e-Navigation infrastructure – should we care?

As the infrastructure that will form the basis of IMO's e-Navigation programme continues to evolve, it is important that technology standards are introduced if the initiative is to truly fulfil its potential, ***writes Fred Pot, Marine Management Consulting***

IMO's Correspondence Group on e-Navigation (CG) is on schedule to recommend a Strategic Implementation Plan (SIP) by December 2014. The SIP will probably specify the dates by which various classes of SOLAS ships and shore-side entities will be required to implement e-Navigation solutions.

These solutions will address many of the 'gaps' that the CG formally identified (see NAV 58-6 Annex 2[1]).

Currently the CG is estimating to what extent each of the 50 or so potential solutions[2] will improve the likelihood that ships complete their voyages safely, securely, efficiently and in an environmentally friendly manner.

The CG will then subject the highest ranked solutions (in terms of their efficacy in mitigating risks) to a rigorous cost/benefit analysis and, at some point in time, develop minimum performance requirements for those solutions that make it all the way through this 'Formal Safety Assessment' (FSA) process.

Many of the potential solutions involve information exchanges between ships and shore-side entities.

Some information exchanges will make decision support information available to the mariner that wasn't available before, for instance information from shore-based water-level, current, wind and other sensors. Other information will likely include real-time bathymetry, bridge clearances, lock openings, etc.

Information exchanges are also being considered to provide shore-based VTS[3], MRCC[4] and other users with decision support information from ship-board sensors, bridge alarms and other sources.

AIS[5] already provides them with basic information but e-Navigation will likely complement that with more detailed information, for instance about the accuracy of the ship's navigation instruments, the health of the ships' systems, its voyage plan, its cargo manifest, etc.

Other information exchanges are being considered to automate updating ENCs[6] and nautical publications and to streamline reporting to coastal and port authorities. The intent of these information exchanges is to lessen the administrative burden on mariners and thus allow them more time to conn the ship.

Other potential solutions will provide mariners and shore-based users with an indication of the accuracy and health of their sensors and make the human/machine interface of their instruments more intuitive and ergonomic.

Automated information

One of the potential e-Navigation solutions is to completely automate information exchanges, relieving mariners and shore-based users from having to operate communications equipment.

What is currently not clear is which of the many potential e-Navigation solutions will be adopted by IMO member states.

It is, however, quite clear that developing detailed specifications for each solution to estimate its costs and (risk mitigation) benefits will take time and that developing a minimum performance standard for each solution once it has made it all the way through the FSA process will take more time.

Decision support information is typically presented to the user on a screen. Radar and ECDIS screens on-board and shore-side VTS screens are examples.

The software that presents decision support information on screen and that gives the user control over what and how information is presented is an 'application'. The application software relies on information that is stored in a database (i.e. ENC), directly received from sensors (i.e. GPS, AIS, Radar, fathometer, etc.) and from the instrument's knobs and controls.

Historically, instruments were independent from each other and only presented information from a single sensor (i.e. radar, fathometer, GPS, Gyro, etc.). It was left up to the user to gain situation awareness by combining information from different boxes.

Gradually applications have become more task-oriented. They soon will present users with all information that they need to perform a particular task.

Proposed e-Navigation System Architecture

Derived from a proposal for e-navigation shipboard technical architecture presented by Woo-Seong Shim, KIOST, Korea

Any User Device with intuitive Human Machine Interface including Audio (i.e. INS, Workstation, Heads Up Display, Tablet, etc.)

Secure connection to e-Navigation Applications running on the Private Computing Cloud

Certified e-Navigation Applications from any vendor

On-Board		Ashore
• Collision Avoidance/Passage Planning • Route Monitoring • Route Planning/UKC/Airdraft/Weather/Fuel • Conning (Mooring/Anchoring/etc.) • Alert Management • Systems Monitoring/Trouble Shooting • Ship Reporting to Authorities (FAL Reports) • Information Subscription Management • CBT including equipment familiarization materials • Database Search Engine that allows geo-referenced and other searches	• ISM/SMS Application • Trim & Stability • Fire Fighting • (SAR) Messaging • Etc.	• MSI Publication Management • Traffic Organization Service (TOS) • Remote Inspection of Quality of Ships' Instruments • Navigation Assistance Service (NAS) • VTS Services Advertising • MRCC Incident Management • Marine Domain Awareness (MDA) • Information Subscription Management • Database Search Engine that allows geo-referenced and other searches • Etc.

Private e-Navigation Computing Cloud

Any Certified Instance of the Open Source Reference System Architecture

Architecture – Certified Services:

- Information Management System (IMS) with S-10X format subscriptions to Information Services from local & remote sensors and other equipment/sources (i.e. Radar, AIS, GNSS, MSI's, Voyage Plan, Manifest, ENC & Nautical Pubs updates, SAR Sources)
- Ship/Shore Radio Communications Network Router to automate wireless digital information exchanges via **any** network
- Ship/Shore Network Connection Status Updates for **all** available communication networks
- Security Key Manager for encrypted communications
- **Any** Data Base Management System and **any** other Application Services

Engine (Service Broker, Port, Context, HAL, UI Framework)

Middleware (**Any** Operating System, Containers, Discovery & Peering, Communications, Load Balancing, other generic services)

Virtualization Layer

Hardware:

- Redundant Physical Servers (**Any** CPU, **Any** Storage Hardware or Device)
- Networking & Firewalling, Connections to local Sensors, Radar, Radio Communications Equipment, User Devices and other equipment, using **any** network protocol (i.e. TCP/IP, **all** versions of IEC 61162 and **all** proprietary protocols).
- Data Center Mechanical & Uninterruptable Power Supply (UPS)

Required Characteristics of the e-Navigation Open Source Reference System Architecture (similar to AUTOSAR for the auto industry and SAVI for avionics)

1. To make the architecture future proof for industry innovation and to avoid vendor lock-in, it should be technology neutral and thus allow certified e-navigation applications to be deployed on **any** server hardware, **any** operating system and **any** user device without interfering with legacy systems. Also to allow "Mixing and Matching", certified e-navigation applications from different vendors should not interfere with each other.
2. To achieve redundancy, multiple reference architecture instances should be hosted on each physical server with automatic load balancing and failover.
3. To avoid the need to customize e-navigation applications for the local portfolio of sensors and other information sources, these sources should comply with Universal Plug-n-Play (UPnP) standards (IEC 29341-1). Sensors and information sources should be replaceable on-the-fly with automatic discovery & peering.
4. To securely manage complex information exchanges and to allow encryption where necessary, a Pub/Sub messaging pattern should be used.

Examples are collision avoidance in congested waters, mooring/anchoring, voyage planning, alert management onboard; and traffic organisation, SAR[7] incident management and managing MSI[8] publications ashore.

Users will no longer have to go from box to box to gain situation awareness; they can call up relevant decision support applications on 'their' screens for whatever the tasks at hand are. The INS (integrated navigation system) workstation is a good example.

E-Navigation will most likely affect almost all existing decision support applications. E-Navigation solutions will also require a number of new software applications to automate information exchanges, for instance.

E-Navigation will furthermore change the information that sensors provide to add details about their accuracy and their health.

Standards

Unlike the automobile, aviation and many other industries, there currently is no standard system architecture for the marine industry that covers electronic bridge and shore-side systems.

Instead, each vendor builds his own proprietary equipment with a CPU (computer processing unit), an operating system, his own system architecture, his own Human Machine Interface (HMI) and develops his own complement of proprietary decision support applications to run on his equipment.

Most vendors also bundle their sensors with their system and often use proprietary connections between their sensors and the rest of their system. Each individual sensor typically has a CPU, an operating system, a database and runs its own proprietary sensor specific software.

Electronic equipment and systems are typically selected by the shipyard and offered with the ship as a package that can be changed, but the change order fees tend to be significant.

The result is that ship owners and operators typically are prevented from using their own criteria (cost, features, intuitiveness, quality, reliability, maintainability, etc.) to select their decision support applications and their sensors. Ship owners and operators cannot easily 'mix-and-match' electronic equipment from different vendors.

The IEC 61162[9] digital interfaces standard should make that possible, however it can only process sensor values and it cannot process video. It is not suited for reporting sensor health and accuracy, it cannot be used to remotely (i.e. shore side) monitor, trouble shoot and upgrade sensor system software, nor can it process the messages using the verbose e-Navigation S-100[10] standard protocol.

The situation for shore-side equipment is very similar.

The result is that ship owners and coastal and port authorities are typically locked into a single vendor for support and upgrades. That suits vendors because they can, and often do, charge a premium for their support and upgrades.

Partially due to this vendor lock-in, ship owners and coastal and port authorities typically delay a major refit of electronic equipment as long as possible. Yet the pace of technology development is, if anything, speeding up rather than slowing down.

It appears that the CG doesn't intend to change this situation, because it will likely rely on vendors to add e-Navigation solutions to already installed (shipboard and shore-side) electronic equipment through software upgrades and, where that is not possible, to develop and market new stand-alone equipment that has the functionality required by the various solutions.

It doesn't have to go that way. With the introduction of e-Navigation solutions, the CG has a unique opportunity to improve the situation.

It has an opportunity to mitigate the effects of vendor lock-in. Specifically, it has an opportunity to unbundle applications from their computing platform by setting a standard for the platform's system architecture that can accommodate any operating system, any database and any CPU.

Such system architecture will also provide the CG with an opportunity to allow any application to use all local and remote sensors and other sources of information without interfacing issues.

Future-proof

Roll-out of e-Navigation solutions will not likely occur before the 2015-2025 timeframe and technology can be expected to change drastically between now and then. Therefore the CG should anticipate technology improvements and the direction of industry innovation as much as possible to make e-Navigation future proof.

In other industries the trend towards industry-wide reference system architecture (RSA) standards is clear (for instance AUTOSAR[11] in the automobile industry and SAVI[12] in the avionics industry) and has proven to increase availability and quality of solutions while reducing their cost.

The marine industry stands at the cusp of realising the same benefits if it adopts an industry-wide system architecture standard.

If the CG adopts an RSA[13] then it will provide the framework within which any software application (i.e. e-Navigation solution) can run on any operating system on any CPU using any data storage device and use any source of information on any communications network.

The framework will also allow ship owners and port and coastal authorities to adopt better, more reliable and less expensive technology without having to wait for a major refit, because all components will be 'Plug-n-Play[14]' (see IEC 29341-1[15]).

A major reason why the CG should consider adopting a standard RSA is that it will assure interoperability between shipboard and shore-side systems.

It will provide the framework for automatic seamless and secure e-Navigation information exchanges irrespective of the systems that are involved in the exchange, as long as they adhere to the RSA standard.

The aviation industry's SAVI RSA allows it to use fly-by-wire technology and meet all relevant performance standards.

The automobile industry's AUTOSAR RSA allows it to run several mission critical applications on a car's computing platform:

1. Break by wire (i.e. ABS)
2. Steer by wire
3. Accelerate by wire

All of these comply with the automobile industry's stringent performance and reliability standards.

The computing platform that runs these applications is also used to integrate smart telephone and music playback functionality into the car's sound system using a Bluetooth connection, for instance.

For safety, security and performance reasons, the RSA should be the overarching standard for all applications and all computing platform layers will need to be clearly defined ('abstracted').

Most ships already carry a computing environment for business purposes such as e-mail, stores inventory and purchasing, HR, payroll & time keeping, online forms, etc. Using a robust RSA as the overarching standard, and with a few Commercial Of The Shelf (COTS) additions to increase its reliability, the already available computing environment (i.e. servers, LAN, database management system, etc.) could host both business applications and e-Navigation applications without affecting each other.

Using a private cloud for all applications greatly reduces the need for proprietary and expensive single function electronic equipment.

An RSA will also provide a common infrastructure to remotely monitor, troubleshoot and upgrade software for (the remaining) electronic equipment. An RSA provides the necessary secure (ship/shore) real-time communications and access security that will allow vendors to remotely service their electronic equipment in most cases before it fails and without having to dispatch service engineers.

A developer of an (e-Navigation and other) application that is designed to run in an RSA cloud doesn't have to worry about customising it for the portfolio of sensors and the particular computing environment that application will run on the ship or ashore. The RSA cloud insulates developers from such complications.

IT industry experience shows that more than half of the effort to develop an application is spent on adapting it to the computing environment it will run in rather than on the application itself. This is the reason why RSA cloud applications are less expensive and of higher quality.

The number of choices of applications that perform similar functions also typically increases because development is no longer limited to those who are employed by a particular electronic equipment vendor.

Conclusion

Shipowners and port and coastal authorities would be major beneficiaries if the CG were to adopt an RSA for the e-Navigation infrastructure.

Doing so would have the effect of changing the market for electronic equipment from a sellers' market to a buyers' market. It would give you a way to avoid vendor lock-in and allow you to mix and match applications and sensors without interfacing issues.

It would increase competition among vendors to provide you with the best possible (e-Navigation and other) solutions.

It would not only significantly reduce the cost of providing the required e-Navigation infrastructure but, beyond that, it would allow you to future proof all your systems, limiting their total cost of ownership while increasing their quality, reliability and maintainability.

Shipowners and port and coastal authorities are encouraged to verify the claims that this author makes about the advantages of an RSA by consulting their software engineering experts.

If, as expected, your experts agree, then the author urges you to ask your CG representatives with the IMO, the International Chamber of Shipping (ICS) or IALA[16] to encourage the CG to adopt an RSA for e-Navigation. DS

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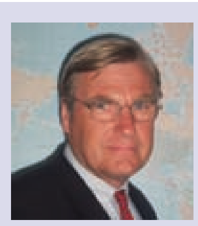

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