Digital Hydrography on the Maritime Web
Embracing the challenges and opportunities

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Abstract

The paper will explore pros and cons of e-Navigation seen from a user's perspective based on real-life examples.

Much information that is exchanged between ship and shore is already available in digital form and also submitted digitally. However, in many cases the same information is re-communicated by various means, increasing the workload and the risk of misunderstandings. Information overload is certainly detrimental to the safety of navigation.

The paper will explore easily achievable options and draw attention to concerns regarding additional new information exchange requirements because it may be technically possible, instead of focusing on simplifying or reducing the requirements.

Issues like consequences of increased traffic control measures from shore for the bridge team workload, liability issues in this context as well as the need for a user driven process to ensure the benefits of e-Navigation can be harvested will be discussed. Comparisons to past experiences with implementation of new equipment will be made, highlighting where enhancements to the development and implementation process may be possible. The differences between the navigating navigator and the monitoring navigator will be discussed and thoughts on the possible consequences of moving towards the monitoring navigator reviewed.

e-Navigation - A user's perspective

Shipping is a business. Safe and efficient shipping is good business, a fact that ship officers and ship owners are keenly aware of. Looking at accident investigations we very often see that the ultimate cause is attributed to human error but rarely, if ever, have an investigation into the underlying issues been made; e.g. could the overall workload on the bridge in a given situation be a contributing factor to the erroneous decision?

A working day on a ship's bridge

Let us have a look at a working day on a ship's bridge. The ship is manned with experienced mariners that know very well how to navigate safely and handle their ship with due respect to the cargo and traffic and weather encountered en route.

As long as the ship navigates the high seas all is well. But when the ship approaches the continental shelf potential trouble looms ahead. Not only from other ships that may pose a collision risk, but increasingly so from well-meaning shore-based authorities that would like to offer assistance and, 'by the way', also absolutely need to know some ship particulars such as dimensions, cargo, current position, course and speed, dangerous cargo carried etc.

An example of a reporting from the VTS system in the Great Belt in Denmark – BELTREP – is illustrated in Figure 1. The fields highlighted in green are transmitted by Automatic Identification System (AIS); the static information least every six minutes while dynamic information e.g. ship manoeuvring information is transmitted every few seconds. Luckily for the navigator, BELTREP, as one of the few VTS systems, accepts information submitted prior to arrival by e-mail and also AIS information as indicated in the illustration.

Nevertheless the VTS must be contacted by VHF when entering or leaving the VTS area, and provided with an interim report when passing from one sector to the next. The interim report is short, consisting of fields A, Q or R and U from the full report. The short form is also applicable when entering the VTS area if the full report has been submitted by email prior to arrival at the VTS limit.
<table>
<thead>
<tr>
<th>Designator</th>
<th>AIS</th>
<th>Non-verbal (e.g. email)</th>
<th>VHF</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Ship identification</td>
</tr>
<tr>
<td>B</td>
<td>Yes</td>
<td>–</td>
<td>–</td>
<td>Date and time</td>
</tr>
<tr>
<td>C</td>
<td>Yes</td>
<td>–</td>
<td>–</td>
<td>Position</td>
</tr>
<tr>
<td>E</td>
<td>Yes</td>
<td>–</td>
<td>–</td>
<td>Heading</td>
</tr>
<tr>
<td>F</td>
<td>Yes</td>
<td>–</td>
<td>–</td>
<td>Speed</td>
</tr>
<tr>
<td>G &amp; I</td>
<td>Yes</td>
<td>–</td>
<td>–</td>
<td>Last port of call, destination and ETA</td>
</tr>
<tr>
<td>H</td>
<td>–</td>
<td>Yes</td>
<td>–</td>
<td>Date and time (UTC) and appropriate reporting line for entering BELTREP-area</td>
</tr>
<tr>
<td>L</td>
<td>–</td>
<td>Yes</td>
<td>–</td>
<td>Route information in BELTREP-area</td>
</tr>
<tr>
<td>O</td>
<td>Yes</td>
<td>–</td>
<td>–</td>
<td>Maximum current draught in metres</td>
</tr>
<tr>
<td>P</td>
<td>–</td>
<td>Yes</td>
<td>–</td>
<td>Cargo</td>
</tr>
<tr>
<td>Q or R</td>
<td>–</td>
<td>–</td>
<td>Yes</td>
<td>Details of defects and deficiencies Any pollution or dangerous goods lost overboard</td>
</tr>
<tr>
<td>T</td>
<td>–</td>
<td>Yes</td>
<td>–</td>
<td>Ship's representation or owner</td>
</tr>
<tr>
<td>U</td>
<td>–</td>
<td>–</td>
<td>Yes</td>
<td>Ship's dimensions, DWT and maximum air draught</td>
</tr>
<tr>
<td>W</td>
<td>*</td>
<td>Yes</td>
<td>–</td>
<td>Total number of persons onboard</td>
</tr>
<tr>
<td>X</td>
<td>–</td>
<td>Yes</td>
<td>–</td>
<td>Miscellaneous</td>
</tr>
</tbody>
</table>

Figure 1: BELTREP reporting form

Provided the AIS is functioning, we could wish that the information in the short form could be reduced further, to only require VHF communication if there are any recent changes to the information submitted by e-mail or transmitted by AIS. Certainly, with ID information submitted every six minutes or more frequently by the AIS and if Marinetraffic.com can extract the required information from the AIS service and broadcast them via the internet, surely the land-based authorities can do the same and distribute the information internally amongst the VTS operators.

The only action required from the watch on the ship would be to contact the VTS if the AIS were, for some reason, defective. So there would be one less thing to worry about whilst the ship is transiting the Great Belt and the amount of VHF communication would be reduced. However, the reporting requirements in BELTREP are far more in the spirit of e-Navigation compared to CALDOVREP, for example, where all information in the similar reports must be transmitted by VHF.

And there are more reports to be made, in particular in preparation for entering port. Customs, immigration, local authorities etc also demand their reports and more often than not the reports must be printed, stamped and signed by the master in advance of port entry. In some cases up to 90 individual documents must be checked so they are up to date prior to entry. So whilst the vessel is navigating coastal waters heading for the port, the master – the most experienced deck officer on board who should be supervising and guiding the younger navigators – is busy printing and signing papers providing information that is already held by the home office, the agent or the port and could be readily shared with the authorities. And to make matters worse, the same reports must frequently be filled out many times in different formats and handed in at the next port of call, even though the port is in the same country.
The potentially positive side of e-Navigation

Imagine that the authorities share a database into which the ships, ship owners and agents could report the required information digitally, using a digital signature of course. At the same time the authorities could extract the information they required prior to a ship arriving. And rest assured, the port will be able to supply exact ETA information because they do know which ship arrives when, from where. This would indeed free up time for the master to actually do what he is trained to do – navigate the ship safely, when he is not having his mandatory rest periods of course.

Credit card companies can monitor transactions all over the world, tell the owner if it is being used in two different parts of the world within the same day and ask if those transactions were really made by the owner. One would think it should be possible to establish similar monitoring of information about a ship, only requesting action if things are changing. This would ease the administrative burden on the ship and contribute to freeing up time to ensure safe navigation.

There is no evidence that the administrative burden put upon the bridge team when navigating in confined waters is part of the underlying causes for accidents, but the administrative burden of a.o. reporting is a part of the overall workload.

There are no technical problems implementing an information sharing system as described above – merely administrative issues between authorities in a country and between authorities in neighbouring states.

In the EU under the European Maritime Safety Administration (EMSA) SafeSeaNet is now in operation. For further information see SafeSeaNet at www.emsa.europa.eu/operations/safeseanet.html.
Vessel traffic monitoring in EU waters (SafeSeaNet)

SafeSeaNet is a vessel traffic monitoring and information system, established in order to enhance:

- maritime safety
- port and maritime security
- marine environment protection
- efficiency of maritime traffic and maritime transport

SafeSeaNet was established as a centralised European platform for maritime data exchange, linking together maritime authorities from across Europe. It enables European Union (EU) Member States together with Norway and Iceland to provide and receive information on ships, ship movements, and hazardous cargoes. Main sources of information include AIS-based position reports and notification messages sent by designated authorities in participating countries.

SafeSeaNet holds much potential to reduce the amount of required reporting provided that the information collected in SafeSeaNet does NOT have to be duplicated.

On the technical side, SafeSeaNet is working on implementing an XML Schema for reporting allowing data suppliers to create automatic extraction routines from the administrative systems used, thus reducing the effort required to compile, provide and update the information.

This reduction of workload by reducing the requirements to provide the same information through different channels over and over again would indeed be a very positive effect of e-Navigation. Sadly, SafeSeaNet only covers EU-ports, but perhaps the initiative can spread to wider areas in the world.

The potentially negative side of e-Navigation

The potentially negative aspect of e-Navigation is that it appears to be mainly driven from the shore-side because, to a large extent, ships already navigate safely and this potentially removes the focus on helping the user onboard.

The shore-side drive is principally in the form of increasing demands for safer maritime traffic and better security measures, including official requirement for civil traffic monitoring and communication, and exchange of information ship-shore and shore-ship. Further, there is a risk that, in the end, it will only be a business opportunity for manufacturers to deliver new systems based on old technology and the added risk of removing the responsibility of safe navigation from the master to the shore-side.

Let us consider two different types of navigators:

- the navigating navigator
- the monitoring navigator

The navigating navigator a.o. continuously monitors:

- ship’s progress along the planned route and takes action to correct if the ship moves astray
- environmental conditions and takes action to ensure safe progress with respect to ship’s construction, passengers and cargo carried
- traffic around the ship taking early action to avoid close quarters situations and collisions
- floating objects encountered along the route taking action to avoid collision and reports dangerous hazards to authorities ashore
- cargo conditions and takes action to rectify the conditions required for the safe transportation of the cargo

The navigating navigator’s own skills will in the future still be essential for the safe navigation of the ship, and the bridge team will be the main backup for the safe functioning of the ship.

The monitoring navigator will have to rely more heavily on automated processes, standardised and harmonised procedures and equipment. Data structures, displays and services will have to be interoperable. A main task will be to monitor the system displays and the indicators of the system’s health or resilience. The role of the monitoring navigator resembles, to a large extent, the role of the pilot of an
airliner; there are those that claim that we should introduce a regime similar to air traffic control into shipping.

But do we really wish to move towards a monitoring navigator?

The navigating navigator is the only 'type' possible today (SOLAS and STCW). However, some coastal states believe that the monitoring navigator will be introduced in the future. e-Navigation in its widest application will be the cornerstone for that scenario to happen as very sophisticated systems will be needed. The idea of the monitoring navigator seems to be a founded on a belief that shore-side personnel, via traffic control, will be able to navigate the ship better than the crew (just like aeroplanes).

We dispute that because the air and the sea are different in nature. Sea traffic control does not function in the way air traffic control does.

Even with very sophisticated systems a control tower (or maybe even a bunker deep within a mountain) will not have the full picture. Let us consider a few examples.

The control tower ashore will not:

- spot the yacht, the kayak and the small fishing vessel but the navigator looking out of the window on board will
- know the real sea and weather conditions and their impact on a particular ship, so shore-side instructions may cause damage to cargo and ship
- spot the lost cargo/container/ice floe floating low in the water but the navigator looking out of the window on board will

Further, air traffic control can separate traffic in three dimensions; this is something that is not possible for shipping (with the submarine as an exotic exception).

Also, commercial interest can impact on how the ship is managed, e.g. what speed the master chooses in order for the cargo to be delivered on time, which traffic control is not aware of.

On the regulatory side UNCLOS, COLREG and SOLAS will have to be amended in order to implement such a regime outside internal waters – and this will be a very long-term process (25+ years?). And what about liability when the responsibility is taken away from the master? Will the shore-side be ready to cover the risks and associated cost of accidents?

All taken together, we do not see technical nor administrative solutions that will allow a move towards the monitoring navigator in the near or medium future, always remembering that e-Navigation is expected to enhance the safety at sea. Nor do we see any desire amongst the seafarers to move in this direction.

Looking at the risk of e-Navigation becoming a business opportunity for manufacturers rather than reducing the workload on the navigators, we hope that the lessons of the past when introducing ECDIS will not be repeated. Equipment manufacturing is a business just like shipping, and this should be borne in mind when planning the development of new standards and means of exchanging between ship and shore. Take the case of SENC distribution. The motivation for this was never really understood in the IHO community – and we cannot claim that we know the main driver for the equipment manufacturers. But allow us to speculate.

How do you make money on software? Basically in two ways:

- by selling many copies
- by selling a maintenance service at a cost higher than that of delivering it

An ECDIS manufacturer probably does not really manufacture much. An ECDIS system is essentially a ruggedised PC with some peripherals and a software kernel. The main part of manufacturing seems to take place when putting it all together in a nice-looking box. Overall, the IT industry is a highly competitive market and it is not easy to make a profit.

Selling many copies is rather difficult in the ECDIS business, due to the limited number of ships required to carry it. And, once fitted, ship-owners tend to leave the equipment onboard a ship until the day the vessel is scrapped, unless legislation forces them to do otherwise. The use of grand-fathering clauses when new carriage requirements are introduced is also fairly common and extends the take-up time of
new mandatory equipment. All taken together, the ECDIS manufacturer can hope to make ends meet on first-time sales and have little hope on making money on the maintenance. Where, then, can the manufacturer find a steady stream of cash to tap into?

The only steady income stream is in the supply of ENC data, and the only part of the data supply chain where a profit can be made is in the distribution. The originators i.e. the Hydrographic Offices certainly do not make any money from the supply of the original data and the updates to those data. A typical Hydrographic Office will generate an income of around 10% of their cost for providing and maintaining the data. The rest of the cost of the ENC data supply ends up in the distribution link and herein lies a possibility to generate a profit.

From this we can deduce that the motivation for the pressure to get into SENC distribution comes from a desire to get into the distribution chain and, to a certain extent, tie the supply of the data to the specific equipment. This also appears in the marketing materials where it is claimed that the conversion process from the original ENC data to the SENC is so long and cumbersome that it is best done ashore. This may be so or not, but at the end of the day there is little incentive for the equipment manufacturer to spend the developer's time on speeding up the conversion process – it will be an added cost that cannot be recovered. The conclusion that can be drawn from this is that SENC distribution has effectively put a lid on the development of a faster ENC conversion in the onboard ECDIS.

We hope that when new types of data get specified and distribution mechanisms agreed, the widest possible utilisation of open source solutions are supported, so the widest possible freedom of choice is open to the shipping community.

**Better support for electronic navigation using ECDIS**

ECDIS is and will continue to be an important part of e-Navigation in the foreseeable future.

Standardisation of electronic navigation information is well progressed and the new standards for exchange of digital information enshrined in S-100 and associated standards show the promise of an easier pathway to updating the read and display capability of particular onboard ECDIS equipment. We can only voice support for the drive towards increased standardisation and interoperability, including easier means of updating the software onboard the ship. But whilst efforts in this direction continue we hope that consideration is also given to legacy data i.e. the contents of the ENCs that are used today.

Let us have a look at a very specific example:

Consideration towards improving the data content of the ENC might well have the potential to provide the biggest benefit to future e-Navigation users via provision of denser depth areas allowing the mariner to select a safety contour that actually matches the ship's draught and planned under keel clearance.

Today the vast majority of ENCs are based on an initial digitisation of paper charts and then maintained by inclusion of new information as it becomes available e.g. new survey information. Only a few countries have put resources into large scale resurvey operations with modern techniques; Norway and Australia are fine examples and, in particular, Australia is showing the way by providing a 1m depth area interval covering critical routes. This approach really supports the use of ECDIS as intended, and greatly simplifies the ECDIS display in confined waters.

One cannot help being surprised when reading the May 2013 issue of the magazine Tanker Operator, where a product manager from a very notable Hydrographic Office writes: "Paper Charts come with tremendous embedded value, having already been set up to contain all information required for safe navigation on the chart scale in question".

First reaction on reading this is incomprehension. Does this mean that the ENC doesn't contain all the information required for safe navigation? Or is the navigator using ECDIS systems incapable of selecting for display the information necessary to navigate safely? We beg to differ on many levels not least that the mariner is very well capable of selecting the information necessary to navigate safely. And no, the paper chart does not contain all the information required for safe navigation – the mariner has to consult numerous handbooks as well as the paper chart to navigate safely, because as a medium the paper chart does not have room for all the information the mariner needs.
The mariner is trained to search and select from the information that is presented in the paper chart. The paper chart is, at best, a compromise that aims at supporting many different kinds of navigation all at the same time. As such, it is actually quite far from the ultimate goal of cartography, which is to present the user with the right information for the exact purpose at hand.

Today a paper chart is a highly refined product based on centuries of experience in arriving at a cartographic compromise that aims to support navigation for almost everything that floats from the boater or yachtsman to the super tanker. Thus any mariner navigating a larger ship finds much information on the paper chart, e.g. inside the 10m depth contour, that is of very little if any use but that must be kept up-to-date to satisfy zealous port state control inspectors. Further, the selection of depth contours on paper charts seem to suggest that they were designed to support navigation at a time when a ship with a draught over 5-6m was a rarity. At least the ECDIS display gives the possibility to deselected information that is of no interest for the task at hand – whilst retaining the minimum required for safe navigation and the option to switch to that minimum with 'single operator action' as prescribed by the ECDIS performance standard.

When navigating a ship with a 14m draught using a paper chart, the mariner has to make up his own danger areas, often based on very little information because there are only scarce soundings showing minimum depth between the 10m and the 20m depth contour in the paper chart.

In the examples above, which are Norwegian charts from before and after 2003, it is evident that the presentation of depth contours has been amended to better reflect modern shipping. The dotted line in the old chart represents the 6m depth contour and in the new version we see 6m, 10m, 20m, 40m. An improvement indeed, but we are not quite there yet. Of course, paper as a medium sets some limitations on how much can be drawn, but these limitations do not exist in ENC. So it is entirely possible to provide a denser set of depth areas in the ENCs that will support the navigation task at hand on the individual ship, freeing the mariner of the burdensome and error-prone task of creating no-go areas based on just a few soundings.

So why don't we see denser depth areas? How can a Hydrographic Office produce a 10m and 20m contour line with great confidence, but not a 12m or 14m contour line?

Maybe someday someone can provide a good reason why such helpful presentation of information is withheld.
Where do we want e-Navigation to go?

We acknowledge that there is a need for improved systems both ashore and on the ship. Further there is a cost side, so existing systems should be the starting point and, if at all possible, new carriage requirements should be avoided or, at least, limited as much as possible by emphasising the use of existing equipment and means of communication.

It is also important to always remember and bear in mind that e-Navigation is intended to enhance navigation and increase the safety at sea. Therefore e-Navigation should focus on the positive sides (as mentioned above) making life easier for the operators onboard the ship, so that the navigator onboard can concentrate on navigating the ship safely from port to port.

We do not need e-Navigation as a means for traffic control from ashore as there are safety issues which have not been solved and we doubt that a shore-based controller will ever be in the position of being better qualified to have the complete picture, for example, of how a ship is moving in bad weather or the optimum decision to take to navigate it through the storm.

Summing up, we see some commercial possibilities for e-Navigation that might help the implementation process:

- shore and ship communicate less as data can be relayed, so that they do not need to be repeated over and over (lower the administrative burden)
- slots to port driven by ETA concepts (good for fuel consumption and GHG issues)
- deepwater vessels navigate more effectively with real-time tidal information (more effective shipping)
- better services from shore regarding difficult parts of passage in internal waters

To support the move forward the following need to be considered:

- cost of transmitting electronic documentation and data in cost-benefit calculations
- the ship owns data sent to shore – will this create problems with e.g. relay?
- how to ensure that information is reliable, updated and kept confidential so only relevant parties can access the data required (data protection)?

Moving ahead with e-Navigation we sincerely hope that the positive potential of e-Navigation can be harvested and the negative potential avoided. We are indeed looking forward to contributing to the continued discussions.