ACCSEAS Legacy Report

Including a sustainable plan for future Work

Issue: 1

Issue Status: Approved

Issue Date: 18/05/2015

Lead Author	Reviewer	Approved for Release
Name: Pieter L. Paap	**Name:** Transnational Project Co-ordination Group	**Name:** Project Steering Committee
Job Title: WP8 Contributor	**Job Title:** N/A	**Job Title:** N/A
Partner: Rijkswaterstaat / The Netherlands	**Partner:** All	**Partner:** All
Signature: Pieter L. Paap	**Signature: pp Alwyn I. Williams**	**Signature:** pp Alwyn I. Williams

Document Disclaimer

Document is uncontrolled when removed from iManage (either electronic or printed)

Document Information

Project Title	ACCSEAS
Work Package No.	8
Document Title	ACCSEAS Legacy Plan
Description	Provides an overview of the legacy of the ACCSEAS project, and develops the Sustainability Work plan for the North Sea Region.
Date	18/05/2015
Lead Author	Pieter L. Paap
Lead Author's Contact Information	Mail - pieter.paap@rws.nl Mob - +31 6 466 36 190
Contributing Author(s)	All beneficiaries
iManage Location	29927
Circulation	1. Client 2. Project Files (i-manage) 3. Transnational Project Co-ordination Group 4. Project Steering Committee
NSRP Secretariat Approval	~~Yes~~ / No

Executive Summary

Chapter 1 provides background to this document, describing the tasks of Work Package 8, the purpose of this document and clarifies the identified different levels of legacy of the ACCSEAS project: Organizational Legacy, Substantial Legacy and the Material Legacy.

Organizational Legacy

Because of the complexity of the e-Navigation concept and aware of the large variety of stakeholders involved, with their different interests and responsibilities, Section 2 and following explains the compelling need for a future NSR transnational coordination for the further development and implementation of e-Navigation and, as a legacy of ACCSEAS the proposed organizational aspects (including the justifications) on how to realize a regional collaboration with a description of the intended fora. The Terms of Reference of these fora are reflected in Annex B to this document.

Substantial Legacy

In Section 3 and following the Substantial legacy of ACCSEAS is given in its full extend covering the Work Packages 2 until 7, including the achievements on Publication and Communication (WP3), the results of research (WP3) in setting the Baseline and Priorities for the NSR, followed by the aspects on Architecture and Simulation and Training (WP4), a reflection of the performed tests and their results on Resilient PNT (WP5). After this the focus is on the work and tested the candidate solutions and summarizing their results (WP6). With every subject Future Work items have been indicated, which finally is categorized and numbered in Annex C to this report.

Material Legacy

Section 4 describes the material legacy of ACCSEAS with specific subsections on the Geographic Information System for the NSR (GIS-NSR), Ship Positioning equipment and e-Navigation Services software.

Work plan 2020+

Finally Section 5 gives a number of considerations in respect on to organize the future work items after the project ends including a proposal on how to disseminate relevant work, results and legacy to international, regional organisations, administrations, competent authorities and other stakeholders.

Contents

1   Background

1.1   Scope and tasks of Work Package 8

In accordance with the formal Application Format for the ACCSEAS project the primary role of Work Package 8 is to assure the future co-ordination and harmonized implementation of e-Navigation in the NSR as a legacy of ACCSEAS.

This can be achieved by the establishment of the proper and needed organizational platforms ensuring the involvement of current and future stakeholders such as a *NSR e-Navigation Forum*[1] and a *NSR e-Navigation Service Providers Co-ordination Group*[2] or any other platform that after project ends ensures

a)   the future involvement of all relevant stakeholders in order to sustain a basis for future *vertical integration* between stakeholders with maritime access priorities in the NSR (2020+);
b)   *horizontal integration* between service providers and responsible competent authorities to coordinate the evolution and implementation of e-Navigation in the region to 2020+ as a means of continuing improvement of regional maritime access;
c)   transparent and sustainable decision making processes.

These platforms may, where appropriate and convenient, be linked to similar legacy events from other projects and programs.

Another role for WP8 is to capture, in order to ensure continuity and harmonization of ACCSEAS e-Navigation outcomes from 2015-2020, the results and recommendations of the Work Packages 3 - 7 into a 'Plan for the Sustainability and Harmonization of e-Navigation in the NSR'. This plan[3] provides the basis for a program of future work and an eventual roadmap for service expansion, ensuring that ACCSEAS results and impact may, as a legacy of the project, continue or are used after project ends.

1.2   Purpose of this Legacy Report

This document is intended to capture the legacy items from the ACCSEAS project, and to ensure that a project-wide understanding of what these are, and how they relate to the implementation activities of e-Navigation in general, and in the North Sea Region (NSR) in particular.

The legacy items noted in this document are derived from the outcomes described in the ACCSEAS Application Form and supporting documentation as produced by the project. Where appropriate, the items will be referenced to the original document.

1.2.1   Considerations - Sustainable Plan for future work / Roadmap for service expansion

With a view to highlight identified candidate future work in this document the future work has been categorized, numbered (FW..) and summarized in Annex C.

Recognizing
- the evolving international developments on the e-Navigation concept, developments in the NSR,
- final (policy) decisions on the implementation of e-Navigation services in the region, and
- the (intended) start/continuation of relevant other projects

---

[1] ACCSEAS Application, para 8.1 refers
[2] ACCSEAS Application, para 8.2 refers
[3] ACCSEAS Application, para 8.3 refers

The TPCG came during ACCSEAS to the conclusion that setting up a Roadmap for service expansion was too premature at this stage. This task (enlisted in future work) shall have to be done in a joint effort by the appropriate competent authorities and service providers in the NSR after project ends.

1.2.2   The use of the term "item"

The use of the term *"item"* in this document may incorporate a variety of aspects to be considered, such as: future regional coordination and collaboration on the development and implementation of e-Navigation, organizational aspects, transnational/multilateral/bilateral agreements, a service or combination of services, an application, a system or systems, hard and software, proposals for harmonization and standardization, training aspects, legacy and/or sustainability issues.

1.2.3   The levels of legacy of the ACCSEAS project

The legacy items of ACCSEAS can be distinguished in the following levels:

- **Organizational legacy**

To assure the future co-ordination and harmonized implementation of e-Navigation in the NSR as a legacy of ACCSEAS is the primary role of Work Package 8 of the project. The co-ordination may be carried out, based on the organizational legacy of the project, as in several strands detailed in chapters 2 and 3.

- **Substantial legacy**

The substantial legacy items of the project are to be differentiated into
- o The results of research, identification and study of recent and future developments and challenges in the NSR;
- o The results of the identification, development, testing and simulation of candidate solutions;
- o The feedback and recommendations of stakeholders (users consultations) during the development period of the project as well as gained during the Annual Conferences and the organized Workshops under the umbrella of the NSR e-Navigation User Forum;
- o The dissemination and sharing the results and experiences with all relevant and interested inter-national, regional and national parties (Communications & Publications under Work package 2).

These descriptions, results, conclusions, recommendations and identified candidate future work per subject are described in Section 3 and following and an overall summery of candidate future work is reflected in Annex C as an input and contribution to a future Sustainable Workplan for the NSR.

- **Material legacy**

As a part of the ACCSEAS project funding, a budget was made available for "*Material Investment*" in order to purchase the required equipment to perform the demonstrations in the test-bed area, to develop software and other instruments needed for test beds etc. The material legacies of the project are reflected in Section 4 including the recommendations and eventual agreed future ownership and utilization of these material legacies.

The intention is keep this document *"live"* to ensure that the current status of the legacy items remain true.

2   Organizational legacy

For the management of the ACCSEAS project a number of organizational instruments have been developed and were embedded in the project structure. These can be distinguished into two categories:

The first **category** is the regular organizational aspects such as a central Project team and Secretariat (Work Package 1) including a Communications structure (Work Package 2), a Project Steering Group (PSC) and a Transnational Project Co-ordination Group (TPCG).

The **second category** of organizational instruments were deemed to be necessary by the project partners, in accordance with the ACCSEAS Application Form and supporting documentation, in order to guarantee

a. capturing the specific user needs for potential solutions to be developed, tested, simulated and demonstrated;
b. collecting the feedback of users and user groups on these potential solutions and other ideas;
c. dissemination of the interim project results to stakeholders and users/user groups and other interested parties;
d. internal project horizontal integration of developments, embedding, test beds, substantial tuning etc.
e. horizontal integration of relevant aspects of these potential solutions in the project with the aim to enhance coherency, transparency and the identification of organizational, functional and technical communalities;
f. decision making shall take place on the proper level on issues surpassing the mandates or competences of the project beneficiaries;
g. guidance and advise on these (mostly policy or strategic) issues being provided in time by national administrations or competent authorities.

The organizational instruments in this category during the ACCSEAS project in this category were:

Instrument	Relation
• Vertical integration Workshops (VieWs)	a, b, c
• Horizontal Integration Groups (HIGs)	d, e
• Service Providers Coordination Group (SPCG)	a, b, c, d, e
• Transnational Advisory and Guidance Group (TAGG)	f, g
• NSR e-Navigation Forum	a, b, c, d,
• The ACCSEAS Annual Conference	a, b, c, d,

Fig. 1 The project structure of ACCSEAS and its fora
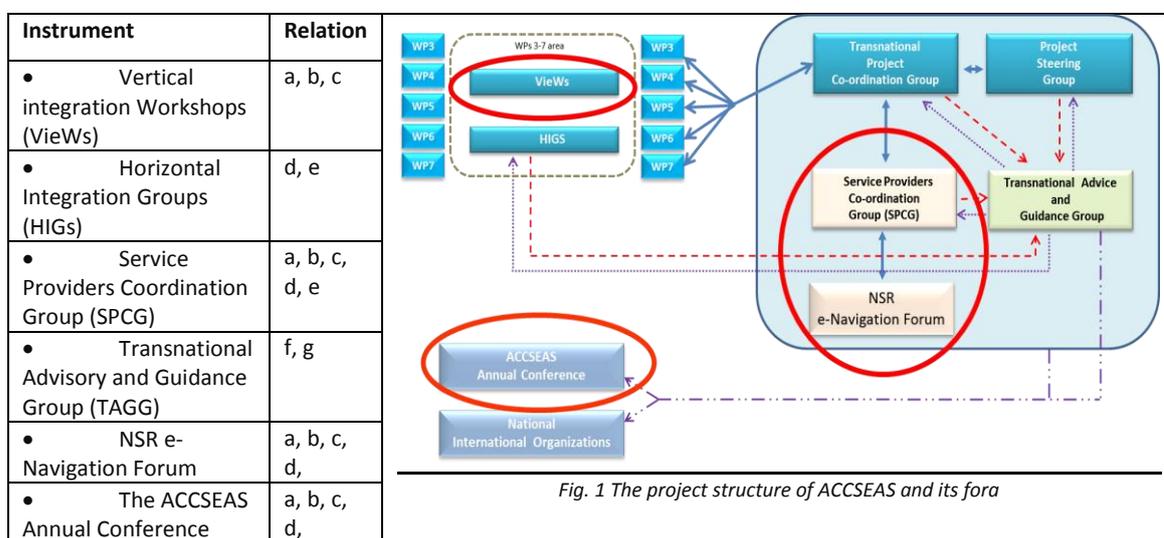
As the regular internal ACCSEAS project blocks (reflected in blue in the diagram above) will be gone after project ends there are good reasons (described as such in the following sections 3.1 until 3.9) to recommend that the NSR-SPCG, TAGG, NSR e-Navigation Forum and Annual Conferences may continue as platforms as a legacy of ACCSEAS. The employment and style of work in organizing VieWs and HIGs may, where convenient and useable, also be maintained in a new structure or approach.

2.1   The compelling need for future NSR co-ordination of e-Navigation

2.1.1   Different geographical, (future) traffic and utilization circumstances

It is well recognized that circumstances, conditions and developments may differ in various sea regions due to for instance geographical and tidal circumstances, the intensity and diversity of shipping, the organization of and responsibilities for traffic management and the differences in demands for the utilization of marine space).

2.1.2   Different interests and competences of parties involved

During the ACCSEAS project it was noted that the parties involved (e.g. competent authorities and administrations) and identified relevant stakeholders (e.g. service providers and end users) differ in interests and competences. It was well understood that

- envisaged national and regional policies, frameworks and views of the relevant NSR countries and regions towards future developments or measures to be taken dealing with safety, accessibility and maritime spatial planning related issues in the NSR may differ;
- within the duration of the ACCSEAS project, the development of the implementation period of e-Navigation as well as within the implementation period of the e-Navigation concept itself these various interests, policies, frameworks and views stakeholders have to be taken into account;
- at certain moments - in the near future - provisional decisions and even permanent choices may be or will have to be made in order to establish a future harmonized and coherent e-Navigation in the NSR. These decisions and choices may have a policy, an organizational, or an operational, a technical or an architectural character;
- the organization of competencies in this respect may differ between the relevant NSR countries and regions, for instance:
    - policy responsibilities, decision making or the coordination may be assigned to various administrations, departments or competent authorities;
    - national or regional competent authorities may not act as service providers, as well as
    - service providers may not act as a regional competent authority (and therefore has no policy decision making competences);
    - in some countries national or regional competent authorities also act as a service provider.

2.1.3   Development milestones of e-Navigation

During the development period of e-Navigation 2006-2014 under the flag of the IMO (with considerable substantial support of the IMO member states and relevant NGOs and IGOs) user needs were identified, a Formal Safety Assessment according to IMO regulations and a GAP analyses performed, potential solutions identified (covering the core aspects: Human elements, Communications and data management, GNSS and Resilient PNT, harmonized provision of functional and technical services, Uniformity of formats for reporting, Electronic Nautical Charts and Architecture). After an assessment with Risk Control Options and a preliminary list of candidate solutions actions was setup, an overarching e-Navigation Architecture approved. Finally 5 actions were prioritized connected to 17 identified Maritime Service Portfolios (MSPs) and incorporated into the IMO Strategy Implementation Plan (SIP) for e-Navigation. This plan was approved by the IMO Maritime Safety Committee at its 94th session in December 2014.

2.1.4   Developments and influences from outside the NSR

The development and implementation of e-Navigation is not just a regional or national decision making process. In most cases national administrations and competent authorities are on one hand committed for the provision of maritime services to overarching Conventions and underlying relevant Resolutions (e.g. SOLAS[4]), international regulations, regional directives and legislation (e.g.

---

[4] IMO Convention of Safety Of Lives At Sea, 1974 and amendments

EU). On the other hand they have committed themselves and adjusted national legislation and policies to follow Guidelines, Recommendations and Standards provided by other international bodies (e.g. IALA, IHO, IEC).

Other programs, concepts and framework under development outside the region, here relevant, will definitely affect the choices to be made on how to implement e-Navigation and its candidate solutions, for instance

- following the results and in support to the *UN Conference on Sustainable Development*, known as the *"Rio+20 process" of implementing sustainable development and the transition by a green economy* the IMO Secretary General introduced and explained the proposed worldwide Sustainable Maritime Transportation System (SMTS).[5]
- the IMO approval of the Strategic Implementation Plan (SIP) for e-Navigation and the agreed focus on prioritized solutions[6], ushering in the practical implementation period of the e-Navigation concept;
- the decision by the IMO Maritime Safety Committee[7] on the insertion of prioritized tasks mentioned in the SIP into the IMO High Level Action Plan (HLAP) for the biennium 2016-2017 and 2018-2019.
- the establishment of a EU framework for maritime spatial planning[8];
- the establishment of an EU community vessel traffic monitoring and information system[9];
- reporting for formalities for ships arriving in and/or departing from ports of the EU Member States[10].

On the other hand e-Navigation, and as such the results of ACCSEAS in its role as being a test bed for this concept, may significantly contribute to and impacts the development of SMTS and European developments such as e-Maritime. This is reflected in section 3.4 and following in this document.

2.1.5 Common accepted consequences of e-Navigation

The ongoing discussions on e-Navigation (2006-present) led to a worldwide awareness and acceptance of the fact that the implementation of e-Navigation will have consequences for and affect - the degree depending to the international, regional, national and even the local context -:

- Legislation (international, regional and national);
- Responsibilities (both ashore - authorities, service providers - and aboard - mariners -);
- Organisation (both ashore and aboard, human resources, including training);
- Processes (operational, technical and management - including the management of data -);
- Service provision (current and new in Maritime Service Portfolio's - a combination of functional and technical services-), based and depending on various and evolving stakeholder's needs and requirements;
- Shore based infrastructure (navigation, communication, data systems and networks, man/machine interfacing);
- Equipment on board vessels (navigation, communication, data equipment, portrayal and man/machine interfacing);
- Financial resources**.**

---

[5] World Maritime Day, September 2013, published on IMO website www.imo.org

[6] 94th session of the IMO Maritime Safety Committee, November 2014

[7] 95th session of the IMO Maritime Safety Committee, June 2015

[8] Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014

[9] Directive 2002/59/EC of the European Parliament and of the Council of 27 June 2002 repealing council Directive 93/75/EEC, OJ L 208, 5.8.2002 20

[10] Directive 2010/65/EC of the European Parliament and of the Council of 20 October 2010 and repealing Directive 2002/6/EC

Future work: Administrations, organizations and competent authorities to investigate and determine. collectively (transnational) or individually (national), the consequences of the (future) implementation of e-Navigation taking into account the list of common accepted consequences of e-Navigation (section 2.5 of the Legacy Report) on regional and national level, including undertaking a risk analysis ("*what if, what if not*") and a cost/benefit analysis.

2.1.6   Conclusion

Considering all previous reflected issues collaboration and tuning between administrations, competent authorities and service providers in the NSR will be necessary and highly recommended after the ACCSEAS project ends, with an eye for evolving user needs, changing circumstances and the variety of measures, instruments and solutions potentially dealing with the future challenges in the region.

This collaboration may be achieved and organized by taking into account the opportunities and proposals provided by the organizational legacy of ACCSEAS, as described in the sections 2.2 until 2.10 hereafter.

2.2   NSR e-Navigation Co-ordination Platform (NSR-eNAV-CP)

Section 2.1 of this document shows there is a compelling need for an overall future coordination of the further development and implementation of e-Navigation for the NSR taking into account all interests (policies, service provision, user needs, implementation strategies and agreements, future service expansion etc.). Based on the above risk analysis it has preference and recommended to position the NSR-SPCG and NSR-PHG under the umbrella of **NSR e-Navigation Coordination Platform (NSR-eNAV-CP)** or an existing regional recognized body.

2.2.1   Considerations for harmonized implementation of e-Navigation under an existing
recognized body

During the deliberations within ACCSEAS concerning a future organizational legacy of the project it was considered to position the harmonized implementation of e-Navigation in the NSR under the umbrella of an existing regional recognized body. Two potential bodies were considered:

2.2.1.1   OSPAR

The Convention for the Protection of the Marine Environment of the North-East Atlantic or *OSPAR Convention* is the current legislative instrument regulating international cooperation on environmental protection in the North-East Atlantic. It combines and up-dates the 1972 Oslo Convention on dumping waste at sea and the 1974 Paris Convention on land-based sources of marine pollution. Work carried out under the convention is managed by the OSPAR Commission, which is made up of representatives of the Governments of the 15 signatory nations, and representatives of the European Commission, representing the European Union.

OSPAR has first developed, and is implementing, a suite of five thematic strategies to address the main threats that it has identified within its competence (the Biodiversity and Ecosystem Strategy, the Eutrophication Strategy, the Hazardous Substances Strategy, the Offshore Industry Strategy and the Radioactive Substances Strategy), together with a Strategy for the Joint Assessment and Monitoring Programme, which assesses the status of the marine environment and follows up implementation of the strategies and the resulting benefits to the marine environment. These six strategies fit together to underpin the ecosystem approach.

Although this is not a separate Strategy, the OSPAR Commission has also considered the relevance of climate change issues in a wider context. The OSPAR Commission is an active member of the global group of Regional Management Organisations and cooperates closely with its partner organisations, e.g. the Helsinki Commission (HELCOM) for the Baltic Sea and the different programmes established under the UNEP Regional Seas Programme.

The OSPAR Commission works jointly with other competent management authorities for the North-East Atlantic to counter marine pollution and deliver sustainable ocean management in a consensual and robust way. To further strengthen cooperation the OSPAR Commission has agreed Memoranda of Understanding or Agreements of Cooperation with a number of relevant international organisations including the North-East Atlantic Fisheries Commission (NEAFC), the International Maritime Organization (IMO), the International Council for the Exploration of the Sea (ICES), the UN Economic Commission for Europe (UN ECE, the International Atomic Energy Agency (IAEA) and the Sargasso Sea Alliance. Close collaboration is also maintained with the European Commission and the European Environment Agency.

The OSPAR Commission also contributes to the global discussions on marine conservation, held e.g. in the UN General Assembly, the Convention on Biological Diversity (CBD) and the International Union for Conservation of Nature (IUCN), and provides regional approaches to protecting the marine environment and managing natural resources.

The North Sea Network of Investigators and Prosecutors (NSN) was established as a body of the OSPAR Commission following an invitation from the ministerial North Sea Conferences and provides a direct link to the Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances (Bonn Agreement).

It is recognized that *Marine Spatial Planning* (specifically the planning of alternative energy sources - windmill farms - in the NSR has high attention of OSPAR. Apparently here lies the link with ACCSEAS and future organizational aspects of the project, as indicated in the ACCSEAS "*ACCSEAS Baseline and Priorities Report*".

However, it is also recognized that the primary focus of OSPAR is on the "*green*" environmental aspects and has in general no particular interest or substantial expertise on aspects such as the safety of navigation, the efficiency of maritime transport and logistics. There is a considerable risk, when positioning a NSR e-Navigation Coordination Platform under OSPAR, that these interests will be snowed under in the OSPAR programs and its core subjects of attention. This may on one hand cause conflicts with the intentional views on the implementation of e-Navigation (IMO SIP) and delays for the actual implementation of the concept and its services.

2.2.1.2   North Sea Commission (NSC)

The North Sea Commission is a cooperation platform for regions around the North Sea. Our mission is to further partnerships between regional authorities which face the challenges and opportunities presented by the North Sea. This Commission recognizes that a key challenge in the North Sea is the management of conflicts between different sectors, as well as finding a sustainable balance between environmental protection, blue growth and social issues. This could be a potential barrier to unlocking the potentials of the region. The energy "trilemma" of security of supply, sustainability and affordability is one of the greatest tests facing Europe today. This brings with it a pressing need for collaboration between NSR States, regions and private partners on energy and major power generation infrastructure.

In 2013 the European Parliament granted 250.000 euros for a preparatory action for the North Sea region. The aim was initially to analyse the region's growth potential and to use the findings to investigate the added value of a Macro Regional Strategy for the North Sea area. A macro regional strategy for the Baltic Sea was adopted in 2009; similar strategies for other sea basins are under development at EU-level. There is not yet a macro regional strategy for the North Sea. This preparatory action gives an opportunity to define the added value for increased cooperation in and around the North Sea.

European Commission DG Mare is responsible for implementing the preparatory action and is organising two stakeholder events. In the light of the recent EU Directive on Maritime Spatial

Planning the first event (29th January 2015) will focus on maritime spatial planning and offshore renewable energy.

Through dialogue and formal partnerships the North Sea Commission seeks to promote common interests, especially in relation to European Union institutions, national governments and other organizations dealing with issues that are relevant to the North Sea.

The main objectives of the North Sea Commission are
• To promote and create awareness of the North Sea region as a major economic entity within Europe;
• To be a platform for developing and obtaining funding for joint development initiatives;
• To lobby for a better North Sea region.

Cooperation focuses on 5 main themes (*Marine resources, Transport, Energy and climate change, Economic development, Culture and tourism*) and involves policy development and political lobbying, development of transnational projects and exchange of knowledge and best practice.

It is recognized that two of the main themes (*Transport and economic development*) are close to the ACCSEAS objectives and the period after this project ends. Risks here, when positioning a NSR e-Navigation coordination Group under NSC, are that an *increase of politics* will dominate the discussions on a practical implementation of e-Navigation and sight will be lost on the key objectives of the concept: *harmonisation, standardisation, safety of navigation and accessibility of the region*.

2.2.1.3   Cooperation with existing regional recognized bodies
Nevertheless, there are sufficient keystones to establish and assure close cooperation with both OSPAR and the NSC. This can be achieved by a clear window of the future NSR e-Navigation organization for these organizations, the proclamation of its objectives and a well-structured information exchange.

2.2.2   Recommendation for of a NSR e-Navigation Coordination Platform (NSR e-NAV-CP)

Taking all above considerations in the previous sections into account it is recommended to establish as a legacy of ACCSEAS **a *NSR e-Navigation Coordination Platform (NSR e-NAV-CP)*** that

• embraces the proposed NSR Policies Harmonization Group (NSR-PHG) on e-Navigation,
  the NSR e-Navigation Service Providers Co-ordination Group (NSR-SPCG) (see the sections 2.3 and 2.4 hereafter) and
• organizes the proposed NSR e-Navigation Users Forum and NSR Biennial e-Navigation Conferences (see the sections 2.5 and 2.6 hereafter).

In the past two other regional collaboration platforms were established with various objectives. These platforms may act as examples on how to organize and establish the proposed *NSR e-Navigation Coordination Platform.*

2.2.2.1   North Sea Regional Coordination Conference GMDSS (NRC/GMDSS)
In the period 1984-1991 IMO developed the worldwide Global Maritime Distress and Safety System (GMDSS), a maritime communication network under the auspices of the SOLAS (Safety Of Life At Sea) Convention. New technologies (e.g. Satellite communication, NAVTEX and Digital Selective Calling) were introduced. The implementation period of GMDSS started on 1st February 1991 and ended around the North Sea in 31 December 1998. The formal implementation period ended globally in 2005.

The consequences for the implementation of GMDSS are comparable with the implementation of worldwide e-Navigation concept (see section 2.7). These consequences were well recognized by the various NSR administrations, competent authorities and service providers of GMDSS. Also recognized was the compelling need for regional coordination and collaboration.

In 1991, initiated by The Netherlands, UK, German, Danish and Norwegian administrations therefore the *Northsea Regional Coordination Conference under GMDSS (NRC/GMDSS)* was established. At the same time a similar platform was established for the Baltic Sea (BRC/GMDSS).
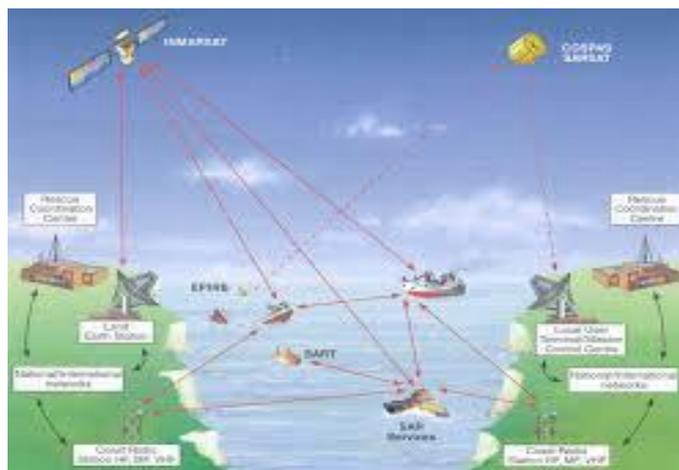
Fig. 2 Architectural image of GMDSS

The way of working of these platforms, their composition (policy decision makers, service providers - e.g. coast guards, coastal stations such as VTS - and mariners participating in various working groups) and the substantial conceptual complexity was quite similar as now proposed for the NSR e-Navigation Coordination Platform. NRC/GMDSS and BRC/GMDSS resulted in a very well coherent approach and smooth implementation of GMDSS in both regions. The last and final meetings of those platforms - highly valued for their results and output dissemination and recognized by IMO/COMSAR and other international organizations - took place in 2000.

2.2.2.2   Northwest European Loran-C System (NELS) organization

A large number of people know of the GPS (Global Positioning System). It was recognized that complete relying on a military system such as GPS was not desirable. Also in the NSR it was noted that second system of navigation assistance was available in many areas of the Northern Hemisphere: LORAN-C. Countries around the North Sea decided to set up a LORAN-C network for the northwestern part of Europe and established in the eighties of the past century the Northwest European Loran-C System (NELS).

This system consisted of 9 transmitter stations: Bo, Jan Mayen, Vaerlandet and Berlevg in Norway, Ejde on the Faeroe Islands, Sylt in Germany, Lessay and Soustons in France and Loop Head in Ireland.NELS was controlled by a Steering Committee with representatives from member nations Denmark, France, Germany, Ireland, The Netherlands and Norway. Non-member, but interested, parties such as the United Kingdom contribute as observers.

To implement decisions taken by the Steering Committee, a Coordinating Agency Office was established by the Norwegian Defense Communications and Data Services Administration (NODECA) acting on behalf of the Royal Norwegian Ministry of Fisheries. Each member nation has also set up a National Operating Agency (NOA) to implement Loran-C policy and operations.

In itself the organization of NELS functioned well. Key aspect for this was the focus on only one and well understood subject/system and was not aggravated with the complexity of a concept such as e-Navigation. In the beginning of the second millennium the NELS organization was dissolved, mainly because of the fact that the regional LORAN-C system as proposed persisted mainly in a semi-operational and test bed environment and NELS kept struggling to find connectivity and convincing potential user groups (maritime and other shore based transport modalities).

2.2.2.3   Benefits of an regional overall NSR-eNAV-CP

The benefits of an overall NSR-eNAV-CP are

- a clear recognizable organizational structure with a clear window function for other relevant regional existing recognized bodies with common grounds on the utilization of sea space (e.g. OSPAR), European and international platforms/organizations;
- maintaining focus on the relevant maritime e-Navigation subjects and shipping interests.
- a rather high degree of cohesion and short lines between the various stakeholders (policy decision makers, service providers, mariners, ports and logistic interested parties);
- opportunities for coherent dissemination of regional developments and vision in the international fora, blocking opportunities for regional interests assurance;
- connecting opportunities to similar representative groups of neighbouring regions (e.g. Baltic Sea Region - BSR).
- fulfilment of the example function for other regions (within and outside EU);
- reducing the risks as described in section 3.3.

2.3 NSR Policies Harmonization Group (NSR-PHG) on e-Navigation

2.3.1 Policy issues affect choices for systems, solutions and applications

Although some national or regional competent authorities and/or service providers have participated in their capacity of project beneficiaries in the ACCSEAS Project Steering Group (PSG) and in the Transnational Project Co-ordination Group (TPCG), it became clear that both groups, respectively dealing with steering the project and the coordination of the Working Packages, would not cover the competences for policy decision making issues with regards to the developments in the NSR in general and the coherent implementation of e-Navigation (elements) as such. It was noted that

- most participating coastal administrations and/or competent authorities - responsible for their areas of responsibilities, EEZ and 12-miles zones - developed their own national or regional policy plans (based on facts, figures, studies and assumptions) to increase safety, efficiency, security and to protect the environment in those areas for the future;
- these policy plans and views (e.g. how to manage traffic flows, Marine Spatial Planning, transport of dangerous goods, no-go areas, accessibility of national ports, measures to decrease threats to safety, transport efficiency and environmental protection etc.) may differ between the projects beneficiaries or the relevant national administrations.

2.3.2 Need for a policies harmonization and decision making on e-Navigation

In order to achieve a common developed and implemented e-Navigation in the NSR (many systems, solutions and applications are expected to cross border) it will be necessary to pro-actively discuss, harmonize and tune those different policy issues, expectations, heading views and choices for the region where appropriate and practicable towards common shared visions. After all, these aspects will eventually affect the choices to be made for the right e-Navigation architecture, services to be provided, systems, solutions, applications (PNT, communications, information management etc.) during the project and beyond that. It is most likely that tuning of national/regional policies and perceptions in most cases are not within the mandate of operational orientated service providers.

2.3.3 NSR-PHG as a legacy of ACCSEAS

After the closure of ACCSEAS a platform with the mandate for tuning and harmonizing the various national policies in the NSR and decision making on policy related implementation issues is needed to ensure the optimum benefits between policy, operational and technical orientated choices. This platform, based on the intended *Transnational Advisory and Guidance Group (TAGG)* of ACCSEAS and renamed as **NSR Policies Harmonization Group (NSR-PHG)**, may continue as a legacy of the project either as a stand-alone group or under the umbrella of specific NSR e-Navigation Coordination Platform (NSR-eNAV-CP) or an existing regional recognized body.

The focus of this platform should be

- the actual harmonized implementation of e-Navigation in the NSR from Coastal State and Port State perspectives;
- the tuning of relevant national/regional policies and perceptions;
- to sustain future transnational collaboration between administrations, competent authorities and service providers involved, resulting in organizational, technical, operational and financial (investments) benefits;
- to develop, where appropriate, common shared views and positions on safety and accessibility and e-Navigation related issues for dissemination in the proper international organizations (IMO, IALA, IHO and others) and regional bodies (EU DG Move, EMSA, EU IMO preparatory meetings).

2.3.4   Composition of a future NSR-PHG, its Terms of Reference

The composition and the provisional Terms of Reference for the NSR-SPCG, as a stand-alone group or as part of an overall NSR e-Navigation Coordination Platform are provided, with an eye for the future, in Annex B to this Report.

2.3.5   Advantages and disadvantages of stand-alone NSR-SPCG and NSR-PHG

It is recognized that establishing of two stand-alone groups as described in the previous sections, NSR-SPCG (focus on operational and technical service provision) and NSR-PHG (focus on harmonization of policies, decision making and transnational cooperation) may have both advantages and disadvantages. A general risk analysis has to be considered before a final decision will be made on the establishment of these platforms.

Advantages	
Mutual substantial understanding of relevant subjects	Subject orientated expertise and mandates availability
Smaller groups	More comfortable decision making processes
	Easier development of common shared views and positions for dissemination
Disadvantages	
Risk of potentially gaps between policy and service provision interests	Longer tuning processes, time consuming communications
Risk of coherency issues	
Risk of complexation	
Increase of number (international meetings)	Risk of meeting fatigue
	Risk of increase of administrative workload
	Larger claim on human resources
	Larger claim on financial resources (organization, travelling)
Risk of less recognition	Small groups in a playing field of larger platforms

2.4   NSR e-Navigation Service Providers Co-ordination Group (NSR-SPCG)

The development of solutions and services for e-Navigation as well as of applications contributing to the implementation of these solutions and services is an ongoing process and will accelerate now the Strategic Implementation Plan (SIP) for e-Navigation has been approved by the Maritime Safety Committee (November 2014). Although the SIP indicates 5 prioritized solutions to start with, the emphasis is on the development of navigation, communication and information services (Maritime Service Portfolios - MSPs -) to enhance the interaction between ships, ship-to-shore, shore-to-ship and shore-to-shore with the aim to enhance safe and secure navigation, the accessibility of sea areas and port approaches, the efficiency of shipping (berth-to-berth and linking to other transport modalities) and the protection of the marine environment.

There is a common understanding that e-Navigation will be supportive to other major programs/concepts such as the IMO Sustainable Maritime Transportation System (SMTS) and e-Maritime (EU). The candidate solutions of the ACCSEAS project will not only contribute to the general aims as mentioned above, but also will lead to benefits (direct or indirect) for aspects of the

EU Green and Blue belts programs, e.g. efficient navigation, route advices, no-go areas etc. contribute for example to reduction of CO_2- emissions.

The key words in the e-Navigation process are the *'harmonization'* of these services (where many stakeholders are involved) and the *'standardization'* of equipment aboard, infrastructure ashore, system interfacing, as well as the delivery and exchange of data and information. Specific attention shall be given to the Human-Machine Interface (HMI) and the portrayal of data. A core element of e-Navigation and key to a future successful implementation is its integrated architecture.

It is obvious that a specific group of stakeholders, the **service providers ashore**, will play a major role by developing and implementing the variety of services and that a co-ordination platform between these stakeholders would be necessary to assure harmonization of services and applications and standardization technology and data exchange. Manufacturers would be required for implementation of those services in appropriate procurement processes, and they play a vital role in the system engineering processes that ensue, providing also feedback from their implementation.

In the ACCSEAS project, which has identified the future challenges for the North Sea Region *(WP3: Baseline Report)* this was recognized at the start of the project and a platform *"Service Providers Co-ordination Group" (SPCG)* was incorporated in the project structure. However, it should be noted that this group, due to the priority given to the development of candidate solutions and the setup of the various test beds and awaiting the international developments and progress of the IMO SIP for e-Navigation, didn't meet yet. The majority of relevant issues were discussed within the project, specifically in the *Transnational Project Coordination Group (TPCG)*, based on current national plans and views of several administrations and competent authorities.

2.4.1   NSR-SPCG as a legacy of ACCSEAS

It is foreseen that the SPCG, to be renamed in the **"NSR Service Providers Coordination Group" (NSR-SPCG)** - emphasizing the regional character -, will continue as a legacy of ACCSEAS after project ends (February 2015), either as a stand-alone group or under the umbrella of specific NSR e-Navigation Coordination Platform (NSR-eNAV CP) or an existing regional recognized body. The NSR-SPCG should, in close conjunction with the also established NSR User Forum also provide advises to policy makers, national administrations, authorities participating in the proposed **NSR Policies Harmonization Group (NSR-PHG)** (see section 2.3).

2.4.2   Composition of a future NSR-SPCG, its Terms of Reference

The composition and the provisional Terms of Reference for the NSR-SPCG, as a stand-alone group or as part of an overall NSR e-Navigation Coordination Platform are provided, with an eye for the future, in Annex B to this Report.

2.5   NSR e-Navigation Users Forum

During the ACCSEAS project a NSR e-Navigation Users forum was established with the aims to
- promote e-Navigation awareness;
- inform the variety of users (stakeholders) about the progress of the development of the concept in the relevant international fora (IMO, IALA, IHO);
- disseminate information from the ACCSEAS project;
- ensure users (stakeholders) participation and collect feedback on project's findings;
- outline the project's findings and the work of the ACCSEAS Horizontal Integration Groups (HIGs);
- offer workshops (taking format and structure from the ACCSEAS VieWs meetings) centering on discussions about project's findings, ideas and proposals;
- collect and verify user needs and specific requirements.

For organizing the NSR User Forum a 2-days meeting format was chosen, in combination and back-to-back with the Annual ACCSEAS Conference.

It is well understood that

- the (further) development and implementation of e-Navigation, as a concept and individual services is an ongoing process; as such the needs and requirements of stakeholders will continuously evolve;
- the North Sea is becoming more hazardous and complex to navigate; without the integration of new technologies and deployment of effective e-Navigation tools the mariners safety is at risk;
- the navigable space will be reduced by up to 25000 km^2 in the next few years in the NSR while 90% of all goods are transported by sea; it is clear that the pressure on both the accessibility of the region and its seaports as well as the safety of navigation is increasing;
- the future management of vessel traffic as well as the efficient transport and handling of goods and people in ports require an improved interaction between shore and ship based on provided harmonized services and reliable / in time data and information.

In order to deal with all the identified future challenges and potential risks and to achieve a well harmonized implementation of e-Navigation in the NSR it is obvious that future participation of stakeholders should continue, in fact will be essential. Therefore the consultation of these stakeholders and the dissemination of the progress of developments should continue after project ends. This may be organized by the continuation of a stand-alone NSR e-Navigation User Forum (using the same mode of operation as under ACCSEAS) **or** under the umbrella of the NSR e-Navigation Co-ordination Platform (NSR-eNAV-CP) as described in section 3.4.

2.6   Annual or Biennial NSR e-Navigation Conference

ACCSEAS organized in the period 2013-2015 three Annual Conferences with a deliberately chosen regional orientation on e-Navigation, accessibility and safety related issues in the NSR, where for instance the annual e-Navigation Underway Conferences - organized by the Danish Maritime Administration (DMA) in conjunction with IALA, CIRM and the Nautical Institute - were more globally orientated. The Annual ACCSEAS Conferences demonstrated to the external world that ACCSEAS is publicly disseminating information from its findings and was open to all interested parties and were organized:

2013   5-7 March   Flensburg / Germany
2014   4-6 March   Edinburgh / Scotland
2015   17-19 February   Rotterdam / The Netherlands

It may be considered that instead of an Annual NSR e-Conference a Biennial NSR e-Navigation Conference will be held organized, initiated and under the auspices of the NSR-eNAV-CG. Considerations for the proposal for a NSR Biennial Conference - taking into account the now adopted time schedule for the IMO SIP for e-Navigation - are the need to a) keep stakeholders, the public and other interested (EU/international) parties informed about the progress of the regional implementation of e-Navigation, b) to organize overall NSR User forums and workshops - as during the ACCSEAS project -, c) to present new developed services and ideas, d) to discuss and exchange views on high level issues with other relevant regional recognized bodies, e) promotion of the region and f) less demand on financial and human resources.

The organisation can be resigned to an organisation committee of that Group, the Conference itself may be hosted in turns by one of the NSR countries.

2.7   Schematic survey of the organizational legacy of ACCSEAS
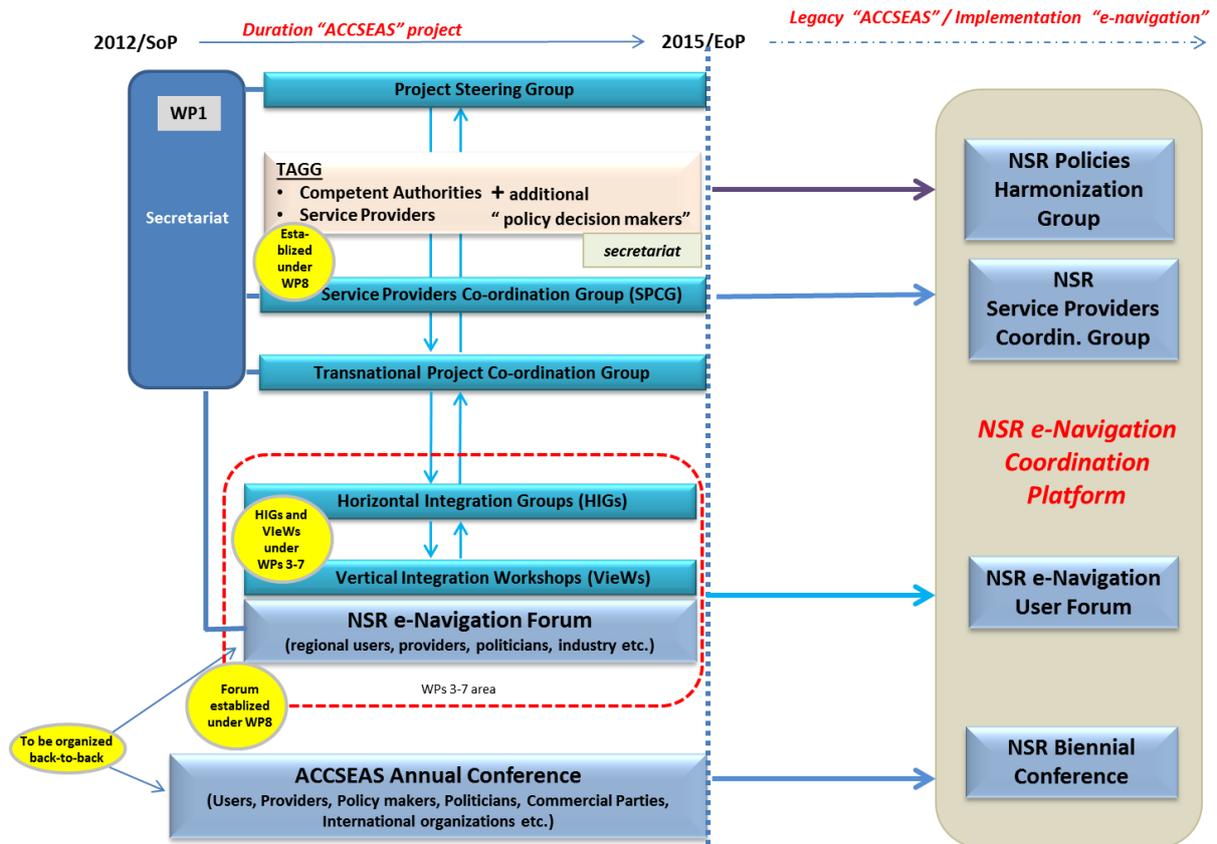
2.8   Schematic survey of a future organizational structure NSR e-Navigation
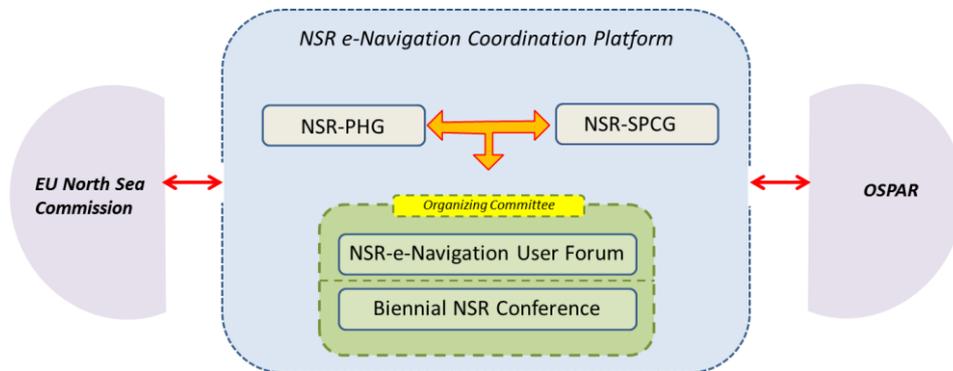
2.9   Initiative setting up the structure of coordinated NSR e-Navigation

As a start the initiative for setting up the organizational structure of NSR e-Navigation can be taken by one or more national NSR administrations by organizing and hosting a preparatory coordination meeting. Advanced information should be provided to the potential partners

-   describing the intentions and aims of such a meeting (including the compelling need for regional cooperation as described in Chapter 2 of this document, the proposed structure as described in Chapter 3 and the Terms of Reference for the fora as provided in the Annex B to this document);
-   a description of the expected deliverables of such a meeting;
-   a list of invited potential parties (with the aim to verify whether the proper competent administrations and service providers shall be involved).

Future work: One or more national NSR administrations organizing and hosting a preparatory coordination meeting for setting up the organizational structure of future coordinated e-Navigation development and implementation in the NSR.

This page is deliberately blank.

3   Substantial Legacy

The major substantial aspects for the legacy of the project are to be differentiated into three categories:

a. The research, identification and study of recent and future developments and challenges in the NSR
b. The identification, development, testing and simulation of candidate solutions.
c. The role and position of ACCSEAS in a wider context, its relationship with international and European developments

3.1   The research, identification and study of recent and future developments and challenges in the NSR

Results of investigations based on literature search and study, and contacts with different stakeholders and their eventual consequences for the safety of navigation, the accessibility of the region and its seaports, the utilization of navigable waters and to the marine environment (by comparing the current maritime status of the North Sea Region with expectations, assumptions and views for the future NSR development, based on information from respected international sources). The results are reflected in the "*ACCSEAS Baseline and Priorities Report*"[11].

It is recognized that the validity of different forecasts of the future can always be questioned. Looking into the future, it is only possible to extrapolate from the present situation and use assumptions. Unknown, maybe paradigmatic, shifts could be unforeseeable.

The very idea of the mentioned report was to open stakeholders' eyes and drawing the attention of administrations and authorities to a possible future conflict in the open sea space of the NSR, and the engagement of the marine and maritime stakeholder communities – including users, service providers and authorities – may in turn bring about changes.

During the project the preliminary results as reflected in the "*ACCSEAS Baseline and Priorities Report*" have already frequently been used as an input to international organizations dealing with the e-Navigation development such as the International Maritime Organizations (IMO) and the International Association of Marine Aids to Navigation (IALA), to other EU projects and as a source for national policy making and conceptual developments, where appropriate.

As a legacy of the project the content of the "*ACCSEAS Baseline and Priorities Report*" (WP3, described in section 3.1 and following of this document), the results of research, used data and information, methodologies, stakeholders views and assumptions can therefore further be used as a valuable source, supplementary or complementary, for other related studies, projects, international or regional programs and conceptual developments in other sea areas (within and outside the EU).

3.2   Work Package 2 Publicity and Communications

The ACCSEAS Project is funded under the **"European Regional Development Fund"** (ERDF). The fund promotes interventions which use public and private investments to reduce regional disparities across the Union through the concept of territorial cohesion. The ERDF aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions. To do this the ERDF supports programmes addressing regional development, economic change, enhanced competitiveness and territorial cooperation throughout the EU. It is within this EU framework, specifically infrastructure linked to improved regional access, that the ACCSEAS project has been developed and implemented.

---

[11] ACCSEAS Baseline and Priorities Report, edition 3

The ERDF associated policies are cascaded to the North Sea Region via the **Interreg IVB North Sea Programme** (http://www.northsearegion.eu/). Implementation of ERDF policies at the NSR level is set out in the Operational Programme document. ACCSEAS is implemented in accordance with this programme under its Priority 3, 'Accessibility'.

A key requirement of ERDF is to publically communicate and disseminate the work of an operational project and that project's outcomes derived from the implementation of ERDF funding. Project communication requirements are set out in: COMMISSION REGULATION (EC) No 1828/2006. Further guidance is provided by the Interreg IVB North Sea document COMMUNICATION PLAN 2007-2013: Guidance for Projects. These documents were used to develop the ACCSEAS Communications Strategy, submitted for approval with the project application.

3.2.1   Legacy of Work Package 2

WP2 coordinated and communicated techniques, methods and plans to assist the further development   of
e-Navigation services across the NSR by
- setting up an efficient ACCSEAS project Communication structure within the projects framework;
- the development and implementation of an Communications Strategy was implemented with, a focus on outreach/in-reach methods and measures at beneficiary, regional, national, EU and international levels. Interaction with existing and proposed EU projects and initiatives (e.g. e-Maritime, additional INTERREG projects, EfficienSea 1.0., Mona Lisa 1.0 and 2.0, framework for Galileo, European Radio Navigation Plan).

Throughout the project the work and the (interim) results of ACCSEAS have been successfully made public and disseminated in various ways, by:
- providing in a dedicated ACCSEAS project website (www.accseas.eu);
- using web-based media (e.g. Twitter, LinkedIn);
- publication of the Work Package reports;
- publication of research and test results;
- development of the demonstrators (including video's) concerning identified candidate solutions;
- presentations at a variety of international, regional and national conferences and meetings;
- providing input documents to relevant international and regional organizations (e.g. IMO, IALA, CIRM, IHO, IHMA, IMPA, RTCM, EC, EMSA, ESA and others).

During ACCSEAS close transnational cooperation with and the collection of feedback by stakeholders was achieved by organizing
- Horizontal Integration Groups (HIG s);
- Vertical Integration Workshops (VIeWs);
- Workshops on specific ACCSEAS related issues;
- 3 Annual ACCSEAS Conferences, back-to-back with the NSR e-Navigation Forum (including workshops);
- meetings with decision- and policymakers (e.g. members of the European Parliament or representatives of regional (EU Directorate Generals) and national administrations.

The **legacy of Work Package 2** can be best summarized as:
- a general brand awareness of the Interreg IV/B project ACCSEAS
- a common accepted awareness regarding present and future developments, challenges and opportunities in the North Sea Region
- a contribution to further transnational cooperation in the NSR;
- a considerable substantial and innovative contribution, globally and regionally, to the development   of
e-Navigation;

- the evolving preparedness of organizations, authorities, operational/technical users and service providers (including the maritime industry) for future close cooperation and involvement;
- the awareness that results of ACCSEAS may be utilized as building blocks for further development of systems, services and applications;
- the availability of an impressive network of organisations, experts, stakeholders, authorities, policymakers and other parties involved; this developed and coordinated network could, where appropriate, be utilized for follow-up or other projects (future or under development) or the organization of events for the coordination of e-Navigation in the NSR;
- a set of organizational structures, formats, plans, methods suitable for reuse in future projects;
- being an example on how to organize publicity for similar (future) EU projects.

Future work: To keep the ACCSEAS website www.accseas.eu "in the air" after project ends. During the project it was already agreed that the website will be kept available until 12 months after the project formally was ended. It may be considered to update the website during this period with relevant or crucial developments on e-Navigation in general or in the NSR will be inserted to keep the interested community updated as far as practicable.

Future work: Through proper measures (e.g. website) to ensure that the ACCSEAS reports, results of testbeds, demonstrators and videos will be kept available for the relevant international, regional and national parties.

Future work: Beneficiaries of the ACCSEAS project are strongly invited, in conjunction with the relevant Guidelines by IMO and IALA, for sharing the testbed results on a central public website www.enavigation.net (currently hosted by the Danish Maritime Authority).

Future work: Through proper measures to ensure that the data and information of the ACCSEAS network (of organisations, experts, stakeholders, authorities, policymakers and other parties involved) will be preserved for future work and to the beneficiaries of the project.

3.3   Work Package 3 - Establish baseline & priorities

3.3.1   Short description of the scope and content of the WP3

The scope and content of WP3[12] was, in close collaboration with stakeholders,
- to identify issues and trends related to NSR maritime transport routes, the access to ports and peripheral maritime are as reliant on these routes;
- to identify existing navigation service provision and the planned evolution of these services;
- to assess and prioritise potential e-Navigation solutions which could resolve identified navigation issues
- to provide future transnational co-ordination of e-Navigation for the NSR;
- to analyse (from existing information) of the NSR's maritime transport routes to 2020+, to identify trends and risks (congestion, bottlenecks, accident and environmental threats).
- collect user needs through interviews and field studies.

The above should result in
- databases of shipping routes connected to an ACCSEAS Geographic Information System (GIS) for the NSR showing the in-reach and outreach awareness (dissemination of results) raising of shipping routes and their associated risks, and stakeholder needs, to NSR maritime accessibility.

---

[12] ACCSEAS Application, Work Package 3, para A3.1 and A3.4

- the identification of NSR e-Navigation requirements to improve maritime access to gateway ports and peripheral maritime areas, including simulation requirements for e-Navigation training and demonstration purposes and virtual realisation of high risk NSR in simulation.

3.3.2   Summarized regional description

In its main deliverable[13] WP3 provided a summarized description of the NSR including
- geographical boundaries
- movement of shipping and the role of Short Sea Shipping
- summarized port activities in 2010
- differentiation of NSR seaports and their handling of a variety of goods
- a perspective on the marine accessibility
- accessibility assumptions for Key Ports (Rotterdam, Antwerp, Hamburg) and Sea Areas (Dover Strait, Kattegat, Kiel Canal)

3.3.3   Identification of risk areas and "hot spots"

For designing future shipping lanes a risk analysis has been performed using 2011 AIS data (fishing vessels not included!) in the IALA Waterway Risk Analysis Program (IWRAP,2012) - a probabilistic collision and grounding analysis tool -. In combination with a large variety of other factors (e.g. predicted traffic developments, space utilization plans, EMSA accident statistics) the following risk areas (with differentiation of risk levels) have been determined as "hot spots":

o   *North Sea Northern Part* - 5 high risk areas: Skagerrak, the approaches to Hamburg, Kiel Canal, Bremerhaven, and the Traffic Separation Scheme (TSS) north of The Netherlands;
o   *North Sea Southern Part* - 5 high risk areas: the approaches to Felixstowe, London and Antwerp (area west of the Wester Scheldtriver), the southern entrance/departure area of the Traffic Separation Scheme (TSS) northwest of The Netherlands, as well as the entire area along The Netherlands western coast (including the approaches to Rotterdam and Amsterdam).

During the process of the work it was concluded that building on the results of ACCSEAS for further monitoring and establishing sustainable views and to provide in realistic predictions on the developments in the NSR the provision, collection and validation of relevant updated data should continue as future work after project ends.

Future work: NSR Administrations, relevant organizations and competent authorities to investigate the opportunities to collect and share regional AIS data over a period of at least 5-7 years (2011-2018) period with the purpose for research, identification of trends, risk analysis and assumptions. At present, the provision and sharing is constraint - in most cases a result of national confidentiality legislation or internal agreement -. A regional position in this matter should be developed and a collaboration agreement be negotiated.

Future work: EMSA to continue with the collection and provision of yearly accidents statistics for the NSR and extend the period from 2010 until 2020. During ACCSEAS a two years period 2010-2012 was available which is considered to be too short for doing statistics.

Future work: NSR Administrations, relevant organizations and competent authorities to perform after a period of 2-3 years after project ends (2017-2018) - and after that on regular intervals a risk analysis -, using IWRAP, updated data in conjunction with the Route Topology Model, with the aim to identify risk areas where e-Navigation Maritime Service Portfolio in combination with other measures are needed.

3.3.4   The picture of the North Sea Region tomorrow

---

[13] ACCSEAS Baseline and Priorities Report, edition 3, Chapter 1

ACCSEAS identified many sources of data that provides a picture of competing demands on sea space in the NSR in the 2020+ timeframe. Planned wind farms by various countries provide a simple introduction to the nature of growth in offshore renewable energy installations. It is apparent that large areas of the North Sea could be dedicated to this utilization thereby reducing the sea space for ships to navigate and manoeuvre. When taken together with the trend in the growth in shipping – both in numbers and size of vessels – it is clear that higher density of ships may be forced to navigate in more restricted sea areas, which could correlate with greater risk of grounding and collision, hence impacting the safety and efficiency of access to the region's ports.

To compile the picture of the NSR 2020+ ACCSEAS used a number of official and industry sources. Industry sources have in most cases been cross checked with official government sources. Very few of the wind mill areas are built today, most of them are in different stages of planning, one has to realize that this picture might not represent exactly what the NSR will look like in, let's say, 2025. Political decisions affecting state subsidies, global financial development, increased pressure to reduce carbon emissions might change the picture to the better or to the worse. The combination of various data sources overlaid on each other produce the very complicated picture of the NSR in 2020+[14].

It should be noted that, when looking at this picture, it
- builds up the layers of oil & gas installations, offshore renewable energy installations, fisheries, environmentally sensitive sea areas and leisure uses, together with shipping densities, traffic separation schemes and port approach data;
- is particularly congested with conflicting and competing uses for sea space in the southern part of the North Sea;
- not all the designated areas under consideration for offshore renewable energy installations will necessarily be developed in the 2020+ timescale; it is also unlikely that in practice wind turbines will be built within TSS; demonstrates the need for transnational coordination of sea space management and marine spatial planning is evident; consequently the NSR maritime community should be adequately represented in future transnational Marine Spatial Planning to vouch for the shipping interests.

Future work: The maritime community to ensure an adequate representation in future transnational Marine Spatial Planning to couch its interest, preferably through transnational coordination.

3.3.5   Ship traffic 2020+

The International Union of Marine Insurance calculated in its 2013 spring prognosis an annual growth of seaborne transportation to 2015 to 5-6 % per year (IUMI, 2013). Lloyd's register presented in April 2013 its Global Marine Trends 2030 report, predicting that the total world tonnage and vessel numbers will increase for all major ship types. The increases for tankers will be at a slower rate. The total tonnage of tankers is expected to grow only 1.7-1.8 times, compared to bulk carriers, containerships and LNG, which are expected to grow between 1.8 and 3 times over the next two decades (Lloyd's, 2013). They expect that the global economy by 2030 will be 2.6 times the size of that in 2010 and that the transportation need will increase even more.

ACCSEAS calculated the forecasts[15] with a moderate 2 times increase in transportation volumes to 2020+. But because ships will also increase in size the increase in number of ships will not increase the same amount. It is assumed that the increase in transportation capacity is carried to 30 % by bigger ship sizes, leaving the increase in ship numbers compared to present-day traffic by a factor 1.5.

---

[14] ACCSEAS Baseline and Priorities Report, edition 3, para 2.1

[15] ACCSEAS Baseline and Priorities Report, edition 3, para 2.2

Renewable energy deployments such as the wind farms proposed in the NSR will play a crucial role in reducing carbon emissions and decreasing the dependency on nuclear energy, but they could also pose a significant threat to maritime safety as shipping traffic continues to grow. The shipping community wholeheartedly supports the renewable energy agenda.

One of the biggest problems is that there is at present no formal consultation programme with the transnational shipping community when projects such as offshore wind farms are planned. There needs to be much stronger collaboration and co-operation between industry organizations and governmental administrations in order to achieve solutions that reflect the interests of all parties. Such cooperation needs to be coordinated on a transnational basis across the stakeholders on the member states bordering the seas of the NSR. This may be achieved based on the organizational legacy of ACCSEAS as described and recommended in Chapter 2 of this Legacy Report.

Future work: For the development of future regional (transnational) NSR policies and national plans administrations and competent authorities should, taking into account ongoing readjusted data of relevant international/national sources perceptions, further assess and validate the forecasts provided by ACCSEAS.

3.3.6   The identification, development, testing and simulation of candidate solutions

Some international developments have taken place in parallel with the ACCSEAS project that may assist in resolving these issues and concerns. One of these developments where there is such a large potential, is the *IMO's e-Navigation strategy.* It is believed that e-Navigation methods and technologies, so-called "*candidate solutions*" have the potential to reduce these risks through safer, more accurate navigation and management of traffic in order for turbines, other offshore obstacles, and ships to coexist safely in the NSR, but potentially also may lead to reducing hazardous emissions (CO_2).

Together with some other relevant international developments they constitute part of the "*baseline*" of the ACCSEAS project, leading finally up the development of the ACCSEAS candidate solutions.

3.3.7   Overview of candidate solutions

ACCSEAS identified, developed, tested and evaluated an agreed number of candidate solutions (services, employment of modern technologies, applications, developed methodologies, architectural proposals and additional measures) within the international framework of e-Navigation.

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 comprising both Multi Source Positioning Service and infrastructure to provide Resilient PNT (such as R-Mode and eLoran)
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 Operation Coordination Tool (VOCT)
10. Dynamic Predictor (for tug boat operations)
11. Augmented Reality / Head-Up-Displays (HUDs)
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

Short descriptions of these candidate solutions, the results of the respective test beds and identified potential future work as a legacy of ACCSEAS are given in section 3.7 and following in this Report.

3.3.8   Limitations of candidate solutions

These candidate solutions may potentially contribute in defying to some of the identified future challenges in the NSR (and similar ones in other sea areas, within or outside EU). However, it should also be recognized that
- circumstances, conditions, requirements and developments may differ in various sea regions;
- the e-Navigation concept or aspects thereof cannot be seen as providing the ultimate or only solution(s) in dealing with all the future challenges and problems;
- the ACCSEAS project made us aware that there is no single solution, but only a **combination of measures and instruments** (e.g. Routing, VTS, Marine Spatial Planning, improved interaction between stakeholders - ship-shore vice versa, shore-shore - through e-Navigation services, technologies and enhanced data management, exchange and provision) can lead to success;
- consequently the preliminary list of potential solutions as developed, tested, demonstrated and evaluated under ACCSEAS are not (yet) the ultimate solutions.

3.3.9   Legacy of tested candidate solutions as contribution to further developments

As a legacy of the ACCSEAS project tested candidate solutions or developed services, methodologies and instruments as well as the experiences and results gained so far during the project period may
- contribute directly to the further development of the e-Navigation concept, - worldwide, in Europe and in the NSR -, supportive to a future sustainable and coherent maritime transportation system and the completion of various programmes under development (e.g. e-Maritime in Europe);
- contribute directly or indirectly to fulfil in a harmonized manner existing and future functional and technical user needs;
- need further development;
- form the basis for new user driven service developments (Maritime Service Portfolio's) and the employment of new/modern technologies.

3.3.10 Sharing ACCSEAS results and positioning of future work

As such the dissemination and sharing the results and experiences with all relevant and interested parties is a legacy of the project. Furthermore future work should be considered after project ends in order to fully meet the identified (or evolving) user requirements with the aim to enhance safety and secure navigation, the accessibility of sea areas and ports and to guarantee future protection of the marine environment. This further work, entirely or partially, may be carried out
- in a follow-up project of ACCSEAS;
- in conjunction with or under the umbrella of other Interreg IV/V or planned EU projects;
- as part of a new project (EU or non-EU);
- by one or more NSR countries;
- supplementary or complementary to other e-Navigation test beds (EU or non-EU), in accordance with the approved IMO Strategic Implementation Plan (SIP) and the relevant IMO and IALA Guidelines.

3.4   ACCSEAS' wider context

While ACCSEAS' *"focus is on regional priorities at key locations within the NSR"*[16], regional aspects cannot be dissolved from international and pan-European developments. It was recognized that

---

[16] ACCSEAS 2012, 4.2

there are baselines and priorities "*from within,*" and "*from without*". The last category are beyond the remit of ACCSEAS, however during the project had to be taken into account. Recognizing this, ACCSEAS has taken the position from the outset to be as responsive as possible to international and European developments. The same is true for any related future work as a legacy of ACCSEAS or during the further development and implementation of e-Navigation in the NSR.

3.4.1 The relationship with international developments

Two major international initiatives occurred during the duration of the ACCSEAS project:
* the initiative to establish an IMO Sustainable Maritime Transportation System (SMTS)[17]
* the development, finalization and approval of the IMO e-Navigation Strategy Implementation Plan (SIP)[18]

These initiatives did not overtake ACCSEAS; quite the contrary, due to pre-empting these developments, ACCSEAS was and is now in a position to provide initial answers.

3.4.1.1 IMO Sustainable Maritime Transportation System (SMTS)

In response and support to the results of the UN Conference on Sustainable Development (Rio de Janeiro, 2012), better known as "*Rio+20 process of implementing sustainable development and the transition to a 'green economy'",* the proposal was presented for an IMO "*Sustainable Maritime Transportation Plan*".

3.4.1.1.1   The existing Maritime Transportation System

The <u>existing</u> Maritime Transportation System (MTS) appears to be well established and well understood, namely in itself as well as in regard to the international logistics chain.

"The Maritime Transportation System is global in nature. (…) The maritime transport industry, because of its globalized nature, has no specific home and tends to be 'invisible' in people's daily lives. Ships spend their working lives out of sight – sailing the seas and oceans between different countries and legal jurisdictions, very often far away from their country of registry, in support of the global economy. International maritime transport employs over 1.5 million seafarers and many more port and logistics personnel, who are responsible for the safe and reliable delivery of food, raw materials, energy and consumer goods to the world's seven billion people every day: a relatively 'invisible' service, but one which is, nevertheless, an indispensable component of the world economy. (…) Maritime transport exists in conjunction with the many shore-side infrastructures, services and personnel for cargo handling and delivery and for the financial and support services essential to maintain an efficient – i.e. cost effective, reliable and seamless – operation. As such, the Maritime Transportation System is a vital link in an international logistics chain, moving cargo across the world at the service of global trade, economic development and growth. By the same token, all actors in the chain are equally essential for the Maritime Transportation System to work cohesively."

A full description of the existing MTS is provided in the ACCSEAS *Baseline and Priorities Report*, edition 3, para 3.1, including the structure, the stakeholders, a top-level architecture, an economical process, organisations (so-called "precursors") which provide essential pre-requisites for being involved in the maritime transport activity at all and/or to achieve a "*safe, secure, clean and efficient maritime transport*". The whole of the Maritime Transport Activity today is highly regulated, namely by "*IMO Regulations*"
affecting "*Safety,*" "*Environment,*" "*Liability and Compensation,*" "*Seafarers,*" and "*Security*".

3.4.1.1.2   Transition existing MTS in three steps to a Sustainable Maritime Transportation System

---

[17] IMO World Maritime Day, Secretary-General IMO, September 2013

[18] IMO, MSC94, November 2014

If all the actors in the shipping sector, while fulfilling their different functions, work together in support of this value chain, the Maritime Transportation System will not only function well for all stakeholders concerned, including civil society, it will also have a sustainable future. However, as the SG IMO stated, the transition to a ***Sustainable*** Maritime Transportation System (SMTS) is not granted:

"The movement of goods by the Maritime Transportation System is subject to economic, social and environmental responsibilities and requirements on many levels. The <u>challenge</u> lies in how these can be translated equitably and fairly across the chain of actors in order to make the whole System sustainable. This is particularly difficult <u>because coordination between shore-side maritime actors and the international shipping sector is not well-established</u>, due to a prevalent tendency towards profit-maximizing by each of the actors, who may succeed in shunting costs to other actors, and this may in turn affect the sustainability of those other actors' operations, and so affect the logistics chain as a whole. In other words, a loss of resilience, and of sustainability, in one link risks degrading the chain over time."

The challenge mentioned can be met in three steps:

Step 1:   *Define the key elements of SMTS (as requirement statements and compiled in brief) as follows*

- "… well organized Administrations that co-operate internationally and promote compliance with global standards, supported by institutions with relevant technical expertise, such as classification societies acting as recognized organizations;"
- "… coordinated support from the shore-side entities intrinsic to shipping, such as providers of aids to navigation, oceanographic, hydrographic and meteorological services, incident and emergency responders, port facilities, trade facilitation measures, and cargo-handling and logistics systems;"
- "… a reliable supply of fuel for ships (…) [and] a qualified and flexible work force;"
- "… the collaboration of shore-side actors, both from industry and Governments, (…) for the protection and provision of care for seafarers;"
- "… global standards that support 'level playing fields' across the world, supporting global safety and environmental standards, *addressing technical and operational requirements for ships as well as the appropriate education and training of crews*;"
- "… security (…), yet it is largely beyond the control of its actors;"
- "… support of a sound financial system to support its evolving requirements for economic, social and environmental sustainability;"
- "… *active engagement with Classification Societies, academic institutions* and other research and development entities, in order to embrace *new technologies and new operational practices*;"
- "… coordination at national and international levels," while the international coordination should be done by IMO;" and – last but not least –
- "… awareness initiatives such as the Day of the Seafarer and World Maritime Day."

It is noted that IMO is aware of partners needed for any degree of success in achieving the SMTS; these organisations are dubbed "*IMO's Partners*" (listed and addressed throughout).

Step 2*:   Translate the key elements of SMTS into correlated ten goal domains and specific goals for each and every of those goal domains*.

A compilation of those goal domains and specific goals, including the relationship with IMO's partners are provided in the "*ACCSEAS Baseline and Priorities Report"*, para 3.1.2, Table 3-1.

Step 3*:   List for each and every goal domain specific actions, each in turn in conjunction with the relevant IMO's Partners.*

Those Actions where ACCSEAS contributes specifically are addressed from an architectural point of view in the "*ACCSEAS e-Navigation Architecture Report*" while even more detailed operational and technical issues are addressed in other consecutive reports.

3.4.1.1.3   ACCSEAS general contributions to the envisaged SMTS

A brief review of the proposal for a SMTS shows that it was possible and necessary to establish how ACCSEAS contributes to and thereby supports a SMTS in general terms.

ACCSEAS, as a project for the North-Sea Region, is invited to consider the SMTS proposal in order to create awareness for sustainable development as applied to the maritime domain at the regional level.

In the reflected list of key elements of a SMTS and in the compilation of SMTS goal domains, goals and IMO's Partners needed (Table 3-1), ACCSEAS highlighted the specific key elements, goal domains, goals and IMO's Partners where ACCSEAS – in a regional fashion, i.e. for the NSR – directly contributes, both in terms of content specification and in terms of partnership. The Table 3-2 in section 3.1.2 of "*ACCSEAS Baseline and Priorities Report*" indicates those contributions. The Table 3-2a in the same section reflects the contributions of ACCSEAS to the SMTS key elements and goals in general terms.

ACCSEAS supports the IMO proposed SMTS and directly contributes to its goal domains as follows:
- "Education and Training in Maritime Professions, And Support for Seafarers" (No. 2)
- "Maritime Traffic Support and Advisory Systems" (No. 5)
- "New Technology and Innovation" (No. 8)

Although the third role of states throughout the IMO SMTS document not clearly stated, i.e. their role as coastal states, they are essentially contained "in disguise": Both the impact of e.g. the Marine Spatial Planning is recognized as well as the role of shore-based services appreciated (there is a whole goal domain for shore-based and shore-provided systems alone, namely No. 5).

Future work: IMO should make expressive the importance of the role of coastal states for shipping in a future reviewed edition of the SMTS.

The IMO vision on SMTS has specifically incorporated the IMO e-Navigation strategy by reference, e.g. within the goal domain No. 5 *"Maritime Traffic Support and Advisory Systems*." e-Navigation therefore is specifically recognized as a potential contributor in particular to that goal domain, in accordance with the following explanation and rationale given:

"In more crowded seas, with greater traffic density and larger ships, shipping routes will need to be supported by better and clearer information systems (including meteorological, oceanographic and hydrographic services, aids to navigation, light houses and technology such as Vessel Traffic Services (VTS), Global Maritime Distress and Safety System (GMDSS) and satellite communication technology), for vessels to achieve the required efficiency while enhancing safety. Likewise, rapid technological advances in aids to navigation bring challenges for both safety and efficiency, as does the general lack of standardization in the shipping industry with respect to harmonization of equipment and systems. e-Navigation is expected to integrate existing and new navigational tools, in particular electronic tools, in an all-embracing system that will contribute to enhanced navigational safety while simultaneously reducing the burden on the navigator."

It should be concluded that there are *two major challenges* identified, namely the *"more crowded seas with greater traffic density and larger ships"* and the *"rapid technological advances,"* which affect aids to navigation as well as shipboard electronic equipment to which e-Navigation seems to provide an answer*:* Not by inventing a new operational procedure or a new device, but rather by integrating, and in the process, harmonizing what exists in itself and in conjunction with new tools which happen to emerge.

Future work: The proposed IMO SMTS should - taking into account as a legacy of ACCSEAS the identified SMTS key elements, the compilation of goal domains, goals, identified partners - further be studied and projected on the NSR, in order to further investigate and identify all potential contributions and actions, as well as to determine their consequences. This future work may not only benefit the NSR region but also to contribute and connect to EU developments (programs such

as e-Maritime and other relevant projects) and other EU regions and provide as an example function a blueprint for other regions.

3.4.1.2 IMO e-Navigation Strategy Implementation Plan (SIP)

While the most fundamental document of IMO regarding e-Navigation, namely the "IMO e-Navigation Strategy" (IMO MSC 85/26/Add.1, 2009) has been available before the start of ACCSEAS, the   "IMO e-Navigation Strategy Plan (SIP)", as set out in IMO doc. NCSR 1/28, Annex 7, was adopted by IMO (MSC94) in November 2014, i.e. after most of ACCSEAS's duration has expired already. However, it was necessary to absorb the content of those two important documents during the project because of their relevance for NSR.

In the "*ACCSEAS Baseline and Priorities Report*", section 3.2.1, in accordance with the "*e-Navigation Strategy*" the definition of e-Navigation, its objectives, the vision, the potential users and the identified user needs (based on a GAP analysis) are reflected.

IMO has translated the vision expressed in the IMO e-Navigation strategy into a "*e-Navigation Strategy Implementation Plan* (SIP)" the main goal of which is to implement a small number of so-called "*prioritized solutions (S)*" until 2019 (IMO 2014, para 3). To that end, the definition of e-Navigation was rendered and thereby interpreted as an "*expectation*" of the results of the e-Navigation strategy: (IMO 2014, para 1):

> *"As shipping moves into the digital world, e-Navigation is expected to provide digital information and infrastructure for the benefit of maritime safety, security and protection of the marine environment, reducing the administrative burden and increasing the efficiency of maritime trade and transport."*

The SIP (an overview of the structure of the SIP is reflected in the "*ACCSEAS Baseline and Priorities Report*", section 3.2.2, Table 3-6) explains by which 18 "*tasks (T)*" 5 select prioritized solutions and their "sub-solutions" are to be achieved. These in turn are meant to empower the so-called "*Risk Control Options (RCOs)*" which were defined in the process of a preceding Formal Safety Assessment (FSA). Although the derivation, description, and scheduling of the tasks are the culminating statement of the SIP, it contains both in its body and in three annexes additional relevant information, in particular on the

- *Maritime Service Portfolios (MSPs),*
- the perceived *key enablers of e-Navigation,*
- the *overarching e-Navigation architecture*,
- an elaborate discussion on *communication systems for e-Navigation,* and
- a *communication or awareness raising plan*

From the above "*Prioritized Solutions*" and the "*Sub-Solutions*" derived from them, 18 individual "*Tasks*" have been identified in order to achieve them. During the ACCSEAS project each task was correlated with the (Sub-)Solutions it is specifically designed to contribute to (see "*ACCSEAS Baseline and Priorities Report*", section 3.2.2, Table 3-6). This correlation is given by the SIP itself, as well as the additional "*Task Action*" information given at each (Sub-)Solution (IMO 2014, right columns of Tables 1-5). The (Sub-)Solution tables contain specific "Task Actions," most of which reach beyond IMO's own instruments and are therefore relevant for the international maritime community at large. Finally, it should be noted that a single Task may contribute to several (Sub-)Solutions in several cases.

During ACCSEAS a more complete picture was developed of the tasks stipulated by IMO and their reach beyond IMO's own instruments to the international community at large. This compiled table ("ACCSEAS Baseline and Priorities Report", section 3.2.2, Table 3-7) was used when mapping

ACCSEAS' specific contribution to the Tasks in the "*ACCSEAS e-Navigation Architecture Report*" and potentially for reference in consecutive reports.

It should be noted that the identified Tasks are not entirely independent of each other ("orthogonal"), some tasks exhibit some strong interdependency and can therefore not be worked on each in isolation. In order to facilitate the management of such a large international project like e-Navigation a model called "*Seven Pillars of e-Navigation*" (IALA 2014) may assist[19]. In this model all tasks are assigned to seven "pillars", which are directly derived from the overarching e-Navigation Architecture (as approved by IMO). These "pillars" constitute distinct working domains, operated in parallel to finalize the tasks assigned to them individually[20] (compare Table 3-8). The necessary cohesion between "pillars" could be maintained by synchronous reporting to IMO as a governing body. The complexity of the management task would thus be further reduced. The strength and benefit of this approach is, that the required international harmonization for each and every major element of the IMO defined overarching architecture – represented by a "pillar" – would be provided from the very outset: the international "pillar" groups (organizations or project teams) would set out for work on those contributions while maintaining harmonization across the different contributions developed.

3.4.1.2.1　　ACCSEAS general contributions to the IMO e-Navigation Strategy

ACCSEAS has expressively stated that it wants to apply the stipulations of the IMO developed and governed e-Navigation strategy to the NSR[21]:

* The IMO 's concept of e-Navigation, formally recognized by the European Union provides a potential solution via harmonized, integrated and exchangeable electronic maritime information onboard and ashore;
* The North Sea region, as a crossroads of regional and global shipping, is uniquely positioned to benefit from an implementation of e-Navigation that can increase the efficient use of resources, provide better voyage planning and track-keeping and deliver genuine improvements in regional accessibility;
* EU policy development, such as e-Maritime and the single European Transport Area, fits within this international framework (IMO , ITU, IHO , IALA) to improve maritime accessibility, efficiency and safety by the use of e-Navigation;
* 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 situational awareness on a vessel's position and intended routing;
* ACCSEAS aims to implement and demonstrate e-Navigation systems to alleviate NSR navigation risks;
* The aim of ACCSEAS is to identify issues which obstruct maritime access to the NSR, identify solutions, pilot and then demonstrate the successful solutions at regional level to develop a strategy for future e-Navigation provision. The entire process will be supported by training and simulation;
* ACCSEAS' outcomes are designed according to IMO' s e-Navigation guidance; these are readily transferable to other EU regions and the international level.

3.4.1.2.2　　ACCSEAS specific contributions to the IMO e-Navigation strategy

ACCSEAS supports the IMO e-Navigation strategy as follows:

* 　　all of the "core objectives" defined by IMO;
* 　　addresses many of the user needs captured by IMO;

---

[19] ACCSEAS "Baseline and Priorities Report", edition 3 para 3.2.3 figure 3-2

[20] "ACCSEAS Baseline and Priorities Report", edition 3, para 3.2.3. table 3-8

[21] ACCSEAS 2012, para 4.1

- certainly qualifies as "regional cooperation activity" in the sense of the SIP[22]

ACCSEAS contributes to the SIP defined concepts in general terms as reflected in "ACCSEAS Baseline and Priorities Report", section 3.2.4, Table 3-8, with a focus on major ACCSEAS contributions; there may be smaller contributions to other SIP defined concepts, further to be identified.

Important conclusion: Since it was possible to demonstrate that ACCSEAS, as a regional project – regional both from a global point of view as well as from an European point of view –, contributes to the IMO e-Navigation strategy as demonstrated, the reverse is also true: It is thereby demonstrated that the IMO e-Navigation strategy can be applied to relevant regions, like the NSR with its specific challenges for navigation and maritime traffic, e.g. by employing the ACCSSEAS approach. Hence, the implementation of the IMO's e-Navigation strategy in NSR may also serve as a lighthouse project for other regions globally.

3.4.1.2.3   *Important IMO development to the SIP and consequences after ACCSEAS project ends*

IMO when approving the SIP at its 94th session of the Maritime Safety Committee and considered document MSC 94/18/8, proposing the plan of work for the Organization for the harmonized implementation and future development of e-Navigation, together with document MSC 94/18/10. It was decided to
- review each of the tasks listed in the SIP with a view to reducing the numbers of outputs;
- prepare a full justification for each reviewed output in accordance with the information required in annex 3 to resolution A.1062(28);
- prepare a comprehensive prioritized plan of work, which should include the time required for the completion of each output; and
- submit the information to MSC 95 (May 2015) for consideration with a view for inclusion in the post-biennial agenda of the Committee.

Future work: Consequently prior to decisions for and the actual implementation of e-Navigation (Sub-) Solutions as identified in general and particularly by ACCSEAS - as the results provided and final approval by IMO/MSC95 will take place after the ACCSEAS projects ends - further work may be necessary in order to bring the tables mentioned in the sections 6.7.1 and following and as reflected in the "ACCSEAS Baseline and priorities Report" as well as relevant parts of the "ACCSEAS Architecture Report" (e.g. mapping) in line with the results of the actions initiated by IMO/MSC94 and MSC95.

3.4.2   The relationship with European developments

3.4.2.1 ACCSEAS advise to policy and decision makers in the EU

The ACCSEAS project is run in accordance with the EU regional policies administered by the European Commission Directorate for Regional and Urban Policy (DG REGIO), who manage the European Regional Development Fund. The ACCSEAS project
o has an objective of advising policy and decision makers in the EU and internationally, based on the 'proof of concept' prototype solutions that are established by the project to address regional maritime accessibility
o provides a basis for future harmonization of evolving e-Navigation services across the NSR, influencing and preparing advice for policy and decision makers.

---

[22] "Regional and technical cooperation activities could be held in various parts of the world. The aim would be to promote and provide information on the status of the implementation of IMO's e-Navigation initiative. It would also provide a meeting arena for knowledge exchange on the process." (IMO 2014, Annex 3, para 6)

o identifies information to advise the further development of standards for future e-Navigation provision, by regional, EU and international decision makers.

It was noted that

- ACCSEAS' impact will be far-reaching, outcomes will influence EU decision making & promote debate of IMO & IALA international policy based on the pioneering achievements of the implemented North Sea solutions[23].
- ACCSEAS contributes to EU policy through development, testing & provision of e-Navigation to the EU maritime transport policy framework by improved access via TEN-T Short Sea Shipping & Motorways of the Sea, as part of Single European Transport Area;
- ACCSEAS addresses issues related to increase maritime traffic predicted by the EU Maritime Transport Policy;
- ACCSEAS is a key link between international e-Navigation policy framework of the Navigation Sub Committee of the IMO & the EU Maritime Transport White Paper by providing the collaboration[24];
- ACCSEAS takes forward the intention of the Single EU Transport White Paper to promote cooperation between regional, EU, International (IMO / IALA) & others for higher safety and environmental protection standards[25];
- IMO Navigation Sub -Committee 57th session (NAV57) & EU Maritime Transport White Paper set out collaborative work at EU & International levels that cascade to the local level[26];
- ACCSEAS will promote coherence to these joint policies and national systems by demonstrating the practical application of e-Navigation at a local to regional level[27].
- ACCSEAS identifies information to advise the further development of standards for future e-Navigation provision, by regional, EU and international decision makers. It is envisaged that this is achieved by
  o the transformation from the international domain, namely from the IMO concept for the SMTS, the IMO's e-Navigation Strategy and the IMO' SIP, to the specifics of the European situation in the NSR
  o by the analysis work performed in the "*ACCSEAS Baseline and Priorities Report*" which needs to be brought to the attention of relevant EU representatives;
  o the direct interaction in person of ACCSEAS partners with policy makers of the EU Commission, the EU Parliament, and regional EU bodies by employing the ACCSEAS Annual Conferences and the annual NSR e-Navigation fora (compare in particular the reports of the ACCSEAS Annual Conferences and NSR e-Navigation fora 2013, 2014, and 2015);
  o the creation and communication of the "*Plan for Sustainability and Harmonization of e-Navigation in the North Sea Region*" (e-Navigation Sustainability Plan)".

3.4.3   Relevant pan-European and regional European initiatives

3.4.3.1 Previous Relevant INTERREG Projects
The outcomes of a number of previous INTEREG Projects influenced the development of ACCSEAS. Notable examples of those projects are reflected in the "*ACCSEAS Baseline and Priorities Report*"[28] and shortly described in the following section including actions to be taken as a legacy of ACCSEAS.

---

[23] ACCSEAS 2012, para 6.2

[24] called for by Section 6.24 of IMO NAV57 WP6

[25] ACCSEAS 2012, para 8.1

[26] see Sect 6.24 of NAV57 WP6

[27] ACCSEAS 2012, para 9.1

[28] Section 3.1.2

3.4.3.2 EfficienSea (Baltic Sea Region)

The EfficienSea project[29] ran between 2009 and 2012, and was based in the Baltic Sea Region. As with BLAST, a number of project partners in EfficienSea are involved in ACCSEAS, and they bring with them a number of ideas and knowledge critical to ACCSEAS. The overall aim of the project was to "*contribute to the efficient, safe and sustainable traffic at sea*". It looked, amongst other things, at human factor elements of maritime navigation, particularly with regards to competence and recruitment challenges in the sector. It also looked at IMO's e-Navigation concept, and how it can be used to bring the right information at the right time to the mariner.

There is a clear link between EfficienSea and ACCSEAS, particularly with regards to the use of e-Navigation that is a core part of ACCSEAS. In ACCSEAS, the e-Navigation solutions are either novel, or based on initial ideas from EfficienSea. For this reason, including the human elements aspect of the project, this is a strong connection between the two projects.

In January 2015 an application for a follow up project EfficienSea 2.0 was approved.

Future work: Dissemination of the work and results of ACCSEAS to EfficienSea 2.0 as building blocks for the further development of the Maritime Cloud, Maritime Safety Information, Route exchange and Route Advice, Automated FAL reporting, digital shore based infrastructure, Resilient PNT.

3.4.3.3 BLAST (North Sea Region)

The *Brining Land And Sea Together* (BLAST)[30] project was a NSR Programme project that finished in 2012. Its objective, amongst other things, improve the information exchange in the coastal margin of the region. It also looked at using Electronic Navigation Charts (ENC) to determine inconsistencies in the navigation data used by mariners and harmonise them. The BLAST project looked at route planning in the form of the Digital Mariners' Routing Guide which is effectively a database of features that would help the mariner to plan their voyage through the Region.

A number of ACCSEAS partners were also involved in the BLAST project, and they bring their expertise and knowledge gathered within the project into the work in ACCSEAS, particularly in the area of route exchange and Geographic Information Systems (GIS).

3.4.3.4 Maritime Transport Cluster (North Sea Region)

During the current programme, an Interreg IV/B Maritime Transport Cluster project[31] was undertaken within the NSR. This project provided outcomes on:
• A Leading Maritime Region
• Efficient Transport
• Smart Solutions
• Combining the Modes
• Infrastructure – the Solid Base
• Planning the North Sea Region
• Green Maritime Transport
• Research and Knowledge Management
• Working in the Transport Sector
• Maritime Business Perspectives

The MTC Policy Paper "Maritime Transport and Future Policies - Perspectives from the North Sea Region" is a compilation of results generated by the North Sea Region Programme project Maritime Transport Cluster in 2011/12. It comprises an analysis of all transport related projects within this programme, maritime transport research and the results of a consultation with the maritime

---

[29] For more information: http://www.efficiensea.org/

[30] For further information: http://www.blast-project.eu

[31] For further information: http://www.maritimetransportcluster.eu/

industry in the North Sea Region. This paper offers a holistic perception and represents a common voice for stakeholders of the Interreg IV B North Sea Region Programme on maritime transport, enriched by the challenges, opportunities and experiences of the maritime industry.

Future work: Dissemination of the work and results of ACCSEAS to the Interreg IV/B Programme to complement and supplement the results of the Maritime Transport Cluster.

3.4.4 Marine Spatial Planning and Environmental Issues[32]

The main objective of the ACCSEAS project is to review issues of maritime accessibility and safety in the North Sea Region and propose solutions that can mitigate risks in those areas. In terms of EU policy areas, this can be broken into two areas: *marine spatial planning* and *marine transport*. In the sections hereafter policies in the area related to marine spatial planning are indicated.

3.4.4.1 Integrated Maritime Policy (IMP)

The EU has recognised that competition for marine space and the cumulative impact of human activities on marine ecosystems require a collaborative and integrated approach to the wide range of policy areas affecting maritime issues. As a result, in October 2007, the Commission adopted the Blue Paper launching '*An integrated maritime policy for the European Union' (COM(2007) 574 final)'*. The aim of the IMP is to achieve the full economic potential of the seas in harmony with the marine environment. It is the first time a policy has brought together all the sectors that affect the oceans. The policy seeks to maximise the sustainable use of oceans and seas, enhance Europe's knowledge and innovation potential in maritime affairs, ensure development and sustainable growth in coastal regions, strengthen Europe's maritime leadership and raise the profile of maritime Europe.

The policy recognises the complex interaction of stakeholders and interests in the EU maritime sector. As a result the policy is designed to provide a more coherent approach to maritime issues, with increased coordination between different policy areas. It focuses on issues that do not fall under a single sector-based policy e.g. "blue growth" (economic growth based on different maritime sectors), and issues that require the coordination of different sectors and actors e.g. marine knowledge.

The transnational framework, territorial cohesion, policy advice and communications structure of INTERREG projects make ideal vehicles to find methods for advising and co-ordinating different policy areas and communicating with stakeholders in the maritime sector at regional level.

ACCSEAS has the potential to advise decision-makers in a number of these policy areas. By Identifying and tackling issues impacting access to ports, studying interactions between the renewable energy sector and shipping, together with associated environmental impacts (e.g. reducing risk and preventing pollution from shipping accidents), ACCSEAS is providing solutions which support the "Blue Growth Policy", particularly by linking Short Sea Shipping access with wind energy generation. It should also be noted that by contracting e-Navigation system providers within the NSR, ACCSEAS will be promoting "Blue Growth" and assisting SMEs within the NSR to be world leaders in e-Navigation. This interlinks fundamental parts of EU maritime and territorial cohesion policy.

Similarly, by providing a database and analysis of AIS information, ACCSEAS is providing transport information which improves marine data and knowledge at a sea basin level.

Future work: Dissemination of the policy related work, results and potentials of ACCSEAS to the European Commission (e.g. DG Move and DG Mare).

The Integrated Maritime Policy defines **Maritime Spatial Planning** as a structure for planning and regulating all human uses of the sea, while protecting marine ecosystems. It focuses on marine

---

[32] "*ACCSEAS Baseline and Priorities Report*" edition 3, section 3.1.3

waters under national jurisdiction and is concerned only with planning activities at sea. The aim of this policy area is to balance frequently competing sector-based interests. ACCSEAS

- by developing e-Navigation tools, is providing solutions which address the need to use marine space and resources safely, efficiently and sustainably, particularly if in order to achieve this, vessels need to use prescribed or narrower shipping channels in a multi-use area;
- contributes to providing a framework whereby informed e-Navigation decisions can be taken based on sound data and in-depth knowledge of the sea;
- focus is primarily on e-Navigation stakeholders and associated international convention/structures, the project has only very limited means to inform other activities, interests and users in the NSR.

The Integrated Maritime Policy recognises that Maritime spatial planning remains a prerogative of individual EU countries and it was noted that plans for shared seas should be compatible, to avoid conflicts and support cross-border cooperation and investments. Common principles agreed at EU level can ensure that national, regional and local maritime spatial plans are coherent.

Future work: The European Commission to ensure that national, regional and local maritime spatial plans are coherent taking into account the interests of all stakeholders.

The ACCSEAS project does not extend to a mechanism to achieve compatibility, avoid conflicts or support cross-border co-operation with other maritime activities, as it concentrates on e-Navigation users, service providers, suppliers and associated stakeholders, together with informing policy makers and standards. Therefore, there is an extant risk that project outcomes will not be compatible or coherent with other types of spatial plan.

This, to some extent, can be dealt with in the NSR through the North Sea Commission[33] which has the aim to manage marine resources in the region. There is strong connection between the North Sea region Programme and the North Sea Commission, with the Programme being a key partner.

The ACCSEAS project outputs can inform such projects by demonstrating accessibility solutions that support the future agreement of common principles to ensure safe and efficient shipping access is maintained whilst avoiding conflicts with other stakeholders. The cross border co-operation and investment in e-Navigation solutions within ACCSEAS and beyond provide a series of tools which could support such common principles if integrated with a Maritime Spatial Planning structure.

A mechanism outside of ACCSEAS would be needed to advise how e-Navigation can assist compatible and coherent use in the context of the common principles.

Future work: Dissemination of the work and results of ACCSEAS to the North Sea Commission (NSC)

Future work: Dissemination of the work and results of ACCSEAS to relevant recognized platforms dealing with Marine Spatial Planning issues e.g. OSPAR

Future work: Establish a regional mechanism outside of or beyond ACCSEAS to advise how e-Navigation can assist compatible and coherent use in the context of common principles. This mechanism may incorporated in the establishment of the proposed NSR-eNAV Coordination Platform, as described in sections 3.1 and next in this Legacy Report.

Within the Integrated Maritime Policy, a link is made to the *Common Information Sharing Environment* (CISE) being developed jointly by the European Commission and EU/EEA member states. The objective is to integrate existing surveillance systems and networks and give all concerned authorities access to the information they need for their missions at sea. *CISE* aims to

---

[33] http://www.northsea.org/

make different systems interoperable so that data and other information can be exchanged easily through the use of modern technologies.

It is suggested that data generated by e-Navigation systems could form part of *CISE*, therefore the information and outcomes provided by ACCSEAS could be used to inform this EU policy area.

Future work: Dissemination of the work and results of ACCSEAS, inform about the capabilities and potentials of e-Navigation systems on data provision to CISE

The Integrated Maritime Policy includes a **Sea Basin Strategy** policy to promote growth and development of strategies that exploit the strengths and address the weaknesses of each large sea region in the EU, including the North Sea. Present activity within the EU Maritime Forum related to the North Sea concentrates specifically on fisheries, and there appears to be little linkage with Maritime Spatial Planning and shipping access issues at present.

Future work: Dissemination of the work and results of ACCSEAS to the EU Maritime Forum

3.4.4.2 Marine Strategy Framework Directive

The Marine Strategy Framework Directive[34] is intended to be encompassing legislation which aims to protect the marine environment and natural resources. To achieve this, the Directive establishes a framework for the sustainable use of marine waters in 2008 and forms a pillar and links to the Integrated Maritime Policy.

The objective of the directive is to achieve Good Environmental Status (GES) of the EU's marine waters by 2020, whilst protecting the resources the Community's marine-related socioeconomic activities depend upon. The directive integrates the concepts of environmental protection and sustainable use by using the ecosystem approach to manage human activities which have an impact on the marine environment. The Directive establishes European marine regions and links to the Regional Sea Conventions, such as OSPAR and HELCOM.

ACCSEAS has the potential to contribute to this policy by providing information about vessel traffic density in the North Sea by 2020 to those organisations engaged in developing marine strategies, by giving an indication of the potential impact of shipping. The e-Navigation systems provided by ACCSEAS also have the potential to manage shipping activity as part of these strategies.

Future work: Dissemination of the work and results of ACCSEAS to OSPAR and HELCOM; establish a link between the proposed NSR-eNAV Coordination Platform, as described in sections 3.1 and next in this Legacy Report, and OSPAR.

3.4.4.3 Integrated Coastal Zone Management

The Integrated Maritime Policy does not cover direct management of coastal zones or spatial planning of the sea/land interface where port activities take place. Currently, this policy area is defined by Recommendation 2002/413/EC of the European Parliament and of the Council concerning the implementation of Integrated Coastal Zone Management (ICZM)[35] in Europe. The recommendation defines the principles of sound coastal planning and management. It predates, but is complimentary to the integrated maritime policy. The recommendation was established in response to the perception that coastal planning activities or development decisions were often taken in a sectorial, fragmented way, leading to inefficient use of resources, conflicting claims on space and missed opportunities for more sustainable coastal development.

At the time of writing and with the advent of the integrated maritime policy, the EU is currently preparing a follow-up to the recommendation which will bring ICZM policy in line with the *Integrated Maritime Policy.*

---

[34] For further information see: http://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/index_en.htm

[35] For further information: *http://ec.europa.eu/environment/iczm/home.htm*

ACCSEAS could potentially advise territorial cohesion in this policy area; contributing to ICZM policy by providing information on the need to maintain access to the NSR ports and detailing potentially valuable e-Navigation solutions which aid and manage access within ICZM frameworks.

Future work: Dissemination of the work and results of ACCSEAS to members of the European Parliament and to the Council with reference to the Integrated Maritime Policy.

3.4.4.4 BE-AWARE and BE-AWARE 2

BE-AWARE and BE-AWARE 2 projects[36] reside under the Bonn Agreement Secretariat with the purpose of analysing the North Sea Region to assess the future risk of shipping accidents and the implications for pollution response. ACCSEAS has been working with one of the project's partners to compare the analysis of the Region and to establish the means of determining risk. Both projects have developed what is called "Route Topology Model" to model ship movements in the region.

The BE-AWARE 2 project continues from the first project to model how pollution moves using hydrodynamic models of the region. Whilst this is beyond the scope of ACCSEAS, the potential solutions in ACCSEAS could have a positive effect on the pollution clean-up response or on reducing the risk on pollution in the first place. It is recognised that ACCSEAS and the BE-AWARE projects have different, very worthwhile, outcomes for the region.

There are enough synergies between the projects to ensure that the risks to the environment due to the increase and changes in maritime traffic flows highlighted by BE-AWARE can be mitigated through the potential solutions in ACCSEAS.

Future work: Dissemination of the work and results of ACCSEAS to the BE-AWARE projects

3.4.5   EU Maritime Transport

The second area that ACCSEAS can have a major impact is on EU maritime transport policies and initiatives[37].

Maritime transport provides the main mode for EU imports and exports to the rest of the world: around two fifths of the EU's external freight trade is seaborne; short sea shipping plays a significant role in intra-EU trade. Almost 90% of European external freight trade is seaborne, with short sea shipping representing 40% of intra-EU exchanges in terms of ton-kilometres.

The EU's maritime transport policies aim to prevent substandard shipping, reducing the risk of serious maritime accidents and minimising the environmental impact of maritime transport.

The joint aims of cost-efficient maritime transport services which ensure the long-term capacity of the EU shipping sector are dependent on the continuing safe and efficient access to the NSR ports. The continual access is not only important at a regional level, but also at an EU scale. In 2010, EU ports handled an estimated 3.6 billion tonnes of goods.

The trade was dominated by the North Sea ports, which handled 38.3% of all maritime goods handled in EU coastal regions. Approximately 15% of the total tonnage of goods handled in EU ports was in Netherlands, with the UK ports being the second largest handler of goods in and out of the EU (14.1%). The three largest EU ports, both in terms of gross weight of goods and volume of containers handled, are all in the NSR. These are Rotterdam, Antwerp and Hamburg. Rotterdam

---

[36] Bonn Agreement and the BE AWARE Projects: http://www.bonnagreement.org/

[37] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0008:FIN:EN:PDF
    http://ec.europa.eu/transport/modes/maritime/index_en.htm

alone accounting for more than 10% of the total EU tonnage in 2010. In addition, seven of the EUs top 10 Short Sea Shipping ports are located within the NSR: Rotterdam, Antwerp, Hamburg, Immingham, Gothenburg, London and Amsterdam.

The maritime transport policy provides the foundation of the ACCSEAS project's interventions at the NSR level to promote territorial cohesion, and sets out that by 2018, the capacities of the EU's maritime transport system should be strengthened by putting in place an integrated information management system to enable the identification, monitoring, tracking and reporting of all vessels at sea and on inland waterways to and from European ports and in transit through or in close proximity to EU waters.

Future work: Promote and contribute to an integrated information management system to enable the identification, monitoring, tracking and reporting of all vessels at sea and on inland waterways to and from European ports and in transit through or in close proximity to EU waters.

Such a system would be part of the e-Maritime Initiative and develop into an integrated EU system providing e-services at the different levels of the transport chain. In that regard, the system should be able to interface with the e-Freight, e-Customs and Intelligent Transport Systems, allowing the users to track and trace the cargo not only during the waterborne part of the journey, but across all transport modes in a true spirit of co-modality. With reference to the development of the IMO SMTS and the common recognition is that e-Navigation will be supportive to both e-Maritime and SMTS. The current structure of ACCSEAS as well as the proposed establishment of a NSR e-Navigation Coordination Platform after project ends to contribute to territorial cohesion across the NSR in respect to EU maritime and transport policy by providing information on the need to maintain access to the NSR ports and potentially valuable e-Navigation solutions which aid and manage this access.

3.4.5.1 e-Maritime

e-Maritime[38] is an initiative by the European Commission's DG MOVE to "foster the use of advanced information technologies for working and doing business in the maritime transport sector." [39] A key aim of the policy is to encourage interoperability between port information systems. The objective is that such systems will provide quality and efficiency gains in port operations.

This initiative has strong synergies with the premise of e-Navigation, the concept being demonstrated in the ACCSEAS project. The Ship-to-Shore and Berth-to-Berth e-Navigation systems could be interlinked with port logistics in order to provide an information exchange. This policy intervention could also be linked to the Integrated Maritime Surveillance and CISE.

Future work: Dissemination of work and results of ACCSEAS to the DG Move with a reference to e-Maritime

3.4.5.2 Trans-European Network – Transport (TEN-T)

The Trans-European Network – Transport (TEN-T) initiative by the EU to improve transport links throughout the entire EU. It includes all modes of transport, including maritime, with some modes of transport more developed than others. It is recognised that maritime transportation is a critical part to ensure the efficiency and safety of Europe's logistics.

3.4.5.2.1   Ports

Vessels travelling to, or through, the NSR ultimately terminates at a port, and the processes that occur at a port have a direct influence on the traffic at sea. This has been clearly recognised by the European Commission in their report "Ports: Gateways of the TEN-T" [40]. Approximately 25% of the ports identified in the document as "core" ports reside in the NSR, and so it is clear that the impact

---

[38] For further information: http://ec.europa.eu/transport/modes/maritime/e-maritime_en.htm
[39] http://ec.europa.eu/transport/modes/maritime/e-maritime_en.htm
[40] http://ec.europa.eu/transport/modes/maritime/ports/doc/2014-04-29-brochure-ports.pdf

of any initiative to improve port accessibility can have a major impact on the logistics flow through Europe.

Identified actions are the need for ports to be encouraged to

- act as enablers of inter-modality, for instance by taking the necessary arrangements in order to provide information on traffic flows allowing the better organisation of intermodal logistics". It is here that e-Navigation and the flow of information about the location and movement of vessels can help the ports achieve this from the maritime side of their operations.
- the distribution of traffic between ports will be considered.
- further develop its initiatives to promote the use of electronic information for the reduction of administrative burden and doing business (relating to e-Maritime).

3.4.5.2.2   Engaging ports, enhance awareness on e-Navigation

ACCSEAS has successfully developed an e-Navigation test bed to trial technologies that will help the shipping industry embrace e-Navigation by the IMO's deadline of 2020.

Proving technologies is only part of the solution – engaging with ports so that they support and help deploy the technology is quite a different thing. Here we outline a strategy and tactics that could be to employed to ensure that there is "*customer pull*" as well as "*technology push*".

e-Navigation must be communicated within the context of port operations and the benefits it can bring them. Increases of capacity, the threats of terrorism, smuggling and stringent carbon emission targets placed on ports by governments have made their operating environment more demanding than ever before. If they are to meet the needs of their customers and remain competitive, ports need both industrial stability and a high level of investment in infrastructure, people and technology. e-Navigation must be seen as the technological step that can help to improve this situation and positively impact their bottom line.

The EU and North Sea Region need well-performing ports across all maritime regions. Bottlenecks in ports and their hinterland due to the lack of high quality infrastructure or poorly performing port services result in congestion and higher costs. By embracing e-Navigation – ports will be able to gain competitive advantage and better service their customers.

When communicating with ports, it will be important to link e-Navigation to the hinterland and wider logistics chain that keep ports as hubs of activity that generate economic growth. Competition between larger and smaller ports is also currently a particularly hot topic and the adoption of e-Navigation technologies could be highlighted as way of re-balancing this competition by enabling smaller ports to operate more efficiently.

Key messages for dissemination to port and harbour authorities could include the below:

- *e-Navigation technologies have been tested and proven and will be widespread by the IMO deadline of 2020*
- *e-Navigation will enable more efficient berth to berth sailing, improving the safety and carbon footprint of shipping traffic*
- *Adopting e-Navigation technologies early will give ports first mover advantage over competitors*
- *e-Navigation technologies connect with the wider logistics chain meaning less congestion and greater efficiencies in the area around them*
- *e-Navigation enables mariners to deliver 'personalised' updates to ports*
- *A North Sea e-Navigation system embracing all container ports would boost pan-European trade*
- *Integrated maritime 'Big Data' would create intelligent ports that can analyse long-term trends and model future scenarios feeding new innovations and policies*
- *e-Navigation gives ports the same 24-hour full-spectrum visibility over the seas as Air Traffic Control Centres*

- *Ports will process greater amounts of trade at higher speed than ever before with the widespread adoption of 'e-Navigation'*

Engagement through stakeholder organisations

An important route to this audience is through the trade bodies and member organisations that represent them. Many of these organisations have conferences, workshops and seminars that could be targeted, as well as social media channels, newsletters and publications. Ambassadors should be identified and a speaker programme developed that enables ports to hear presentations or take part in workshops where the benefits of e-Navigation technologies are clearly explained.

It will also be important to place articles in the house media of these organisations and to share ACCSEAS (and successor) materials such as brochures, reports and films on their social media channels. Some organisations that could be included in this activity are:

- *European Sea Ports Organization (ESPO)*
- *International Harbour Masters Association*
- *International Association of Ports and Harbours (IAPH)*
- *The Federation of Private Port Operators (FPPO)*
- *International Chamber of Shipping (ICS)*
- *International Maritime Pilots' Association (IMPA)*
- *European Maritime Pilots' Association (EMPA)*

Engaging through media coverage

Media coverage not only raises the profile of the organisation but also carries the tacit endorsement of the media title itself, which is known and respected by its consumers. A series of contributed articles should be placed in the media that explain the benefits of e-Navigation to ports as well as some of the individual technologies that it involves.

If more testing by partners or successor programmes is planned – news stories should be developed and disseminated that inform the community of the latest results through key titles.

Port authorities need to see and understand in both practical and economic terms how they can benefit from e-Navigation. A recommended approach to communicating this would be through the development of an illustrated high-level whitepaper-style document specifically aimed at senior port stakeholders, which demonstrates the potential of the 'port of the future'.

With an emphasis on the role of e-Navigation as an enabler for positive change, the report should be developed in conjunction with input from a number of key stakeholders in order to enhance its credibility. This would also ensure that the development process itself provides a number of valuable opportunities to engage directly with the target audience. By involving senior port stakeholders in its development, it ensures they are already bought into the concept, and will later be inclined to publicise the paper through their own networks.

Clearly, additional resources (both human and financial) would be required to take these activities forward and to maximise the impact of the good work done by the project. The benefits of e-Navigation technologies must be communicated to those who can benefit from them and ports are a crucial part of this audience.

Future work: Dissemination of work and results of ACCSEAS to the maritime port community in order to enhance the awareness on e-Navigation among port authorities indicating the benefits of the ports involvement in the e-Navigation concept.

3.4.5.2.3   Motorways of the Sea

Motorways of the Sea is a TEN-T initiative set up by the EC with the aim to "introducing new intermodal maritime-based logistics chains in Europe". It identifies major shipping routes within European waters that link major parts of the hinterland. This is where e-Navigation can ensure that

vessels that need to join them in the NSR, or transit from one "motorway" to the other, can do so in the most efficient and safest manner. The potential solutions in the ACCSEAS project will be of keen interest to those that would like to see how the concept can be implemented.

Future work: Dissemination of work and results of ACCSEAS to the DG Move, DG MARE and EMSA with a reference to TEN-T, Horizon 2020+, Motorways of the Seas, and other relevant projects.

3.4.5.2.4   *MONALISA and MONALISA 2.0*

The MONALISA and its sequel, MONALISA 2.0, are projects funded through the TEN-T initiative directly. A number of partners in the projects are also partners in the ACCSEAS project, which strengthens the potential to take the developments in ACCSEAS beyond the North Sea Region.

The MONALISA project was originally focused on the Baltic Sea Region, looking at potential solutions to improve maritime transport safety and efficiency. Solutions include dynamic route planning and maritime information exchange to improve spatial awareness for maritime users both at sea and on shore. The MONALISA 2.0 project, amongst other things, further develops the solutions of MONALISA into the Sea Traffic Management concept. This is a holistic view of the maritime space that ensures all users share their intentions and current status in order to ensure maximum efficiency in the maritime transport system. There are some synergies between the potential solutions in ACCSEAS and the services required in the MONALISA projects to provide the required management functionality.

Future work: Dissemination of the work and results of ACCSEAS to MonaLisa 2.0 as building blocks for the further development of for instance the Maritime Cloud, Maritime Safety Information, Route exchange and Route Advice, Automated FAL reporting, digital shore based Infrastructure, data exchange in the maritime domain.

3.4.5.2.5   *Maritime Safety*

Maritime safety policies have been significantly influenced by the history of maritime accidents and consequential pollution, notably the Erika in 1999 and the Prestige in 2002. European policy and directives relevant here are **ERIKA I, II, III.** The three EU Maritime Safety Packages: Erika I, Erika II and the 3rd Maritime Safety Package (2009-2012) are important to regional to e-Navigation in the North Sea Region and to the ACCSEAS test-bed solutions. The links refer in particular AIS, Vessel Traffic Monitoring, Oil Spill Response, SafeSeaNet, CleanSeaNet and Long Range Identification and Tracking (LRIT). Hence ACCSEAS can add value to and influence the future of these European policy areas.

3.4.5.2.6   *INSPIRE Directive*

In 2007, the EU approved Directive 2007/2/EC to provide for an Infrastructure for Spatial Information in the European Community (*INSPIRE*) to establish "an infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment." It provides for a harmonised means of describing various spatial elements needed by other policies and initiatives.

One of the areas covered by the INSPIRE Directive is Transport links, including the maritime domain. Unfortunately, the maritime descriptions are somewhat underdeveloped at the time of writing.

Future work: It is recognised within the ACCSEAS project that the Route Topology Model (one of the "candidate solutions" of ACCSEAS) has the potential to directly fill the identified gap in the INSPIRE Directive concerning the somewhat underdeveloped maritime descriptions. This is to ensure that the maritime requirements, such as shipping routes and areas are identified in a harmonised way.

3.4.6   Policy link between EU and International levels

The link between EU Policy and the international implementation of e-Navigation is provided by the Maritime Transport Policy. The policy supports the work of the specialised international organisations in the maritime transport field, including the IMO, ILO, WTO and WCO, as well as its strong and growing network of bilateral maritime transport agreements and dialogues with key shipping and trading partners. As part of this, the member states and EU will push for a comprehensive international regulatory framework for shipping, suited to face the challenges of the 21st century. The specific link with e-Navigation is reinforced by Section 6.24 of the IMO NAV57 which calls for collaboration between the EU and IMO.

Future work: ACCSEAS provides policy advice to decision-makers concerning this link. ACCSEAS partners are involved in the working programmes of the IMO, IHO and IALA.

3.5   Work Package 4 "e-Navigation Architecture and Standards"

3.5.1   Short description of the scope and content of the WP4

The objections of WP4 were defined as: "Develop a convergent overarching architecture and inform the development of standards for a NSR e-Navigation test-bed that will demonstrate 'Proof-of-Concept' of prototype e-Navigation services at key locations in the region which upgrade the region's maritime accessibility and takes into account criteria for harmonisation and integration of e-Navigation between national service providers"[41].

It was stipulated that beneficiaries use the findings of WP3 to set out a proposed portfolio of e-Navigation services; based upon a novel architecture and associated new and improved standards. WP4 will use design technique to provide an innovative e-Navigation architecture for the future provision of operational & technical services to improve maritime accessibility of the NSR. Activities from WP4 will be used to inform EU and International development of standards via WP2[42].

3.5.2   Scope and content of the WP4 "ACCSEAS e-Navigation Architecture Report"

In accordance with the approved ACCSEAS Application 8th Call WP4 "e-Navigation Architecture and Standards" produced the "*ACCSEAS e-Navigation Architecture Report: "Implementing e-Navigation in the North Sea Region – the ACCSEAS Contribution"*. This Report contains the following sections:

- *"Design of innovative e-Navigation architecture for ship/shore services"[43]*
  described by the chapter "ACCSEAS potential solutions and IMO's overarching e-Navigation Architecture."
- *"Innovative e-Navigation architecture for ship positioning"[44]*
  description of the ACCSEAS potential solution "*Innovative Architecture for Ship Positioning: Multi Source Positioning Service / R-Mode*" as described in the corresponding sections.
- *"Design Techniques Section"[45]*
  a detailed description, due to the nature, addressing system engineering and simulation techniques specifically, in a part of this Report dedicated to this topic.

---

[41]   ACCSEAS Application, Work Package 4, para A4.2

[42]   ACCSEAS Application, Work Package 4, para A4.4.4

[43]   ACCSEAS Application, Work Package 4, para A4.6 *"Design of innovative e-Navigation architecture for ship/shore services and virtual realisation in simulation"*

[44]   ACCSEAS Application, Work Package 4, para A4.5 *"Design of innovative e-Navigation architecture for ship positioning and virtual realisation in simulation."*

[45]   ACCSEAS Application, Work Package 4, para A4.1 *"Harmonisation of architectural de-sign and simulation techniques, which can be applied to e-Navigation."*

3.5.3   Architecture and architectural terms: definition and explanation

In ACCSEAS the *term "architecture"* is used in the same way as within system theory (as opposed to architecture proper or civil engineering proper) as follows:

"*A system architecture or systems architecture is the conceptual model that defines the* **structure, behaviour,** *and* **more views** *of a system".*

An <u>architecture description</u> is a formal description and representation of a system, organized in a way that **supports reasoning** *about the structures and behaviours of the system.*
A <u>system architecture</u> can comprise system *components*, the *externally visible properties* of those components, the *relationships* (e.g. the behaviour) between them. It can provide a *plan* from which products can be procured, and systems developed, that will work together to implement the overall system. (…) One can think of system architecture as **a set of representations** *of an existing (or future) system.* It conveys the *informational content* *of the elements comprising a system,* the **relationships** *among those elements*, and the **rules** *governing those relationships.*

The <u>architectural components</u> and set of relationships between these components that an architecture description may consist of hardware, software, documentation, facilities, manual procedures, or roles played by organizations or people. A system architecture primarily concentrates on the **internal interfaces** *among the system's components or subsystems,* and on *the* **interface(s) between the system and its external environment, especially the user.**"

From the above definition and explanation it can be derived that *several views or angles of perspective* would be required to completely describe *the "e-Navigation Architecture".* Also, it follows, that they are - if done correctly - *complementing* each other*.*

As the focus of ACCSEAS is on the North Sea Region (NSR), the geographical scope of this Report is the NSR. However, it is also expressively stated[46], that influences external to the NSR should be taken into account, namely those from the international domain (e.g. IMO, ITU, IHO, IALA) as well as from the pan-European domain (EU initiatives and directives). Hence, any e-Navigation Architecture for the NSR would need to look for relevant international and pan-European conceptual imports.

Conversely, as a legacy of ACCSEAS there is a requirement to identify potential feedback from the NSR to relevant international and pan-European bodies.

Future work: Beneficiaries of ACCSEAS and representatives in the relevant international and pan-European bodies shall identify conceptual imports on e-Navigation Architecture as potential feedback for the NSR.

3.5.4 Mapping ACCSEAS candidate solutions

With respect to the ACCSEAS candidate solutions (see section 6.6.1 above) the "ACCSEAS e-Navigation Architecture Report" (May 2015), abbreviated "*AeNA Report*" from now on,
* analyses their operational and/or technical architectures;
* harmonises these architectures with stipulations imported from the international domain:
o by addressing how candidate solutions fit into the IMO Secretary General's proposed Sustainable Maritime Transportation System (SMTS) from an architectural point of view and
o by looking at their place within the IMO e-Navigation Strategy, namely within the IMO e-Navigation overarching architecture as contained in the IMO e-Navigation Strategy Implementation Plan (SIP).

This process is called **'mapping'***: 'Mapping' means 'showing how it is supportive' to the different architectural perspectives at hand. Hence, when mapping candidate solutions to the different*

---

[46] ACCSEAS Application, Work Package 4, para A4.4.1

architectural perspectives, it is demonstrated not only that the candidate solutions have a place in those different architectural perspectives, but in what regards the candidate solutions support them.

- assesses them from a strategic point of view in architectural terms.

Specifically, following 10 candidate solutions are investigated in this *AeNA Report* (sections 3.3 until 3.9) in detail in architectural terms[47]:
  - o Maritime Service Portfolios (MSPs)
  - o Route Topology Model (RTM)
  - o 'Maritime Cloud (MC)' as an underlying technical framework solution
  - o Innovative Architecture for Ship Positioning comprising both:
  - o Multi Source Positioning Service
  - o R-Mode at existing MF DGNSS and AIS Services
  - o Maritime Safety Information/Notices to Mariners (MSI/NM) Service
  - o Augmented Reality (AR) / Head-Up-Displays (HUDs)
  - o Harmonized Data Exchange – Employing the Inter-VTS Exchange Format (IVEF)
  - o Real Time Vessel Traffic Pattern Analysis and Warning Functionality for VTS

The architectural analysis arrives at the following conclusions:
- Architectural mapping is feasible
  - o with all candidate solutions investigated here;
  - o with the wide scope of qualities they exhibit individually;
  - o with the external stipulations imposed (e.g. from IMO e-Navigation) and the methods applied,
- with a meaningful result each, i.e. at least one starting point for further operational and/or technical exploration and research *or* even NSR implementation suggestions in no un-precise terms.
- This prove of feasibility in itself carries a two-fold success, namely:
  - o The generic e-Navigation target architectures, both for the shipboard and shore sides, are 'working' and therefore can be considered 'correct' to the extent of what they want to show at their respective levels of detail;
  - o Each candidate solutions investigated can be considered as 'solid in architectural terms to the degree of detail investigated.'
- There is a lasting wealth of ACCSEAS regarding the transformation of the international SMTS and e-Navigation strategies into their appropriate NSR implementations.
- From an architectural perspective, ***some of the ACCSEAS candidate solutions are also demonstrated mature enough to be seriously considered for actual operational implementation in the near to intermediate future at least in the NSR as a legacy of ACCSEAS.***
- Other ACCSEAS candidate solutions require further analysis and exploration in due course.

Future work: The mapping results and considerations of the candidate solutions reflected in the sections 3.3 until 3.9 of the "ACCSEAS e-Navigation Architecture Report" shall be noted and kept under review once the relevant implementation aspects of these solutions progresses.

3.5.4.1 Mapping ACCSEAS candidate solutions - IMO Sustainable Maritime Transportation System

The "AeNA Report" para 2.2 concluded on how ACCSEAS can support the SMTS in architectural terms:

---

[47] Not all 14 candidate solutions were investigated to the same degree of detail, solely due to ACCSEAS project resource limitations; there were

   no other reasons. All 14 ACCSEAS candidate solutions are included in the mapping of ACCSEAS' support for the IMO SG's SMTS, however.

- *Candidate solutions specifically address four different goal domains of the SMTS, namely 'Education and Training in Maritime Profession' (No. 2), 'Port-ship interface' (No. 3), 'Maritime Traffic Support and Advisory Systems' (No. 5), and 'New Technology and Innovation' (No. 8).*
- *Not surprisingly, one focus of ACCSEAS contributions is on No. 5, where there is also mentioned 'e-Navigation:' The starting point for No. 5 was the recognition by the IMO SG that there is 'more crowded seas, with greater traffic density and larger ships.' – This was also the starting point for ACCSEAS. Thus, in hindsight, the SMTS No. 5 provides an independent justification for a project like ACCSEAS (but also for work beyond along similar lines).*
- *A strong support in terms of candidate solutions is given to the SMTS' concern for education and training in maritime professions, namely by the development of application-specific Human-Machine-Interfaces by the candidate solutions, by the identification of training needs for those candidate solutions and finally by the use of simulators and simulation. This is due to the many academic institutions working with shipboard and shore-based users participating in the project.*
- *The strongest support is for the SMTS' goal domain 'New Technology and Innovation' as ACCSEAS introduces some innovation in every candidate solution.*

Future work: Taking into account that the further development of both the SMTS and the e-Navigation concepts, as well as the now identified and eventual candidate solutions for the NSR, are subject to an evolving process the table 1 "Mapping of ACCSEAS features and candidate solutions to the SMTS' Actions" as presented in the "ACCSEAS e-Navigation Architecture Report" (May 2015), para 2.2, shall be kept under review and analysed during future work.

3.5.4.2 Mapping ACCSEAS candidate solutions - IMO's overarching architecture for e-Navigation

The "AeNA Report" section 3 and subsections provides in a *number of technical architecture definitions*.

This chapter therefore reflects on the IMO defined '*overarching architecture'* for e-Navigation. The goal here is to show where and how the NSR e-Navigation architecture would fit into the overarching architecture. Thereby, the support of the ACCSEAS candidate solutions for the IMO SIP (IMO 2014), including the identified 'Solutions,' 'Sub-Solutions,' and 'Tasks' contained therein, is identified and presented in no un-precise terms, since all these 'Solutions,' 'Sub-Solutions,' and 'Tasks' can be themselves similarly referenced back or 'mapped' to the overarching architecture in no un-precise terms.

Potentially, some of the mappings of the ACCSEAS candidate solutions may be even identical to any such mapping of 'Solutions,' 'Sub-Solutions,' and 'Task' fulfilments, at least in some cases, thus rendering a directly applicable architectural mapping.

Figure 3-1 in section 3.1 demonstrates and clarifies how the major entities connect and cooperate, specifically:
- *'Shipboard user' and 'Shore-based user'*
- *'Operational services'*
- *'Technical services'*
- *'Maritime Service Portfolios (MSPs)'*
- *'Shipboard technical equipment supporting e-Navigation (incl. its Human-Machine-Interfaces)'*
- *'Common technical shore-based system harmonized for e-Navigation (incl. its Human-Machine-Interfaces)'*

Figure 3-2 in section 3.2 shows a generic technical shipboard architecture supporting e-Navigation and figure 3-3 in this section reflects an example of a *'Common technical shore-based system harmonized for e-Navigation (incl. it's Human-Machine-Interfaces)*, introducing some individual technical services. Basically all technical services shown do what is implied by their name:
  o *the Data Collection and Data Transfer Services*
  o *the Value Added Data Processing Services*

- *the User Interaction Service*
- *the Gateway Service*

3.5.4.3 Mapping ACCSEAS candidate solutions - Maritime Service Portfolios (MSPs) for the NSR

Future work: Depending on various regional and local circumstances, differences in users perspectives as well as results of the international development processes of the e-Navigation Architecture (IMO, IALA)

- the mapping of the identified and future candidate solutions
- the descriptions, definitions and the final embedding and application possibilities as presented and proposed in the "ACCSEAS e-Navigation Architecture Report" (May 2015), para 2.2, shall be kept under review and evaluated for implementation in the NSR.

3.5.4.4 Some considerations on a transnational MSPs Registry and its interaction with stakeholders and their systems

In respect to *MSPs meta-level data*, on the shipboard side the MSPs descriptions must be exchanged between onboard systems. On the shore side the MSPs meta-level data model as a whole could reside in a technical service within in the group of the *Value-added Data Processing services*, in a dedicated service called ***Maritime Portfolio Registry Service (MPR)***.

Maritime Portfolio Registry Service (MPR)
- **is intended** to facilitate the implementation of the MSPs concept by providing a *repository for the meta-level specification of operational and technical services and provisioned service instances*, thereby making it a *single reference point* for provision and discovery of meta-level descriptions.
- **contains** *service specifications from a data modelling point of view* according to an envisioned *Maritime Service Specification Standard* and provisioned *service instances* implemented according to a service specification
- **aims** at improving the visibility and accessibility of available maritime information and services. This enables service providers, consumers, and regulatory authorities (each with a different access role) to share a common view on service standards and provisioned services
- **enables** the 'provider' to 'publish' information related to its service instances so that the 'consumer' is able to 'discover' them and obtain everything (e.g. interface information) required to ultimately use those services.
- **supports** some of the cornerstones of *Service Oriented Architectures (SOA):* Service loose coupling, abstraction, reusability, autonomy, composability, discoverability and standardized service contracts.
- **does _not_ provide** maritime information but a meta-level specification of services and the information-/data they carry, and the technical means to obtain it.
- **provides** the mechanisms to manage the life cycle of meta-level service specifications and service instances, from a data modelling point of view.

3.5.4.4.1　　The need for a transnational MSPs Registry

- The MSPs concept is an integral part of IMO's e-Navigation strategy because it has the potential to massively contribute to the _harmonization_ which is the most fundamental goal of that strategy.
- To exploit that potential, a *transnational MSPs Registry* is required considering the pre-dominantly national scope of shore-based service providers today.
- Ideally, transnational would mean *international, i.e. global*, though, to achieve the maximum harmonization.
- Consequentially, IMO has asserted the role to govern the definition of the MSPs by taking 'initial action' (IMO 2014, Table 9). When this action will have been fulfilled, there will have been developed the concept of an *International MSPs Registry.*

- *The latter* may not be easy to implement from the outset for a completely new paradigm like the MSPs. Hence, a *migration path* towards such an International MSPs Registry may need to be considered, via:
  - *Regional MSPs Registries* in different regions across the world, *w*hile regions setting up those MSPs Registries would strive to harmonize their meta-level descriptions from the outset.
  - Considering Europe as a region, this would render an *European MSPs Registry.* Considering the NSR alone, would render an *NSR MSPs Registry.*

The recognition of the need for such a discussion is an important legacy of ACCSEAS.

Future work: Considering the massive efforts needed to set up all the generic meta-level service descriptions to be contained in any (generic) MSPs Registry and considering also the fact that e-Navigation is most desired by those regions where there is a high demand due to the traffic situation present and future like in the NSR, *it appears prudent to start with setting up a NSR MSPs Registry as a first step for a much broader international development to come and finally replace the NSR MSPs Registry.*

3.5.5   Use of Simulators in e-Navigation Training and Demonstration

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.

As part of Work Package 4 the Use of Simulators in e-Navigation for 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" was investigated, discussed, identified and tested .

This included 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 were considered:
  a) Standardization,
  b) Training for technology based systems and
  c) Introducing new technology regarding the human element,
for the training of seafarers when introducing new technology, which 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.

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"*
Such changes generate new demands on training institutions and on instructors working within them.

3.5.5.1 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*"

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

a) Standardization:
b) Training for technology based systems:
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.

Watch keepers 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.

MSC/Circ. 1091 concludes with summarizing that new technology installed on board can improve the efficiency and effectiveness of watch keeping 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. e-Navigation specific training

3.5.5.1.1   *e-Navigation specific training*

The implementation of all prioritized e-Navigation solutions (IMO SIP, 2014) require specific training referred to the used technical methods and new operational procedures to comply with the key messages for all stakeholders. Scrutinizing the solutions in detail it becomes clear that the solutions S1 and 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 be 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" must be revised. A possible solution could be an IMO Model Course: "Operational use of VTS Services".

Future work: IALA should be attended to documentary consequences in respect to "IALA Model Course V-103/1 – Vessel Traffic Services Operator Training" as a result of the prioritized solution S9, which may require new technical and operational competencies for VTS personnel.

3.5.5.2 The evolution of using simulators in maritime education and training

An overview is provided about 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 visualization.

A summary was presented on what modern ship handling simulator contributes to the skills for new students (candidate mariners), allowing them access to a real time simulation of the conditions aboard ships 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. In summary 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 as on the bridge of modern ships.

Today marine simulators take over an increasing part in maritime training to raise safety standards. STCW 2010, 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".

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.

3.5.5.3 ACCSEAS candidate solutions relating to education, training and using simulators

It should be noted that during and at the end of ACCSEAS project the solutions reached a different stage of development.

3.5.5.3.1   Thoroughly investigated solutions

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

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

3.5.5.3.2   In principle recognized solutions

The following 3 solutions are in principle recognized but were during their stage of development not yet ready for developing training arrangements.

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

3.5.5.4 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.'

3.5.5.5 Use of the e-Navigation Prototype Displays (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 was 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.

3.5.5.6 Simulator requirements for different shipboard usages based on STCW regulations

All in section 3.5.5.3.1 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.

3.5.5.7 Simulator requirements for training purposes

3.5.5.7.1   Types and classes of current maritime simulator systems

With input from the "International Marine Simulators Forum" (IMSF), the classification society DNV-GL 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.

"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"

3.5.5.7.2   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.

3.5.5.8 "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".

Key benefits are e.g.:

• International standard protocol for simulation networks (IEEE 1278)
• Open standard with no license 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 tunneling mechanism of Virtual Private Networks.

3.5.5.9 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 should be created within the ACCSEAS test-bed, based on the results of the following 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".

Future work: For further testing and training purposes of candidate e-Navigation solutions a simulator network of VTS stations and vessels should be created within a future test-bed, based on the results of the following EMSN concept.

3.5.5.9.1   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.

Future work: For further testing and training purposes of candidate e-Navigation solutions both the simulator and the trainees have to be prepared relating to IBS and INS.

3.5.5.9.2   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*"

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.

3.5.5.9.3   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.
- Building on the introduction to e-Navigation the parts of the definition (and related issues) must be explained in a short and demonstrative way, for example:
  - Collection of maritime information
  - Integration of maritime information
  - Exchange of maritime information
  - Presentation
  - Analysis

- 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.

3.5.6   Referenced activities in ACCSEAS for each solution

During ACCSEAS the individual solutions were carved out on the use of simulators for training and demonstration, indicating the kind of Human-Machine Interface (HMI) required and the function area(s) of required simulators.

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

- *Kind of Human-Machine Interface (HMI):* HMIs to shipboard and shore-based users
- *Function area(s) of required simulators:* Ship operation, Shore operation
- *Use of simulators for training and demonstration:* Not yet investigated

3.5.6.2 Route Topology Model (RTM)

- *Kind of Human-Machine Interface (HMI):* RTM can be construed as "maritime traffic support system"
- *Function area(s) of required simulators:* Not relevant
- *Use of simulators for training and demonstration:* Not relevant, only simulation of portrayal

3.5.6.3 Maritime Cloud

- 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 Hu-man Machine Interface to control the "more" technical service.
- 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
- Use of simulators for training and demonstration: During period of ACCSEAS no simulation activities ware planned or carried out.

3.5.6.4 Innovative Architecture for Ship Positioning:
a)   Multi Source Positioning Service (MSPS),
b)   R-Mode at existing MF DGNSS and AIS Services

- *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.
- *Function area(s) of required simulators:* Bridge operation
- *Use of simulators for training and demonstration:* During ACCSEAS several test simulations have been carried out (simulate GPS jamming, simulation of Resilient PNT).

Future Work: 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.

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

- *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"

- *Function area(s) of required simulators:* Bridge operation, MSI/NM operation
- *Use of simulators for training and demonstration:* 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",

Future work: It should be investigated, using the EPD simulation, how to present messages with no geo-graphical information on graphical clients such as ECDIS and ensure that they are read by the officer on watch (OOW).

3.5.6.6 No-Go Area Service

- *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"
- *Function area(s) of required simulators*: Bridge operation
- *Use of simulators for training and demonstration:* During runtime of ACCSEAS project the ACCSEAS simulation workgroup (WG-Sim) 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"

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 (training requirements):

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

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.

3.5.6.7 Tactical Route Suggestion Service (shore-ship)

- *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 as possible the EPD ship stations were almost seamless integrated in the bridges of a ship handling simulator fulfilling the INS/IBS concept
- *Function area(s) of required simulators:* Bridge operation, VTS operation, future trend: Remote pilotage operation
- *Use of simulators for training and demonstration:* During runtime of ACCSEAS project the WG-Sim 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). In 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 ship handling simulators (Bridge operation), manned with BTM crew.

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

- *Kind of Human-Machine Interface (HMI):* The Tactical Exchange of Intended Route can be construed as a "maritime traffic support system". 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.
- Function area(s) of required simulators: Bridge operation, VTS operation, future trend: Remote pilotage operation
- *Use of simulators for training and demonstration:* During runtime of ACCSEAS project the WG-Sim 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). 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 ship handling 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 ship handling simulators (Bridge operation), manned with BTM crew should be established.

3.5.6.9 Vessel Operations Coordination Tool (VOCT)

- *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". 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.
- *Function area(s) of required simulators:* Bridge operation, MRCC operation
- *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. 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 ship handling simulators (Bridge operation), manned with BTM crew.

3.5.6.10   Dynamic Predictor (for tug boat operations)

- *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.
- *Function area(s) of required simulators:* Tug operation, often is included as tug operation module in a bridge operation simulator
- *Use of simulators for 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 focusing on training demands was not carried out during ACCSEAS project.

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

- *Kind of Human-Machine Interface (HMI):* 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 displaying this on a Head-Up Display. E.g. at a bridge window or OOW cocoon. HMIs to shipboard users
- *Function area(s) of required simulators:* Bridge operation
- *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 WG-Sim meetings and 3rd Annual Conference. Simulation focusing on training demands was not carried out in ACCSEAS project.

3.5.6.12   Automated FAL Reporting

- *Kind of Human-Machine Interface (HMI):* HMIs to shipboard and shore-based users
- *Function area(s) of required simulators:* Not investigated during ACCSEAS project
- *Use of simulators for training and demonstration:* Not investigated during ACCSEAS project

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

- *Kind of Human-Machine Interface (HMI):* HMIs to shipboard and shore-based users
- *Function area(s) of required simulators:* VTS operation, MRCC operation, Bridge operation

- *Use of simulators for training and demonstration:* Within ACCSEAS no simulation trials were conducted. Real-life tests were conducted in December 2014 between vessels and the Netherlands Coastguard Centre.

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

- *Kind of Human-Machine Interface (HMI):* There is no further description in technical and operational terms or practical evaluation done within the ACCSEAS project. Not investigated within ACCSEAS project.
- *Function area(s) of required simulators:* VTS operation
- *Use of simulators for training and demonstration:* Not investigated within ACCSEAS project

3.6   Work Package 5 Testbed Implementation: Ship Positioning

3.6.1   Short description of the scope and content of WP5

Implement prototype systems and infrastructure to provide resilient positioning of vessels and robust navigation information for shipping in the North Sea. Prove the concept that these innovative positioning solutions underpin the safety of navigation in the region and enable e-Navigation services that address the efficiency of maritime logistics for improved access in the region. The task breakdown includes:

- Implementation of integrated robust ship positioning, based on GPS, within an e -Navigation prototype.
- Prototype implementation and simulation of a terrestrial back-up to GPS for resilient ship positioning.
- Construct a test plan for assessment, demonstration and simulation of resilient ship positioning in WP7.
- Conduct of a Training Needs Analysis related to the implementation of e-Navigation ship positioning and communications.

3.6.2   Multi Source Positioning Service (MSPS)

An ACCSEAS Multi Source Positioning Service (MSPS) has been proposed based on existing shore-side infrastructure. The service provides Resilient PNT currently through fall-back to existing e-Loran infrastructure, however it incorporates future thinking in terms of R-Mode developments, based on both Medium Frequency (MF) and AIS (VHF) techniques.

The highlight of the service is the recognition that, whatever the source of PNT, there is a need to provide the mariner (and shore side operators) with an indication of integrity and positioning accuracy through the provision of "*integrity equations*" intended to compute a Horizontal Protection Level (HPL), which is then compared to a "Horizontal Alert Limit" appropriate to the application or operation currently being performed.

Future Work: *S-100 Product Specifications* will be required to be developed for data provided by Technical Services and the Operational Services provided by the Multi-Source Positioning Service. The first step will be the development of data models for the following:
1.   Vessel positioning information
2.   eLoran ASF data
3.   eLoran transmitter almanac data
4.   Medium Frequency (MF) R-Mode Transmitter Almanac Data Model
5.   AIS (VHF) R-Mode Transmitter Almanac Data Model
6.   Differential-Loran Reference Station almanac data

Future Work: *Collaborative Navigation*. With "Collaborative Navigation" the aim would be to take advantage of the availability of the Maritime Cloud to share radio navigation system calibration data (for example eLoran ASFs) with shore-side databases and other vessels. The ACCSEAS Multi-Source Receiver contains all the necessary components to make propagation data measurements that are vital to the functioning of terrestrial radio navigation systems. This data may be collected during normal operations of the receiver installed aboard vessels going about their business.

Future Work: Expansion with *ARIADNA Functionality*. The inclusion of aspects of the EU Framework 7 project ARIADNA could be performed under a future programme of work, including expanding the use of the HPL computation to affect the "volume" of the vessel.

3.6.2.1 Prototype Multi-Source PNT Receiver

An ACCSEAS Multi Source Resilient PNT Receiver has been developed and used within tests and demonstrations (see hereafter). This is a state of the art receiver, which together with ACCSEAS PNT Data Processing Software is capable of detecting interference on GPS signals and then seamlessly and automatically swapping from GPS as the primary source of navigation and positioning information to a complementary backup system such as eLoran. The contract for development of the receiver also included forward thinking to include R-Mode functionality once the signal specification becomes available from the output of the R-Mode feasibility studies.

Future Work: Both the multi-source PNT radio navigation receiver as well as the PNT data processing software are prototypes and bespoke, non-commercialised and developed for running under the mathematical programming environment Matlab™. Future work would involve producing a more "*commercialised*" version of the receiver, with software/firmware provided at the circuit board level. This would present a form factor that is much more appealing to mariners. Although work is underway by the contractors who developed and supplied the Multi-Source Receiver to understand how to build in R-Mode functionality, this will not be achieved under the current ACCSEAS project and there is therefore scope to expand the receiver's capability. It would also be appropriate to investigate the type approval of such a receiver for the ready installation aboard vessels intending to the test MSPS.

3.6.2.2 PNT Data Processing Software

Software has been developed by the GLAs for running on the Multi-Source Receiver platform. This software performs the following functions:
- Computes a position solution based on TOA measurements from eLoran or R-Mode (when available) receivers, as required
- Stores and applies propagation data corrections (e.g. eLoran ASFs)
- Applies differential correction data to the pseudorange measurements of terrestrial PNT services
- Computes and maintains the Horizontal Protection Levels (HPL) for complementary PNT services and the primary GPS service
- Detects incidents of GPS interference and jamming, and monitors the interference level
- Potentially can be used to analyse the data output from an eRadar for the integrity assurance of absolute radar positioning
- Automatically and seamlessly switches the main PNT output of the service to the best available backup source given the prevailing interference/jamming conditions
- Generates alarms for the purposes of notifying the mariner and shore-based stakeholders

Future work: *Horizontal Protection Level*. It was suggested that HPL was a parameter that was only of interest to system designers as an indicator about whether the system is performing as expected. Some further consultation would be required with mariners to determine the level of usefulness of the feature. It is however, important that the mariner has some indication about which system is currently being used to provide positioning information.

3.6.3   Description of the tests

3.6.3.1 Testing hard- and software for Resilient PNT

The work package developed software which is capable of detecting problems with GPS and swapping positioning source for another, complementary, source of positioning information called **e-Loran**.

Test 1 - A test and demonstration of this software was performed off the coast of Harwich in the UK in February 2013 aboard the Trinity House Vessel Galatea. This test employed a live GPS jammer operated by the UK MoD, and a first prototype of a Multi-Source Radio Navigation Receiver. Following Test 1 a second version Prototype Multi-Source Receiver was employed, additionally further developing the Resilient PNT software.

Description and Result: The demonstration illustrated the effect of the loss of GPS on ship's positioning and other systems. The test employed a military grade GPS jammer the signal from which signal was slowly brought up in power level. This simulated the vessel's approach to a jammer at a fixed location with the vessel slowly approaching it; as would, for example, should a jammer be installed within a vehicle, perhaps at a port. The resilient PNT receiver was set up to feed many ship's systems with GPS and as the jammer signal increased in power, alarms began to sound around the bridge GPS became unreliable. Eventually a power level was reached where GPS was lost completely. The scenario was run again with the "Resilient PNT" system activated. As the jammer signal power was once again raised the software within the receiver detected the effect of the jammer signal on the GPS satellite signals and switched over to eLoran before any alarms sounded. As far as we are aware this was the first time that this seamless, automatic transition to a complementary maritime backup source of PNT had been demonstrated.

ACCSEAS Legacy: - further developed software capable of detecting problems with GPS and swapping positioning source for another, complementary, source of positioning information;
                 - a second prototype of a Multi-Source Radio Navigation Receiver;
                 - a video, which is available for download, and even inclusion in training material.

Test 2 - A further test was performed in October 2014 aboard the P&O Ferry Pride of Hull where Resilient PNT information was integrated with the ACCSEAS e-Navigation Prototype Display (developed by DMA).

Description and Result: The vessel sailed from Rotterdam to Hull. The work was performed in conjunction with Humber VTS and involved demonstrating test scenarios employed to show several proposed
e-Navigation services including MSI, Route Suggestion and No Go Area. The EPD had been modified to accept data from the newly developed prototype ACCSEAS Multi-Source Receiver. Under normal circumstances the receiver output GPS positioning information to the EPD. However, during one scenario, that of a Route Suggestion from the Humber VTS, the ACCSEAS team instigated a total loss of GPS (by pulling the GPS antenna from the receiver). This caused the receiver to swap automatically to output eLoran positioning data to the EPD, and we clearly demonstrated the ability of the mariner to continue unhindered by the GPS outage into the port approach area of the Humber Estuary.

Conclusion: Both physical GPS outage tests (1 and 2) of the resilient PNT techniques developed under the ACCSEAS project were very successful. It was, for the first time, to clearly illustrate the effect of interference or jamming to GPS and to demonstrate a possible solution for providing Resilient PNT as a seamless and complementary backup to GNSS.

ACCSEAS Legacy: - test scenarios employed to show several other e-Navigation services;
        - a video, which is available for download, and even inclusion in training material.

Simulator Work - Simulation work performed included the development of methods of perturbing the simulated GPS input to fully bridge simulators. This included adding the capability to simulate the imperfect nature of GPS positioning, against the current assumption that a plotted position is perfectly precise. Flensburg was supplied with GLA developed software to feed the instrument panels within the bridge simulator with noisy GPS position fixes, thus simulating more closely what would happen in reality. The level of noise can be adjusted. In addition, jamming can be simulated by the activation of a random walk function where the GPS would wander off slightly (simulating the effect of low level jamming or interference).

ACCSEAS Legacy: - methods of perturbing simulated GPS input to bridge simulators
                                      - software to feed instrument panels within the bridge simulators

3.6.3.2 Absolute Radar Positioning Trial

Test 3 - ACCSEAS performed an absolute radar positioning trial off the East Coast of England using a prototype and experimental, solid-state radar ("New Technology Radar") provided by Furuno and e-Racons provided by Tideland. The e-Racons were installed at Southwold and Lowestoft lighthouses. The radar was installed on THV "Alert" and this vessel was used for the trials.

Description and results: The e-Radar unit is capable of triggering e-Racons and receiving the returned e-Racon signature. The e-Radar then demodulates the e-Racon position data, which is modulated onto the dash of the e-Racon return. The e-Radar then performs a position computation using either one or two such e-Racon returns. Each e-Racon provides a single line-of-position (LOP) consisting of range and bearing information from the e-Radar to the e-Racon. Positioning may be performed using one LOP, but two LOPs are required for the highest level of accuracy.

Although the installations of the radar on board the vessel and of the e-Racons at the lighthouses were of a temporary nature and not in ideal positions, the system was shown to be effective and the results indicated ranges and accuracies that could be achieved with an operational system. The absolute radar positioning test demonstrated successful positioning ability, with positioning accuracies of approximately 5m within 10 nautical miles from the coast using two e-Racons. An e-Racon every 10NM up the coast provided the highest accuracy being available only within 10NM of the coast. These results were then used for a preliminary assessment of the viability of radar positioning as an option for achieving the resilient PNT required for e-Navigation.

Conclusions: The initial conclusions are that the system can provide the required performance for a complementary positioning system to GNSS, although the range would be limited as the efficacy of the technique is constrained by the amount of shore infrastructure required. Using a single e-Racon reduces the positioning accuracy by an order of magnitude. The cost in terms of infrastructure, would be manageable. However, the timescale for implementation would be very long, since all existing radars would have to be replaced and international consensus would be needed.

Future Work: to employ the "passive" radar technique, for example, that developed by Russell Technologies, an early version of which was implemented in Vancouver in the 1980s. This system relies on the addition of an interface box to the already existing ship's radar and cheaper "passive" reflectors rather than e-Racons. The system can even learn the pattern of already existing infrastructure around a port, removing the need for shore-side reflectors altogether. Further work could investigate this latter, more cost-effective method.

3.6.3.3 R-Mode as a PNT system alternative to GNSS

The vulnerability of GNSS (GPS, Glonass and in future Galileo) is commonly acknowledged. A variety of technological solutions to an alternative backup system are available, of which one is **Ranging Mode (R-Mode)** Position Navigation and Timing (PNT) alternative to GNSS. Two studies and field tests were carried out during ACCSEAS.

3.6.3.3.1   R-Mode using MF DGPS Transmissions

In support of an improved maritime access to the North Sea Region through minimizing navigational risk studied and tested specifically the so-called "Signals of OPportunity" (SoOP) approach in the radio frequency (RF) domain.

Study 1 - Subject to this feasibility study was
- the use of the Differential GNSS (DGNSS) broadcasts as a SoOP. These medium frequency (MF) RF broadcasts, in the 283.5-315 kHz (Region I) marine band, currently transmit correction and integrity information for the GNSS using minimum shift keying (MSK);

During this study a variety of potential ideas and methods to implement R-Mode were identified (described in a Milestone 1 report) ; these could be described as building blocks for a full solution. Each of the building blocks was evaluated using various metrics such as technical feasibility and implementation cost and difficulty; this evaluation was also detailed in the Milestone 1 report. The building blocks were grouped into mutually independent solution sets. These solution sets were then combined into four potential solutions:
- L1 – Optimum Existing Case: this solution combines adding a new message and an increased data rate
    of 200 bps to the existing MSK signal.
- L2 – Narrow Aiding Channel: this solution consists of adding CW signal(s) to the existing MSK signal.
- L3 – Combination: this solution is a combination of L1 and L2.
- L4 – Wide Aiding Channel: this solution is similar to L2 but ignores the bandwidth constraints and could consist of, perhaps, the two-tone concept.

Each of the primary solutions (L1 – L3) was examined in some detail. The analysis shows that all can provide TOA (Time Of Arrival) performance. In the case of L1 this is achieved using either an estimate on the phase of the carrier or on the bit transitions using a new (fixed) message. In the case of L2 and L3 this is achieved using a phase estimate on the CW signal. In all cases the cycle (lane) ambiguity must be resolved. In the case of L1 and L3 this is done using bit transition estimation on the new message. In the case of L2, this is done using the beat frequency of the two CW signals. The recommended solution is L3, MSK with a single CW signal added.

The <u>TOA performance</u> is achieved using phase estimates on the CW signal, which is easier than phase estimates on the MSK carrier. Cycle resolution is achieved using bit transitions on the new message (but only needed periodically, not continuously, so the MSK data channel throughput is preserved).

The <u>Ranging performance</u> is impacted by a variety of factors that were explored during this feasibility study: time stability and synchronization, self-channel sky wave interference, ground wave propagation variances, co-channel interference (other DGNSS broadcast on the same frequency), and geometry. In the position analysis it is assumed that the time stability (on the order of 1 ns) and synchronization (to within 50-100ns) to a common reference such as UTC is achievable. Sky waves can have a large impact on ranging performance at night so separate results are presented for day and for night. Propagation variances and co-channel interference are assumed to have minimal impact.

ACCSEAS Legacy: Study 1 was concluded with the delivery of the Report "*Feasibility Study of R-Mode using MF DGPS Transmissions*", which is now available. The DGNSS ranging system described in this report is directly linked to the IALA e-Navigation Architecture being both a mitigation system

to GNSS failures (part of the WWRNS) and part of the CSSA as a technical service (part of the Medium Wave Broadcast Service).

This Report includes the **main conclusions**:

- DGNSS R-Mode is a backup to GNSS that can meet the resilient PNT requirements of e-Navigation;
- The geometry of the position solution, as measured by the Horizontal Dilution of Precision (HDOP), is a major factor in overall positioning performance, but HDOP values in the North Sea Area are quite good (generally less than 2);
- The predicted daytime bound on R-Mode positioning using TOA accuracy bounds is very good – better than 10m accuracy in most of the North Sea Area;
- The nighttime R-Mode performance is about a factor of 10 worse than daytime performance, but still better than 100m accuracy for most of the North Sea Area.

This report **also provides**

- the system modifications (both transmitter and receiver) necessary to implement a test of R-Mode;
- a description of conceptual test beds for both near-term (during and shortly after ACCSEAS) and medium-term (future German test bed);
- the presentation of architecture for a future all-in-view R-Mode receiver;
- several other ideas for future improvements.

Test 1 - A test on R-Mode using MF DGPS Transmissions was carried out during ACCSEAS (as from January 2015 until project ends) at IJmuiden DGPS station in the Netherlands. Due to local circumstance the test was continued from another site in Noordwijk/The Netherlands. For this purpose a prototype of an MF-DGPS R-Mode transmitting site consisting of

- new developed R-Mode modulator
- standard unmodified MF transmitter and
- standard MF antenna have been developed

After the setup of the R-Mode equipment in IJmuiden and Noordwijk a first measurement campaign was performed over two days. The recorded data were analyzed with respect to signal to noise ratio and the accuracy of the range accuracy phase measured from the phase determination of the two CW signals and the beat frequency of both signals to solve the ambiguity. The initial R-mode tests consists of:

- usability of standard MF transmitter and antenna setup for R-Mode operation
- proof of R-Mode concept using MF transmissions from IALA radio beacons
- co-existence of R-Mode signals and DGPS-transmission
- achievable accuracy figures (range and timing) in the test area
- mutual influence of R-Mode and DGNSS signal

Results and Conclusions:

 - So far the test already showed that R-Mode using existing DGPS stations is feasible.
 - The results are unexpectedly and surprisingly good taking into account a 1 station testbed:

- The daytime bound on R-Mode positioning using TOA accuracy bounds is very good – better than 3-5m accuracy in most of the North Sea testbed area;
- The nighttime R-Mode performance is about a factor of 10 worse than daytime performance, but still better than 50 m accuracy for most of the North Sea testbed area.

ACCSEAS Legacy: - Report "*Feasibility Study of R-Mode using MF DGPS Transmissions*"

- new developed R-Mode modulator

- standard unmodified MF transmitter and

- standard MF antenna have been developed

- Further tests are aimed to show that a full position solution is possible with the technology, providing improved resilience to PNT required onboard vessels. This would be a very significant legacy outcome for ACCSEAS (even after project ends) and would be **world first for the technology**.

Future Work:

- Further tests will be required after the project has ended to determine the performance of the signal at different distances from the transmitting station and to ensure that the R-Mode signal does not interfere with the existing DGPS communications channel.

- Continuation of the short term test bed (2015)

- Perform a mid-term test bed (already intended Germany, potentially in The Netherlands)

- Tests shall be performed involving the following topics:

• measuring the influence of sky wave and other environmental variations

• measuring the influence of transmitter and receiver setup

• assessment of various R-Mode solutions (based on R-Mode feasibility study)

- Opportunities should be explored to enlarge the testbeds to include transmissions from AIS shore infrastructure.

- A testbed to test combination of solutions (R-Mode MF, R-Mode VHF-AIS - see section 3.6.3.3.2 below -and e-Loran) should be established.

- Equipment of at least two further MF-radio beacons with R-Mode setup should be purchased to perform real positioning tests.

- The current R-Mode receiver should be further developed

• to perform position calculations

• to use AIS transmissions

• towards a user friendly receiver

3.6.3.3.2   *R-Mode using AIS Transmissions*

Study 2 -   Subject to this study, building on the ideas of study 1, was the use of the **Automatic Identification System (AIS)** broadcasts as a SoOP.

AIS broadcasts are in the Very High Frequency (VHF) maritime mobile band (156.025 - 162.025 MHz) and currently transmit information both ship-to-shore and shore-to-ship (the base station broadcasts) using Gaussian minimum shift keying (GMSK) in a time division multiple access (TDMA) mode. This study considered several VHF-based solutions to provide a Ranging Mode (R-Mode) Position Navigation and Timing (PNT) alternative to GNSS.

During this study a variety of potential ideas and methods to implement **VHF R-Mode** were identified (described in a Milestone 3 report); each was evaluated using various metrics such as technical feasibility
and implementation cost and difficulty; this evaluation is also detailed in the Milestone 3 report. Three potential solutions were examined:

• Existing AIS: this solution involves ranging off of the existing base station AIS messages, using Message 8s to increase the signal energy and duty cycle;

- <u>CW Aiding</u>: this solution consists of adding continuous wave (CW) signals in other VHF channels and ranging off of the carrier phase of beat signals generated from pairs of such CW signals.
- <u>Spread Spectrum</u>: this solution considers using more of the VHF bandwidth by transmitting direct sequence spread spectrum signals, akin to GNSS pseudolites.

Each of these solutions was examined in some detail. The ranging performance is impacted by a variety of factors that are explored during this study: time stability and synchronization, signal power loss with distance, noise levels, and geometry. In the position analysis it is assumed that the time stability (on the order of 1 ns) and synchronization (to within 50-100ns) to a common reference such as UTC is achievable. Algorithms to predict power as a function of distance for the line-of-sight transmission of VHF signals are known. Noise in the VHF band has been previously studied.

The **recommended solution** is <u>Existing AIS including Message 8s</u>. With this solution 10m performance appears achievable using the existing system with no modifications other than adding some additional transmissions. The CW solution is not preferred as it requires additional VHF channels plus adds the complexity of resolving cycle ambiguity. Spread spectrum, while interesting, is also not preferred as its coverage area is likely to be more limited than the other solutions.

Study 2 was concluded with the delivery of the Report "*Feasibility Study of R-Mode using AIS Transmissions*", which is now available. This Report includes the **main conclusions**:
- VHF R-Mode is a potential backup to GNSS that can meet the resilient PNT requirements of e-Navigation;
- The geometry of the position solution, as measured by the Horizontal Dilution of Precision (HDOP), is a major factor in overall positioning performance, but HDOP values in the North Sea Area are quite good (generally less than 2);
- The predicted bound on R-Mode positioning using TOA accuracy bounds is good – better than 100m accuracy in most of the North Sea Area;
- Accuracy at the 10m level could be achieved in critical waterways (e.g. Kiel Canal and Elbe River and other confined waters) by the addition of a few additional transmitter sites.

and **provides**
- the system modifications (both transmitter and receiver) necessary in an all-in-view R-Mode receiver;
- a description of conceptual test beds.

ACCSEAS Legacy: - Report "*Feasibility Study of R-Mode using AIS Transmissions*"

Future Work: Further tests are needed to show that a full position solution is possible with the technology, providing improved resilience to PNT required onboard vessels. This would be a very significant legacy outcome for ACCSEAS (even after project ends) and would be **world first for the technology**. Opportunities are recognized to use the technology in combination with Real Time Kinematic (RTK) positioning networks, not only covering harbour approaches, port areas and inland waterways, but also providing a candidate Resilient PNT solutions for other transport modalities such as road and rail.

3.7 Work Package 6 Testbed Implementation: e-Navigation Services

3.7.1 Short description of the scope and content of the WP6

Beneficiaries work together to implement a testbed to pilot Ship and Shore e-Navigation services based upon, and providing added value to, the testbed framework developed by the EfficienSea Baltic Sea project. The testbed will be extended functionally and geographically into the region of the North Sea. The WP then undertakes an analysis of training needs from this process.

The following activities shall be performed:

- Implementation of prototype e-Navigation services, including geographic & functional expansion of the EfficienSea prototype implementation (and possibly the dynamic and proactive route planning concepts of MonaLisa, if assessed to be feasible within the testbed), to accommodate the results from WP4. Develop test plans for tests and demonstrations in WP7. This activity shall result in prototype e-Navigation ship-to-shore services as an aid to improved maritime access to the NSR.
- Set up and employ Ship & Shore simulations to support implementation of e-Navigation services and the portrayal of e-Navigation information for the Human Machine Interface, utilizing findings from the Work Packages 3 and 4. This activity shall result in
  - o simulations of e-Navigation services based upon technical, crew behavioural and ship's bridge ergonomic models and support to Training Needs Analysis;
  - o together with the realization of information portrayal determine the presentation of e-Navigation information to mariners and other stakeholders within the functionality of the service being developed;
- Training needs analysis for pilot systems implemented by WP6, in accordance with IMO developments (NAV, COMSAR - as per 2014 combined into NCSR - and STW) and IALA Guidelines and Recommendations, documented within ship-to-shore service section of ACCSEAS "*Training Needs Analysis*".
- Establish the exchange of data and information ship-to-shore within the testbed and an interface with the testbed for interchange of data shore-to-shore via an open interface standard (IVEF). This shall result in an innovative open standard interfacing to enhance effective interoperability between e-Navigation systems and services in all navigable waters (including harbour approaches, ports and connecting inland waters). Identify benefits to safety of maritime navigation and regional accessibility.

3.7.2   Services developed and tested under WP6

Within the international framework of e-Navigation ACCSEAS under WP3 (see section 3.3.7) identified candidate solutions. Under WP6 these candidate solutions (services, employment of modern technologies, applications, developed methodologies) were developed, tested and evaluated:

1.   Maritime Service Portfolios (MSPs) for the NSR (NSR-MSPs)
2.   Innovative Architecture for Ship Positioning: Multi Source Positioning Service
3.   Tactical Route Exchange Service
4.   Maritime Safety Information/Notices to Mariners (MSI/NM) Service
5.   No-Go Area Service
6.   Route Topology Model (RTM)
7.   Augmented Reality / Head-Up-Displays (HUDs)
8.   Automated FAL Reporting
9.   Vessel Operation Coordination Tool (VOCT)
10.   Dynamic Predictor (for tug boat operations)
11.   Harmonized Data Exchange – Employing the Inter-VTS Exchange Format (IVEF)
12.   Real time warning system based on historical AIS targets behaviour

Architectural proposals and additional measures were developed and provided under WP4 (*ACCSEAS e-Navigation Architecture Report: "Implementing e-Navigation in the North Sea Region – the ACCSEAS Contribution")* and in this Legacy Report reflected in section 3.5 and following.

The legacy of these developed and tested candidate solutions are reflected in general terms section 3.3.9 of this report.

3.7.2.1 Innovative Architecture for Ship Positioning: Multi Source Positioning Service (MSPS)

3.7.2.1.1   Short description of the service[48]

The Multi Source Positioning Service (MSPS) provides position, navigation and timing information with a dependable level of performance wherever it is needed within the ACCSEAS test-bed. The specified service level will assure the accuracy, integrity, availability and continuity of service of the PNT information and 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 operators. It will also ensure that the navigation risks inherent in e-Navigation services are reduced through the recognition of the quality of PNT data and the use of dependable uncertainty and integrity information. Examples of services that could benefit are the display of safety margins to prevent groundings and collisions and the use of uncertainties in calculations of intended routes and route exchange.

3.7.2.1.2   Trigger and principles for the development of the MSPS

GNSS (principally GPS and GLONASS) have become the primary source of positioning, navigation and timing (PNT) for maritime operations. GNSS-based positioning is used by many systems on vessels and it is the source of the vessel's position used by AIS and GMDSS. Safe navigation, the protection of the marine environment and the efficiency of access to ports in the North Sea Region are highly dependent on the availability, continuity accuracy and integrity of GNSS- based positioning.

GNSS (in the near future also GALILEO) is vulnerable to jamming and natural interference. When GNSS is denied, PNT information can be seriously affected in ways that increase risks to the safety of navigation. PNT data may become unavailable for a period, resulting in alarms being raised by many bridge systems. In some cases, Hazardously Misleading Information (HMI) may occur in which position errors are large enough to have an impact on navigation safety but small enough that no alarms are raised. These erroneous positions could go unnoticed by the mariner and significantly increase the risk of grounding or collision.

Additionally, the functioning of The Maritime Cloud, the backbone of e-Navigation data communications, will depend on reliable vessel positioning information for its geo-location based architecture.

The resilient PNT solutions within ACCSEAS aim to provide dependable positioning at all times, even under GNSS interference and jamming conditions, through the use of complementary backup positioning systems that are independent of GNSS. The Multi Source Positioning Service (MSPS) is a critical service that assures the appropriate use of positioning and its associated uncertainties for the portrayal and reporting of the vessel's position and for applications within other services on board and ashore.

The ACCSEAS Multi-Source Positioning Service assumes that shore-side infrastructure is available for the provision of Resilient PNT; including signals in space, propagation data, associated reference station installations, and transmitter and reference station almanac information. The service follows the principles of the IMO overarching architecture for e-navigation. The MSPS Operational Services will be provided for the ACCSEAS e-Navigation Prototype Display (EPD).

3.7.2.1.3   Testbeds results and future work

Resilient Positioning, Navigation and Timing (PNT) is a core element of e-Navigation and forms an important part of the IMO Strategy Implementation Plan (SIP), as such it is fully anticipated that

---

[48] An exhausting description is provided in the ACCSEAS document "Service Description: Multi Source Positioning Service", January 2015

options that can form part of a resilient PNT approach will be developed further as the SIP is enacted.

ACCSEAS has considered the need for resilient PNT and also options to enable it and it is widely recognised that different position systems will meet the requirements of different users and different systems will be available in different locations. As such, the need for resilient PNT and the potential solutions that could be used to enable it will continue to be developed after ACCSEAS.

These potential solutions under MSPS tested in ACCSEAS are described in section 3.6.2 and following in this document as well as the results and identified future work.

3.7.2.1.4   Ship Positioning Equipment

A number of resilient PNT receivers have been developed under the ACCSEAS project. These receivers were purposefully designed to enable future expansion; however they currently contain hardware to provide DGPS and eLoran PNT information. Software developed by the project partners, is executed on the on board computer board within the receiver case; this software is able to quantify the performance of the available position, navigation and timing sources and can select the best for output, seamlessly swapping sources when the primary becomes unreliable or unavailable.

These receivers were designed to be future proof and can be upgraded to enable R-mode (300kHz) functionality, and R-mode with eLoran integration. The receivers can also receive data from additional sensors for process within the software and as such could be used for a multitude of follow-on operations and follow-on resilient PNT tests.

Under the ACCSEAS project, several receivers have been installed on different vessels in and around the North Sea Region to test the functionality and gather feedback from users. It is envisaged these receivers will remain in situ at the close of the project and data from them could be used in subsequent projects.

3.7.2.1.5   Multi-source navigation receivers

Related to this, ACCSEAS project partners have contributed to the development of '*multi-source navigation receiver*' performance standards by the IMO's Navigation, Communications and Search and Rescue Committee (NCSR). These standards have been finalized in March 2015 and are forwarded for approval to the IMO Maritime Safety Committee (June 2015).

Following the development of the performance standard, an IEC test specification is required against which receivers will be tested to ensure they meet the IMO performance requirements. It is envisaged this could take a further two years and therefore, it could be the end of 2017 before resilient PNT receivers can become an approved item for use on board SOLAS vessels.

Therefore the receivers developed by the project could be useful for subsequent projects and in the development, and testing, of IMO and IEC standards.

3.7.2.1.6   Training needs for MSPS

During ACCSEAS the training needs for MSPS for both users on-board ships and ashore were identified and reflected in Chapter 6 of the ACCSEAS document "Service Description: Multi Source Positioning Service", January 2015.

3.7.2.2 Tactical Route Exchange Service

3.7.2.2.1   Short description of the service[49]

---

[49] A full description is reflected in the ACCSEAS document "Service Description: Tactical Exchange of Intended Routes", April 2015.

3.7.2.2.2 Trigger for the development Tactical Route Exchange Service

"What is your intention?" is a common question over the VHF when two ships are in doubt of each other's intentions. Misunderstanding each other's intentions is not seldom the cause of accidents at sea. Even worse is when ships in doubt do not ask for intentions, but instead make a presumption.

Communication problems were one of the most prominent causes of accidents at sea. The most frequently identified causes were lack of communication and misinterpreting information. Underlying human factor issues, they concluded, were the reluctance of navigators to exchange information.

Every ship is by regulations forced to do a berth-to-berth route plan before leaving port (ICS, 1998). This intended route resides locked in the navigation system of each ship. By enabling vessels to send and receive each other's intended routes, and display them on their own ECDIS, a possibility to decrease the risk for conflicting situations appears. Further, by making it possible for shore-based services to send routes to vessels, pilots and VTS operators can assist ships unknowingly heading into danger, a situation not quite uncommon.

Previously, the **EfficienSea** and **MONALISA** projects have developed, explored and tested route exchange functionality using the e-Navigation Prototype Display (EPD).

This involved concepts such as:

- **Intended route exchange**: A ships currently active route is broadcast via AIS to other ships and shore centres in range.
- **Route suggestion service**: A shore-based VTS centre may send a suggested route to a vessel via AIS. The vessel can see the suggested route and reject or accept the proposal.
- **Strategic route exchange**: A vessel can send a proposed voyage plan to a nearby shore-based VTS centre. Subsequently, the involved VTS centre and vessel can send amended route proposals back and forth; 'negotiate', until both parties have accepted or rejected the voyage plan.

3.7.2.2.3 Testbed description and results

As part of the ACCSEAS project, it was decided to improve and develop these concepts further. Additional functionality, improved user experience and Maritime Cloud integration has been implemented using the e-Navigation Prototype Display (EPD), and field tests involving ships and shore-side VTS centres together with simulation sessions have been conducted with good results.

Using AIS as the means of route exchange has substantial advantages. However, in practice it has turned out to be too fragile, due to the limitations in the protocol and poor robustness of delivery. In the ACCSEAS project, all services have been migrated to use the Maritime Cloud Maritime Messaging Service (MMS) as the means of communication,

To improve the user experience, the route exchange services, along with other maritime services such as MSI, messaging, and general notifications, have been integrated into a unified Notification Centre with a standardized way for presenting and handling notifications of varying severity (notices, warnings and alerts).

Simulations

The Intended Route service was tested during the 29 September to 3 October simulator session at Chalmers University in Gothenburg in parallel with the No-Go area services. The method used was Usability test. Usability is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO 9241-11) No efficiency or effectiveness measures were used but qualitative data collected.
Special focus was on usability, professional acceptance and unintended consequences of change.

Live demonstrations

The primary goal of the live tests was to demonstrate the services and solutions working in real life. During the demonstrations with MV Pride of Hull and Humber VTS the No-Go area service was

performed via the Maritime Cloud. Intended Route Data was requested and exchanged via the Maritime Cloud without any problems.

The service was both in simulations as during the live demonstrations assessed by professional master mariners, pilots and VTS-operators on four levels: Conceptual, Procedural, Functional and Human Machine Interface level.

3.7.2.2.4   *Feedback and conclusions*

- All participants agreed that this is a valuable service and rated the service as very good and useful, responding to the primary aim: to enhance the safety of navigation. Even after a short time of introduction and training operating the service was experienced as good and effective to operate in practice.
- During the intensive and substantial discussions with the participants a number of important issues were raised:
- the reliability of the data
- the workload for the operator (that may vary between ship and shore, between large and smaller vessels
- the importance that rather than displaying all ships Intended routes in an area all the time (which would clutter the display) one could "interrogate" the display for intentions of vessels of interest;
- the possibility to cease transmitting route intentions if a ship was some predefined distance from its intended route for a predefined amount of time.
- it was agreed and recommended that the Intended route service should not be used as a collision avoidance tool in close quarters situations
- It was felt that the Intended route service was probably being more important in open seas than in port approaches where mitigation instruments to avoid collision are available
- Approaches to junction points is an example where the Intended route service can be very valuable
- There was a major discussion on whether planned speed or current speed should be used when calculating a ships future position. The Intended route service as it was implemented in the prototype system was using the planned ETA in all waypoints to calculate where own and other ships would be at a certain time. The planned speed was based on the notion that ships should be at their final destination precisely in the planned arrival time.
- In respect to the VTS Traffic Organization Service (TOS) authority the Intended route service would greatly increase the opportunity and possibility to organize the traffic. This would be of great value but could also increase the workload in the VTS.
- It would probably be necessary to have a "harbour" and a "sea" mode with different CPA filter settings in the ECDIS;
- A number of portrayal aspects on the ECDIS were discussed and recommendations for improvement were made.

Future Work: The Intended Route service shall be further developed in the EU projects EfficienSea 2.0 and MonaLisa 2.0 and/or in other related e-Navigation projects. The feedback as reflected in section 4 of the ACCSEAS document   "Service Description: Tactical Exchange of Intended Routes", April 2015, shall be taken into account.

3.7.2.3 The innovative Maritime Cloud

The Maritime Cloud is a proposed highly innovative 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. The framework has been introduced into the NSR as a common framework for the ACCSEAS project, supporting the ACCSEAS testbed, and possibly the future e-Navigation implementation in the NSR.

3.7.2.3.1   Short description of the service[50]

The Maritime Cloud is a digital Information Technology (IT) framework consisting of standards, infrastructure and governance that facilitates secure interoperable information exchange between stakeholders in the maritime community by the principles of Service Oriented Architectures (SOA). The core of the Maritime Cloud consists of 3 key infrastructural components providing central framework services:

- **Maritime Service Portfolio Registry -** Encounter point for those that consume, provide or specify services in the maritime domain. It enables service standardization, and automatic service provision and discovery.

- **Maritime Identity Registry -** Provides all maritime stakeholders with a basic Maritime Identity and basic methods for authentication, integrity and confidentiality in information transfer through the use of digital certificates in a Public-Key Infrastructure (PKI).

- **Maritime Messaging Service -** Geo-aware messaging service taking into account the needs of ships in terms of achieving inter-operability across varying data links with varying availability, technical characteristics and limited bandwidth. Allows geo-casting, a broadcasting method addressing receivers within a certain geographical area.

An important concept in the Maritime Cloud is the **Almanac**. It is an offline digital version of the public parts of Maritime Identity Registry and Maritime Service Portfolio Registry. It will function as a 'white pages/yellow pages phonebook' of registered maritime stakeholders and services, and allow offline use of central framework services like service discovery and secure communication.

3.7.2.3.2   Trigger and principles for the development of the Maritime Cloud

At the very core of the definition of e-navigation lies the fundamental ability to ensure seamless transfer of information. The strategy for e-Navigation in the report of IMO MSC85 (MSC 85-26-Add.1) describes the need for:

"A communication infrastructure providing authorized seamless information transfer on board ships, between ships, between ship and shore and between shore authorities and other parties with many related benefits".

The development of the Maritime Cloud was motivated by this e-navigation need and testbed experience from the EU funded EfficienSea project. In this project potential e-Navigation solutions were implemented and tested, and a need for a common technical framework to facilitate service management, security and additional carrier agnostic communication means was confirmed.

The Maritime Cloud is intended as a refinement of the agreed overarching e-Navigation architecture and dwells on:

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 - or at a higher logical level: The people operating/using these systems.

---

[50] An extensive description is provided in the ACCEAS document "Service Description: Maritime Cloud", April 2015.

To provide efficient and secure delivery of a data/information service from one stakeholder to another in this architecture, an added level of detail was needed. The Maritime Cloud intends to fill this gap. Early on in the development of the Maritime Cloud high-level requirements were identified:

1. Provide additional communication means, initially utilizing Internet connectivity;
2. Service consumers must easily be able to discover provisioned services;
3. Service providers must easily be able to advertise their provisioned services;
4. All maritime actors must have a unique maritime ID with attached attributes as role, nationality, etc;
5. Means for secure communication, that is

- *Authenticity* – guarantee of who I am talking to – allowing authorization (access control) to be enforced by service providers;
- *Integrity* – guarantee that data is unaltered;
- *Confidentiality* – guarantee that data is not accessible by a third party.

The development of the Maritime Cloud is based on a number of guiding principles. These were influenced by the *System Wide Information Management (SWIN)* concept, a concept managed by the *Federal Aviation Administration* intended for greater sharing of *Air Traffic Management system information* within aviation. These principles are

- **Re-use not re-invent -** Utilize existing and proven Information and Communication Technology (ICT) concepts and practices, e.g. from distributed systems, service-oriented architectures, software design patterns, IT security;
- **Separation of information provision and consumption -** Actors are often both providers and consumers of information, which is not ideal to decide in advance who will need what information, obtained from whom and when. Decoupling providers of information from the possible consumers allows the number and nature of providers and consumers to evolve through time.
- **Loose system coupling -** Use a modular design with loose coupling and high cohesion where components of systems have little or no knowledge of the definitions of other separate components. By doing this barriers between systems and applications are removed, and interfaces are compatible. This allows for independent acquisition and composability of system components.
- **Build on open standards -** Open standards means widely accepted and supported standards set by recognized standards organizations or the marketplace. These standards support interoperability, portability, and scalability and are equally available to the general public at no cost or with a moderate license fee.
- **Facilitate Service Oriented Architectures (SOA) -**Driven by analysis of user needs, functionality is developed, packaged and implemented as a suite of interoperable services that can be used in a flexible way within multiple separate systems from several domains within the maritime world.

Legacy of ACCSEAS: The progress made during ACCSEAS (specifically in conjunction with other candidate solutions e.g. MSI/NM, Route exchange, VOCT) is encouraging and provides a common framework for further development. The international support the Maritime Cloud development is increasing inside and outside Europe (IMO, IALA).

Future work: Further testing of entities, organizational, operational and technical aspects of the Maritime Cloud is required and could be incorporated in the programs of the EU projects *EffienSea 2.0* and *MonaLisa 2.0.* The experiences gained during ACCSEAS can therefore be used as a common reference framework.

Future work: Further development of the Service Registry is required for facilitation and implementation of the Maritime Service Portfolio (MSP) concept by providing a repository for the specification of operational and technical services and provisioned service instances. The service

registry is intended to span all maritime services, not only digital services, thereby making it a single reference point for provision and discovery. The Service Specification Standard finally will have to determined.

Future work: The need for the establishment of the *Maritime Identity* in the Maritime Identity Registry and its benefits shall be further promoted and clarified for international support and acceptance.

Future work: The current considerations on issues such as '*Governance*' and '*Operations*" (use of one or more global datacenters and existing infrastructures, as well as the presumed interactions between ship and shore) require further research and the establishment of understanding and support internationally.

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

3.7.2.4.1   Short description of the service[51]

The most important information for vessels is safety-related information, including Maritime Safety Information, Notices to Mariners and chart corrections. These three information types, along with nautical charts and position updates, form the basis for safe navigation at sea.

- *Maritime Safety Information (MSI) is navigational and meteorological warnings, meteorological forecasts and other urgent safety-related messages.*
- *Notices to Mariners (NMs) are promulgated in order to keep paper nautical charts and publications, as far as possible, 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, and other important categories of data. Not all ENCs include T&P information currently. Chart corrections are corrections to paper and digital nautical charts which makes it possible for the Mariner to keep the vessel's charts up to date.*

The main differences between MSI and NM today are the way of promulgation and speed of handling and thereby quality assurance. The content of the two message types are on the other hand more or less the same and they solve the same user need.

MSI is today promulgated in text or voice via SafetyNET, NAVTEX, coastal radio stations and is in some countries accessible on the Internet. NM T&P's are promulgated on paper weekly, fortnightly or monthly and are often accessible on the internet in pdf format. In addition Hydrographic Offices are encouraged to include as many NM T&P's in their ENC updates as possible. There are obvious benefits in this but also disadvantages and pitfalls.

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 promulgation of the messages. The MSI-NM System include features such as:

- An editor for MSI and NM T&P messages.
- Multi-language message support and features such as rich-text descriptions, attachments, etc.
- Management of message life cycles and base data such as categories, areas, charts, etc.
- Promulgation via web services, mailing lists, Maritime Cloud Messaging Service (MMS), NAVTEX, Twitter, etc.
- Web interface and API's for searching and filtering MSI-NM T&P messages.

---

[51] A full description of the service is provided in the ACCSEAS document "Service Description: Maritime Safety Information/Notice to Mariners Service", April 2015

- Map-based portrayal of MSI-NM T&P messages.
- Furthermore, a navigational display test application, the e-Navigation Prototype Display (EPD), has been updated to integrate with the MSI-NM System.

3.7.2.4.2   *Trigger for the development of the MSI/NM Service*

An approach to MSI-handling and promulgation has previously been tested in the EfficienSea project with promising results. As part of the ACCSEAS project WP6, it was decided to develop and test this concept further, and based on analysis and user feedback, to include other important maritime information, specifically temporary and preliminary Notices to Mariners (NM T&P), within an integrated service for authoring, storing and promulgating maritime information.

3.7.2.4.3   *Testbed description and results*

The combined MSI-NM T&P model devised in the ACCSEAS project is conceptually an extension of the MSI system explored earlier in the EfficienSea project, where integration of MSI in navigational charts was tested, including portrayal and relevance filtering of MSI messages.

In the EfficienSea project, the EPD (e-Navigation Prototype Display) was used to simulate a avigational display (ECDIS). It was extended to display MSI messages using standardized icons and graphics (see the Message Portrayal section). Furthermore, methods and schemes for relevance filtering was implemented and tested, taking into account various information types such as time and position.

For the ACCSEAS project, the EPD has been extended again with the following features:
- The EPD now fetches MSI and NM T&P messages from a test MSI-NM system via the Maritime Cloud Messaging Service.
- MSI-NM messages have been integrated in the EPD Notification Centre (warnings and alarms).
- MSI messages are portrayed as before, and NM messages are portrayed in an identical manner, except for the use of an NM icon.
- The MSI relevance filtering now also applies to NM messages.

All MSI-NM systems, present and future, can register themselves with the Maritime Cloud Service Portfolio Registry as MSI-NM service providers within certain geographical bounds. Vessels can thus seamlessly choose to subscribe to the published MSI-NM messages from a specific provider, depending on their current position.

Support for MSI-NM service provider selection, has been implemented in the EPD by adding a Provider selector in the MSI-NM Notification Panel, which displays all the MSI-NM service providers available via the Maritime Cloud Almanac.

A Danish legacy MSI-NM test bench was set up and configured to continually import MSI messages from the Danish legacy MSI production system, and indeed to import production MSI messages from years back in time. The test bench was also extended with a function for importing legacy NM messages by scraping weekly NM PDF digests.

The purpose of this test bench was to test the breadth of a combined MSI-NM model, to verify that the model is backwards compatible and the ability of the MSI-NM System to handle many thousands of messages.

Conclusions from Legacy MSI-NM Test

Whereas the quality of the legacy production MSI import was very high (MSI data was scooped directly from database tables), the quality of the imported NM messages was not so high. Parsing extracted textual descriptions from a PDF into structured data is always an error prone task, and so, imported NM messages needed to be manually post-edited in the MSI-NM Editor to improve their quality.

The conclusion after importing many thousand MSI's and hundreds of NM's was that the proposed underlying MSI-NM model is sound. Before using the MSI-NM system operationally, there needs to be an effort to harmonize base data, such as categories and areas, since that has never been a priority or important for the legacy data.

Performance-wise, the MSI-NM system can easily cater with the years' worth of imported messages. The underlying technology is highly optimized for geographical searches in large volumes of messages, and the presentation of message lists adopts techniques such as paging and clustered map symbols.

MSI-NM User Test

A user test was conducted in the second half of October 2014 with participation of relevant maritime authorities from Denmark, Sweden, Norway and the Netherlands.

An MSI-NM test bench was set up for each country, by creating customized versions of the MSI-NM System tailored to the specific countries in terms of supported languages, authority identifier and base data for administrative users, areas and charts.

Participants were asked to test various aspects of the MSI-NM system, and 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.

MSI-NM User Test Feedback and conclusions

The following is a categorized list of feedback from the workshop, and from input received from participants during the user test and after the workshop.

General Feedback
- It was concluded that there were indeed clear benefits of a combined MSI-NM model/system to the mariner/end user
- A pending task is to flesh out the work process for editors, such as quality assurance.
- In general, there is a need to harmonize naming conventions between MSI and NM messages, and harmonize base data such as areas and categories.
- There is a clear need for compatibility with existing systems, such as NAVTEX, for the foreseeable future.
- Before using the MSI-NM system operationally, it needs lots of UI tweaks and polishing, plus better robustness and browser compatibility.

Feedback on the combined MSI-NM model
- Participants were generally in favor of the global identifier format and sequence numbering scheme adopted by the MSI-NM system, but it was concluded that more investigation was needed. Will e.g. omitting week numbers from NM's have unforeseen consequences?
- Participants were generally in favor of the time model adopted by the MSI-NM system, but the need for an issue-date field was raised. This would be particularly useful for SafetyNET-promulgated MSI messages, since they must be republished every 42 days. This also calls for an alert mechanism prior to the re-publishing deadline.
- Participants were generally in favor of sharing and harmonizing the hierarchical category and area base data between MSI and NM, as adopted by the MSI-NM system.
- As an aside, it was discussed if areas could be left out of the model altogether, since messages are assigned geographical locations. However, the conclusion was that a textual area description is still an important part of a message presentation.
- For NM messages in particular, there may be a need to be able to assign multiple areas to a message.

- It was concluded that a priority (routine, important, vital) should not be part of an MSINM message – it is left to the client (ship) to prioritize the messages.
- Note, however, that the NAVTEX publication of a message still carries a priority.

Message Viewing
- It was proposed to have the option to show MSI and NM messages in separate layers and to consider making the icons more distinguishable.
- In map view mode, message information should be displayed via mouse-over tooltips.
- It was proposed to facilitate integration with real-time information, e.g. by linking messages to the contractor working on the issue that the message pertains to.

Future work: The developments on the MSI/NM service shall be continued under the EU project EfficienSea. The feedback and conclusions as reflected in section 6 of the ACCSEAS document "Service Description: Maritime Safety Information/Notice to Mariners Service", April 2015, shall be incorporated in this future work.

3.7.2.5 Dynamic No-Go Area Service

3.7.2.5.1   Short description of the service[52]

In short the Dynamic No-Go area service will provide the Mariners with tailored depths contours for their ship at preset draught at the present tidal situation. Input to the calculations is:
- Manual by Mariner or VTS operator:
- Vessel draught
- Wanted Underkeel Clearance; taking into account vessels draught, squat, heave, etc.

Automatic:
- Detailed bathymetry (in database; 1 centimeter depth intervals in a 50x50 metre grid is kept in a database;
- Tidal information; in 10 minute time slices and 1 centimetre intervals for the closest Standard Port (Total Tide);
- Weather information adjusting astronomic tidal level (*not tested during ACCSEAS project*).

3.7.2.5.2   Trigger for the development of the Dynamic No-Go Area Service

Of crucial interest to a mariner is how much water he has under his keel (*SOLAS Chapter V, regulation 34*). The way to consider and mark dangerous shallow areas in paper charts are described in the *ICS Bridge Procedures Guide, chapter 2.3.3 The Passage Plan*:

"*At any time during the voyage, the ship may need to leave the planned leg temporarily at short notice. Marking on the chart relatively shallow waters and minimum clearing distances in critical sea areas is one technique which will assist the OOW when having to decide quickly to what extent to deviate without jeopardising safety and the marine environment.*"

For reasons of cluttering, depth information on paper charts are limited to a number of representative spot soundings in the form of a depth figure (in metres, feet or fathoms) or in the form of a depth contour, outlining an area within a certain depth interval.

Depth contours has specific standardized levels depending on the charts scale, e.g. 10, 20, 30, 50 meters. In the electronic chart system (ECDIS) a mariner can more freely select a safety contour to be highlighted to give prominence to areas of shallow water he does not wish to venture into. However the safety contour can only be selected from the limited selection of depth contour contained in the electronic navigational chart (ENC) database, typically 2, 5, 10, 20, 30, 50, etc. meters.

---

[52] A full description of the service is provided in the ACCSEAS document *"Service Description: Dynamic No-Go Area"*, April 2015.

The reason for the ENC not having depth contours for all possible depths is the cluttering issue mentioned above, which in the ECDIS could be solved simply by just showing contours relevant to vessels draught. Other reasons could be tradition and also a need to keep the ENC database to a limited size. There may also be military safety reasons in many countries for not publicizing a full bathymetrical database.

There are a **number of human factor issues** linked to depth information in charts:

- The depth information given in charts is related to a chart datum (a standard water level which can be different in different parts of the world. (So for instance, the chart datum in the parts of the NSR with large tidal variation is referred to Lowest Low Water, while in other parts of the NSR – e.g. Skagerrak and Kattegat is referred to Mean Sea Level).
- To be able to relate the depth figures in the chart to available sea room for own ship the navigator on the bridge need to do some mental arithmetic.
    - *For instance if the safety contour on the chart is set to 20 meters and his ship at present draught draws 15 meters he can calculate that 20-15 leaves 5 meters of under keel clearance (UKC), adding to this a low tide of 2.5 meters, leaves only 2.5 meters. Considering that he with present speed has a squat of 1.2 meters, the UKC is reduced to only 1.3 meters, add to that the heave of the present sea state… and we will see that such arithmetic calculation, if needed to be done on the fly, risk to become error prone.*
- In normal circumstances a voyage is planned with a large UKC and the traditional contours often work well enough as an approximation of navigable water.
- However in a future situation with limited sea space, available space might need to be more efficiently used, and particularly in a situation where ships need to make unplanned evasive manoeuvres, or is drifting due to engine problems and quickly need to know the extent of available water, the **mental workload might be considerable and risky**.
- In planning for a close quarter situation it might sometimes also be valuable to know other ships UKC.

The request for individual UKC in time slices may be used to find best suitable/possible route as they include future tidal states that can be of value to route planning. In any case such a service might lead to cognitive off-loading for the officer on the bridge and thereby reduce the risk of errors leading to groundings or unnecessary close meetings.

3.7.2.5.3   Testbed description

For the tests the No-Go area service has been implemented in the e-Navigation Prototype Display (EPD), a chart display with basic ECDIS functionality. The tests were performed in simulation and live demonstrations.

Simulations

The No-go area service was tested during the 29 September to 3 October simulator session at Chalmers University in Gothenburg together with the Intended and Suggested route services. The method used was Usability test. Usability is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO 9241-11) No efficiency or effectiveness measures were used but qualitative data collected.

Special focus was on usability, professional acceptance and unintended consequences of change.

Live demonstrations

The primary goal of the live tests was to demonstrate the services and solutions working in real life. During the demonstrations with MV Pride of Hull and Humber VTS the No-Go area service was performed via the Maritime Cloud. No-Go Data was requested and exchanged via the Maritime Cloud without any problems.

3.7.2.5.4   Testbeds results, feedback, observations and future work

The service was both in simulations as during the live demonstrations assessed by professional master mariners, pilots and VTS-operators on four levels:

Conceptual level: There was a general agreement that this service was beneficial

- especially for tidal areas as current ECDIS does not take tidal information;
- even for pilots, although they are familiar with an certain area, because the service will supply an at-a-glance reassurance for the rest of the bridge team on watch and the service itself could be considered as an valuable instrument for information sharing; despite the fact that the service provides extra confidence, the service for pilots themselves is more nice than need to have;
- even if one has the availability of "old" ENC cells which have not been updated for a long time, the No-Go areas service will provide the mariner with the latest bathymetrical survey data from the particular area;
- particularly for foreign ships not known to the area.

However, the way the service has to be employed at this stage limits the real benefits. Still to many actions have to be executed manually (e.g. inserting a time interval), instead that the service anticipates automatically within a defined timeframe related to the actual location.

Procedural level: From a VTS perspective it was confirmed that, with an automated availability and provision capability of data based on the most current bathymetric survey in combination with correct tidal information, it would be significantly easier to ensure vessels that they are follow a safe route without the risk of grounding. Consequently the workload for the VTS operator would be decreased as requests for updates for tidal information would not have to be responded verbally any longer.

Functional level: There was general consensus that a Dynamic No-go area service should be delivered automatically along the intended route of a vessel with correlated timing in respect to positions along the planned route. Furthermore it was suggested that an alerting capability for tracks leading into No-Go areas should be embedded in the service.

Human Machine Interface level: Several participants agreed that the NoGo area service, in its current stage of development and operational performance, still was too complex to handle, despite the fact that a familiarization time with the Human Machine Interface was surprisingly limited. The main complaint however was that still too many manual steps and too many windows have to be utilized in order to gain the maximum benefits of the service. Another issue was the lack of system feedback in case of incorrect operations. Suggestions were made in respect to a more noticeable portrayal of the information provided.

The testbed results clearly showed that the intended service is not as far in the development as the other two tested services (Intended and Suggests routes). Mainly this was due to the limited bathymetrical database available and the time-consuming computation of the No-Go areas. During the discussions with the professional participants they emphasized that in general there was support for the development and implementation of an automated No-Go service, although further development was needed and the reflected requirements should be taken care off and feedback considered.

From another perspective an additional benefit for introducing the No-Go area service was identified: once matured and implemented the service potentially bypasses the centralised and time consuming process of chart updating. For areas like the Humber River, with significant changes in the bathymetry (shifting sandbanks are a real challenge for the national hydrographic authority) constantly surveying the area is demanding on financial and human resources at large. However, allowing the No-Go area service to access survey data that has not passed the quality assurance process of a national hydrographic organisation may be constrained by legal limitations, a matter that should be further explored.

Future work: The potential of the Dynamic No-Go area service is recognized and its contribution to safe and efficient navigation has been confirmed, specifically for areas with shallow and confined waters. The service needs to be further developed taking into account the experiences and feedback gained during ACCSEAS. Accessibility issues for the automated collection of and provision of bathymetric data through the service needs to be investigated.

3.7.2.6 Route Topology Model (RTM)

3.7.2.6.1   *Short description of the service[53]*

In mathematical terms, the RTM is a graph model tailored to the vessel traffic situation. As such, a graph model differs from the spatial or topographical point of view a chart takes. However, the graph model will always complement the geospatial and/or topographical information contained in charts.

The RTM is to model traffic options, i.e. it is essentially oriented towards vessel traffic (as opposed to the tactical navigation of an individual vessel) while taking into account natural or man-made constrictions or limitations to traffic. Hence, the RTM does not intend to represent another chart, but an abstraction from that chart domain, which is useful for traffic oriented applications. The chart domain serves as a valuable input to the RTM, however, where it has an impact on the traffic.

It is important to note, that the RTM depicts in an abstract mode the possibilities for a vessel (whatever kind) to make a route: The RTM, once fully completed, contains all possibilities for all kind of vessels, even if the possibilities thus emerging are only rarely used (i.e. only under certain circumstances).

For further details on the context of this description compare 'ACCSEAS Baseline & Priorities Report,' Ed. 3, Chapter 6 (ACCSEAS 2015a) and the 'ACCEAS e-Navigation Architecture Report' (ACCSEAS 2015c). In the latter, there is given an architectural analysis of where and how the (NSR-)RTM fits into and would be supportive to the proposed Sustainable Maritime Transportation System (SMTS) and the IMO defined concept of e-Navigation. The description also serves as a potential source for contributions to relevant international and European standards and regulations. Thereby, this description contributes to the 'set of standards' ACCSEAS is supposed to produce (ACCSEAS 2011, para 14.2i).

3.7.2.6.2   *Trigger for the development of the Route Topology Model (RTM)*

Starting point for the work described in this 'ACCSEAS North Sea Region Route Topology Model (NSR-RTM) Description' was the vessel traffic analysis reported in the 'ACCSEAS Baseline & Priorities Report' in conjunction with lack of available information about the actual routes of the EU Motorways of the Seas (MoS) in the North Sea Region (NSR). At the beginning of the ACCSEAS project only sketchy data and illustrations were available.

Obviously, nobody prior to ACCSEAS has ventured to identify the true locations and the connectivity of the MoS grid in the NSR as a whole. This was recognised as a task to match, in particular, the impact on shipping by the advent of Marine Spatial Planning (MSP) which seems to render even more confined shipping lanes in even more quarters of the region.

The idea was to take up the undisputable existence of those already defined shipping lanes in combination with the ACCSEAS vessel traffic analysis for the present and future NSR situation (compare above 'ACCEAS B&P Report') and transform these facts and findings into an abstract, seamless model of all practically possible vessel routes in the region based on a generic

---

[53] An exhausting description has been provided in the document *"ACCSEAS North Sea Region Route Topology Model (NSR-RTM) - Description and contribution to an international generic RTM definition",* April 2015,

mathematical (or, more precisely topological) model as a basis, called *Route Topology Model (RTM)* in generic and *NSR-RTM* in its regional instance.

3.7.2.6.3   The development process of NSR-RTM

The development of RTM should arrive at a number of relevant findings, including the answer to above introductory question, but also at some spin-offs for future work. The first step was to create the generic RTM using only a minimum of abstract elements, namely '*nodes*' and '*legs*.' The nodes were subdivided into several classes to reflect the different features of nodes in reality, such as waypoints, junctions, cross-border connections, and destinations (e.g. ports). Having in mind the manifold shipboard and shore-based users and stakeholders as defined by IMO's e-Navigation strategy, three fundamentally different but co-existent user display modes for different user applications were developed and portrayed.

These are the **ENC display mode** (based on readily available Electronic Navigational Charts) - which displays any RTM in its true topographical location -, the **London Tube Map (LTM) display mode** - which shows the vessel traffic routes in their essential connectivity relationships - and the **Head-Up-Display (HUD) / Augmented Reality (AR) display mode for the mariners**. Drawing also upon definition work in the European and international domains, this rendered a consistent and – by applying it to the NSR specifics – tested and evaluated generic model to further build on reliably. After the generic definitions work was finalised as described above, the methodology was tested and thereby evaluated using data of the present situation and planning forecasts into ACCSEAS North Sea Region Route Topology Model (NSR-RTM) 2020+ for the whole of the NSR, thus rendering instances of the RTM for the NSR (NSR-RTM) accordingly. This work not only provided the answer to the above initial question of where the MoS in the region are exactly, but also provided a means to identify two other classes of shipping lanes which complement the MoS level to arrive at a seamless, meaningful and versatile RTM for all classes of vessel, down to small craft size, as follows:

- **Motorways of the Sea (MoS)** shipping lanes;
- **Roads of the Sea (RoS) shipping lanes**, i.e. shipping lanes, other than MoS, relevant for professional/commercial shipping (including ferry routes, offshore construction and supply traffic etc.);
- **Trails of the Sea (ToS) shipping lanes**, i.e. all other shipping lanes, which are in most cases only available, due to physical dimensions, for small crafts such as fishing vessels and leisure crafts.

Having in mind also the logistics chain and the connection of maritime transport to other modes of transportation, the original question how the MoS truly connect in the region was answered for the first time ever.

3.7.2.6.4   The development results of NSR-RTM

In conjunction with several user and stakeholder consultations a list of meaningful applications was identified:

- Harmonisation of route definitions of different stakeholders to arrive at a common understanding (the most fundamental benefit);
- Enable (NSR) transport and traffic pattern analysis for policy making;
- Assist in the Marine Spatial Planning of a given sea area;
- Transport management by employing an improved route and voyage planning, both regarding
- initial (pre-trip) and en-route (re-)planning;
- Traffic planning and management in strategic and tactical terms: a number of application notes are given, including shipboard applications as well as VTS applications, regarding in particular Traffic Organisation Service (TOS);
- Just-in-time arrival processes with 'Precision-Estimated Time of Arrival (ETA)-applications';
- Implementation of IMO defined 'shore-based Navigational Guidance and Information Schemes;'
- Support of the IMO defined Maritime Service Portfolios (MSPs) within e-Navigation;

- Maritime information dissemination tailored to the specific needs of different user groups;
- Improved risk assessment by basing the risk assessment on defined routes;
- Establishment of improved Routing Measures, in particular an improved Traffic Separation Scheme (TSS)-grids;
- Extensive or more precise cost / benefit analysis.

Obviously, taking into account the limited duration and resources available in a project like ACCSEAS, the present work opened a field of ACCSEAS 'legacy' work and applications to be further investigated after the project.

It should finally be noted that future such work would result in providing specific contributions to European and international initiatives, strategies and ongoing implementation work, such as TEN-T, INSPIRE, Intelligent Transport Systems (ITS) directives, e-Maritime initiative, an emerging NSR basin strategy, MSP at large, IMO TSS definitions, the IHO Universal Hydrographic Data Model (S-100; GI Registry), IMO 'Navigational Guidance and Information Schemes' and e-Navigation strategy implementations, including in particular the MSPs, and – last but not least, considering the logistics chain – the IMO Secretary General's proposed Sustainable Maritime Transportation System (SMTS).

Future work: To create both a list and a graphical, user-friendly depiction of all shipping lanes existing in the NSR today, together with their true locations as well as their true connectivity amongst each other and with land via ports. This could be done by using one consistent description methodology, 'Route Topology Modelling (RTM),' thus creating a North Sea Region Route Topology Model (NSR-RTM) for the present situation. It will be necessary to distinguish in this NSR-RTM the different classes of shipping lanes as introduced above, both in terms of their features and attributes as well as in terms of their display to the user via a Human Machine Interface (HMI).

Future work: Since this NSR-RTM would use the presently available data, any application implementation would be possible, in principle, within a relatively short-term implementation period.

Future work: Use the NSR-RTM, once developed, for the description of the future situation. Namely, there may be a NSR-RTM for the year 2020+, tentatively dubbed 'NSR-RTM-2020+,' which may assist in describing in a harmonized manner the perceived future situation throughout the NSR.

Future work: Prioritize the applications for the use of NSR-RTM, as described in section 5.2 and following of the document "ACCSEAS North Sea Region Route Topology Model (NSR-RTM) - Description and contribution to an international generic RTM definition", April 2015 for further development and eventual implementation taking into account the needs of relevant stakeholders involved.

Future work: Introduce ACCSEAS NSR-RTM as an example in the relevant international and European fora with the aim to produce Recommendations and Guidelines on the development, implementation and use of RTM in conjunction with other instruments and explore the opportunities for support and acceptance of a generic RTM in support to the various identified developments (e.g. SMTS, e-Navigation, e-Maritime, TEN-T).

Future work: In order to be reliably used by different stakeholders and users, even to the extent of using a NSR-RTM for navigation, the NSR-RTM work needs to be re-done after ACCSEAS taking into account the following considerations. By doing this, the NSR may create benefit for itself but also provide relevant input to pan-European projects and initiatives. The relevant proposals for

future work as reflected in Appendix C (sections 11.1 and following) of the the document "ACCSEAS North Sea Region Route Topology Model (NSR-RTM) - Description and contribution to an international generic RTM definition", April 2015, should be taken into account and considered.

Future work:　　Further explored after ACCSEAS should be:
- Integration of RTM into 'e-Navigation': Adaptable advance route planning.
- Relationship between routes and collision avoidance: Can there be introduced wrong behavior due to route designations?
- Difference between strategic and tactical use of RTM
- Assessment of safety impact for navigational use of RTM

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

3.7.2.7.1　　Short description of the service

The application has *two functions:*

- to alarm the mariner by means of an audible signal together with a visual signal pointing towards the dangerous target;
- a head up display (HUD) of operational information. Operational information is considered in the widest meaning of it.

Mariners are traditionally focused on visual identification of targets. The COLREGS are based as well on visual recognition of a target and its relative course and speed. Therefore the strategy and action of the Watch Officer (WO) to avoid collision is well trained and experienced and, apart from low visibility situations, is always based on visual observation.

Although much effort is taken to minimize the risk of collision, accidents still happen. Accident investigations show that fatigue and human error play an important role in the cause of accidents. Once the WO is distracted from watch keeping, the WO will no longer react according the COLREGS. Although Automatic Radar Plotting Aid (ARPA) can generate an audible alarm as "Collision Warning," distracted mariners will have difficulty to identify the dangerous target and start acting in order to avoid collision in the little time between the alarm and the critical Closest Point of Approach (CPA). Setting the alarm threshold too wide, in order to have more time to react, is considered disadvantageous because it might generate unwanted alarms.

Apart from this "alarm of last resort" function, Augmented Reality can also function as a display of operational information. Once the information of intended or suggested tactical routes or Marine Safety Information MSI or No-Go-Area (compare candidate solutions above) is available, displaying this information on a *Heads Up Display*, e.g. bridge window or WO cocoon, may be an effective combination of electronic navigation and the traditional focus on visual identification and lookout.

3.7.2.7.2　　Testbed description

After identification and development of a first set of data and information Heads Up Displays options were investigated. Window display was simulated. Furthermore a first prototype of a Cocoon for Watch Officers was developed. Desktop exercises proved the feasibility of this application. After some improvements and modifications the Heads Up Display was demonstrated at the 3rd Annual ACCSEAS Conference in Rotterdam, February 2015.

3.7.2.7.3　　Feedback and conclusions

Although the development of this highly innovative application is still in its infancies the target stakeholders (mariners) showed great interest during the demonstration at the 3rd Annual ACCSEAS

Conference. Feedback was provided on the HUD presented information, the usability and ergonomically aspects were discussed.

Future Work: Further development is needed, including identification of specific user requirements. The feedback received at the 3rd Annual ACCSEAS Conference should be taken in account for the further development of the application in a follow-up or other relevant projects (EU and non-EU)

3.7.2.8 Automated FAL Reporting

3.7.2.8.1   Short description of the service

National Competent Authorities for the European SafeSeaNet (SSN) maintain vessel and voyage reporting systems intended for use by commercial marine traffic arriving at and departing from NSR ports.

3.7.2.8.2   Testbed description

The demonstration would be extending, exploring and modelling substantially nongeographic maritime information, in this particular case the "Notice Of Arrival and Pilot Requests (NOA&PR)" and possibly other FAL reporting forms, using the S-100 framework. In a possible demonstration the systems on-board will automatically connect to a National Single Window service provided by the shore side using the internet and submit the obligatory 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.

Due to the available timeframe and resources within the ACCSEAS project the progress on this issue was constraint. The compelling need to establish the service on short notice was recognized. Pending ACCSEAS external developments on FAL-reporting continued on a regional (EU) and international level (IMO FAL-Subcommittee). It was recognized that the development of e-Navigation and its Maritime Service Portfolios will contribute to an automated FAL-reporting, which contributes to the harmonization and uniformity aims of the concept. It was further noted that the development of the Maritime Cloud could support a future seamless reporting process.

With stakeholders representatives user needs were discussed during the ACCSEAS Conferences, User Platforms and Workshops. Their needs were clearly expressed, though noting that solutions will have to be explored and met within the currently ongoing international/regional development processes.

Further substantial discussions took place with representatives of the EU AVANTI project.

3.7.2.8.3   Feedback and conclusions

Automated FAL reporting is considered to be one of the most urgent services that will have to be implemented. This was also recognized in the IMO e-Navigation Strategy Implementation Plan (SIP) 2014. The development and implementation itself is covered under the umbrella of one of the 5 prioritized solutions of the SIP and identified as one of the 17 Maritime Service Portfolios.

Future work: Based on discussions during a number of international Conferences (including ACCSEAS) the stakeholders in the maritime community (e.g. mariners, VTS, ship owners etc.) indicated that the highest priority now is to develop the MSP "Automated FAL reporting" (as referenced to in the IMO e-Navigation Strategy Implementation Plan (SIP)). This development should be in accordance with the IMO regulations and decisions in the FAL-Subcommittee, A number of EU projects (e.g. AVANTI) are directly/indirectly involved in this matter, There is also a link to the development of National Single Windows. The results of ACCSEAS should be disseminated to this projects in support.

3.7.2.9   Vessel Operation Coordination Tool (VOCT)

3.7.2.9.1   Short description of the service

When a serious accident occurs at sea, human lives will be at risk. This might be an aircraft performing an emergency landing at sea, a vessel taking on water, a man overboard or a small boat lost during a storm.

In such incidents, a Search and Rescue (SAR) operation is initialized by the government with jurisdiction over the specific areas in which the accident has occurred. This operation helps to locate people and vessels in risk and resolve the situation.

An operation such as this requires key coordination of a myriad of vessels and personnel ranging from fishing boats to dedicated Search and Rescue vessels and navy vessels. As the ocean is constantly changing, so does the area which needs to be searched which adds to the complexity of the rescue operation.

To rescue someone at sea, access to all possible information, regarding wind, sea currents, ships available for the search and the movements of the ocean are all vital, literally.

The VOCT seeks to solve these issues by allowing automatic distribution of SAR relevant data to all relevant participants in a SAR situation. The VOCT allows for seamless and automatic sharing of relevant data. The VOCT follows the organizational structure of the current standards, allowing an On Scene Coordinator (OSC) or the SAR Mission Coordinator (SMC) the tools to distribute and coordinate any participating Search Rescue Units. Once an operation is underway the OSC can monitor the progress for participating vessels and electronically update the search areas via the Maritime Cloud. The VOCT allows the OSC to calculate SAR data using the built-in SAR calculator or import the SAR data from commonly used commercial drift calculation systems.

When an incident occurs the first steps in a SAR operation is to calculate the likely place that the search object is located. This is done by applying wind and current information to the drifting object to establish a likely search area. The VOCT applies the theory outlined in the International Aeronautical and Maritime Search and Rescue Manual (IAMSAR) and presents the user with an intuitive interface. Once the user enters the necessary data the software performs the calculations. The SAR area is then displayed directly on the electronic chart (for vessels it's displayed on the ECDIS).

Once the SAR area has been calculated, an effective search area can be calculated. This is a statistical calculation that determines the maximum track spacing for a given vessel to maximize their likelihood of finding an object under certain weather conditions with a given search speed.

Each participating Search and Rescue Unit (SRU) gets their own calculated Effective Area. Using the calculated track spacing and the selected search time, an area can be precisely calculated. These areas can then be selected and moved / resized (length vs width, area size remains constant) to better cover the calculated search area.

With the search area and the effective SRU search areas created the OSC can create individual search patterns for the participating vessels.

The VOCT allows creating of the common search patterns outlined in the IAMSAR Manual. Each pattern functions as a route for the selected vessel thus the OSC or the SRU can change the route to accommodate their current position and any possible hazardous terrain.

With the SAR operation created the OSC can switch to the tracking view. In the tracking view the OSC can send out the previously generated data and monitor each vessel as they proceed with the

search. The OSC can re-transmit updated information while automatically receiving the status of the search route for each vessel.

The VOCT also allows for text based communication and log keeping. At any point during an on-going operation the OSC or SRU's can share data via a common text log. This log is automatically transferred to everyone creating a group chat. Vessels will automatically receive and store the received messages with timestamps and sender of said message.

3.7.2.9.2   Testbed description

A simple approach to a search and rescue assistance tool was previously tested in the EfficienSea project with promising results.

As part of the ACCSEAS project WP6, it was decided to develop and test this concept further, and based on analysis and user feedback, to expand on the initial idea of simple communication to allow calculations and more detailed display of Search and Rescue relevant information. The service mirrored the requirements from the practical application of SAR and allowed both the provider and the consumer of SAR data.

The VOCT was implemented and integrated as part of the e-Navigation Prototype Display (EPD), with chart and basic ECDIS/VTS/SAR functionality. The EPD-Shore platform functions as the OSC tool for planning and tracking of SAR operations while the EPD-Ship is utilized as the SRUs ECDIS like display.

The EPD-Shore can create and send SAR operations while the EPD-Ship can create local only (without possibility to invite other vessels) SAR and receive SAR data messages from the EPD-Shore.

All the communication transfer is done via the Maritime Cloud Framework.

3.7.2.9.3   Feedback and conclusions

The VOCT concept was tested live off Den Helder, Netherlands with participation of Netherlands Coast Guard Joint Rescue Coordination Centre (JRCC) and a Coast Guard vessel.

A dummy was dropped off the coast before initiation of scenario. Drift, Search areas and search patterns were then calculated at JRCC and sent via the Maritime Cloud to the Coastguard vessel for direct presentation on EPD. When information was received on board, vessel was tracked for SAR unit management, and additional search information was shared between participants via the shared log functionality.

Both the build in calculation module (IAMSAR calculation) and import from the drift calculation system normally used by JRCC was tested.

The participants were a mix of experienced SAR Mission Coordinators/experienced SAR professionals and ship's crew with background as Master Mariners but without dedicated SAR training.

The VOCT concept was very well received by all participants.

On the shore side (JRCC) the possibility to transfer information digitally and graphically to SRU's were emphasized together with the shared log functionality. Communication is a huge and time consuming task in SAR operations today. Important information may be lost or forgotten when exchanged via voice. Information exchanged via the shared log is stored and may be extracted for later reference and the use of text messages and digital transfer will at the same time ensure that the information sent/stored is the same as received.

The basic calculation functionality based on the IAMSAR Manual may not be sufficient, so the import/export from other drift calculation systems will be very important or communication capabilities based on a standardized exchange format may be part of such systems in the future.

On ship side the crew not normally involved in SAR operations were very positive towards the VOCT concept. Especially when not involved in SAR operations or exercises often, the calculation and

management may be time consuming and difficult. Graphic display and sharing of information may improve search results and reduce workload on ships crew during a SAR operation, also moving focus from communication to the important task of lookout.

All ship side participants expressed concerns on the size of text and numbers used on the screen which were hard to read. Text and numbers need to be bigger.

All participants had hopes that the VOCT concept would be developed further and result in future systems with VOCT-like capabilities.

3.7.2.10 Dynamic Predictor (for tug boat operations)

3.7.2.10.1 *Short description of the service*

SSPA Dynamic predictors have been successfully used on vessels operating on their own in berthing operations to assist the master in predicting the ships behavior reducing risks of hard landing or collision with berth, ramp or dolphins. The dynamic predictor takes external wind and current forces into account but no other external forces. To add the forces provided by a tug is assumed to make the dynamic predictor usable also on vessels requiring tug assistance. It is also assumed that an exchange of predicted positions between tug and ship is useful in the maneuvering. SSPA Dynamic predictor is a feature that can be used to see the vessel's future position within the next few minutes. In the EfficienSea project predictor exchange was tested in collision avoidance application, but little or no use for the exchange was found. Questions arose if the predictor exchange might be useful for ship to ship operations like tug boat assistance.

So far the predictor has been presented as a contour of the ship shown on the map, in the evaluation for EfficienSea the predictor was simplified to a single point, considered good enough for collision avoidance. Alternative presentations is projection on water surface, projection on bridge window (require head tracking) or a simplified contour on map.

3.7.2.10.2 *Testbed description*

The aim for investigation of this candidate solution is to find out if dynamic predictor exchange and tug force exchange is useful for manoeuvring a ship with tug assistance. Identifying risks and opportunities with exchanged predictor information and tug forces is of great importance.

The testbed focussed on exchange of predictor in a tug-ship operation, both pushing and pulling. In a simulator environment an accurate pull and push force is easily available, in reality these are more rough. A comparison with the accurate forces and the forces estimated based on headings, engine RPM and pitch was done. An evaluation was made if the tug operation became more efficient using the dynamic predictor, making the total in port operation time shorter and maybe also more predictable making

the tug use more effective. Manoeuvring studies in simulators with and without dynamic predictor were performed using SSPA Seaman Simulation software and SSPA newly developed visualisation and human interfaces.

3.7.2.10.3 *Feedback and conclusions*

There was a positive feedback provided by the target group (mariners and tugboat captains). The demonstrator provided sufficient information for them to judge usability and identify the benefits of the application. Suggestions were made in respect to portrayal and some operational aspects.

Future work: Based on the feedback provided further development of the application may be considered during the EU projects EfficienSea 2.0 and MonaLisa 2.0.

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

3.7.2.11.1   Short description of the service

The IVEF Service is intended to provide a common framework for the exchange of real-time Vessel Traffic Image information between shore-based e-Navigation systems, such as VTS systems, e-Navigation stakeholders and relevant external parties (***the so-called shore-to-shore dimension***). The IVEF Service is described in IALA recommendation V-145 and may be revised based on the results of the ACCSEAS test. The IVEF protocol was developed by industrial members of IALA in 2012 in order to provide in a protocol capable of the exchange of data and information between (neighbouring) VTS centres (potentially transnational) and between VTS Centres and sensor systems (e.g. radar, other data providing systems). After the development of the protocol it was internationally recognized by IALA and IMO.

As the IVEF service already had proven itself as reliable and effective (in the Netherlands all VTSs are connected to the Coastguard Centre in Den Helder providing and exchanging fused traffic images and other types of data) the challenge was now to explore IVEF in a **ship-to-shore / shore-to-ship dimension** in ACCSEAS in support of SAR and Traffic Organization Services. A testbed was prepared for the transmission of real-time radar images (raw data) from ship-to-shore where this image was fused with the fused data/AIS image at the Coastguard Centre. The now new fused image provides a much more detailed picture of a sea area. This new fused image then was retransmitted to the vessel for portrayal. In fact both shore and ship now had the same image at their disposal. The challenging factor during the test bed was the use of a variety of communication means (radiolink, Satcom etc).

A realistic case was the trigger for this test: As the number of voyages of passenger vessels and ferries (with hundreds if not thousands persons on board) is increasing across the North Sea the risks for accidents due to the decreasing manoeuvrable space is also increasing. For SAR operations it is essential to have a clear situational awareness of the accident area. In case of an accident in most situations the radar on board the accident ship will still be in operation, even during a period in the aftermath of an accident. As long as the ship will be capable to transmit its own traffic image to shore the bigger changes are for a successful rescue operation. The fused overall traffic image - including very small targets, such as lifeboats - could also be exchanged with SAR assets taking part of the operations. In case an accident takes place in an area with a transnational character (e.g. borders of neighbouring parts of the Continental Shelf) the fused overall traffic image again could be shared for joint operations with MRCCs or VTSs of the neighbouring countries (shore-to-shore dimension).

It was the first time worldwide this technology/instrument was successful operationalized.

3.7.2.11.2   Testbed description

The IVEF pilot test bed was setup as well on the shore side as on one ship. At the shore side the present infrastructure was used with some expansion. Connected in such a way that the operational system could not be influenced at all. A secure internet access was granted for the ship to a separate section at the Coastguard system.

On the ship side cables, screens, software and connections had to be made to make everything possible. Special attention was paid to the internet connection and the switching over between a mobile network and satellite.

The main hardware components (already present, within red line are new/extra) are

- Sensors (radar, AIS, GPS and heading)
- The on-board IBS system
- A converter RS322 (IBS NMEA) data to TCP/IP (not shown);

- A device for converting and fusing sensor data from the IBS to IVEF;
- A screen to present the Harmonised VTS picture
- A router determine the preferred connection and to limit the throughput;
- A mobile 3G/LTE (mobile) data unit;
- A VSAT infrastructure;
- An HITT ISIS server. This server merges the traffic image of the Coastguard Centre with the received on-board traffic image and send it back to the ship.

To realise an internet connection that would reduce costs and not interfere with the primary tasks, a combined connection type was introduced with bandwidth management. This solution made use of a mobile network when available and the VSAT connection when out of reach of the mobile networks. Also when operating via the VSAT communication the bandwidth was maximised to 200Kbit in order not to disturb primary systems on-board.

The main software components are:

- A converter from the sensor data in IBS data format to IVEF;
- An encoder/decoder from IVEF to compress data and link format also vice versa. For efficiency reasons, the data link format will not be the IVEF xml text format. It will be compressed;
- An ARAMIS display on the ship;
- An HITT ISIS server. This server merges the KWC traffic image with the received on-board traffic image.

Using mostly standard products for realising the pilot system together with the on-board Integrated Bridge System resulted in a faster realisation of the pilot system.

3.7.2.11.3   Feedback and conclusions

During the tests of the IVEF involved persons on board of the Coastguard vessels and at the Coastguard centre were very enthusiastic about the usefulness of the information. Some of their reactions were foreseen but others came when the project progressed.

Because the data presented was fused with other information for the user it was not easy to determine the difference. F.i. a AIS target seen by the shore system with their sensors and later fused with the radar information would still be the same on the screen unless the AIS has a different position than the radar. Users on ship and shore side gave the following comments:

Ship side

1. The functionality gave the possibility to see further than their own sensors could detect. Therefor they could locate ships earlier what gave them more time to plan;
2. They had the same picture as on shore as on the ship what gave no information gap between ship and shore side. This resulted in less (miss)communication;
3. Drifting buoys or other drifting material without AIS could be identified and transferred to the shore side
4. vessels without AIS (like pleasure crafts) coming into the area were detected earlier in the area where shore based radar images are available;
5. Extra data not present on the ship added on the shore side became available on the ship.

Shore side

1. Smaller targets further away from the shore infrastructure could be tracked due to the higher accuracy of the information from the on-board radar systems;

2. AIS targets with transmission problems could in some cases not be received by the shore system due to distance to the closest base station. These were received by the ships AIS mobile station and then transferred to the shore side;

3. Targets only detected by one of the shore infrastructures sensors could be verified by the sensors on-board of the ship.

General conclusions: a very valuable service in support of SAR-operations, VTS Traffic Organization Services, Enforcement activities and in general contributing to safety and efficiency of navigation, contributing to transnational Coastguard and VTS coordination of activities.

Future Work: The service should be further develop and prepared for operational implementation.
Future Work: An IALA Guideline on IVEF should be reviewed and amended according to this new service. Awareness of the availability of the service should be increased among potential stakeholders.

3.7.2.12   Real time Vessel Traffic Pattern Analysis and Warning Functionality for VTS

3.7.2.12.1   Short description of the service

The idea of this candidate solution is 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 analyzed 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 traffic 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.* For example, if 98% of all vessels in the area are heading north, an eastbound vessel will cause a warning for this behavior. 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 behavior 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. The aim of the demonstration of an implementation of this candidate solution is to investigate if it can be helpful to the prevention of accidents.

3.7.2.12.2   Testbed description

Due to the constraints on time and financial resources only substantial discussions on the provided service have been taken place. The aims and potential value of such a service were recognized. However, actual tests and demonstration could not be achieved.

3.7.2.12.3   Feedback

This service or an (decision supportive) instrument may be subject for further development based on stakeholders requirements in the VTS community. The proposal could be presented to the international organization dealing with VTS matters, the International Association of Marine Aids to Navigation Authorities (IALA). Currently IALA developed a Strategy for the delivery of VTS in a changing domain (Council approval is expected in May 2015). The proposed service could especially be beneficial to one of the primary services of VTS: Traffic Organization Service. Furthermore IALA has developed a Guideline on Decision Tools for VTS and currently is developing a Recommendation

and Guideline on Anti-Collision and Near-Miss reporting. The service proposed may be seen as an instrument contributing to the objectives of these Guideline and Recommendation.

Future Work: Consultancy for such a service among the VTS Community is needed as well as the development of a full service proposal (including Product Specifications). This can be presented to IALA for further comments and investigations, e.g. as part of the development of MSP-3 (IMO SIP, 2014) Traffic Organizations Service, or contributing to the package of decision making tools and reporting of VTS.

3.8   Work Package 7 Demonstration of NSR e-Navigation

With the input of the Work Packages 3 until 6 the results of Work Package 7 can be best visualized as shown in the picture below:
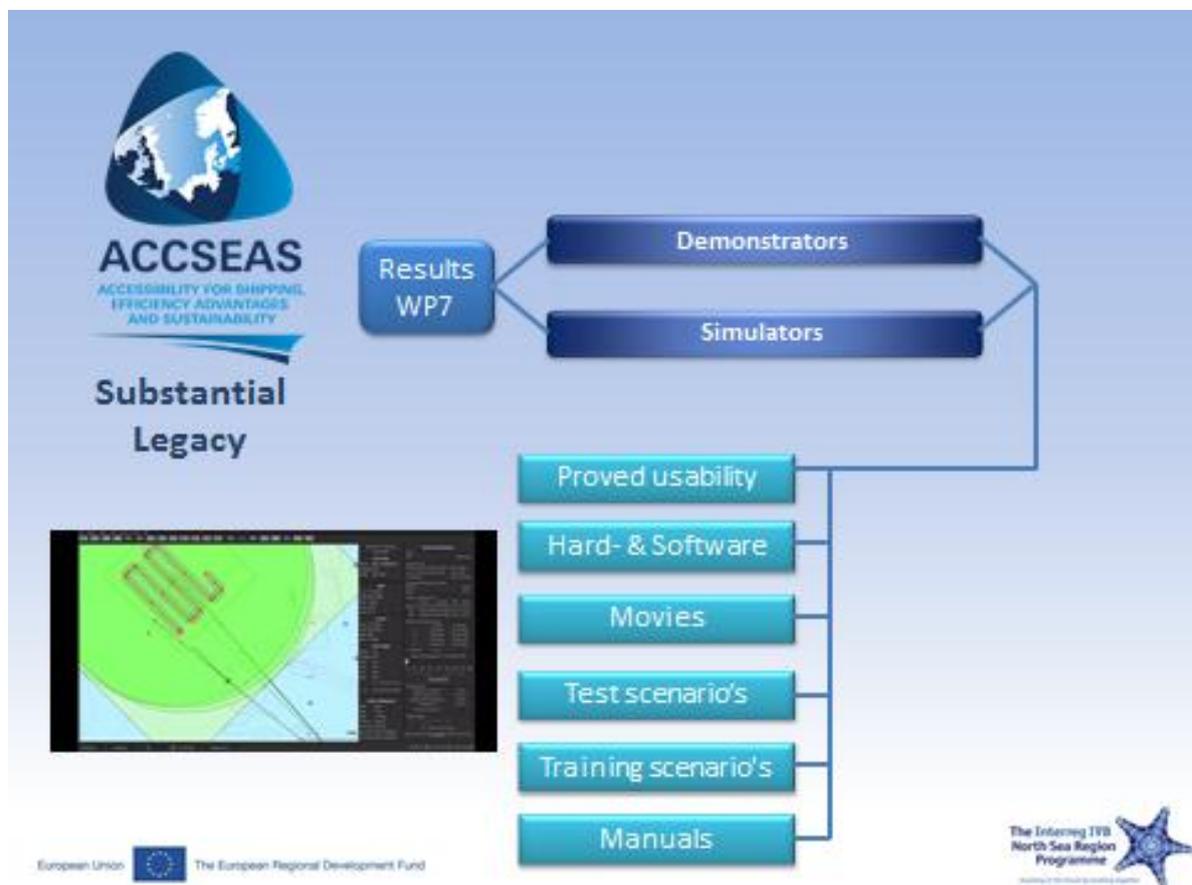
This page is deliberately blank

4   Material Legacy

As a part of the ACCSEAS project funding, a budget was made available for "Material Investment" in order to purchase the required equipment to perform the demonstrations in the test-bed area. Since these purchases are made under the Material Investment budget line, the primary goal of the project is to leave the equipment in place and operating for any future user to use. The hardware and software legacy items are largely the output of the Working Packages.

However, it is recognised that due to logistical, technical or maintenance constraints, it may not be possible to retain the equipment at the locations used for the test-bed.

It should be recognised that the equipment is owned by the organisations that purchased the equipment (with the 50% grant from the ERDF), and that ultimately it is up to those organisations to determine how the equipment is maintained after the project has ended.

There is the possibility, for example, that the equipment is moved and operated at different locations for further trials, possibly in a post-ACCSEAS EU project. This would require a bi-lateral agreement between the owner of the equipment and the operator of the equipment to ensure that the assets are accounted for, and that any issues during their use can be dealt with.

Possible **options** for equipment purchased using the Material Investment budget are:

• Leave the equipment operating and maintained as installed during the ACCSEAS project. If this involves more than one organisation, this will require an agreement between the parties concerned to deal with the legal issues of asset accounting and repairs.

• Move the equipment elsewhere, and operate the equipment in a different part of the NSR. Again, if it involves more than one organisation, this will require an agreement between the parties concerned to deal with the legal issues of asset accounting and repairs.

• Make the equipment available to the next relevant EU project. This will require an agreement between the owner and the new project to deal with the issues of asset accounting and repairs. If the owner is a partner in the new project, then the equipment will be available by default.

• Remove the equipment after the test-bed demonstration has been completed. This should be a last resort option, based on no other option available to keep the equipment in service.

4.1   NSR Geographic Information System (NSR-GIS)

Under the flag of WP3 ACCSEAS has developed and used an overall North Sea Region Geographic Information System (GIS) with the aim to have an instrument at its disposal to support
- the ACCSEAS research on current and future maritime developments in the NSR
- visualization, evaluation and validation of these developments
- visualization, evaluation and validation of expectations and predictions for the future situation in the NSR
- dissemination of the research results of ACCSEAS to a broader audience with the aim to enhance public awareness with respect to spatial developments in the NSR
- identification of areas where implementation of e-Navigation services (current, identified solutions and future) may be needed to anticipate on current and future developments,
- competent authorities during common activities on Marine Spatial Planning for the NSR
- competent authorities in policy developments and decision making anticipating the research results, conclusions and recommendations of ACCSEAS

A categorized overview of all necessary entities and attributes was developed necessary to meet the aim for a NSR-GIS and its supportive contributions. This overview is reflected in Annex A of the

"ACCSEAS Baseline and Priorities Report", final edition 2015. During the project an IALA Workshop in 2013 on Marine Spatial Planning adopted this overview. It was decided to utilize it as a valuable source for the development of a relevant Recommendation and Guideline in support of the international community dealing with the complexity of maritime traffic developments and the allocation of maneuverable space for shipping.

The NSR-GIS as a legacy of ACCSEAS is considered to be a powerful instrument to be utilized in future after project ends in conjunction with other instruments developed by ACCSEAS (e.g. Route Topology Model), specifically to support the proposed regional collaboration as described in the sections 2.2 and following of this report. Furthermore, the NSR-GIS as a legacy of ACCSEAS can act as an example for other regions (EU and non-EU).

In order to preserve of the NSR-GIS for future regional utilization a number of actions needed, such as to organize its governance and its maintenance, to ensure the delivery of data and information needed. Also a number of legal issues will have to be solved.

4.1.1 Governance

As the development of the NSR-GIS was a task in and "owned" by ACCSEAS the governance of the NSR-GIS was subject to the project. In case the NSR administrations/organizations conclude that the NSR-GIS should be preserved for future utilization supportive to the proposed NSR collaboration the governance needs to be formalized. This could be done as an activity under the flag of a future NSR Policies Harmonization Group (NSR-PHG) on e-Navigation (see section 2.3 of this Report). This would imply that this NSR-PHG takes over the governance of the NSR-GIS. Another option could be that a common governance of a future NSR-GIS is assigned the administrations/organizations involved in the option b. for maintenance as described below.

Future work: NSR Administrations and parties participating in a future NSR e-Navigation Coordination Platform (NSR-eNAV-CP) on e-Navigation are invited to discuss and formalize governance of a continued utilization of NSR-GIS.

4.1.2 Maintenance

The operation and maintenance of the NSR-GIS during ACCSEAS was tasked and executed by one of the projects beneficiaries, the Maritime Institute Willem Barentsz (MIWB) in the Netherlands. Due to limited organizational and financial resources MIWB will not be able to continue this task on the same level, considering the fact that it is not a core objective of the MIWB-organization. Other parties in the NSR therefore have to be found willing and able to continue this important work in future. Several options were identified:

a. One of the current ACCSEAS beneficiaries will take upon the work after project ends. *Note: this can be done on voluntary basis or embedded in a following project.*
b. One of the NSR administrations or competent organizations will take upon the work after project ends. *Note: this can be done on voluntary basis or as an assigned task incorporated in the mandate and objectives of the administration/organization in question.*

For both options a. and b. administrations, organizations and other parties involved could create a mandate for the eventual executing administration/organization in question. Eventual reimbursement of costs might be considered if necessary.

c. Presuming that the relevant and competent NSR administrations endorse the importance and continuation of maintaining the availability of a NSR-GIS for mutual utilization, (private) parties in the industry may be interested to perform this task on their behalf.
    Note: Next to a formal contract to be developed and acknowledged by all parties involved also financial resources for the execution of the task have to be allocated. In case of a mutual agreement the burden of finances may be shared by the NSR administrations/organizations involved (limiting individual contributions).

It should be noted that for all three presented options a framework for the maintenance of the NSR-GIS has to be developed (including for instance requests on production, specifications, delivery of data and information, confidentiality aspects, deliverables, publication etc.).

Future work: NSR Administrations and parties participating in a future NSR NSR e-Navigation Coordination Platform (NSR-eNAV-CP)are invited (advised by the ACCSEAS Steering Group) to identify and decide on a common agreed manner to ensure the future maintenance of the NSR-GIS and prepare the relevant arrangements, where appropriate.

4.1.3   Delivery of data and information and legal issues

During ACCSEAS it was noted for instance that the future delivery of AIS, Hydrographic and organization/-administration restrained data (with an policy or economic character) in some of the NSR countries could be constraint by law or privacy regulations. Considering the essential need for these data as a source for the evaluation and validation of future developments and attuning national/regional policies and plans by competent authorities, common efforts of the NSR parties involved is necessary to solve this matter. This could be achieved by putting it on the agenda of a future NSR e-Navigation Coordination Platform (NSR-eNAV-CP) on e-Navigation (see section 2.3 of this Report) or subject to following projects.

Future work: NSR Administrations and parties participating in a future NSR e-Navigation Coordination Platform (NSR-eNAV-CP) on e-Navigation are invited to explore solutions and develop a framework solving legal constraints for the future delivery of data for the NSR-GIS.

4.2   Ship Positioning Equipment

Resilient Positioning, Navigation and Timing (PNT) is an important aspect of e-Navigation and forms an important part of the IMO Strategy Implementation Plan (SIP), as such it is fully anticipated that options that can form part of a resilient PNT approach will be developed further as the SIP is enacted.

ACCSEAS has considered the need for resilient PNT and also options to enable it and it is widely recognised that different position systems will meet the requirements of different users and different systems will be available in different locations. As such, the need for resilient PNT and the potential solutions that could be used to enable it will continue to be developed after ACCSEAS.

A number of resilient PNT receivers have been developed under the ACCSEAS project. These receivers were purposefully designed to enable future expansion; however they currently contain hardware to provide DGPS and eLoran PNT information. Software developed by the project partners, is executed on the on board computer board within the receiver case; this software is able to quantify the performance of the available position, navigation and timing sources and can select the best for output, seamlessly swapping sources when the primary becomes unreliable or unavailable.

These receivers were designed to be future proof and can be upgraded to enable R-mode (300kHz) functionality, and R-mode with eLoran integration. The receivers can also receive data from additional sensors for process within the software and as such could be used for a multitude of follow-on operations and follow-on resilient PNT tests.

Under the ACCSEAS project, several receivers have been installed on different vessels in and around the North Sea Region to test the functionality and gather feedback from users. It is envisaged these receivers will remain in situ at the close of the project and data from them could be used in subsequent projects.

Related to this, ACCSEAS project partners have contributed to the development of 'multi-source navigation receiver' performance standards by the IMO's Navigation, Communications and Search and Rescue Committee (NCSR). These standards have been finalized in March 2015 and are forwarded for approval to the IMO Maritime Safety Committee (June 2015). Following the development of the performance standard, an IEC test specification is required against which receivers will be tested to ensure they meet the IMO performance requirements. It is envisaged this could take a further two years and therefore, it could be the end of 2017 before resilient PNT receivers can become an approved item for use on board SOLAS vessels.

Therefore the receivers developed by the project could be useful for subsequent projects and in the development, and testing, of IMO and IEC standards.

4.3   e-Navigation Services Software

In accordance with the ACCSEAS Partnership Agreement, all software developed in the ACCSEAS project should be open-source and publicly available. Whilst there are a number of options to make software available to users, the e-Navigation portal (http://www.e-Navigation.net) seems to be a suitable repository, and supported by the industry standard Github storage facility.

5   Sustainable Workplan 2020+

As indicated in section 1.2 of this document WP8 is to capture, in order to ensure continuity and harmonization of ACCSEAS e-Navigation outcomes from 2015-2020, the results and recommendations of the Work Packages 3 - 7   into a 'Plan for the Sustainability and Harmonization of e-Navigation in the NSR'. This plan should provide the basis for a program of future work and an eventual roadmap for service expansion, ensuring that ACCSEAS results and impact may, as a legacy of the project, continue or are used after project ends.

5.1   Considerations

In this report the outcomes of ACCSEAS were reflected and per item future work identified. This resulted in a total of **87** suggested/proposed future work items as a legacy of the project ensuring that ACCSEAS results may be further continued or form the building block for new developments.

- At this stage it was uncertain whether the ACCSEAS project could be followed by a project 'ACCSEAS 2.0.
- However, during the project some other relevant EU projects with similar maritime objectives and focus were developed, have started or their applications have been approved. Proposed work items may therefore become subject to these projects.
- Other proposed work items are proposed to be designated to or to be brought under the attention of relevant international and regional organisations or to competent authorities and administrations in the NSR countries.
- Proposed work items on the dissemination of ACCSEAS results or indicating where ACCSEAS results would benefit other EU policies, programmes and projects can be executed along a process and based on considerations of the ACCSEAS Communication Officer (as discussed in TPCG) under the umbrella of Working Package 2: Publications and Communications:

After project ends -

- A formal letter to be sent by the Project Manager, on behalf of all beneficiaries of the project, to all international, regional and national organizations indicating that the project ended and that the results of the project are publicly made available on the website www.accseas.eu
- This letter may be accompanied, for the convenience of the receiver, with an attachment indicating a categorized list of subjects
- In the attachment also a list subject related contacts (name, organizations and contact information) may be provided.

5.2   Plan for future work

This report identified an extensive list of future work items (reflected in Annex C to the report). These now may form the building blocks for an overall plan for future work contributing to the sustainable and harmonized implementation of e-Navigation in the NSR. Prioritisation of the work should be further discussed and therefore may be subject for study and discussion to the proposed NSR e-Navigation Coordination Platform (NSR-eNAV-CP). Some work items also can be incorporated directly into other projects, where convenient or appropriate.

5.3   Roadmap for service expansion

As a indicated in section 1.2.1 of this report setting up a Roadmap for service expansion was too premature at this stage. This task (enlisted in future work) shall have to be done in a joint effort by the appropriate competent authorities and service providers in the NSR after project ends. This may be tasked to the proposed NSR e-Navigation Coordination Platform (NSR-eNAV-CP).

This page is deliberately blank.

Annex A   Coherency ACCSEAS documentation
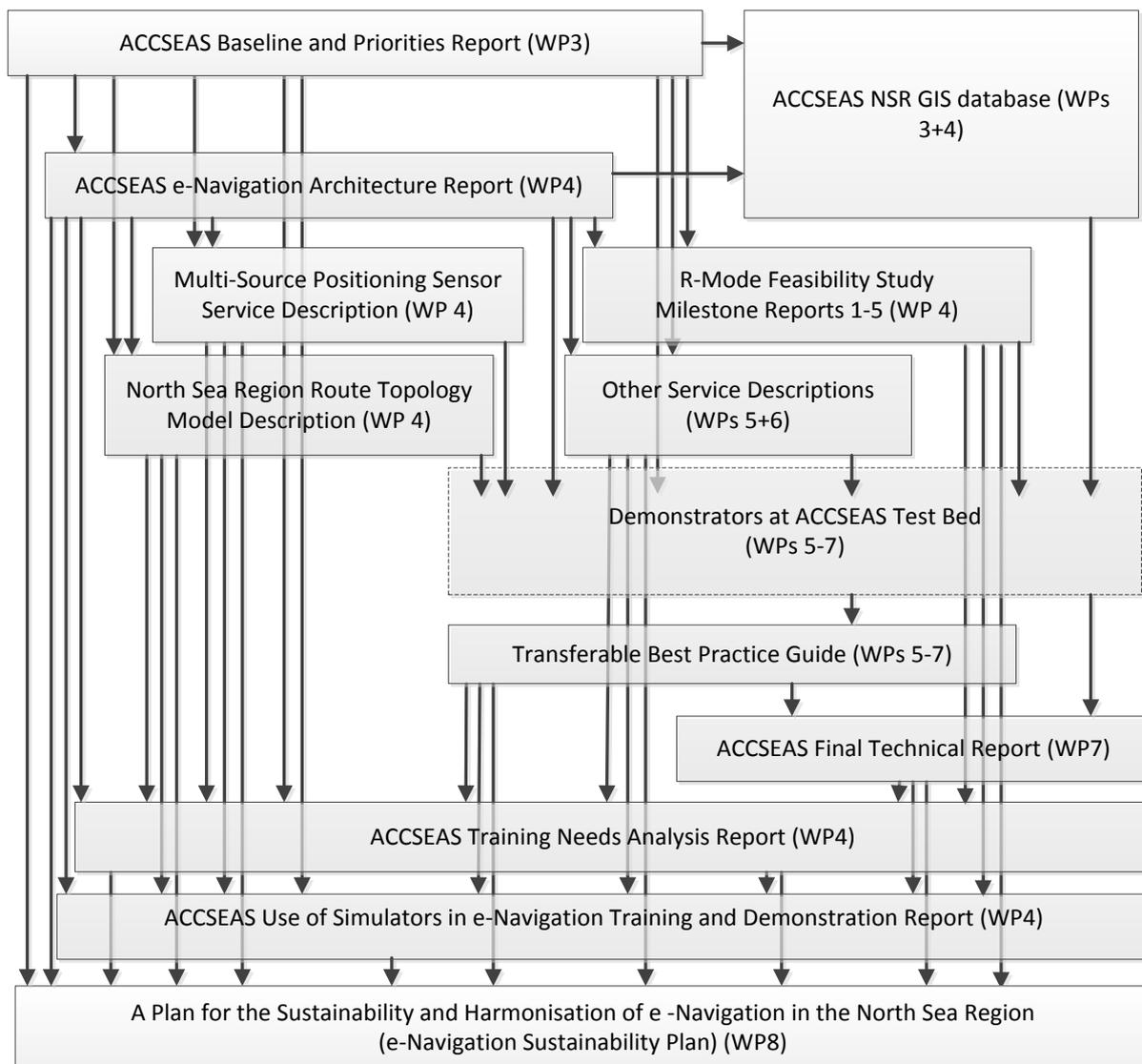
This page is deliberately blank.

Annex B   Organizational Legacy

B.1 Terms of Reference for a NSR e-Navigation Coordination Platform (NSR-eNAV-CP)

The NSR-eNAV-CP as a proposed future platform for the development and overall implementation of e-Navigation in the NSR. Its compelling need and justification are described in sections 2.1, 2.2 and following of this document. Based on historic experiences (e.g. GMDSS) and considering the analysis of the benefits and disadvantages of operating under the umbrella of current existing recognized regional bodies this platform will operate as a stand-alone platform with the focus on e-Navigation.

B.1.1 Objectives

The objectives of the NSR-eNAV-CP are to
- **provide** a sustainable transnational platform for all regional relevant stakeholders with the focus on an efficient and effective development and implementation of e-Navigation;
- **coordinate**, based on transnational cooperation, the further regional development and implementation of e-Navigation in the NSR with the aims to ensure
- future safety and secure maritime navigation, accessibility of the region, navigable waters and regional seaports, protection of the marine environment;
- **provide** a regional contribution and input to the development and implementation of the worldwide e-Navigation concept in accordance with the IMO, IALA frameworks (respectively Strategic Implementation Plan - SIP -, Legislation, Resolutions, Recommendations and Guidelines) and relevant EU programmes (e.g. e-Maritime);
- **take** into account the interests of all e-Navigation stakeholders and relevant aspects (policies, service provision - functional, operational and technical -, user needs, implementation strategies and agreements, future service expansion, infrastructure, architecture etc.);
- **support** the development of a sustainable maritime transportation system in general and to the regional maritime logistic domain specifically;
- **establish** a regional window on e-Navigation for other international and regional organizations and bodies;
- **cater** an example function for other regional sea areas, within and outside the EU.

B.1.2 Composition

The composition of the NSR-eNAV-CP can be distinguished into 1) an organizational and 2) a participation/representation component:

B.1.2.1 Organizational composition

It is believed that, in order to achieve the highest level of efficiency and integrated approach to e-Navigation, the organizational composition of the NSR-eNAV-CP may consist of
- a NSR Policies Harmonization Group on e-Navigation (NSR-PHG)
- a NSR Service Providers Coordination Group on e-Navigation (NSR-SPCG)
- a NSR e-Navigation User Platform
- a Committee for organizing the NSR e-Navigation User Platform and Annual/Biennial NSR e-Navigation Conferences
- a Secretariat structure

B.1.2.1.1   NSR-PHG

Depending further considerations and decision-making by the appropriate regional administrations and competent authorities the NSR-PHG can have meetings stand-alone (participation composition and Terms of Reference are provided in Section B.2) or in combination with the NSR-SPCG where deemed necessary or

desirable. Meetings may be organized in turns by the participating administrations (in order to spread costs and resources). Stand-alone meetings of the NSR-PHG preferably have to be organized back-to-back with NSR-SPCG meetings.

B.1.2.1.2   *NSR-SPCG*

Depending further considerations and decision-making by the appropriate regional administrations, competent authorities and service providers the NSR-SPCG can have meetings stand-alone (participation composition and Terms of Reference are provided in Section B.3) or in combination with the NSR-PHG where deemed necessary or desirable. Meetings may be organized in turns by the participating administrations (in order to spread costs and resources). Stand-alone meetings of the NSR-SPCG preferably have to be organized back-to-back with NSR-PHG meetings.

B.1.2.1.3   *Organizing Committee for NSR User Forum and NSR e-Navigation Conference*

The meetings of the NSR User Forum and the organization of a NSR e-Navigation Conference can be initiated in dialog by the NSR-PHG and NSR-SPCG. For this an Organizing Committee shall be established and staffed with participants from both Groups.

B.1.2.1.4   *Secretariat Structure*

For the coordination of meetings, the distribution of in- and output documents between the groups and participants as well as to provide in a window for international, regional or national organizations outside the scope of the NSR e-Navigation community it will be necessary to set up a Secretariat Structure.

Depending further efficiency considerations and decision-making by the appropriate regional administrations, competent authorities and service providers represented in the NSR-eNAV-CP four options were identified:

a. One overall Secretariat for the NSR-eNAV-CP, the NSR-PHG and the NSR-SPCG; focus on the actual development and implementation of e-Navigation in the NSR.
b. Two separate Secretariats: one combined for NSR-eNAV-CP and NSR-PHG (focus on overall coordination and policy decision making), one for NSR-SPCG (focus on service provision and expansion, technical and architectural aspects);
c. Three separate Secretariats: one for NSR-eNAV-CP, one for NSR-PHG, one for NSR-SPCG;
d. One separate Secretariat for the organization of meetings of the NSR User Forum and the organization of a NSR e-Navigation Conference; this Secretariat will be part of the Organizing Committee to be established.

Nevertheless the choice and decisions made for the Secretariat structure under the options a, b and c it is recommended that the Secretariat(s) will be embedded in the organization(s) of (a) national administration(s) or competent authorities with mandate for decision making. This is to prevent conflicts of interests between public and private service providing organizations. Embedding the one or more Secretariats in the preferred organizations may be in turns or by semi-permanent division over the NSR countries.

B.1.2.2 Participation/representation composition

The permanent participation and representation within the NSR-eNAV-CP will in general be concentrated in the NSR-PHG and the NDR-SPCG meetings. The composition of group members is reflected in Section B.3. In case of a combined meeting of the two groups the major (private) Service Providers without a mandate for (policy) decision making may participate in the meeting in an advisory role. Furthermore a staff member of each relevant Secretariat participates in this meeting.

The non-permanent participation and representation within the NSR-eNAV-CP are foreseen in the NSR-e-Navigation User Forum. This Forum will be initiated by the NSR-PHG and the NDR-SPCG with the general goals of dissemination of information and the collection of feedback of end-users. The

e-Navigation User Forum has no decision making mandate, but has an informative and advisory character to the other groups based on the results of the workshops to be organized.

B.1.3 Tasks and responsibilities

The tasks and responsibilities of the NSR-eNAV-CP are to
- **coordinate** the overall development and implementation of e-Navigation in the NSR;
- **develop** a common shared strategy and policy on e-Navigation for the NSR (including, where appropriate and applicable, a harmonized service provision, standardized shore based infrastructure and architecture) as well as how to deal with future challenges and problems in the NSR;
- **disseminate** the regional views on e-Navigation as recognized formatted input in the relevant international organizations (IMO, IALA, IHO, EU)
- **provide guidance and advise** to national administrations and competent authorities as well as to relevant EU bodies or other regional recognized organizations;
- **coordinate and initiate** future works where appropriate and deemed necessary;
- **initiate and coordinate** the organization of the NSR e-Navigation User Forum and biennial NSR e-Navigation Conferences;
- **inform, communicate and exchange** regional views with recognized regional and EU bodies from a maritime transportation perspective on developments in the NSR.

B.2 Terms of Reference NSR for a Policies Harmonization Group (NSR-PHG) on e-Navigation

B.2.1 Objectives

The objectives of the NSR-PHG are to
- **provide** in a regional platform for national administrations and competent authorities with a mandate for policy decision-making on e-Navigation aspects and transnational collaboration on maritime transport interests from Coastal State and Port State perspectives;
- **notify** the participating NSR countries concerning the individual national e-Navigation strategies and developments related to safety and security of navigation, accessibility issues and the protection of the marine environment;
- **attune** these e-Navigation related national strategies into a regional strategy where appropriate and applicable;
- **develop** the basis for transnational regional collaboration in a wider perspective on maritime shipping interests related matters.

B.2.2 Composition

The NSR-PHG membership may consist of
- representatives from the policymakers of relevant invited NSR Member State and national Government statutory bodies with e-Navigation policy and decision making competences;
- representative of competent and regional authorities and service providers with policy decision making competences;
- replenished with representatives of policy departments where deemed necessary by the participants;
- major (private) operational service providers participating in the NSR-SPCG - with no policy decision making competences - in an advisory role.

B.2.3 Tasks and responsibilities

The tasks and responsibilities of the NSR-PHG are
- **Identify and highlight** emerging e-Navigation related policy issues;
- **Contribute** to the development of

- o the IMO e-Navigation Strategy Implementation Plan and relevant developments as adopted by IMO
- o the relevant developments on e-Navigation and the substantial approved Guidelines and Recommendations by the IALA Council;
- **Indicate** on how international and regional developments can be utilised to help future e-Navigation policy and operationally orientated choices in the NSR;
  - *To set the conditions for harmonized policy choices and decisions on the e-Navigation implementation in the NSR.*
  - *To discuss any issue which exceeds the boundaries of the mandates of the former ACCSEAS individual partners or of NSR service providers and users, and for which decisions should be taken and guidance provided in order to ensure the implementation of e-Navigation in the NSR.*
- **Identify and develop**, where appropriate, common regional positions and input for the development of the e-Navigation concept in the relevant international organizations (IMO, IALA, IHO, EU);
- **Provide** policy integration advice and support with respect to:
  - o Input generated by the NSR Service Providers Coordination Group (NSR-SPCG);
  - o The development of a practical plan for the future, building on the results of the ACCSEAS project, consisting of :
    - *to ensure continuity and harmonisation of e-Navigation from 2015 to 2020 and beyond;*
    - *the co-ordination and harmonisation during the implementation of e-Navigation into a regional Sustainability Work Plan 2020+ and a roadmap for e-Navigation service expansion across the North Sea;*
- **Contribute** to policy discussions and debates of the NSR e-Navigation Users Forum, NSR Service Providers Co-ordination Group and Annual or Biennial regional conferences.
- **Indicate** on how Member States and National Administrations can develop an enduring framework for future maritime access and safety improvements to the NSR
  - o *to develop, establish and monitor the conditions for future collaboration in the NSR;*
  - o *to identify, develop and endorse the use of common (shared) instruments to facilitate this collaboration and to support the development of common policy and infrastructural views for the region;*
  - o *to investigate and discuss adjustment opportunities for eventual partnerships of future implementation of e-Navigation (policies, services to be provided, investments);*
  - o *to discuss future Marine Spatial Planning developments from the Flag State, Coastal State and Port State perspectives from maritime shipping perspectives:*
  - o *taking into account the international developments on this subject in IMO/IALA and in the EU;*
  - o *establishing and maintaining the links with the North Sea Commission and OSPAR;*
  - o *to discuss eventual common shared inputs to these developments;*
  - o *to study and discuss the effects and consequences of e-Navigation on Marine Spatial Planning and other potential instruments in the region;*
- **Maintain** links with non-participating member states and national government decision and policymakers.
- **Advise** Member States, National Governments, other EU regions and successor project(s) of ACCSEAS on the variety of e-Navigation implementation aspects.

B.3 Terms of Reference for the NSR Service Providers Coordination Group (NSR-SPCG)

There is a common understanding that e-Navigation will be supportive to other major programs/concepts such as the IMO Sustainable Maritime Transportation System (SMTS) and e-Maritime (EU). e-Navigation is aiming at safe and secure navigation, the accessibility of sea areas and port approaches, the efficiency of shipping (berth-to-berth and linking to other transport modalities) and the protection of the marine environment. Identified potential solutions (e.g. ACCSEAS project)

will not only contribute to the general aims as mentioned above, but also will lead to benefits (direct or indirect) for aspects of the EU Green and Blue belts programs, e.g. efficient navigation, route advices, no-go areas etc. contribute for example to reduction of SO2- emissions.

The development of solutions and services for e-Navigation as well as of applications contributing to the implementation these solutions and services is an ongoing process and will accelerate now the Strategic Implementation Plan (SIP) for e-Navigation has been approved by the Maritime Safety Committee (November 2014). Although the SIP indicates 5 prioritized solutions to start with, the emphasis is on the development of navigation, communication and information services (19 Maritime Service Portfolio's) to enhance the interaction between ships, ship-to-shore, shore-to-ship and shore-to-shore.

The key words in the e-Navigation process is the 'harmonization' of these services (where many stakeholders are involved) and the 'standardization' of equipment aboard, infrastructure ashore, system interfacing, as well as the delivery and exchange of data and information. Specific attention shall be given to the Human-Machine interface and the portrayal of data. A core element of e-Navigation and key to a future successful implementation is its integrated Architecture.

It is obvious that a specific group of stakeholders, **the service providers**, brought together in a NSR Service Providers Coordination Group (NSR-SPCG) will play a major role by developing and implementing the variety of services and that a co-ordination platform between these stakeholders is necessary to assure harmonization of services and applications and standardization technology and data exchange.

B.3.1 Objectives

The objectives of the NSR-SPCG are to
* **provide** in a regional platform for national administrations, public competent authorities and major private providers of e-Navigation Maritime Service Portfolios (MSPs - a combination of functional, operational and technical services);
* **(further) develop** current and future (new) MSPs and relevant applications;
* **harmonize** the development and implementation of MSPs for the NRS;
* **harmonize** the regional communication, navigation and data transport capabilities for the NSR;
* **standardize** shore based infrastructure, technical and interfacing aspects of systems;
* **standardize** functional and operational processes and procedures where appropriate;
* **develop and advise** on the NSR operational and technical architecture for e-Navigation in the NSR;
* **advise** the NSR-eNAV-CP and the NSR-HPG on matters for policy decision-making.

B.3.2 Composition

Participants in the NSR-SPCG are representatives of
* relevant **national or other competent authorities and organizations** with a mandate providing either functional or technical services, separately or in combination;
* **major (private) operational service providers** with no policy decision making competences;
These services
- are covered by the international agreed definition of Maritime Service Portfolio's as reflected in the IMO Strategic Implementation Plan (SIP) for the e-Navigation concept, as approved by MSC94;
- have the aims to enhance safe and secure of navigation, the accessibility of NSR sea areas and port approaches, the efficiency of shipping and the protection of the marine environment.

B.3.3 Tasks and responsibilities

In general the NSR-SPCG will be a platform where service providers shall
* **Contribute** to the development of the Maritime Service Portfolios for the North Sea Region (NSR-MSPs) and supportive solutions/applications taking into account

- o the IMO e-Navigation Strategy Implementation Plan and relevant developments as adopted by the IMO
- o the relevant developments on e-Navigation and the substantial approved Guidelines and Recommendations by the IALA Council;
- o the relevant EU policy programs, directives and projects;
- o the relevant regional and national policy making for the North Sea Region (NSR)
- o (policy) developments by recognized regional bodies;
- **Contribute and support** to the development of <u>potential</u> services and solutions for e-Navigation;
- **Discuss** user needs (provided to the service providers by above policy makers, maritime industry, the NSR User Forum, and/or individual stakeholders or users) and technical requirements resulting from those and their contribution to the NSR-MSPs and service applications and identify related interoperability and data management related issues;
- **Present and discuss** results of NSR-MSPs and service applications under development;
- **Monitor, identify and discuss** relevant or related projects (global or pan-EU or regional-EU) where NSR developments could connect or where other regions of the EU, the EU at large or even the international maritime community could benefit;
- **Explore** the opportunities for joined developments of service applications, investments as well as for joined establishment, execution and co-ordination of test beds;
- **Validate** the results of test beds for potential NSR-MSPs contributions and service applications under development;
- **Identify and discuss** eventual legislative, organizational, procedural, operational, technical and infrastructural consequences for the implementation of the NSR-MSPs and service applications under development where appropriate;
- **Advise** national administrations and authorities and organizations (with a mandate providing either functional or technical services or in combination) and NSR-PHG on all issues mentioned above, where appropriate;
- **Disseminate** the establishment of test beds and **report** the results and findings to an appropriate internet portal, in accordance with the international Guidelines, and to the NSR e-Navigation User Forum;
- **Support** the evaluation of implemented NSR-MSPs and service applications.

B.4 Terms of Reference for the NSR e-Navigation User Forum

In order to deal with all the identified future challenges and potential risks for the NSR and to achieve a well harmonized implementation of e-Navigation it is essential that future participation of stakeholders shall be assured. Therefore the consultation of these stakeholders and the dissemination of the progress of the regional development and implementation of the concept shall be maintained as long as deemed necessary.

B.4.1 Objectives

The objectives for the establishment of the NSR e-Navigation Users forum are to
- **promote** e-Navigation awareness;
- **inform** the variety of users (stakeholders) about the progress of the development of the concept in the relevant international fora (IMO, IALA, IHO) and associated EU programs and projects;
- **disseminate** information from the NSR e-Navigation Coordination Platform (NSR-eNAV-CP) and the regional development and implementation of e-Navigation;
- **ensure** users (stakeholders) participation and collect feedback on these developments;
- **collect and verify** evolving user needs and specific requirements, where appropriate;
- **collect and evaluate** user experiences after the implementation of (new) NSR Maritime Service Portfolios (MSPs), processes and procedures.

B.4.2 Composition

The focus of the NSR e-Navigation Forum is regional which consequently aims at the participation of regional stakeholders and/or users. These are identified and reflected in section 3.2.1. of the "ACCSEAS Baseline and Priorities Report", table 3-4 (IMO's list of "potential e-Navigation users", IMO 2009, Annex 2). The table provides in a wide range of stakeholders and/or users of e-Navigation who may be invited and may contribute with their feedback and experiences to the further concept and implementation in the NSR. A legacy of the ACCSEAS project are the contact and addressee lists used for events during the project.

B.4.3 Tasks and responsibilities

- **The tasks and responsibilities of the Forum are to**
- **validate** user needs in an on-going process
- **suggest** new e-Navigation related areas for study, attention or development
- **evaluate** implemented NSR Maritime Service Portfolios (MSPs)
- **provide** input for further development of NSR e-Navigation based on 'best practices';
- **provide** answers and views to presented questions and theses on request of the NSR-eNAV-CP and underlying Groups
- **advise** the NSR-eNAV-CP and underlying Groups on user related aspects (equipment, Human/Machine Interfacing, training)
- **inform** the NSR e-Navigation community on new developments, programs and projects.

B.4.4 Organization of the Forum

The NSR e-Navigation Forum shall be organized (using the same mode of operation as under the ACCSEAS project)
- by a Committee installed by and under the jurisdiction of the NSR e-Navigation Co-ordination Platform (NSR-eNAV-CP);
- on a 2-to-3 days meeting format, in combination and back-to-back with an eventual Annual or Biennial NSR e-Navigation Conference; and
- offer workshops (taking format and structure from the ACCSEAS VieWs meetings) centering on discussions about regional e-Navigation developments, service implementations and expansions, on questions and theses as well as on other relevant proposals.

B.5 Terms of Reference for an Annual or Biennial NSR e-Navigation Conference

A NSR e-Navigation Conference should on one hand be regional orientated with a focus on e-Navigation for the NSR, on the other hand be open for ideas from outside the region. Through it objectives a Conference should contribute to an integral view and approach for the implementation of e-Navigation (regionally and globally)

B.5.1 Objectives

The objectives of a NSR e-Navigation Conference should be to
- **promote** e-Navigation awareness;
- **promote and present** the NSR as one of the high-ranking regions in EU and worldwide developing innovative solutions for a rapidly changing maritime environment (example function);
- **disseminate** the development and implementation of e-Navigation MSPs in the NSR;
- **present** its contribution to the development of a sustainable maritime transportation system from a European perspective;
- **share** experiences and results of regional test beds on e-Navigation and other instruments (e.g. Marine Spatial Planning) to deal with challenges in respect to the risks for safe and secure navigation, accessibility of confined sea areas and port approaches;

- **present and share** results and experiences gained during the implementation phase of e-Navigation in the NSR;
- **learn** from similar e-Navigation developments and implementation issues from other sea areas (within and outside the EU);
- **provide** a platform for the maritime industry to present (new) developments in respect to e-Navigation services, applications and technologies.
- **influence** the views on sustainability of maritime transport, the reduction of noxious emissions and their relations to combined instruments (e.g. Marine Spatial Planning, RTM, future VTS, vessel traffic management through enhanced interaction shore-ship, data management, communication and navigation concepts);
- **identify and explore** potential contribution to e-Navigation by all stakeholders, including industry and manufacturers in respect to future work and a sustainable future work plan for the NSR;
- **contribute** directly and indirectly to EU programs (e.g. e-Maritime, e-Freight, development Motorways-of the Seas, Maritime Single Windows and others).

B.5.2 Composition

Participants may be all relevant stakeholders of e-Navigation as identified by IMO (EU or non-EU) and any party interested in the enhancement of the safe and secure navigation, accessibility issues, protection of the environment or the development of a future sustainable maritime transportation system linked to other transport modalities (so-called Synchromodality).

B.5.3 Tasks and responsibilities

The tasks and responsibilities for the Conference shall be to
- **deliver** a substantial report of the Conference reflecting the presentations, discussions and proposals;
- **deliver** a set of professional and valuable conclusions and recommendations for the development and implementation of e-Navigation in the region as well as contributing to the e-Navigation concept globally;
- **present** users feedback as well as suggestions and proposals for future work;
- **disseminate** the input, outcome and output of the Conference to relevant international, regional and nationals organizations.

B.5.4 Organization of the NSR e-Navigation Conference

Taking into account
- **the increase** of Conferences on e-Navigation worldwide;
- **an overload** of the international regular agenda in respect to maritime and transport matters;
- **to avoid** competition with "neighbouring" conferences such as the Annual Conference "e-Navigation Underway" as organized and hosted by the Danish Maritime Authority (and its worldwide perspective) in conjunction with IALA, Nautical Institute and CIRM;
- **keep out** of repetition of (aspects) of programs;
- **lack** of human resources, due to the potential participation of regional representatives in substantial but also time consuming test beds, identified future works as well as EU and other projects (increasing demand on financial and human resources);
- **substantial and organizational** efforts to be made and the demand on (financial/human) resources for organizing international/transnational conferences (experiences gained for instance during the ACCSEAS project)

it is recommended to organize future NSR e-Navigation Conferences **biennially**.

The NSR e-Navigation Conference may be organized biennially, supported by EU funding or in collaboration with other international, regional and national organizations, using the same mode of operation as the annual Conferences under the ACCSEAS project,

- by a Committee installed by and under the jurisdiction of the NSR e-Navigation Co-ordination Platform (NSR-eNAV-CP);
- on a 2-to-3 days meeting format, in combination and back-to-back with a NSR e-Navigation User Forum;
- offering workshops (taking format and structure from the ACCSEAS VieWs meetings) centering on discussions about regional e-Navigation developments, service implementations and expansions, on questions and theses as well as on other relevant proposals.
- hosted by NSR countries in turns.

This page is deliberately blank

Annex C   Plan for Sustainable Work after ACCSEAS Project ends

Relevant subject	Number	Future Work
Consequences of e-Navigation	**FW -1**	Administrations, organizations and competent authorities to investigate and determine. collectively (transnational) or individually (national), the consequences of the (future) implementation of e-Navigation taking into account the list of common accepted consequences of e-Navigation (section 2.5 of the Legacy Report) on regional and national level, including undertaking a risk analysis *("what if, what if not")* and a cost/benefit analysis.
Structure of coordinated e-Navigation in the NSR, fora and Terms of References	**FW -2**	One or more national NSR administrations organizing and hosting a preparatory coordination meeting for setting up the organizational structure of future coordinated e-Navigation development and implementation in the NSR.
Communications and Publications as legacy ACCSEAS	**FW -3**	To keep the ACCSEAS website www.accseas.eu "in the air" after project ends. During the project it was already agreed that the website will be kept available until 12 months after the project formally was ended. It may be considered to update the website during this period with relevant or crucial developments on e-Navigation in general or in the NSR will be inserted to keep the interested community updated as far as practicable.
	FW -4	Through proper measures (e.g. website) to ensure that the ACCSEAS reports, results of testbeds, demonstrators and videos will be kept available for the relevant international, regional and national parties.
	FW -5	Beneficiaries of the ACCSEAS project are strongly invited, in conjunction with the relevant Guidelines by IMO and IALA, for sharing the testbed results on a central public website www.enavigation.net (currently hosted by the Danish Maritime Authority).
	FW -6	Through proper measures to ensure that the data and information of the ACCSEAS network (of organizations, experts, stakeholders, authorities, policymakers and other parties involved) will be preserved for future work and to the beneficiaries of the project.

Building on ACCSEAS research future identification of risk areas and "hot spots"	FW -7	NSR Administrations, relevant organizations and competent authorities to investigate the opportunities to collect and share regional AIS data over a period of at least 5-7 years (2011-2018) period with the purpose for research, identification of trends, risk analysis and assumptions. At present, the provision and sharing is constraint - in most cases a result of national confidentiality legislation or internal agreement -. A regional position in this matter should be developed and a collaboration agreement be negotiated.
	FW -8	EMSA to continue with the collection and provision of yearly accidents statistics for the NSR and extend the period from 2010 until 2020. During ACCSEAS a two years period 2010-2012 was available which is considered to be too short for doing statistics.
	FW -9	NSR Administrations, relevant organizations and competent authorities to perform after a period of 2-3 years after project ends (2017-2018) - and after that on regular intervals a risk analysis -, using IWRAP, updated data in conjunction with the Route Topology Model, with the aim to identify risk areas where e-Navigation Maritime Service Portfolio in combination with other measures are needed.
Couching maritime/shipping interests in sea space allocations	FW -10	The maritime community to ensure an adequate representation in future transnational Marine Spatial Planning to couch its interest, preferably through transnational coordination.
Continuity assessment and validation of maritime growth forecasts provided by ACCSEAS	FW -11	For the development of future regional (transnational) NSR policies and national plans administrations and competent authorities should, taking into account ongoing readjusted data of relevant international/national sources perceptions, further assess and validate the forecasts provided by ACCSEAS.
Sustainable Maritime Transportation System (SMTS)	FW -12	IMO should make expressive the importance of the role of coastal states for shipping in a future reviewed edition of the SMTS.
	FW -13	The proposed IMO SMTS should - taking into account as a legacy of ACCSEAS the identified SMTS key elements, the compilation of goal domains, goals, identified partners - further be studied and projected on the NSR, in order to further investigate and identify all potential contributions and actions, as well as to determine their consequences. This future work may not only benefit the NSR region but also to contribute and connect to EU developments (programs such as e-Maritime and other relevant projects) and other EU regions and provide as an example function a blueprint for other regions.
IMO Strategy Implementation Plan (SIP) after results of actions initiated by IMO/MSC94 and MSC95	FW -14	Consequently prior to decisions for and the actual implementation of e-Navigation (Sub-) Solutions as identified in general and particularly by ACCSEAS - as the results provided and final approval by

		IMO/MSC95 will take place after the ACCSEAS projects ends - further work may be necessary in order to bring the tables mentioned in the sections 6.7.1 and following and as reflected in the "ACCSEAS Baseline and priorities Report" as well as relevant parts of the "ACCSEAS Architecture Report" (e.g. mapping) in line with the results of the actions initiated by IMO/MSC94 and MSC95.
Dissemination of ACCSEAS work as building blocks and input to EU Interreg projects, other EU projects and programs	**FW -15**	Dissemination of the relevant work and results of ACCSEAS to EfficienSea 2.0 as building blocks for the further development of for instance the Maritime Cloud, Maritime Safety Information, Route exchange and Route Advice, Automated FAL reporting, digital shore based Infrastructure, Resilient PNT.
	FW -16	Dissemination of the relevant work and results of ACCSEAS to the Interreg IV/B Programme to complement and supplement the results of the Maritime Transport Cluster.
	FW -17	Dissemination of the relevant policy related work, results and potentials of ACCSEAS to the European Commission (e.g. DG Move and DG Mare).
	FW -18	The European Commission to ensure that national, regional and local maritime spatial plans are coherent taking into account the interests of all stakeholders.
	FW -19	Dissemination of the relevant work and results of ACCSEAS to the North Sea Commission (NSC)
	FW -20	Dissemination of the relevant work and results of ACCSEAS to relevant recognized platforms dealing with Marine Spatial Planning issues e.g. OSPAR
	FW -21	Establish a regional mechanism outside of or beyond ACCSEAS to advise how e-Navigation can assist compatible and coherent use in the context of common principles. This mechanism may incorporated in the establishment of the proposed NSR-eNAV Coordination Platform, as described in sections 3.1 and next in this Legacy Report.
	FW -22	Dissemination of the relevant work and results of ACCSEAS, inform about the capabilities and potentials of e-Navigation systems on data provision to CISE
	FW -23	Dissemination of the work and results of ACCSEAS to the EU Maritime Forum

	FW -24	Dissemination of the relevant work and results of ACCSEAS to OSPAR and HELCOM; establish a link between the proposed NSR-eNAV Coordination Platform, as described in sections 3.1 and next in this Legacy Report, and OSPAR.
	FW -25	Dissemination of the relevant work and results of ACCSEAS to members of the European Parliament and to the Council with reference to the Integrated Maritime Policy.
	FW -26	Dissemination of the relevant work and results of ACCSEAS to the BE-AWARE projects
	FW -27	Promote and contribute to an integrated information management system to enable the identification, monitoring, tracking and reporting of all vessels at sea and on inland waterways to and from European ports and in transit through or in close proximity to EU waters.
	FW -28	Dissemination of relevant work and results of ACCSEAS to the DG Move with a reference to e-Maritime
	FW -29	Dissemination of work and results of ACCSEAS to the maritime port community in order to enhance the awareness on e-Navigation among port authorities indicating the benefits of the ports involvement in the e-Navigation concept.
	FW -30	Dissemination of relevant work and results of ACCSEAS to the DG Move, DG MARE and EMSA with a reference to TEN-T, Horizon 2020+, Motorways of the Seas, and other relevant projects.
	FW -31	Dissemination of the work and results of ACCSEAS to MonaLisa 2.0 as building blocks for the further development of for instance the Maritime Cloud, Maritime Safety Information, Route exchange and Route Advice, Automated FAL reporting, digital shore based Infrastructure, data exchange in the maritime domain.
	FW -32	The Route Topology Model (one of the "candidate solutions" of ACCSEAS) has the potential to directly fill the identified gap in the INSPIRE Directive concerning the somewhat underdeveloped maritime descriptions. This to ensure that the maritime requirements, such as shipping routes and areas are identified in a harmonized way.
Linking EU policy to the implementation of e-	**FW -33**	ACCSEAS provides policy advice to decision-makers concerning between EU Policy and the international

Navigation in support of the collaboration between EU and IMO.		implementation of e-Navigation is provided by the Maritime Transport Policy. The specific link with e-Navigation is reinforced by Section 6.24 of the IMO NAV57 which calls for collaboration between the EU and IMO. ACCSEAS partners are involved in the working programs of the IMO, IHO and IALA.
e-Navigation Architecture and Standards	FW -34	Beneficiaries of ACCSEAS and representatives in the relevant international and pan-European bodies shall identify conceptual imports on e-Navigation Architecture as potential feedback for the NSR.
	FW -35	The mapping results and considerations of the candidate solutions reflected in the sections 3.3 until 3.9 of the "ACCSEAS e-Navigation Architecture Report" shall be noted and kept under review once the relevant implementation aspects of these solutions progresses.
	FW -36	Taking into account that the further development of both the SMTS and the e-Navigation concepts, as well as the now identified and eventual candidate solutions for the NSR, are subject to an evolving process the table 1 "Mapping of ACCSEAS features and candidate solutions to the SMTS' Actions" as presented in the "ACCSEAS e-Navigation Architecture Report" (May 2015), para 2.2, shall be kept under review and analyzed during future work.
	FW -37	Depending on various regional and local circumstances, differences in users perspectives as well as results of the international development processes of the e-Navigation Architecture (IMO, IALA) • the mapping of the identified and future candidate solutions • the descriptions, definitions and the final embedding and application possibilities as presented and proposed in the "ACCSEAS e-Navigation Architecture Report" (May 2015), para 2.2, shall be kept under review and evaluated for implementation in the NSR.
	FW -38	Considering the massive efforts needed to set up all the generic meta-level service descriptions to be contained in any (generic) MSPs Registry and considering also the fact that e-Navigation is most desired by those regions where there is a high demand due to the traffic situation present and future like in the NSR, *it appears prudent to start with setting up a NSR MSPs Registry as a first step for a much broader international development to come and finally replace the NSR MSPs Registry*
Multi Source Positioning Service (MSPS)	FW -39	S-100 Product Specifications will be required to be developed for data provided by Technical Services and the Operational Services provided by the Multi-Source Positioning Service. The first step will be the development of data models for the following: 1. Vessel positioning information 2. eLoran ASF data

		3. eLoran transmitter almanac data 4. Medium Frequency (MF) R-Mode Transmitter Almanac Data Model 5. AIS (VHF) R-Mode Transmitter Almanac Data Model 6. Differential-Loran Reference Station almanac data
	FW -40	*Collaborative Navigation*. With "Collaborative Navigation" the aim would be to take advantage of the availability of the Maritime Cloud to share radio navigation system calibration data (for example eLoran ASFs) with shore-side databases and other vessels. The ACCSEAS Multi-Source Receiver contains all the necessary components to make propagation data measurements that are vital to the functioning of terrestrial radio navigation systems. This data may be collected during normal operations of the receiver installed aboard vessels going about their business.
	FW -41	Expansion with ARIADNA Functionality. The inclusion of aspects of the EU Framework 7 project ARIADNA could be performed under a future programme of work, including expanding the use of the HPL computation to affect the "volume" of the vessel.
	FW -42	Both the multi-source PNT radio navigation receiver as well as the PNT data processing software are prototypes and bespoke, non-commercialized and developed for running under the mathematical programming environment Matlab™. Future work would involve producing a more "*commercialized*" version of the receiver, with software/firmware provided at the circuit board level. This would present a form factor that is much more appealing to mariners. The interest of the industry (manufacturers) has to be triggered.
	FW -43	Although work is underway by the contractors who developed and supplied the multi-source PNT radio navigation receiver to understand how to build in R-Mode functionality, this will have to be achieved after the ACCSEAS project ends there is therefore scope to expand the receiver's capability.
	FW -44	It would be appropriate to investigate the type approval of a multi-source PNT radio navigation receiver for the ready installation aboard vessels intending to the test MSPS.
	FW -45	The software running on the Multi-Source Receiver platform performs a number of functions. One of them computes and maintains the Horizontal Protection Levels (HPL) for complementary PNT services and the primary GPS service. It was suggested that HPL was a parameter that was only of interest to system designers as an indicator about whether the system is performing as expected. Some further consultation would be required with mariners to determine the level of usefulness of the feature (the mariner should

		have some indication about which system is currently being used to provide positioning information.
	FW -46	Within IALA to further develop and finalize a Guideline on the performance of eLoran services
Ranging Mode (R-Mode) PNT	**FW -47**	The ACCSEAS testbed performed by WSV/Germany and Rijkswaterstaat should be continued in 2015 for the short term after project ends. A midterm testbed preferably performed by the same partners (potentially joined by GLA\UK) should be investigated and planned (a midterm testbed has already been planned in Germany, potentially in the Netherlands and UK).
	FW -48	Opportunities for other R-Mode testbeds outside Europe should be explored (taking into account the growing international interest for R-Mode) with the aim to prove usability in different environments worldwide. A partnership with the US Coastguard and the Australian Maritime Safety Agency (AMSA) should be considered. R-Mode testbeds within the scope of the EfficienSea 2.0 project should be explored.
	FW -49	Future work on the development of R-Mode using MF transmissions from IALA radio beacons shall be done involving the following topics: • measuring the influence of sky wave and other environmental variations • measuring the influence of transmitter and receiver setup • assessment of various R-Mode solutions (based on R-Mode feasibility study)
	FW -50	Explore the opportunities to set up and enlarge the testbeds to include transmissions from AIS shore infrastructure. Further tests are needed to show that a full position solution is possible with the technology, providing improved resilience to PNT required onboard vessels. This would be world first for the technology. Opportunities are recognized to use the technology in combination with Real Time Kinematic (RTK) positioning networks, not only covering harbour approaches, port areas and inland waterways, but also providing a candidate Resilient PNT solutions for other transport modalities such as road and rail.
	FW -51	Establish a testbed to test combination of solutions (R-Mode MF, R-Mode VHF-AIS and e-Loran).
	FW -52	Equipment of at least two further MF-radio beacons with R-Mode setup should be purchased to perform real positioning tests
	FW -53	Further develop the current R-Mode receiver • to perform position calculations • to use AIS transmissions • towards a user friendly receiver

	FW -54	Within IALA to develop a Guideline on the performance of R-Mode services
Absolute Radar Positioning	FW -55	To employ the "passive" radar technique, for example, that developed by Russell Technologies, an early version of which was implemented in Vancouver in the 1980s. This system relies on the addition of an interface box to the already existing ship's radar and cheaper "passive" reflectors rather than e-Racons. The system can even learn the pattern of already existing infrastructure around a port, removing the need for shore-side reflectors altogether. Further work could investigate this latter, more cost-effective method.
Maritime Service Portfolio's (MSPs)	FW -57	Beneficiaries, administrations, competent authorities, service providers and other stakeholders are encouraged to identify "new" services and applications contributing to the safety of navigation and accessibility of the NSR.
The Maritime Cloud	FW -58	Further testing of entities, organizational, operational and technical aspects of the Maritime Cloud is required and could be incorporated in the programs of the EU projects EfficienSea 2.0 and MonaLisa 2.0. or other projects (EU and non-EU). The experiences gained during ACCSEAS can therefore be used as a common reference framework.
	FW -59	Further development of the Service Registry is required for facilitation and implementation of the Maritime Service Portfolio (MSP) concept by providing a repository for the specification of operational and technical services and provisioned service instances. The service registry is intended to span all maritime services, not only digital services, thereby making it a single reference point for provision and discovery. The Service Specification Standard finally will have to be determined.
	FW -60	The need for the establishment of the Maritime Identity in the Maritime Identity Registry and its benefits shall be further promoted and clarified for international support and acceptance.
	FW -61	The current considerations on issues such as 'Governance' and 'Operations" (use of one or more global datacenters and existing infrastructures, as well as the presumed interactions between ship and shore) require further research and the establishment of understanding and support internationally.
Dynamic No-Go area service	FW -62	The potential of the Dynamic No-Go area service is recognized and its contribution to safe and efficient navigation has been confirmed, specifically for areas with shallow and confined waters. The service needs to be further developed taking into account the experiences and feedback gained during ACCSEAS. Accessibility issues for the automated collection of and provision of bathymetric data through the service needs to be investigated.

Route Topology Model (RTM)	FW -63	To create both a list and a graphical, user-friendly depiction of all shipping lanes existing in the NSR today, together with their true locations as well as their true connectivity amongst each other and with land via ports. This could be done by using one consistent description methodology, 'Route Topology Modelling (RTM),' thus creating a North Sea Region Route Topology Model (NSR-RTM) for the present situation. It will be necessary to distinguish in this NSR-RTM the different classes of shipping lanes as introduced above, both in terms of their features and attributes as well as in terms of their display to the user via a Human Machine Interface (HMI).
	FW -64	Since this NSR-RTM would use the presently available data, any application implementation would be possible, in principle, within a relatively short-term implementation period.
	FW -65	Use the NSR-RTM, once developed, for the description of the future situation. Namely, there may be a NSR-RTM for the year 2020+, tentatively dubbed 'NSR-RTM-2020+,' which may assist in describing in a harmonized manner the perceived future situation throughout the NSR.
	FW -66	Prioritize the applications for the use of NSR-RTM, as described in section 5.2 and following of the document "ACCSEAS North Sea Region Route Topology Model (NSR-RTM) - Description and contribution to an international generic RTM definition", April 2015 for further development and eventual implementation taking into account the needs of relevant stakeholders involved.
	FW -67	Introduce ACCSEAS NSR-RTM as an example in the relevant international and European fora with the aim to produce Recommendations and Guidelines on the development, implementation and use of RTM in conjunction with other instruments and explore the opportunities for support and acceptance of a generic RTM in support to the various identified developments (e.g. SMTS, e-Navigation, e-Maritime, TEN-T).
	FW -68	In order to be reliably used by different stakeholders and users, even to the extent of using a NSR-RTM for navigation, the NSR-RTM work needs to be re-done after ACCSEAS taking into account the following considerations. By doing this, the NSR may create benefit for itself but also provide relevant input to pan-European projects and initiatives. The relevant proposals for future work as reflected in Appendix C (sections 11.1 and following) of the document "ACCSEAS North Sea Region Route Topology Model (NSR-RTM) - Description and contribution to an international generic RTM definition", April 2015, should be taken into account and considered.
	FW -70	Further explored after ACCSEAS should be:

		• Integration of RTM into 'e-Navigation': Adaptable advance route planning. • Relationship between routes and collision avoidance: Can there be introduced wrong behavior due to route designations? • Difference between strategic and tactical use of RTM • Assessment of safety impact for navigational use of RTM
Maritime Safety Information/Notice to Mariners Service	**FW -71**	The developments on the MSI/NM service shall be continued under the EU project EfficienSea and/or other related e-Navigation projects. The feedback and conclusions as reflected in section 6 of the ACCSEAS document "Service Description: Maritime Safety Information/Notice to Mariners Service", April 2015, shall be incorporated in this future work.
Intended Route Service	**FW -72**	The Intended Route service shall be further developed in the EU projects EfficienSea 2.0 and MonaLisa 2.0 and/or in other related e-Navigation projects. The feedback as reflected in section 4 of the ACCSEAS document "Service Description: Tactical Exchange of Intended Routes", April 2015, shall be taken into account.
Harmonized Data Exchange – Employing the Inter-VTS Exchange Format (IVEF)	**FW -73**	The service should be further develop, tested in conjunction with the Maritime Cloud and prepared for operational implementation.
	FW -74	An IALA Guideline on IVEF should be reviewed and amended according to this new service. Awareness of the availability of the service should be increased among potential stakeholders.
Vessel Operation Coordination Tool (VOCT)	**FW -75**	The service should be further develop and tested in the EU project EfficienSea 2.0 and prepared for operational implementation.
	FW -76	Awareness of the availability of the service should be increased among potential stakeholders.
Automated FAL reporting	**FW -77**	Based on discussions during a number of international Conferences (including ACCSEAS) the stakeholders in the maritime community (e.g. mariners, VTS, ship owners etc.) indicated that the highest priority now is to develop the MSP "Automated FAL reporting" (as referenced to in the IMO e-Navigation Strategy Implementation Plan (SIP)). This development should be in accordance with the IMO regulations and decisions in the FAL-Subcommittee, A number of EU projects (e.g. AVANTI) are directly/indirectly involved in this matter, There is also a link to the development of National Single Windows. The results of ACCSEAS

		should be disseminated to this projects in support.
Real time warning system based on historical AIS targets behavior	**FW -78**	Consultancy for such a service among the VTS Community is needed as well as the development of a full service proposal (including Product Specifications). This can be presented to IALA for further comments and investigations, e.g. as part of the development of MSP-3 (IMO SIP, 2014) Traffic Organizations Service, or contributing to the package of decision making tools and reporting of VTS.
Dynamic Predictor (for tug boat operations)	**FW -79**	Based on the feedback provided further development of the application may be considered during the EU projects EfficienSea 2.0 and MonaLisa 2.0
Augmented reality: Head Up Display (HUD)	**FW -80**	Feedback after demonstrations showed that there is an interest among potential users (mariners) for this highly innovative service. As the main focus so far concentrated on the portrayal of data ergonomically aspects should be further investigated. Further development is needed, including identification of specific user requirements. The feedback received at the 3rd Annual ACCSEAS Conference should be taken in account for the further development of the application in a follow-up or other relevant projects (EU and non-EU)
Use of Simulation	**FW -81**	IALA should be attended to documentary consequences in respect to "IALA Model Course V-103/1 – Vessel Traffic Services Operator Training" as a result of the prioritized solution S9, which may require new technical and operational competencies for VTS personnel.
	FW -82	For further testing and training purposes of candidate e-Navigation solutions a simulator network of VTS stations and vessels should be created within a future test-bed, based on the results of the following EMSN concept.
	FW -83	For further testing and training purposes of candidate e-Navigation solutions both the simulator and the trainees have to be prepared relating to IBS and INS.
	FW -84	It should be investigated, using the EPD simulation, how to present messages with no geo-graphical information on graphical clients such as ECDIS and ensure that they are read by the officer on watch (OOW).
NSR Geographic Information System (GIS)	**FW -85**	NSR Administrations and parties participating in a future NSR e-Navigation Coordination Platform (NSR-eNAV-CP) on e-Navigation are invited to discuss and formalize governance of a continued utilization

		of NSR-GIS.
	FW -86	NSR Administrations and parties participating in a future NSR e-Navigation Coordination Platform (NSR-eNAV-CP) on e-Navigation are invited (advised by the ACCSEAS Steering Group) to identify and decide on a common agreed manner to ensure the future maintenance of the NSR-GIS and prepare the relevant arrangements, where appropriate.
	FW -87	NSR Administrations and parties participating in a future NSR Policies Harmonization Group (NSR-PHG) on e-Navigation are invited to explore solutions and develop a framework solving legal constraints for the future delivery of data for the NSR-GIS.