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e-MARITIME SERVICES FOR COMMUNICATION WITH CLASS AND FOR ENHANCED SAFETY, SECURITY AND ENVIRONMENTAL PROTECTION IN SHIPPING

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Abstract: e-Maritime can be considered as an extension of the e-Navigation concept currently being discussed at the International Maritime Organization (IMO). It can be construed to include e-Navigation and promotes the use of all maritime data and information, distributed by way of information and communication technologies, to facilitate maritime transportation and provide value added services. This paper investigates possible e-Maritime services related to safety, security and environmental protection of shipping and for interaction with class. The paper reviews a number of existing services and current initiatives and relevant research projects and discusses if and how the value of such services could be increased if they could be offered as e-Maritime services to the industry. Furthermore, two services have been selected and successfully implemented as pilot e-Maritime services. Based on this survey and the pilot implementations, it can be suggested that there are great potential for offering a number of existing and future services related to safety, security and environmental protection as e-Maritime services. However, standardisation of the framework and of specific maritime data types, messages and codes might be necessary to facilitate a development towards widespread adaptation of e-Maritime solutions.

Keywords: maritime transportation, e-Navigation and e-Maritime, ship-shore communications, maritime safety and security, ship classification.

1. Introduction and Background

1.1. e-Navigation

The concept of e-Navigation was initially introduced by the International Maritime Organization (IMO) to increase safety and security in commercial shipping by way of improved organization of data and improved data exchange and communication between ship and shore. The scope of e-Navigation as defined by the IMO and formulated by IALA (International Association of Lighthouse Authorities) is *the harmonized collection, integration, exchange, presentation and analysis of marine information onboard and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and for protection of the marine environment.* Hence, the strategic vision of e-Navigation is related to the utilization of existing and new navigational tools, i.e. electronic ones such as ECDIS (Vanem et al., 2008), in a holistic and systematic way.

One main motivation for the initiative was studies that indicated that the combination of navigational errors and human failures

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was increasingly contributing to ship accidents. A number of ship- and shore-based technologies have been developed and are available, including AIS (Automatic Identification System), ECDIS (Electronic Chart Display and Information System), IBS/INS (Integrated Bridge Systems/Integrated Navigation System), ARPA (Automatic Radar Plotting Aids), radio navigation, LRIT (Long Range Identification and Tracking) systems, VTS (Vessel Traffic Services) and the GMDSS (Global Maritime Distress Safety System). It is believed that such technologies may contribute to significantly reduce navigational errors and failures, and simultaneously reduce the burden on the navigator, but that they need to be co-ordinated and integrated in order to reap the full benefits of such technologies. Hence, e-Navigation aims at integrating existing and new navigational tools, in particular electric tools in an all-embracing system that will contribute to enhanced navigational safety (Kystverket, 2012).

Even though e-Navigation is essentially meant to improve safety and security aspects of maritime transportation, it also has the potential to increase efficiency of ship operations, a main concern for ship-owners, operators and their service providers. The Marine Electronic Highway system in the straits of Malacca and Singapore is a trial project where possible e-Navigation solutions can be tried out (Marlow and Gardner, 2006; Dahalan et al., 2013).

An extensive list of possible e-Navigation solutions was proposed in (IMO, 2012e), and it was found necessary to focus on a limited number of generalized and prioritized solutions. Hence, the correspondence group on e-Navigation to NAV 59 prioritized the following five main potential e-Navigation solutions (IMO, 2013):

- Improved, harmonized and user-friendly bridge design,
- Means for standardized and automated reporting,
- Improved reliability, resilience and integrity of bridge equipment and navigation information,
- Integration and presentation of available information in graphical displays received vie communication equipment,
- Improved communication of VTS service portfolio.

These solutions have been subject to risk and cost-effectiveness assessment according to the Formal Safety Assessment (FSA) which has been used as basis for proposing various risk control options for implementation at IMO. Central in the e-Navigation concept is reliable and automated communication and information exchange, which rely on a common maritime data structure (CMDS). When relevant, it will make use of the International Hydrographic Organization (IHO) standard for hydrographic data (IHO, 2010; Ward and Greenslade, 2011).

1.2. The e-Maritime Strategic Framework (EMSF)

e-Navigation is not intended to cover commercial interests, but commercial users may expect services and capacity for carrying additional information to improve operational efficiency of shipping as well as improving the safety and security of navigation. Such a system for adding maritime commercial interests to e-Navigation is often referred to as e-Maritime. e-Maritime thus includes e-Navigation and promotes the use of all maritime data and information, distributed through ICT, to facilitate maritime transport and provide value added services. Hence, e-Maritime aims at both reducing costs for shipping and coastal states and delivering benefits for the commercial shipping industry.

The e-Maritime Strategic Framework is a target model for maritime transport pertaining to common industry interests and business benefits to be realized in short or long term. It includes a description of processes, actors, rules, information flows and other domain entities. In particular, it will describe information exchange requirements for different user communities and explain how these can be achieved through appropriate processes, standards and policies. The specification of the e-Maritime Strategic Framework is addressed in the eMar deliverable D1.3 (Cane et al., 2013).

The e-Maritime Strategic Framework is used by an e-Maritime Ecosystem which supports the execution of various e-Maritime applications built up from elementary e-Maritime services. The interrelationships between the main e-Maritime components are shown in Fig. 1. The EU-funded research project eMar has been initiated to support the development and specification of the e-Maritime Strategic Framework (Project website: www.emarproject.eu/).

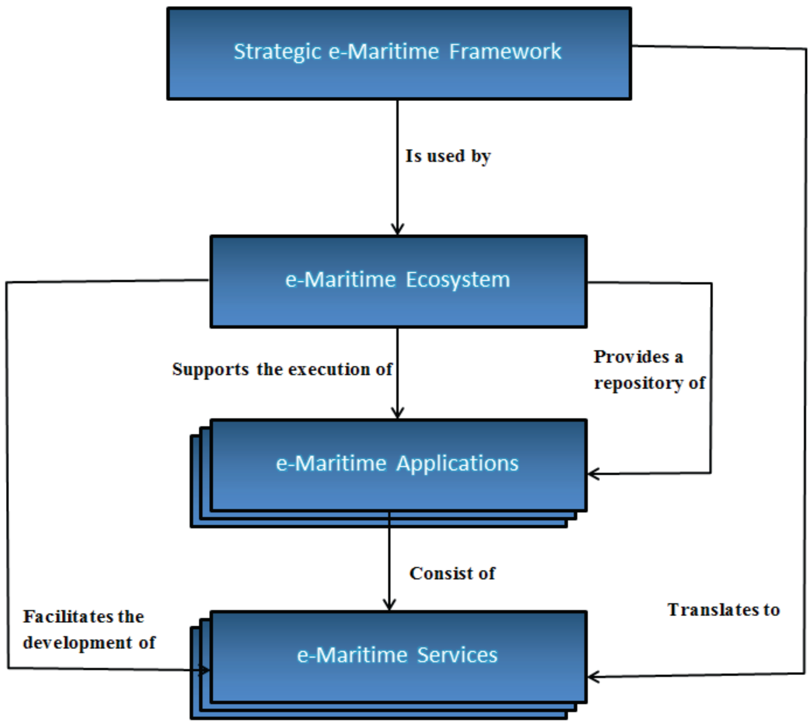

Fig. 1.
e-Maritime Components

1.3. The e-Mar Ecosystem

The eMar Ecosystm should support the implementation of the e-Maritime Strategic Framework, utilizing existing technologies and components. It should provide a repository for e-Maritime application and services, a run-time environment that supports the operation and interaction with the e-Maritime applications and a software development environment for producing additional applications and to integrate with existing ones. The eMar architecture and base software platform are outlined in the eMar deliverable D2.1 (Katsoulakos et al., 2013).

A Service-Oriented Architecture (SOA) will be adopted to support functional reusability and independence of technology. An e-Maritime service is an elementary piece of software that may be used as building blocks for e-Maritime applications. It is interoperable software which translates directly from the e-Maritime Framework.

The eMar Ecosystem will provide connectivity and security services to support different categories of users and application developers. Furthermore, shared information and knowledge will be provided and semantic services will be developed within the eMar project to give all actors a common understanding of relevant concepts, processes and object within the e-Maritime system. This includes an e-Maritime ontology with the formal terminology of all information exchange between all stakeholders as specified by the e-Maritime Strategic Framework, support for semantic annotation of e-Maritime web services, support for run-time interoperability among different platform users and maritime transport specific interface-based mechanisms for automated discovery and integration of suitable services.

The e-Maritime applications consist of software components and data feeds that perform meaningful functions in maritime transportation. Reference e-Maritime applications will be developed for improved business, supporting port operations, ship operations and transport logistics, and for interfacing with administrations and regulatory systems.

1.4. A Maritime Common Reporting Schema (CRS)

In order to support semantic interoperability in information exchange, there is a need for agreeing on data types and code lists. Hence, the development of a common reporting schema (CRS) for maritime was initiated in the EU-project e-Freight (Project website: http://www.efreightproject.eu/) and is being continued and extended in the eMar project. The e-Freight project focused on promoting a standard framework for freight information exchange, and important components are a single European transport document for carriage of goods, a single window concept for all forms of reporting to all authorities and the e-Freight connectivity infrastructure. A common reporting schema was developed, and it was strongly recommended that this CRS should be accepted as standard interface for the national single windows. Standardization is deemed important for industry take-up of the framework (Vayou et al., 2012). However, even though e-Freight is Eurocentric, the inherent international nature of shipping makes global standardization an important success factor and it is recommended to aim for a common standard in the international communities.

The common reporting schema is a single, standardized, electronic reporting document that includes all information fields that are necessary and sufficient for reporting to Authorities in all member states; it defines the structure and content of information that must be reported. It could be extended to include elements other than freight-related information, which is currently being investigated within eMar.

1.5. eMar Applications

The SafeSeaNet (SSN; URL: http://emsa.europa.eu/operations/safeseanet.html) is important for the development of e-Maritime. SSN is a vessel traffic monitoring and information system established as a centralized European platform for maritime data exchange between maritime authorities across Europe. Maritime authorities may provide and receive information of ships, ship movements and hazardous cargo through the SSN, where information are collected from AIS-based position reports and notification messages sent to designated authorities in participating countries. The overall objective is to enhance maritime safety, port and maritime security, marine environmental protection and the efficiency of maritime traffic and maritime transport.

The SSN architecture includes a European Index Server (EIS) which acts as a secure and reliable index system within a network where users can provide and/or request data. The EIS is able to locate and retrieve information on vessels related to one member state upon a request made by another. The main notification reports submitted to SSN are Ship Notification (ships' voyage and cargo information), Port Notification (ships bound for a specific port), Hazmat Notification (ships carrying of hazardous materials) and Incident Report (information on a specific incident). Users may exchange messages through two different interfaces, i.e. an XML-based interface allowing applications of member states to communicate programmatically with SSN (automatically between systems) and a browser-based web interface that enables users to visualize the information stored in EIS.

The National Single Window (NSW) is a means to provide operators with a single point of contact for all reporting requirements relating to vessel movement and cargo and that the relevant information is transmitted automatically to the various national authorities, SSN, e-Customs etc. National Single Windows by different nations are being developed with different national approaches and is influenced by developments in SSN, e-Customs and output from research projects. For example, e-Freight is developing a National Single Window for Latvia as well as a common reporting interface to link businesses to NSWs and this will serve as a baseline for the work in eMar.

Classification societies are often delegated the certification of ships according to IMO conventions, in addition to issuing class certificates and keeping track of survey status. Classification societies are increasingly making use of e-services. In this paper, the potential for interfacing such and related services with the e-Maritime platform will be investigated.

2. Information Exchange between Ship Operators and Class

All sailing ships are required to have valid statutory and class certificates, and it is the ship owners that are responsible for obtaining mandatory certificates and for renewal of mandatory certificates before they expire. Hence, there need to be some information exchange between the ship operators, the ship owners and the classification societies. Often, classification societies are also delegated issuance of statutory certificates on behalf of the national authorities (flag states) that are responsible for the overall safety control of the ship.

Classification of ships is conducted according to the classification rules (see e.g. DNV (2013) for legacy DNV rules) and any other standards to which reference therein are made. A classification certificate is issued upon assignment or renewal of class in accordance with the class rules and is normally valid for five years, conditioned on successful completion of annual and intermediate surveys. The main class is mandatory and stipulates requirements for the vessel's main functions. In addition, a ship may have optional class corresponding to additional requirements for particular vessels, features or systems. A statutory certificate refers to an IMO convention certificate which is issued by national authorities. In principle, the flag authorities are responsible for the safety control of its vessels but statutory certificates may be issued by a classification society on behalf of the national authorities for flag states that has delegated this to class. In principle, valid statutory certificates are a prerequisite for valid class certificates.

Classification of a ship implies that it has been subject to design approval, are surveyed during construction and tested before taken into survey. Furthermore, it is surveyed regularly during its operational life to ensure that the required rule standards are maintained. Complete files on all classed ships are kept by the classification society covering the documentation required by the rules, and this information will not be disclosed to any other party, apart from national authorities involved, without the consent from the owner. The classification society undertakes all required reporting to national authorities with respect to safety certificates.

In the operational phase, compliance with the classification rule requirements is verified by the classification society by a system of periodic surveys. During the five-year period a class certificate is valid, the ship is subject to annual and intermediate surveys covering various parts, equipment and systems depending on the assigned class. The most comprehensive survey is carried out in connection with class renewal. Furthermore, the class society will evaluate the extent of possible damages sustained and verify ensuing repairs to confirm retained validity of class. Any conversions or alterations of a ship that may influence its class status should also be surveyed by class. If deemed necessary by the class society, the ship may also be subject to other unscheduled surveys. The ship owner should inform its classification society if the ship is retained in port state controls.

The ship owner must ensure that the ship is handled in accordance with the rules, that the ship is maintained to rule standards at all times and that all required surveys are undertaken. Furthermore, all necessary information and documentation shall be made available to the class society. Failure to meet any of those requirements may lead to withdrawal of all class and statutory certificates. However, in order to assist the owner in this regard, the classification society normally supplies regular status reports on certificates, surveys and possible conditions of class. In legacy DNV, for example, such information is shared with the clients via the Internet web-based DNV Exchange. With this service, the owner can check the certificate status and surveys due at all times and will also have access to a lot of other information such as vessel history, rules and standards and optionally electronic vessel documentation and scanned vessel certificates. Requests for surveys can also be sent via DNV Exchange. Hence, DNV Exchange facilitates information exchange between ship operators and class. Parts of the information provided by DNV Exchange have been offered as an eMar web service in a pilot implementation, to be outlined later in this paper.

E-class or electronic classification is used to describe a possible future classification system where all documentation and required information are exchanged electronically between the classification society and its clients. It is easy to imagine a development towards electronic certificates and documents.

However, future e-class services may extend beyond this and possibly include systematic collection of data. For example, reported defects may be kept in a central database and used in trend analyses, developing inspection strategies and for highlighting defects. It may help the classification societies issuing safety alerts and corrective actions when necessary. With an electronic system, the ship owners may be granted access to the in-service inspection program and may add data and use the electronic tool for their own follow up on the hull. A full overview of inspection results including e.g. cracks and other findings may be provided. In practice, the DNV exchange tool already fulfils much of this, and is an important step towards e-class.

Future e-class services may also include condition monitoring of the hull and of machinery and critical components (see e.g. DNV (2011)). This yields the advantage of monitoring and exchange of information between the ship and shore and may reduce the burden of surveys and improve the quality of inspections. Such a future classification regime could presumably benefit from interfacing with the eMar Ecosystem, which might provide a useful framework and interfaces in this regard.

3. Potential e-Maritime Solutions for Cooperation in Safety, Security and Environmental Risk Management

In the following, a survey of potential e-Maritime services based on current services and on-going and recent research projects will be briefly outlined. It is emphasized that this selection of possible services is not exclusive; the intention is merely to give some examples of possible e-Maritime services to demonstrate its attractiveness for the maritime industries. Some of the results from this survey have previously been presented in Vanem (2014).

3.1. Emergency Response Services (ERS)

Many classification societies offer voluntary emergency response services to aid ships in distress, although the ERS is not a part of the core class services. A brief discussion on the role of classification societies in casualty management is presented in Panev et al. (2012) and the description below pertains to the DNV ERS (URL: http://www.dnv.com/industry/maritime/servicessolutions/consulting/ers).

The main idea of the emergency response services is to provide advisory on appropriate actions in case of an emergency. Calculations regarding stability, residual strength, ground forces and residual buoyancy in damaged conditions, as relevant, are performed and situations where the vessel's survivability is at risk may be evaluated. The ERS communicates directly with the client through dedicated communication lines, and may share information with other parties involved, e.g. classification services, the port state or the flag state, upon request from the client.

Upon subscription of the emergency response services, 3D computerized models (NAPA-model) of the vessel should be prepared in advance and submitted to the onshore emergency response centre. If damage occurs, the ERS need to receive damage reports and the loading condition of the vessel. As an option, the loading conditions may be reported upon every departure and archived at the ERS so that the actual loading condition at the time of an accident can be estimated without delay. This information is combined with up-to-date information about local weather conditions and tides as well as AIS data for nearby vessels that may be called for assistance.

Typically, emergency response services provide advice based on stability and strength calculations and may determine whether a damaged ship will survive the actual damages. The need for partial or full cargo discharge or re-stow can be evaluated and advice on time to capsize can be given to support decisions of the safest action. In case of fire, the effect of fire fighting water on the strength, stability and residual buoyancy of the vessel can be evaluated to advice on the amount of water that can be used in the fire fighting.

The emergency response service can also provide services in the post-emergency phase by performing calculations to support salvage operations and calculations to support transit to repair yards. Moreover, loading conditions for docking the ship after damage may be prepared.

The actual information that needs to be exchanged during an emergency situation depends on the ship type and specific ship particulars as well as on the accident scenario, and this information needs to be combined with the digital ship models and other relevant information and imported into the ERS tools and software.

The emergency response service involves critical information exchange between the ship and shore and between different shore-based stakeholders during emergency situations and also exchange of information prior to and following an incident (e.g. digital ship models upon subscription, possibly regular reports on loading conditions and post-accident information related to repair and docking operations). Hence, it is believed that such services could benefit from interfacing with the eMar Ecosystem and that it is a prospective e-Maritime service for cooperation in safety and environmental protection.

Emergency preparedness services are a related set of services for gap analyses and assessments of incident response plans and procedures for ensuring safety and preparedness in advance of an incident. Typically such emergency response plans are based on training, exercises, resource management, personnel qualifications and standardized systems as well as a well reflected implementation structure. Possibly, such services could also be provided via the eMar Ecosystem.

3.2. Environmental Monitoring Services

Environmental performance has recently become important for maritime transportation and the shipping industry is offered a wide range of environmental services for demonstrating environmental performance and promoting this as a competitive advantage.

The triple-E (URL: http://www.dnv.com/industry/maritime/servicessolutions/consulting/triple-e/) rating scheme provides a rating from 4 to 1, with 1 being the highest, based on an independent verification of the environmental performances of a ship. The key elements in this scheme are:

- Environmental management system in place and implemented,
- Energy efficient operation is a part of policies, action plans and daily operations,
- Energy efficient ship design,
- Verifiable monitoring, measurements and documentation schemes.

The steps involved in a triple-E rating of a ship are typically the establishment of a contract, the ship owner's self-assessment, third party verification and issuance of a ship specific triple-E rating declaration. Guidelines, supporting documents and tools are provided upon signing of the contract. The triple-E rating is published on the internet and voluntary renewal and upgrading may be requested at any time.

The Energy Efficiency Design Index (EEDI) has been made mandatory for new ships with the aim of promoting the use of more energy efficient, and hence less polluting, equipment and engines (IMO, 2011). The EEDI is non-prescriptive and dictates performance requirements in terms of grams of CO_2 emission per capacity-mile. Three important guidelines have since been adopted related to EEDI, i.e. the guidelines on the method of calculation of the attained EEDI for new ships (IMO, 2012a), the guidelines on survey and certification of the EEDI (IMO, 2012c) and guidelines for calculation of reference lines for use with the EEDI (IMO, 2012d).

At the same time, the Ship Energy Efficiency Management Plan (SEEMP) was made mandatory for all ships, and guidelines for the development of a SEEMP were adopted (IMO, 2012b). The SEEMP is an operational measure that establishes a mechanism to improve the energy efficiency of a ship in a cost-effective manner. The Energy Efficiency Operational Indicator (EEOI) may for example be used as a monitoring tool for ship performance over time (IMO, 2009). This indicator enables operators to measure fuel efficiency of the ship in operation and to assess the effect of any changes in operation such as improved voyage planning or the introduction of technical measures.

In order to assist in structured reporting of emissions to air, en environmental accounting system – *Nauticus Air* – has been developed by DNV. Nauticus air provides a method for ship owners and operators to monitor their emissions to air. It is a system for registration of fuel consumption, transported cargo and the distance sailed. The EEOI can then be calculated on a day-by-day basis or for a selected period, e.g. for each voyage leg, and displayed in graphical charts. Air emissions such as SO_x, NO_x, PM and CH_4 will be reported.

Using this tool, the computed indicator values can be compared for a fleet, for sister ships or for specific periods of time (e.g. voyages). In this way, it may be used to minimise the emissions and help drive the industry towards higher energy efficiency and lower emissions.

The *Nauticus Environment* is an extended environmental performance system that covers additional environmental aspects of the operation beyond air emissions. In addition to the EEOI it includes aspects such as discharges to sea, ballast water, chemicals and waste handling. It hence provides a more complete overview of the ship's environmental profile, which can be benchmarked against industry best practices to document and profile environmental performance internally and externally.

Environmental monitoring services, such as the triple-E rating scheme and the Nauticus Air and Nauticus Environment tools involves exchange of operational data between the ship, a shore-based service provider and the ship operator's shore-based offices. Furthermore, documentation may need to be shared with charterers, authorities and other stakeholders upon request. It is therefore believed that these types of services could benefit from an interface with the eMar Ecosystem, and that these could be examples of e-Maritime solutions for cooperation in maritime environmental risk management.

3.3. Voyage Optimisation Services

NavTronic is a recently completed EU-funded research project that developed a novel routing optimization system for safer, more efficient and environmental friendly maritime trade (Chen, 2013). It aims at providing a holistic routing optimization taking safety, time of arrival, fuel consumption, air emission, comfort and fatigue into account. It would involve on-board dynamic and static sensors, utilize forecasted and measured metocean data such as waves wind and currents and have self-learning capabilities by way of neural networks.

The NavTronic service has an onshore control centre with access to different data sources and the ability to communicate with the ships, where there will be an offshore integration platform and on-board sensors. The offshore integration platform will be located onboard the ship and can access data from the vessel data recorder (VDR) as well as communicate with the onshore control centre, for example over the internet. The NavTronic system will integrate local ship borne real-time sensor data and near real-time remote sensing observations with numerical weather prediction data delivered through the onshore control centre. Locally collected sensor data may include measurements of waves, wind, surface current, fuel consumption and other parameters.

The route optimization includes a sail planning module coupled with evolutionary algorithm software that generates different candidate sail plan solutions. These candidates are evaluated iteratively until converging to a set of recommended routes. An estimated time of arrival and the expected fuel consumption will be associated with each route. The sail planning module will be run on the onshore control centre and will be initiated whenever a request for a sail plan is received, either directly from the ship of from the operating company. It utilizes several sub-modules such as the metocean, hydrodynamic and propulsion (propeller and engine) sub-modules.

The metocean sub-module continually assesses the performance of a number of numerical weather prediction models and the most consistent model in the period preceding a ship passage will be selected as initial input to the sail planner. The hydrodynamic sub-module predicts hull performance under the forecasted metocean conditions for the passage. The propulsion sub-module includes the propeller and engine models and required propulsion will be calculated based on the ships resistance and the selected speed, to determine the expected engine operating characteristics and fuel consumption. In addition, various constraints might be set, e.g. not allowing unrealistic sail plans due to higher speeds than the engine can provide in the relevant sea states or avoiding hazardous areas (no-go areas e.g. due to shallow waters, ice or forecasted extreme weather condition).

Another main module of the NavTronic system is the monitoring and analysis module, and this will constantly monitor the sail plan performance and the sub-module performances. Different post-voyage analyses, comparing expected and measured performances, will be used to automatically improve the sail plan model. Moreover, an optimization module will provide multi-objective optimization of the sail plans based on some optimizing strategy. The modular construction of the system will permit inclusion of additional modules and sensors in future developments, and a set of secondary modules are identified for future improvements of the system, e.g. the emission model and the hull fatigue model.

The NavTronic system, offering route optimization services from a control centre onshore to sailing ships based on various onshore, onboard and remote data sources, is believed to be an obvious candidate for integration with the eMar Ecosystem. It involves a significant amount of information exchange between ship and shore, with respect to data exchange as well as service requests, negotiations and delivery.

3.4. Observation and Protection of Critical Maritime Infrastructure

Parts of the functionality of the NavTronic system outlined above are based on functionality developed in the previous EU-project SecTronic (Project website: URL: http://www.sectronic.eu/). SecTronic is a security system for ships, other maritime infrastructure, ports and coastal zones, exploiting communication lines between an onshore control centre and remote sensing systems of critical maritime infrastructures. The main idea is to network all accessible means of observation, from offshore, onshore, air and space, of the infrastructures under surveillance via the onshore control centre. End-users and permitted third parties should be able to access a composite of the observations in real-time so that the protective measures can be taken in security-critical situations. It is believed that such a system for cooperation on maritime security could benefit from an interface with the eMar Ecosystem.

3.5. Ship Reporting Services

The Navigator Port service is a software service aiding the mariners with information exchange between ship and shore. It simplifies the port clearance procedures and helps ensure that the crew on board a ship has the right information whenever it is needed.

The port manager is the core of the Navigator service, providing vessels with timely and correct information and forms according to the Port State Authorities' requirements. The main aim is to reduce paperwork on the bridge, simplify and speed up the ship to shore reporting, ensure smoother port clearance procedures, reduce delays and possible penalties during port calls and ultimately to ensure safer navigation by allowing the master to focus on his main navigational tasks. The information is structured and combined in a way to make it easily accessible through port entry and departure checklists.

More than 1200 port clearance forms are currently available, covering 10 000 ports, terminals and pilot stations in more than 180 countries. These are programmatically linked to the logs and the databases of the vessel. In this way, pre-filled forms with the relevant data automatically appear as soon as they are opened, reducing the time needed for preparation of such reports to a minimum. Included are inter alia eNOAD (Electronic Notice of Arrival/Departure. URL: https://enoad.nvmc.uscg.gov/) reporting to the US Coast Guard as well as electronic reporting to many other countries.

In addition to the port state reports, the Navigator report generator may generate company specific forms, environmental reporting forms and daily reports meeting requirements from the charterers. Some examples of generated reports are shown in Fig. 2. Standard xml-based data interfaces are used for data sharing and integration with other software systems.

The core service is supplemented with different optional modules. The passage planner module is a tool designed to assist the navigation officer in the voyage-planning process. The work and rest hours module is a tool for registering planned and executed work hours and provides a cost-effective way of demonstrating compliance with relevant regulations on seafarers' rest hours. The fleet manager module facilitates data exchange between vessels via the office and distribution of information from the office to the vessels. It consists of two parts, one for the vessel and one for the office. Data is easily exported to Excel for transfer to the office and all ship data is stored and maintained in the office for use in planning for individual ships or the fleet as a whole.

In particular two parts of the Navigator Port service are relevant for interfacing with the eMar platform and hence being offered as e-Maritime services. These are the on-board data base ('Data Entry and Logs') containing ship specific data and the port papers and forms used for reporting and communication from ship to shore.

Depending on requirements defined by the authorities or other parties, completed forms and reports may be submitted electronically in different formats. If Internet is available, secure online data submission is possible, otherwise the electronic files may be submitted by e-mail. In either case, the Navigator Port is identified as a potential e-Maritime service that could gain added value from interfacing with the eMar Ecosystem. In fact, this service has been selected for pilot implementation within the eMar project, and the pilot implementation will be described later in this paper.

Fig. 2.
Some Forms Generated by the Report Generator

3.6. Dynamical Navigational Risk Management

A dynamical risk model with the aim of reducing the risk of coastal oil spills from ships has been developed in previous research projects (Eide et al., 2007a; Eide et al., 2007b). The model is intended to be used at a shore-based VTS centre (Vessel Traffic Service) for assessment of risk levels of individual oil tankers sailing along a specific coastal stretch. Comparison of ships in the relevant area can support decisions on which ships to focus attention on. It is suggested that this will make ship traffic monitoring at a VTS more intelligent by differentiating between vessels in terms of the risk of environmental pollution.

The model is based on linking AIS data such as position, course and speed, identity, ship type and dimensions, destination, cargo and keel depth with other sources of data in order to indicate the vessel risk level. The risk in each case is estimated based on information from a number of sources. A particular focus is given to drift grounding where the risk is estimated based on real-time ship position, ship drift modelling and real-time tug position data.

The model is extended to include dynamic information about the ship's immediate surroundings and operating environment in order to provide real-time risk assessment and also short-term risk forecasts (Eide et al., 2007b). An environmental sensitivity index and an oil type significance index are introduced to describe the vulnerability of an oil spill.

Operational procedures may utilize this risk model for dynamical prioritisation of ships and divert most attention to high-risk ships. For example, various attention thresholds could be established based on this model dictating either a heightened level of monitoring or even initiation of risk reduction measures, e.g. rerouting of vessels, deployment of escort tugs and positioning of contingency resources. With the extension of the vulnerability of the coastal areas, different geographical locations can also be differentiated. Thus, the system combines information about high- and low-risk ships with vulnerable and less vulnerable areas and hazardous and safe weather conditions.

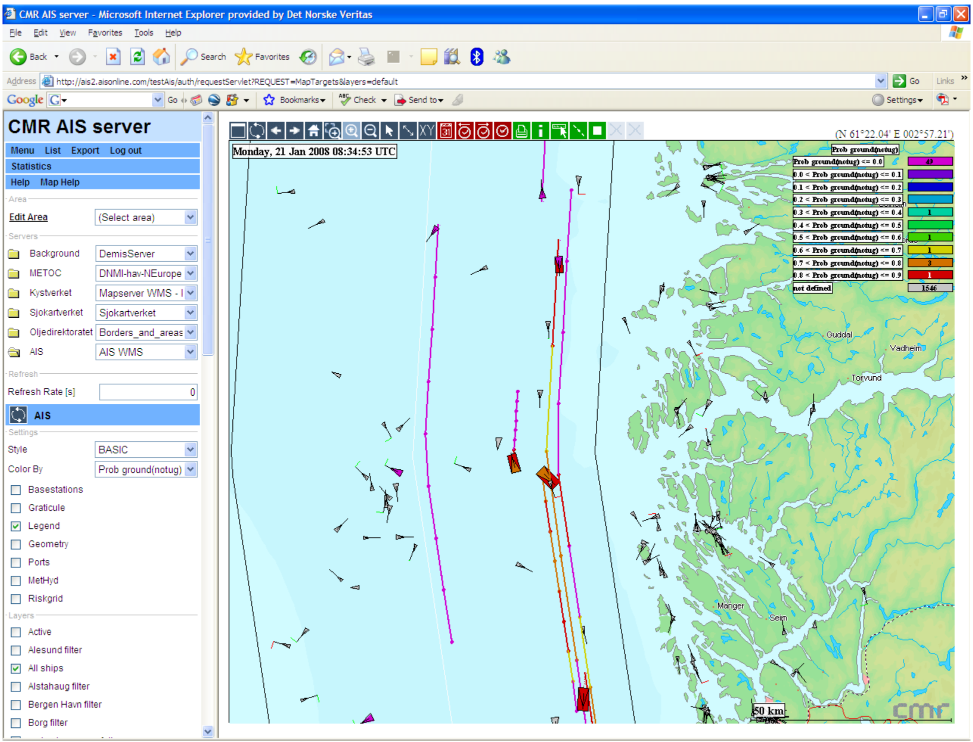

Fig. 3.
Web-Based Demonstrator for a Dynamical Risk Management Service at a VTS Centre

A screenshot from a demonstrator of this service is shown in Fig. 3: High risk vessels are identified and can be given special attention at the VTS centre. This service involves real-time data exchange between ships and shore, combined with information from other data sources to enhance coastal safety. Hence, it is believed that this and related services could benefit from integration with the eMar Ecosystem.

3.7. Education and Training Services

The competence of seafarers and shore based personnel is important to ensure safe and environmental friendly shipping, and there are international regulations in force to ensure that seafarers are trained and qualified to carry out their duties on board (ILO, 2006; IMO, 2010). In response to these requirements from the maritime industry, there are a number of training facilities and programmes offered to shipping companies to ensure that prevailing regulations are always complied with and that the officers and other crew are qualified for their duties as seafarers. Services related to training include classroom, onboard and distance learning courses as well as supplementary services such as electronic libraries and services related to the administration of required personnel competence, training and career planning, keeping track of training profiles and records, monitoring and reporting of training and competences and screening and recruitment processes.

Such services involve a notable amount of communication and data need to be exchanged between the ship, land based offices and training centres. It is therefore believed that these types of services could effectively be offered via an interface to the eMar Ecosystem.

4. Pilot eMar Services

The previous subsection presented a survey into possible e-Maritime services for enhanced safety, security and environmental protection, and two pilot services have been implemented in the eMar project. These are ship port-pre-arrival reporting and ship and survey status offered as eMar web services, utilizing the Common Reporting Schema (CRS). These pilot implementations will be briefly outlined in the following.

4.1. Navigator Port as an eMar XML Web Service

In order to allow the ship to report pre-arrival information to the relevant Port Authorities, the data must first be entered into the Navigator Port. Then, when the user is initiating a pre-arrival report, the data is automatically formatted according to the CRS specification and submitted via a web service to a common reporting gateway that is hosted remotely. A confirmation message will immediately be received and shown to the user indicating that the ship notification has been successfully received and processed at the reporting gateway. If, on the other hand, the submission is incomplete or is not successful for any reason, an error message should be received indicating what went wrong. This way the Navigator Port eMar pilot acts as a web service consumer, submitting onboard data to the onshore server hosting the web service.

In the initial pilot version of the service, only information regarding the vessel ID, i.e. the IMO number, the vessel name, the port of departure, the port of arrival and the estimated time of arrival is submitted. This information is already available in the system and it has been demonstrated that it can successfully be transferred from the Navigator Port client to a remotely hosted testbed, with an immediate confirmation of success. Furthermore, useful error messages are received if the forms are incorrectly filled in or some necessary information is missing. For example, omitting the vessel name gives the error message “Error: Datafield (operand 1) “VesselName” cannot be recognized, or is empty”.

To submit an eMar message to the reporting gateway from the Navigator Port eMar pilot, simply update the logs with the vessel data and the voyage history and press the "submit to eMAR" button from the voyage history view. The user interface for doing this is shown in Fig. 4, with a confirmation of successful submission. Verification about the successful submission of the information can be obtained by logging into the common reporting gate-way at the testbed, where information about recent ship notifications can be seen. The ship pre-arrival eMar service requires a broadband connection between the ship and the shore, and can simplify further the ship to shore reporting procedures on board compared to the current service.

Currently, only a limited set of functionalities are included in the eMar Navigator Port pilot service and only a limited subset of the available information is submitted. This provides a proof of the concept and demonstrates that the ship pre-arrival reports can successfully be submitted as an eMar web service adopting the CRS, provided an internet connection is available onboard the ship. However, the pilot service can easily be updated to handle more information and more functionality.

Fig. 4.
User Interface for Submitting a Pre-Arrival Report as an eMar XML Web Service

4.2. Ship Survey Status as an eMar XML Web Service

The DNV Exchange web tool provides an interface for clients and other parties to obtain information about their business relationship with class as well as other general information from, from anywhere and at any time. Different subscription types yield different service levels, contents and features.

The basic service gives secure, web-based access to class survey certificate and general class reference documentation. It features access to reports detailing certificates, periodic surveys, any conditions of class, memos to owner, retroactive requirements, continuous machinery and continuous hull surveys at any time. It also provides online survey requests and graphical survey scheduling tools as well as updated rules and standards and general casualty in-formation.

Additional services may be included depending on subscription level, such as electronic scanned vessel certificates, additional vessel documentation, port state control checklists and guidance material. The amount of information that is available is different for owners and managers, flag and port state authorities, ship yards, etc. The owner may allow other parties to access the information pertaining to their vessels, as required. However, some of the information is publically available in the register of vessels. This is the vessel particulars and general information as well as certificates and survey lists and possible overdue certificates and surveys.

The vessel info in the DNV Exchange web tool is searchable by vessel name, class ID, IMO number, Builder's number and flag and contains the following information: Vessel summary, dimensions, classification, registry, hull summary, machinery summary and yard owner. The class and statutory certificates status in the DNV Exchange web tool lists all relevant certificates and green, yellow and red flags, respectively, indicates whether the certificates are valid (green flag), due within the next few months (yellow flag) or overdue (red flags). Similar views for the class and statutory survey status are publically available in the DNV Exchange web-tool.

The information currently available through the DNV Exchange web-tool is displayed on the screen and needs to be interpreted by a human being. However, if the information can be made available in XML format as a web-service, it can be used programmatically by other web services in order to provide value added services, possibly in combination with other information. With this in mind, the vessel info and the ship certificate and survey status have been implemented as a pilot eMar web service using the specifications of the common reporting schema (CRS). Currently, a first version of this service is available, containing the public information from DNV Exchange, i.e. the vessel info and certificate and survey status for class and statutory certificates and surveys. Information is searchable by, inter alia, vessel name class ID and IMO number and the first version of the pilot service can be accessed at https://exchange.dnv.com/exchange/VesselInfoWS.asmx?WSDL.

One possible extension of the ship survey status as an eMar XML web service is to include other, non-public information. This would require additional security services related to the protection and authentication of the information and identification management for authorization of access to the in-formation. Furthermore, it is possible to extend the search criteria options to be used and to allow for aggregated information at fleet or company level. Finally, the service could be updated with more robust error handling and more informative error messages, for example if some of the search criteria are not found or is inconsistent. For now, however, this is left for possible future work and further development of the service.

5. Summary and Conclusions

This paper has presented a survey into possible e-Maritime services related to information exchange for safety, security and environmental protection as well as for communication with class societies. Both existing services and current research initiatives have been investigated and a number of potential services are identified. These could benefit from exploiting the e-Maritime concept and added value can be obtained by offering the services within the e-Maritime framework. This indicates that once such a framework is in place, it might be populated with relevant services and applications serving the maritime industry.

Two pilot services have been selected and successfully implemented as eMar XML web services to add value to the current versions of the services. These pilots demonstrate that the current version of the CRS is quite adequate for facilitating improved information exchange between different stakeholders within the maritime industries. Indeed, the XML specifications were sufficient for exchanging all the information in the two implemented services, containing information needed for ship pre-arrival reporting and the status of certificates and surveys.

However, agreement of common standards is deemed important for realizing the potential benefits from e-Maritime and for example the Common Reporting Schema could be accepted as an international standard to facilitate and speed up the implementation of e-Maritime services. The implementation of the two pilot service provide a proof-of-concept and substantiate that the CRS is useful for information exchange within the maritime industries.

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