of Intended Route. The use of simulators for Tactical Route Exchange Training should consider all STCW requirements determined in appendix 4 of Model Course 1.27 [21]. - In summary the observations during the simulation-tests and the gained experience with ECDIS 1.27 training courses, max. 2.0 hours of additional simulator training is sufficient.

In the future more effective training seems to be possible using a simulation network of one or more VTS simulators, manned with real VTS operators and a useful number of shiphandling simulators (Bridge operation), manned with BTM crew.

For training courses “Remote Pilotage” a simulation network of one “Remote pilotage” simulators, manned with pilots and a useful number of shiphandling simulators (Bridge operation), manned with BTM crew should be established.

8.9 Vessel Operations Coordination Tool (VOCT)

8.9.1 High level technical and operational description

Communication, timely and correct, between parties during a Search and Rescue (SAR) operation is of utmost importance. Today information is primarily exchanged via different ways of voice communication, which is both time consuming and contains a great risk of misunderstandings.

The VOCT is a tool to optimize communication and improve situational awareness during Search and Rescue (SAR), counter pollution and similar operations. Important relevant information required to be exchanged is, amongst others: search areas, search patterns, datum, drift calculations and areas searched. This important data are exchanged electronically between parties, both onboard and ashore. They are presented graphically on vessels and coordinators navigational displays. The coordinators are the SAR Mission Coordinator (SMC) and the On-Scene Coordinator (OSC).

8.9.2 Nature of service and kind of Human-Machine Interface (HMI)

The VOCT can be construed as “maritime traffic support system”.

“The VOCT directly influences the operation of the vessels participating in the SAR operation at hand which in turn influences the surrounding vessel traffic” [9].

The VOCT employs existing technologies of communication in existing and well understood fields of application in a novel way, i.e., by an optimal communication path selection in combination with an innovative HMI.

8.9.3 Function area(s) of required simulators

Bridge operation, MRCC operation

8.9.4 Use of simulators for training and demonstration

During life span of ACCSEAS some VOCT demonstration with back to back connected ship-side EPDs and a shore-side EPD station were carried out within workgroup meetings and at the 2nd ACCSEAS conference.
Based on the subject areas and topics described within the “ACCSEAS Baseline and Priorities Report”, section 4.10 [1] and the VOCT “Service Description” [25], it becomes apparent that the existing IMO Module Course 1.27 “Operational use of Electronic Chart Display and Information System (ECDIS)” [21] could be used as basis for VOCT training.
In particular the subject areas “ECDIS Route Planning and Monitoring” and “ECDIS Targets, Charts & System” of Model Course 1.27 containing subjects look very similar to the VOCT subject “transmitting search patterns”. Also the Model Course “Exercise 4 Simulator exercise – restricted waters (advanced integrated Navigation with ECDIS)” may easily be adapted by implementing operational objects of Tactical Route Suggestion in a course of a SAR operation.
The use of simulators for VOCT Training should consider all STCW requirements determined in appendix 4 of Model Course 1.27 [21]. - In summary the observations during the demonstration tests and the gained experience with ECDIS 1.27 training courses, max. 2.0 hours of additional simulator training is advisable.

In the future more effective training seems to be possible using a simulation network of one or more MRCC simulators, manned with real MRCC personnel and a useful number of shiphandling simulators (Bridge operation), manned with BTM crew.

8.10 Dynamic Predictor (for tug boat operations)

8.10.1 High level technical and operational description

The aim for investigation of the candidate solution “Dynamic Predictor (for tug boat operations)” is to find out if dynamic predictor exchange and tug force exchange is useful for manoeuvring a ship with tug assistance. It is also a tool to give the tugmaster more situation awareness in the manoeuvring.
Investigating risks and opportunities with exchanged predictor information and tug forces were the main objectives.
Once a tug comes close to the ship it is supposed to assist a wireless link for predictor exchange will be established. When established the tugmaster will see the ships predictor contours and the tug will send the forces to the ships predictor.
It is of interest to test if the tugmaster have good use of seeing the predictor and if the officer in charge of manoeuvring the ship has use of the improved accuracy achieved by the tug forces input.

8.10.2 Nature of service and kind of Human-Machine Interface (HMI)

The dynamic prediction of own vessel’s movements is transferred to the specifics of tug boat dynamic and operation in combination with an innovative shipboard user HMI.

8.10.3 Function area(s) of required simulators

Tug operation, often is included as tug operation module in a bridge operation simulator

8.10.4 Use of simulators for testing, training and demonstration

Desktop Simulation:
Over the period of ACCSEAS testing of interface and portrayal were carried out internally in desktop simulation using “SSPA Seaman” simulator. - Desktop simulator or a portable bridge simulator can be used for demonstration. The test bed was set up in cooperation with DMA to incorporate and use the ship-side EPD as main chart display.

Bridge Simulation:
Tests in bridge simulator were focusing on the operational service. For the tests SSPA “SeaMan Simulator” was used. The setup used the 330 degrees bridge. In the consoles the main chart was the ship-side EPD developed by DMA. The second chart display showed the chart in the open source software “Open CPN”. The third display showed the ships conning display, including rudder, speeds, engine rpm, wind speed and direction. The radar was not used in the tests of the predictor operational service.
Bridge simulation focussing on training demands was not carried out during ACCSEAS project.

8.11 Augmented Reality / Head-Up-Displays (HUDs)

8.11.1 High level technical and operational description

The application “Augmented Reality / Head-Up-Displays (HUDs)” (AR) has two functions. One is to alarm the mariner by means of an audible signal combined with a visual signal pointing towards the dangerous target, the other is a Head-Up Display of operational information. Operational information is considered in the widest meaning of it.
The most important functionality of AR is to point directly and visually in the direction of the dangerous target, thus inducing an immediate focus of the officer of the watch (OOW) on the dangerous target.
Apart from this 'alarm of last resort' function, AR can also function as a display of operational information. Once the information e.g. of a “Tactical Exchange of Intended Route” or “Maritime Safety Information (MSI)” or “NoGo Area” is available, displaying this information on a Head-Up Display. E.g. at a bridge window or OOW cocoon. This tool seems to be an effec-

tive combination of electronic Navigation and the traditional focus on visual identification and lookout.

8.11.2 Nature of service and kind of Human-Machine Interface (HMI)

HMIs to shipboard users

8.11.3 Function area(s) of required simulators

Bridge operation

8.11.4 Use of simulators for training and demonstration

Extensive simulator demonstrations in the test-bed were performed with the mobile ACCSEAS simulator, using the EPD ship-side software in Hamburg over 4 days during the leading international maritime trade fair SMM 2014 and during the ACCSEAS WGSim meetings.
Simulation focussing on training demands was not carried out in ACCSEAS project.

8.12 Automated FAL Reporting

8.12.1 High level technical and operational description

At the present time National Competent Authorities for the European SafeSeaNet (SSN) maintain vessel and voyage reporting systems intend for use by commercial marine traffic arriving and departing from NSR ports.
The planned demonstration would be extending, exploring and modelling substantially nongeographic maritime information, in particular case the "Notice Of Arrival and Pilot Requests (NOA&PR)" and possibly other reporting forms, using the S-100 framework.
The systems on board will automatically connect to a National Single Window service provided by the shore-side, using the internet and submit the information required e.g. upon a port call or at a reporting line. The National Single Window service acknowledges, and the shore based National Single Window system makes the submitted information available to other authorities.

8.12.2 Nature of service and kind of Human-Machine Interface (HMI)

HMIs to shipboard and shore-based users

8.12.3 Function area(s) of required simulators

Not investigated during ACCSEAS project

8.12.4 Use of simulators for training and demonstration

Not investigated within ACCSEAS project

8.13 Harmonized Data Exchange – Employing the Inter-VTS Exchange Format (IVEF)

8.13.1 High level technical and operational description

The Inter-VTS Exchange Format (IVEF) has been developed in a joint effort by the maritime industry. IVEF has been recognized by both IALA and IMO as an international standard.
The purpose of testing IVEF within the scope of ACCSEAS is to identify its possibilities and capabilities for the transnational exchange of Data between competent authorities and service providers in the ACCSEAS test-bed (VTSs, MRCCs, port authorities) as well as applications for services between shore-ship and ship-shore.

8.13.2 Nature of service and kind of Human-Machine Interface (HMI)

HMIs to shipboard and shore-based users

8.13.3 Function area(s) of required simulators

VTS operation, Bridge operation

8.13.4 Use of simulators for training and demonstration

Within ACCSEAS no simulation trials were conducted.

8.14 Real Time Vessel Traffic Pattern Analysis and Warning Functionality for VTS

8.14.1 High level technical and operational description

The "ACCSEAS Baseline and Priorities Report" [1] contains in section 4.15 a description with the idea of this candidate solution. There it is named:

> "an additional functionality at a VTS operator's workplace as follows: For the area monitored by the VTS, historical vessel traffic data, e.g. from AIS is constantly statistically analysed to determine the *"normal" pattern of the vessel **traffic** situation*. The statistical analysis builds in particular on vessel data such as heading, speed over ground, course over ground and draught. The thus derived "normal" vessel traffic patterns will be stored onshore e.g. in a database supporting the VTS. This data is then constantly compared with the continuously incoming fresh vessel data. A *warning is given to the VTS operator if an **individual** vessel is detected that behaves in a way deviating from the stored "normal" pattern*. On being alerted, the VTS operator can then focus on the vessel(s) behaving unexpectedly or deviating from the "normal" pattern to see if there is a risk of accident or if their behaviour is safe, potentially resulting in a warning to the vessel(s) under consideration or to the vessel traffic at large.
>
> To facilitate the automated evaluation the VTS area can be subdivided by using cells of fixed size into a "safety grid". Each cell contains the above relevant vessel traffic data and its associated analysis. Different grids may be created, e.g. by discriminating by vessel size or vessel type, to allow for further differentiation and/or ease of computation".

There is no further description in technical and operational terms or practical evaluation done within the ACCSEAS project.

8.14.2 Nature of service and kind of Human-Machine Interface (HMI)

Not investigated within ACCSEAS project.

8.14.3 Function area(s) of required simulators

VTS operation

8.14.4 Use of simulators for training and demonstration

Not investigated within ACCSEAS project

9 Terms and Acronyms

Acronym or Term	Definition
ACCSEAS	Accessibility for Shipping, Efficiency Advantages and Sustainability
AIS	Automatic Identification System
AR	Augmented Reality
ARPA	Automatic Radar Plotting Aid
BTM	Bridge Team Management
CBT	Computer based Training
DGNSS	Differential Global Navigation Satellite System
DIS	Distributed Interaction Simulation
DNV	Det Norske Veritas
ECDIS	Electronic Chart Display and Information System
ENC	Electronic Navigational Chart
EPD	e-Navigation Prototype Display
ESMN	European Maritime Simulation Network
ETA	Estimated Time of Arrival
FAL	Facilitation of Maritime Traffic Reporting
FUAS	Flensburg University of Applied Sciences
GL	Germanischer Lloyd
GLA	General Lighthouse Authority
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positioning System
HAL	Horizontal Alert Limit
HF	High Frequency
HMI	Human-Machine Interface

HPL	Horizontal Protection Level
HUD	Head Up Display
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IBS	Integrated Bridge System
IMO	International Maritime Organisation
IMSF	International Marine Simulators Forum
INS	Integrated Navigation System
IVEF	Inter-VTS Exchange Format
MC	“Maritime Cloud”
MF	Medium Frequency
MMS	Maritime Messaging Server
MRCC	Maritime Rescue and Coordination Centres
MSC	Maritime Safety Committee (of IMO)
MSI	Maritime Safety Information
MSPS	Multi-Source Positioning Service
MSPs	Maritime Service Portfolios
MSRX	Multi Source Receiver
NAVTEX	Navigational Textmessages
NCSR	Sub-Committee on Navigation, Communication and Search and Rescue
NM	Notices to Mariners
NOA&PR	Notice Of Arrival and Pilot Requests
NSR	North Sea Region
OOW	Officer of the Watch
OSC	On-Scene Coordinator
PNT	Position, Navigation, Timing
R-Mode	Ranging Mode

RTM	Route Topology Model
SAR	Search and Rescue
SIP	IMO e-Navigation Strategy Implementation Plan
SMC	SAR Mission Coordinator
SMM	Shipbuilding, Machinery & Marine Technology
SOLAS	Safety of Life at Sea Convention
SSN	SafeSeaNet
STCW	Standards of Training, Certification and Watchkeeping
STM	Sea Traffic Management
T&P	Temporary and Preliminary
UKC	Under Keel Clearance
VOCT	Vessel Operations and Coordination Tool
VTS	Vessel Traffic Services
WGSim	Workgroup Simulation

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