Published in the Proceedings of the International Symposium Information on Ships, ISIS 2014. Hamburg 4-5 September 2014. pp 64-79. ISSN 2191-8392

Ship traffic management route exchange: acceptance in Korea and Sweden, a cross cultural study

Thomas Porathe[1], Ole Borup[2], Jung Sik Jeong[3], Jin Hyoung Park[4], David Andersen Camre[2], Anders Brödje[5]

[1] Chalmers University of Technology, Sweden,
[2]Danish Maritime Authority
[3]Mokpo National Maritime University
[4]Korea Research Institute of Ships and Ocean Engineering
[5]Swedish Maritime Administration

Abstract

Accidents at sea are today much more rare than in present days. Improvement in technical reliability is a large reason for that. And also innovation in systems that aid the human in decision-making. These systems can be technical (like the GPS and AIS), but can also be organizational (like Traffic Separation Schemes and Safety Management Systems). Still accidents occur. IMOs e-Navigation concept aims at collecting, integrating, exchanging and presenting information to aid the awareness of dangerous situations and the analysis of risk situations. One such attempt is the route exchange concept developed in the EU projects EfficenSea, MONALISA and ACCSEAS. The idea is that by coordinating routes from all vessels in an area, close quarter situations can be predicted and avoided at an early stage. A prototype system has previously been built and tested in simulator trials with Swedish mariners with good results. This paper presents a ship trial in Korea with Korean cadets and experienced bridge officers. The tests showed no cultural differences and good acceptance to the suggested system. Some important concerns were also expressed.

1. Introduction

1.1 The collision between M/V Fu Shan Hai and M/V Gdynia

On the 31 of May 2003 the Chinese dry bulk carrier *Fu Shan Hai* collided with the Polish container vessel *Gdynia* 3 miles NW of the northern point of the island of Bornholm in the Baltic Sea. The 225 meters long Chinese vessel was under way with 65 000 MT fertilizer from Ventspils in Latvia to China. The 100 meters long Polish vessel was under way with containers from the port of Gdynia in Poland to Hull in the UK. They collided a few minutes after noon. The visibility was good with a wind of 8 meters per second.

Fig. 1. The Chinese dry bulk carrier Fu Shan Hai sinks after a collision in the Baltic Sea in 2003.

Having *Fu Shan Hai* on his starboard side, *Gdynia* was the give-way vessel according to the COLREGS '72. For some reason *Gdynia's* starboard turn was made very late and resulted in a collision that subsequently sank the Chinese vessel (see Figures 1 and 2). For details of the accident, see the report of the Danish Maritime Authority (2003).

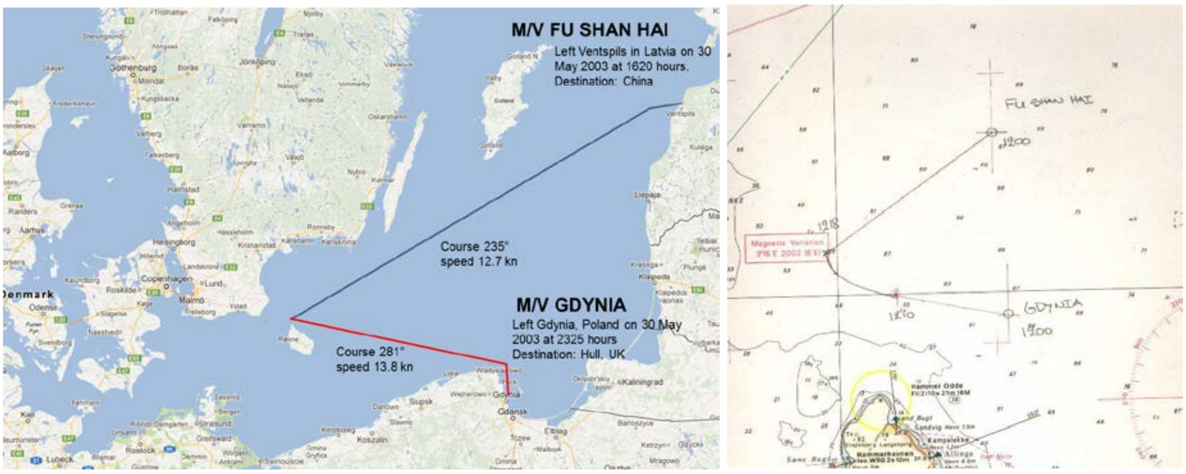

Fig. 2. The left map shows an overview of the southern Baltic Sea and the initial routes of the two vessels. The right map shows a reconstruction of the last hour of the two ships track made by the accident commission based on Swedish maritime radar surveillance.

Much can be said about this collision, about the behaviours of the officers involved: of not following regulations, of misunderstandings and it all boils down to yet another accident due to what is despondently called “human error”.

But humans make mistakes. That is part of the human condition. We break rules and we take shortcuts. We think about other things, we are un-concentrated, we forget, we have a limited span of attention; we even fall asleep when we are not supposed to. Much of the safety work done in shipping is about mitigating these human shortcomings.

However, shipping has become much safer. During the three years 1833-1835, on average 563 ships per year were reported wrecked or lost *in United Kingdom alone* (Crosbie, 2006). Today the total number of tankers, bulk carriers, containerships and multipurpose ships in the world fleet has risen from about 12,000 in 1996 to about 30,000 in 2014. In the same time, the number of ships totally lost per year (ships over 500 GT) declined from 225 in the year 1980, to 150 in 1996 and less than 60 in 2012 – and this is *worldwide* - according to The International Union of Marine Insurance (IUMI, 2014). But still accidents happen. How can we avoid an accident like the collision between *Fu Shan Hai* and *Gdynia*?

Having two ships in a close quarters situation opens up to time critical decision-making of a type that challenge the human shortcoming mentioned above. One solution is keeping ships apart as much as possible.

1.2 Ship traffic separation

The idea of keeping ships with conflicting courses from coming close to each other is not new. Traffic Separation Schemes (TSS) has been in use since the International Maritime Organization (IMO) opened the first one in Dover Strait in 1967 and “a significant fall was seen in the number of collisions between ships on opposing courses” (IMO, 2014). Today TSSs exists in all of the worlds most congested waters. But still collisions occur. One solution that might improve safety further could be to extend the notion of TSS to a complete route network, just like we have a road network for vehicles on land. (In fact, a Route Network

Topology Model for the North Sea is presently being developed in the EU project ACCSEAS.) But as everyone knows, we have collisions on roads as well, because somewhere routes will unavoidably cross, and we can today see, that although the TSSs are fairly safe, accidents occur to a larger extent where they end. So how can we promote separation between ships? Maybe by route coordination and remote monitoring? Let's look at the air industry.

Airplanes have due to their speed much tighter time constraints and a very limited view from the cockpit windows. Therefore air traffic control was introduced already in 1921 (Transport Trust, 2014). By monitoring the airspace with radar and transponders, air traffic controllers in radio contact with the airplanes can make sure that they do not come into close vicinity of each other. Of course to do so they must know the exact routes the airplanes are taking and special air corridors have been defined for that purpose. Currently change is underway because of an increasing congestion in the European air and suggestions are that flights should not have to use the special corridors, as long as they share their route in advance so that separation can be predicted and enforced (SESAR, 2014). Could a similar idea be implemented for maritime traffic?

1.3 Route exchange

The idea of "route exchange" was first investigated in the EU EfficienSea project (2009-2012) coordinated by the Danish Maritime Safety Administration. The idea was that since all SOLAS ships by regulation must have a voyage plan premade prior to departure, and this voyage plan, now a days resides in electronic format in an Electronic Chart Display Information System (ECDIS), some waypoints ahead of a ships present position could be broadcasted using the transponder from the also compulsory Automatic Identification System (AIS). This way a ships intended route could be made public in the interest of mitigating misunderstandings. This idea of sending out a limited number of waypoints ahead of the present position was called "tactical route exchange" (Porathe, 2012; Porathe, Lützhöft, & Praetorius, 2012)

An extension of the idea, called "strategic route exchange", where not only a few waypoints, but the entire voyage plan is in advance sent into a traffic control centre, was investigated in the project "Motorways and electronic navigation by intelligence at sea" (MONALISA), a TEN-T, EU project started in 2010. The first phase was finished in 2013, and presently is MONALISA 2.0 underway with 30 European partners coordinated by the Swedish Maritime Administration. For business integrity reasons the whole voyage plan cannot be publicised publicly, but instead it is sent to a Ship Traffic Coordination Centre (STCC), where the routes of all ships in an area can be coordinated to make sure no two ships is at the same place at the same time. Theoretically the close quarters situation of *Fu Shan Hai* and *Gdynia* could have been detected already at departure and a warning and a recommendation to make a very small speed change could have solved the situation. In reality ships speeds are not that exact and other unknown factors influence a ships voyage, but an automatic system constantly monitoring the progress of all ships in an area could easily detect and warn ships of upcoming close quarters situations.

1.4 The route exchange procedure

A voyage plan has to be made in advance by all ships today. So in that respect there is no change compared to now. The new thing is sharing the voyage plan with a shore-based Ship Traffic Coordination Centre, the STCC. This is done before the ship departs from port or enters a STCC area. In the prototype system tested this is done using the electronic chart system. The navigator right clicks on the voyage track on the display and selects "Send to

STCC". The track in the chart now becomes enhanced with a yellow hashed pattern, signifying it is "pending". The procedure and the symbology used in the electronic chart are described in Figure 3.

STCC then checks the route against other ship's routes as well as against requested under keel clearance and restricted areas. If no problems are found, STCC "recommends" the route. It becomes green hashed. In such a case it is the captain who has the final say and if he acknowledges the agreement, the route becomes "agreed", symbolised by a green backdrop (see Figure 3).

Of course there is also a possibility that the coordination centre suggests changes in the voyage plan sent in. It might be that two ships plan to be at the same place at the same time (as in the case with *Fu Shan Hai* and *Gdynia*) or it might be that a ships plans to pass on the wrong side of buoys and risk grounding (the Swedish-Danish *Sound VTS* calls ships about 40 times a year having detected faulty courses in the passage through the strait - personal communication). Negotiations between the ship and the STCC can be carried out in the chart system using text messages accompanying each new rote suggestion (as well as the traditional VHF radio communication, if necessary).

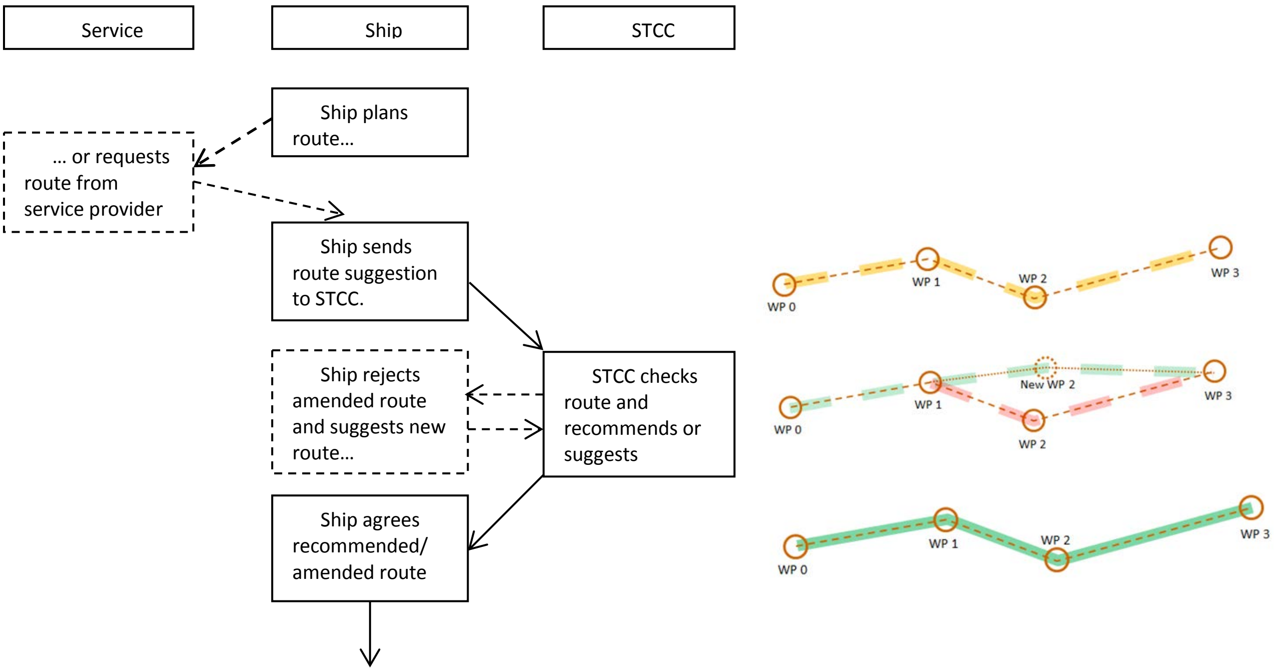

Fig. 3. To the left is a simplified diagram of the information flow for the route exchange process. To the right, the symbology used in the electronic chart systems to signify (top) a "pending" route sent from ship to shore, now awaiting optimisation, then a stage in a route negotiation (middle) where a deviation is "recommended" (green hashed) instead of the original (red hashed) segment. Finally (bottom) the "recommended" route has been "acknowledged" by the ship and becomes green/"agreed".

To have your voyage plan checked by an outside authority is something new. It can be seen as an extra safety check, but it can also be seen as an infringement of the ship master's integrity or intrinsic role. Once the ship is underway along the agreed route, there will be a greater expectation that the ship should adhere to the route, since it is now coordinated with all other vessels (ideally) in the area. The result must be a change in how ships own routes are perceived: instead of being simply a guideline for the mariner to follow, ships must strictly adhere to the route to avoid an accident. What is the opinion within the shipping community to these new ideas? Could these be accepted if the up-side is increased safety? These have previously been the research questions to Swedish mariners after having tested route exchange in a simulator (Porathe, de Vries, Prison, 2014). But shipping is very much an international business and profound changes to the way shipping is conducted has to be tested internationally. Therefore the route exchange concept was tested on Korean cadets and experienced mariners during a ship-borne training session in April 2014.

1.5 IMO's e-Navigation and the Korean SMART-Navigation project

The International Maritime Organization (IMO) in 2006 started the work on a concept called "e-Navigation" (IMO, 2006). e-Navigation is defined as *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 protection of the marine environment* (IALA, 2014). The driving force behind this initiative was a concern among many stakeholders that lack of standards made development of new applications difficult and that the possible benefits of integration could not be reached. The important aspects were safety and efficiency and in the centre stood the human element that had to deal with a plethora of unintegrated systems. Much information necessary to solve real world problems was already out there, but needed to be made available in a user friendly way. Some of the misunderstandings leading to accidents could perhaps avoided by presenting the information in a more effective way.

The Republic of Korea in 2013 presented the SMART-Navigation project (Safe maritime, Multi beneficial, Aggregated Reliable, Total transport) that is a localized version of e-Navigation aiming at reducing maritime accidents in Korea by 30% by applying e-navigation concepts to the maritime safety services of Korea. The statistics of maritime accidents between 2008 and 2012 in Korea shows that fishing vessels have caused more than 72.5% of maritime accidents (Korean Maritime Safety Tribunal, 2014). The project would focus on providing e-Navigation services dedicated to fishing vessels in addition to IMO-defined e-navigation services that is dedicated to SOLAS vessels.

Sharing data already present in every ships navigation system seems like a good way to attempt e-navigation. It seems to have a potential of increasing safety within the maritime domain. The first issue to find out is: would it be an acceptable way for mariners to do their work?

2. Method

2.1 Usability Test

Usability testing involves observing users while they perform tasks with hardware or software systems. The system may be a prototype at some stage of completion, or a finished product. In this case the test was a formative evaluation, which is conducted early in the design process to find problems which can then be used to improve the product (but the tests can also be summative evaluations, conducted to validate the design against specific goals). Usability testing involves recruiting participants who are representative of the real users of the system and asking those users to complete a set of tasks. A test facilitator conducts the testing via a test protocol, asking the test persons to "think aloud". The test sessions are typically recorded either by a video operator and/or an automated testing tool (Usability Body of Knowledge, 2014).

In early concept phases of development projects, when software interfaces are still un-developed, simple, qualitative results, such as finding out the professional acceptance of the system, can be motivated. In this case the system consisted of both a technical system as well as new working procedures. To be able to have an opinion about this new concept the participants needed to be professional mariners (or, e.g. VTS operators) with background knowledge of the work as it is done today. They then need to get a feel for how the work will be done in the new way. To increase the ecological validity the test was conducted in a real ship setting.

2.2 Participants and test procedure

The Korean partners were the Korea Research Institute of Ships and Ocean Engineering (KRISO), the Korea Maritime and Ocean University (KMOU) and Mokpo National Maritime University (MMU). Two training vessels, one from each university were used: the *Hanbada* and the *Sae Nuri* (see Table 1).

Ship Name	Specification
T/S *Hanbada of KMOU* 	• G/T(Gross Tonnage) : 6,686 G/T • LOA(Length Over All) : 117.2 m • Max. Speed(knot) : 17.5 knots • Max. Draft : 5.95 m • Construction : Dec. 2005.
T/S *Sae Nuri of MMU* 	• G/T(Gross Tonnage) : 4,701 G/T • LOA(Length Over All) : 103.2 m • Max. Speed(knot) : 16.8 knots • Max. Draft : 6.00 m • Construction : March 2003

Sae Nuri, was scheduled to depart a port of Mokpo at 11:00 am, 15th April, 2014, bound for the port of Yeosu with ETA 09:00am, 16th April, 2014, while *Hanbada* navigated Korea southern coast, leaving a port of Busan for a port of Yeosu with the same ETA.

The training vessels were both equipped with multiple bridges and not to endanger the navigation, the disconnected training bridge, behind the real operational bridge was used for the experiment. On the operational bridge cadet training according to the universities regular curriculum was conducted at the same time as the experiment took place further back on the bridge. 10 third year cadets (mean age 21.1 and mean seagoing experience 0.5 yrs) as well as 8 experienced officers (mean age 37.5 and mean seagoing experience 11.3 yrs) participated in the experiment.

Test procedures

Each of the two training ships had made a voyage plan in advance taking them from Busan and Mokpo respectively to the port of destination Yeosu that is located in the middle of southern coast line of Korea. Not to pose any risk the ships were navigated along the planned route but in a normal manner which meant a cross track error up to a mile from time to time.

The test participants were before the test given a short introduction in English and a detailed briefing in Korean on how the prototype system worked. They then spent a 20-30 minutes long session during which the participant were to send in the pre-made voyage plan (the actual plan the ship was using) to STCC.

Fig. 4 shows the voyage plans respectively. On the way to the port of Yeosu, the two ships were planned to pass through a head-on situation.

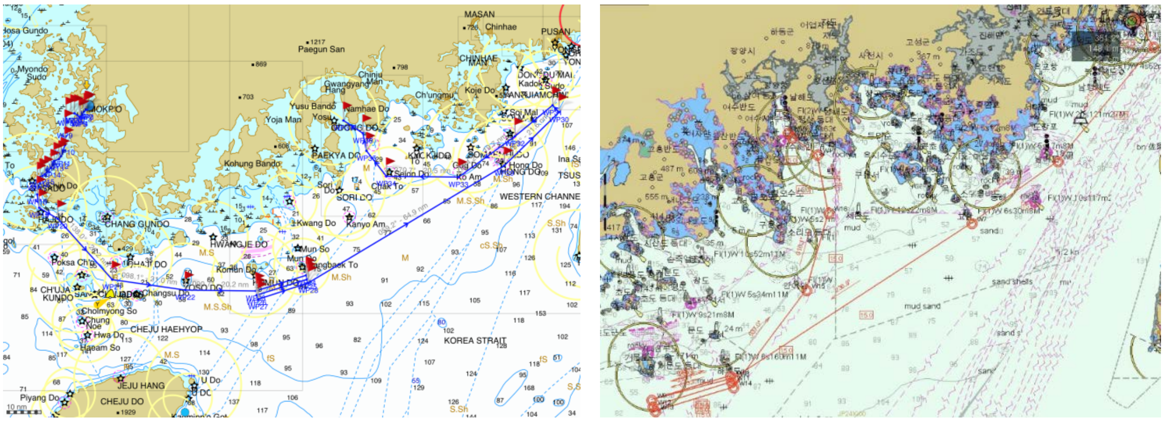

Fig. 4. The voyage plans of T/S Sae Nuri from Mokpo to Yeosu (left) and of T/S Hanbada from Busan to Yeosu (right)

2.2 Technical setup

Communication between ships and ship and shore was facilitated by a prototype of the Maritime Cloud. The Maritime Cloud is defined as: *A communication framework enabling efficient, secure, reliable and seamless electronic information exchange between all authorized maritime stakeholders across available communication systems.* The Maritime Cloud is not a 'storage cloud' containing all information about every ship or cargo. Nor does it refer to 'cloud computing'. It can be seen as a communication and Infrastructure-as-a-Service Cloud.

The Maritime Cloud consists of standards, infrastructure and service reference implementations that, together with governance, enable the efficient exchange of information between authorized maritime parties via interoperable information services, utilizing highly automated interfaces for different communication options, enhancing general communication related to berth-to-berth navigation and related services for safety and security at sea and protection of the marine environment.

The Maritime Cloud has three key components (see Figure 5):

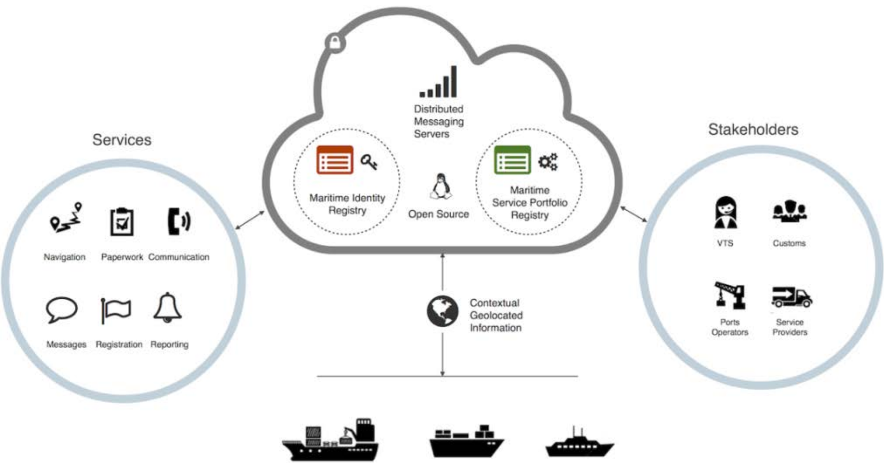

Fig. 5.The schematic structure of the Maritime Cloud (see text for details).

- The Maritime Service Portfolio Registry – A catalogue of where instances of information services are available, in a machine-readable format. The registry will facilitate easy service provision and discovery.
- The Maritime Identity Registry – A catalogue of identities for all maritime stakeholders. Each identity will have an attached digital certificate facilitating secure communication using a public-key infrastructure.
- The Maritime Messaging Service – A messaging service build on top of the Internet as an overlay network to facilitate broadcast, multicast and geocast communication between maritime stakeholders.

The Maritime Cloud is a dynamic concept derived from a user-driven process based on experience gained from several e-navigation test bed projects. It is a scalable enabler of seamless information exchange between a variety of available systems and across different physical communication links in the Maritime Domain. The Maritime Cloud is proposed to be the realization of the communication strategy for e-navigation described by the IMO.

The technical setup for the tests is shown in Figure 6.

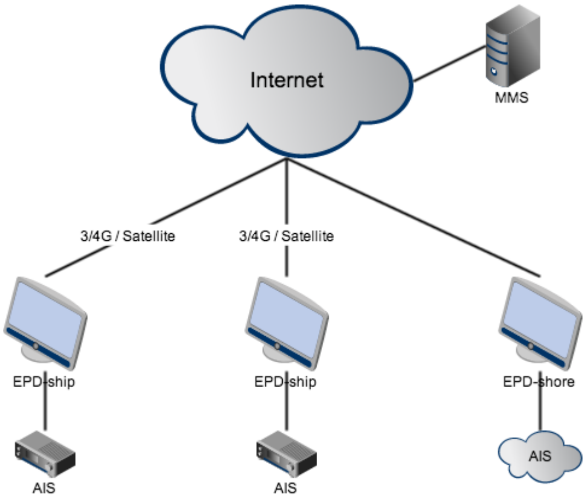

Fig. 6. The technical setup of the experiment.

The main components are:

- On both vessels an instance of the ship version of the E-navigation Prototype Display system (EPD-ship) running on a laptop with attached 24-inch monitor. The EPD's were connected to the AIS transponders onboard for AIS and navigational data, and to the Internet through either 3/4G mobile broadband or satellite connection.
- For the STCC side an instance of the shore version of the EPD (EPD-Shore) was used, connected to the Internet and connected to an AIS source with data for the relevant area.
- A server running on Amazon Web Services (AWS) was used to provide the prototype Maritime Messaging Service (MMS) for communication.

2.3 The E-navigation Prototype Display (EPD) and the test procedure

For the test a prototype system developed by the Danish Maritime Authority was used: the E-navigation Prototype Display (EPD). The EPD is an open source ECDIS-like test platform on which different e-navigation services has been implemented, in this case the route exchange features described in section 1.4 above. The EPD can be downloaded for free from http://www.e-navigation.net. The EPD has a shore and a ship based interface to allow tests with exchange between ship and shore. For the test, Korean Electronic Nautical Charts (ENCs) was installed.

The STCC, with the shore-side EPD, was for the test located in a separate cabin at the *Hanbada* and connected to the Maritime Cloud.

Before departure, the actual voyage plan for the ships journey on the 15th and 16th April was uploaded to the two ship EPDs. The EPDs was connected to the ships' pilot plugs and was then capable of receive and displaying the ships own GNSS position as well as AIS information for surrounding ships. Each participant was then to perform three tasks: 1) to send the present voyage plan to the STCC (see Figures 7 and 8).

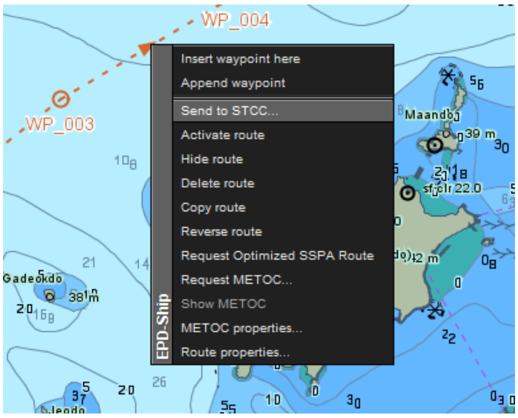

Fig. 7.To send a route to STCC the navigator right clicks on a route segment and selects "Send to STCC"

Fig. 8. The navigator may then select STCC (if there are several) give the route a name and maybe add a text message. Then click "Send".

STCC checks the route and returns it as "recommended", possibly with a text comment. Ship has a choice of "Accept" or "Reject" (see Figure 9).

Fig. 9. The route has been checked at the STCC against separation to other ships, under keel clearance and violation of restricted areas. It has now received the status "recommended".

The navigator then clicks “Accept” and the route changes status to “Agreed” with a solid green backdrop (see Figure 10).

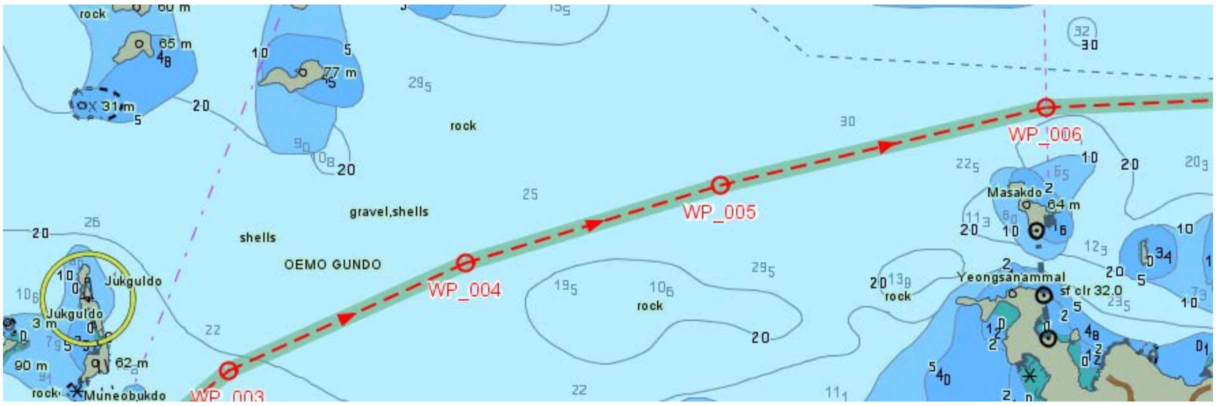

Fig. 10. An “Agreed” route with a solid green backdrop signifying that this is a route that has been coordinated and optimized and mutually agreed between the ship and the STCC.

2). In a second task the participants were asked to make a route change and send this modified voyage plan to STCC for coordination. 3) The third and final task was that the participants received a route change request, but this time initiated from the STCC. In this case there was also a route negotiation, when the ship wanted to modify the “recommended” route.

The three tasks took about 20-30 minutes to conduct and after short de-briefing and resetting the equipment a new test person was brought in.

The tests were moderated by one English speaking Swedish researcher, but the Think Aloud method was conducted in Korean as well as follow-up questions and was handled by a Korean researcher. Two teams were working, one on each ship.

After the test, each participant was asked to fill in a demographic questionnaire and an acceptance rating scale.

3. Results

3.1 Results from tested features

On the Hanbada and the Sae Nuri 10 cadets and 9 experienced bridge officers participated. They were all given an initial presentation of the route exchange service and the EPD, and then a 20 to 30 minutes long individual usability test where they conducted the three tasks described above. During the test comments were recorded on video and later analysed. The comments were given in the participants’ native language Korean (except in one case where the participant was a Philippine cadet that spoke English).

On the major question issue of acceptance, a questionnaire handed out to the participants after the test. The answers are presented below. The figure within parentheses is the answer from the 18 Swedish cadets and experienced officers that did the similar tasks in a simulator test in September 2013 (Porathe, de Vries, Prison, 2014).

Table 1: Answers to the questionnaire handed out after the trial. Number in parentheses answers from Swedish study 2013.

Question	**Very good**	**Good**	**Don't know**	**Bad**	**Very bad**
What is your opinion about the tested route exchange concept?	11 (4)	8 (9)	0 (4)	0 (0)	0 (0)
	Most probably	**Probably**	**Don't know**	**Probably not**	**Most probably not**
Do you think a similar route exchange concept will become reality in the future?	6 (4)	12 (13)	1 (0)	0 (1)	0 (0)

Table 2: Professional Acceptance Rating Scale. The question was: What is your professional opinion about the system tested? (Put an X in the box which best fits your opinion)

Scale value	Scale name	Description	Results (numbers of x)
0	Totally unacceptable	I think this is a very bad idea. Definitely not.	0
1	Not very acceptable	Not a good idea. Best let it be.	0
2	Neither for, nor against	I am neutral.	0
3	Acceptable	Good idea. I am for it.	3
4	Very acceptable	I think this is a very good idea. I am definitely for it	14
5	Extremely acceptable	One of the best ideas I have heard of. (Even regular users would seldom give this score.)	2

As can be seen above the overall opinion of the concept was very positive from the Korean test persons (but also from the Swedish participants from the 2013 test). However, concern was also expressed. Below is a summary of concerns expressed by the Korean participants during the test.

- A concern from several participants was the effects of all non-AIS vessels including finish vessels.
- Navigational risk by over-reliance on ship traffic route exchange
- In congested areas, during close encounter situations, and in narrow channels, the Officer Of the Watch (OOW) needs to give full attention to look-out. The work load may then be too large to allow for an exchange of information between ship and STCC.
- Human error due to display misunderstanding
- The EPD terminal display represents an overflow of information. Frequently, the OOW needs to have customized information and also a simplified window. Especially, there is not time enough to understand information shown in the display for urgent situations.
- Shipping companies are not likely to open their ships' route information

- A novice tends to over-rely on the EPD, while a senior officer may be reluctant to use the EPD.
- In close encounter situations or communication errors, the OOW may fail to get new route information including dangerous areas to be avoided.
- The relieving officer may overlook new route information when the OOW is relieved.
- In summary, it follows that the participants point out human errors that can occur during the use of a new e-Navigation system, i.e, the EPD.

The use of the EPD as a common test platform, being based on open source, freely available, and open for collaboration for all interested parties, was found to be a valuable tool for testing and evaluating e-navigation solutions.

It was indicated that the use of the Maritime Messaging Service of the Maritime Cloud as an information carrier is a viable solution for the exchange of maritime information in a volatile environment.

3.2 Unpredicted interruptions during the test

The two training ships departed according to schedule from Mokpo and Busan respectively on the morning of 15th April 2014. Because the experiments on the Hanbada were followed by about 20 journalists, circumstances very unfavourable why only results from 3 participants from that vessel have been included in the test results presented here.

Technical problems with the wireless communication onboard the Hanbada and the cellular phone coverage needed to connect to the Maritime Cloud also caused problems for the tests onboard that vessel. One important finding relating to this is that although mobile phone coverage maps indicated coverage during the whole voyage, the real conditions were a lot less favourable when using mobile phones inside the ship bridge. Other experiments have shown that using external UMTS antennas and amplifiers can mitigate these problems. While on the Sae Nuri, which used satellite communication, the EPD was the whole time connected to the Maritime Cloud.

3.3 Untested features

Some features that is part of the route exchange concept was not tested during the Korean trial due to the fact that the ships, for safety reasons, was not actually navigated using the system. The training vessels were sometimes traveling well beside the actual planned route and this meant that the features of the "safe haven" and the "proximity warning system" could not be tested in the desired way.

Safe Haven

To allow the route exchange system to infer a future breach of separation between vessels the system needs to know precisely where the ship is. The AIS transponder will tell the present position, but to be able to tell where the ship will be in the future, the ship will have to adhere to its planned voyage (something that will also be important for port logistics planning). The ship's planned position along the track can be visualised by a "safe haven", a rectangle with the width of the allowed cross track error for the present leg and the length of the allowed time window. Because all waypoints also include an Estimated Time of Arrival (ETA) the position of the safe haven can be calculated for the whole voyage. The under keel clearance and the separation of the area of the safe haven is then calculated, and as long as the ship is within the safe haven it can be safe from groundings, and from collision with other ships participating in the route exchange system. N.B. not from vessels not participating, e.g. fishing boats or leisure crafts, or “free movers” that has left their safe haven.

The safe haven feature was implemented on the EPD, but as can be seen in Figure 11 the *Sae Nuri* was well north of its planned track and the safe haven (in red circle) at the time of the screen shot. At the bottom right margin of the screen a head-up view of the safe haven is seen, it is red here, because the ship is outside of it. When inside it becomes green.

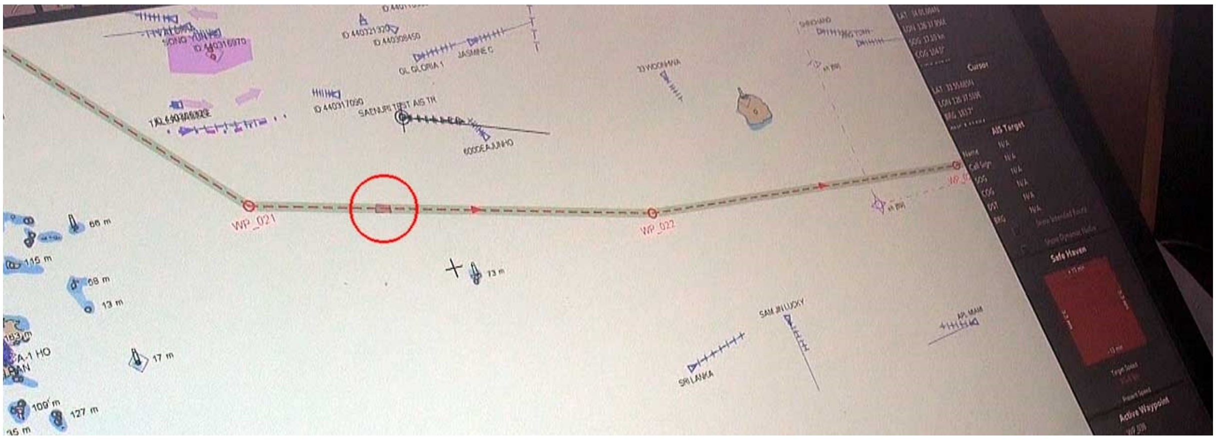

Fig. 11. The screen of the EPD. The planned position of the vessel is within the safe haven in the red circle. For safety reasons the route exchange system was not used for the actual navigation of the ship why the ship at this time is seen well north of its planned position.

Proximity warning

The EPD also contains “proximity warning” feature. The proximity warning is triggered when the calculated future distance between two vessels becomes less than a certain threshold, e.g. 1 mile. The calculation is done with configurable time steps along the planned route of ships and when the distance between the ships are less than the configured safety distance the warning is triggered and the calculated distance is marked with a yellow backdrop (see Figure 12).

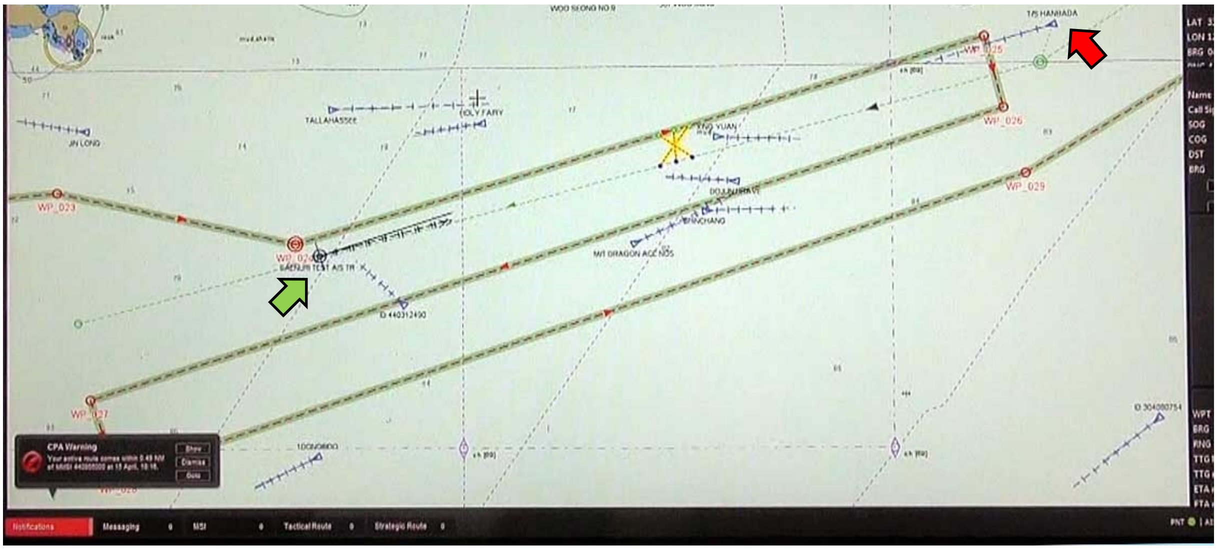

Fig. 12. The proximity warning has been triggered by the close quarters situation between the planned tracks of the two training vessels (Sae Nuri, green arrow and green planned track, and Hanbada, red arrow and red dashed planned track.). But note that the two vessels at this time just happen to be on each other’s planned track.

The proximity warning can be of use for manual monitoring in the STCC but is intended for the tactical route feature when ships sends intended routes from their transponders, not for the strategic route exchange when such situation will be detected and mitigated already at the planning stage.

4. Discussion

First of all it is interesting to note the positive reception of the route exchange concept in much the same way by the Korean cadets and officers as well as by the Swedish colleagues in the test the year before. Although the concerns were expressed, no participant was against the concept.

Secondly, the participants expressed concern about the effect of the large amount of non-AIS vessels in Korean waters. In coastal areas, a ship's course may need to be frequently changed because of movements of fishing vessels. According to accident statistics over the last 5 years – 2008 to 2012 - 46 % of the total collisions occurred in Korean coastal areas have been between fishing vessels and non-fishing vessels (Korean Maritime Safety Tribunal, 2014). Figure 13 shows the trajectories of fishing vessels for 24 hours, from 15th April 2014 to 16th April 2014, which were observed at WANDO area in Korean south coast. Taking the movements of fishing vessels into account, it may turn out difficult to find a safe route without information about the movements of non-AIS vessels including fishing vessels.

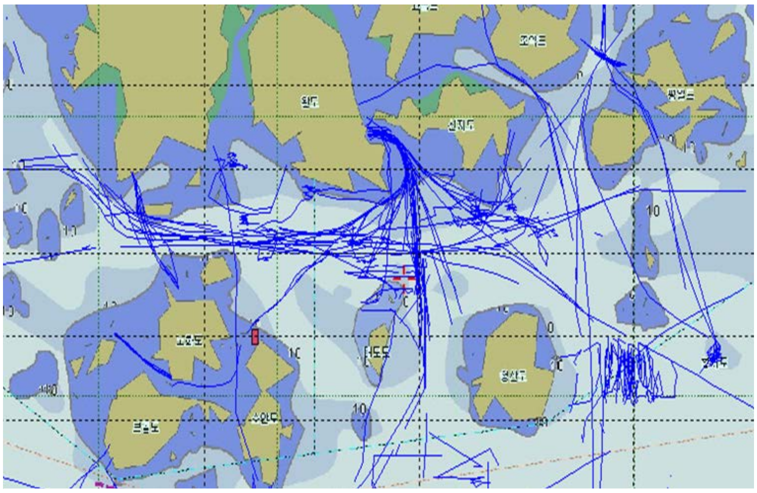

Fig. 13. Fishing vessels trajectories for 24 hours, observed at the WANDO area in Korean south coast from 15th April to 16th April, 2014.

Finally, the effect of ship's course and speed changes need to be studied. The STCC recommends ship's routes on the premise that other ships keep their routes as precise as possible. However it would be very rare for a ship not to change its routes during her way to the destination. The effect of these route alternations and disturbances on the whole system needs to be studied closely.

5. Conclusions

In this study we have reported some results from a usability test on the route exchange concept. All participants were positive to the concept as it was tested. Having said that, there were also concerns among the participants relating to the problem of how to deal with ships that are not part of the route coordination service (e.g. fishing boats).

Another concern was related to the workload when using the system considering that the most important task for the watch officer is to look out of the window and conduct collision avoidance.

One has to be aware of the limited validity of these findings considering the small number of participants. However this study with Korean participants closely follows a simulator study made with Swedish officers and cadets, showing very similar results: a positive opinion to the concept, with concerns in some special areas. The major finding from this study is the coherence of subjective ratings from two culturally diverse parts of the maritime community.

In this paper we have presented some examples of work with the human element. The aim is to survey the personal opinion on the route exchange system from the perspective of Korean cadets and experienced officers after ship trial in Korean water. Under cross-cultural environments, a global testbed is the major motivation of this research. And the tests showed no cultural differences and good acceptance to the suggested concept.

The results was reported to the IMO's sub-committee on navigation, communication and search and rescue 1st session (NCSR 1) in July 2014 as an INF paper (IMO, 2014b).

Future research
In the MONALISA 2.0 project the next step will be simulator studies of ship traffic coordination in high congestion areas e.g. the north-eastern entrance to the TSS in the English Channel. The intention is to connect several European simulators in a network. The EPD prototype platform will be replaced by a 2nd generation prototype based on a commercial ECDIS developed by the industrial partner Transas.

Acknowledgements
This research has been possible thanks to funding from the European Union's Seventh Framework program for infrastructure TEN-T, the InterReg IVB program and also from the Swedish Region Västra Götaland.

References

ACCSEAS. (2014). *The WP 3 Baseline and Priorities Report*. http://www.accseas.eu/project-information/project-baseline-and-priorities [acc. 2014-07-23]

Crosbie, J. W. (2006). Lookout Versus Lights: Some Sidelights on the Dark History of Navigation Lights. The Journal of Navigation, 59, 1–7.

Danish Maritime Authority. (2003). CASUALTY REPORT: Collision between Chinese bulk carrier FU SHAN HAI and Cypriot container vessel GDYNIA. Copenhagen: Division for investigation of maritime accidents, Danish Maritime Authority.

IMO, (2006). "Aids to navigation in a digital world". Keynote address by Efthimios E. Mitropoulos, Secretary-General of the International Maritime Organization, Shanghai, 22 May 2006. Website: http://www5.imo.org/SharePoint/mainframe.asp?topic_id=1322&doc_id=6334 [acc. 2014-03-15]

IMO. (2014). *Ships' routing*. London: International Maritime Organization. http://www.imo.org/OurWork/Safety/Navigation/Pages/ShipsRouteing.aspx [acc. 2014-07-10]

IMO. (2014b). Report on the international joint test for e-navigation solutions in Korean waters as a first step toward implementing a global e-navigation testbed, NCSR 1/INF.16. London: International Maritime Organization.

IUMI, International Union of Marine Insurance (2012). IUMI 2012 Shipping Statistics – Analysis. http://www.iumi.com/images/gillian/Spring2014/IUMICasualtyandWorldFleetStatisticsJan2014.pdf [acc. 2014-07-09]

Korean Maritime Safety Tribunal. (2014) http://www.kmst.go.kr/eng/main/main.jsp [Acc. 2014-06-10]

Porathe, T. (2012). Transmitting intended and suggested routes in ship operations: cognitive off-loading by placing knowledge in the world. IOS Press, Work, (41), 4873-4878.

Porathe, T., de Vries, L., Prison, J. (2014). Ship voyage plan coordination in the MONALISA project: user tests of a prototype ship traffic management system. In De Waard, D., Brookhuis, K., Wiczorek, R., Di Nocera, F., Barham, P., Weikert, C., Kluge, A., Gerbino, W., and Toffetti, A. *Proceedings of the Human Factors and Ergonomics Society Europe Chapter 2013 Annual Conference*.

Porathe, T., Lützhöft, M., & Praetorius, G. (2012). What is your intention? Communicating routes in electronic nautical charts. Elsevier, Procedia - Social and Behavioral Sciences (48), pp.3266-3273.

SESAR-project. (2014). Single European Sky ATM Research project. Brussels: European commission. http://ec.europa.eu/transport/modes/air/sesar/ [acc. 2014-07-14]

Transport Trust. (2014). Croydon Airport. London: Transport Trust. http://www.transportheritage.com/find-heritage-locations.html?sobi2Task=sobi2Details&catid=91&sobi2Id=273 [acc. 2014-07-14]

Usability Body of Knowledge. (2014) Usability Testing. http://usabilitybok.org/usability-testing. The User Experience Professionals' Association