**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*

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**Proposed e-Navigation System Architecture**

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

<table>
<thead>
<tr>
<th>Certified e-Navigation Applications from any vendor</th>
<th>Certified Services of the e-Navigation Open Source Reference System Architecture</th>
<th>Required Characteristics of the e-Navigation Open Source Reference System Architecture (similar to AUTOSAR for the auto industry and SAVI for avionics)</th>
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</thead>
<tbody>
<tr>
<td>• Collision Avoidance/Passage Planning</td>
<td>• Information Management System (IMS) with S-10X format subdivisions to Information Services from local &amp; remote sensors and other equipment/sources (i.e. Radar, AIS, GNSS, MSSI’s, Voyage Plan, Manifest, ENC &amp; Nautical Pub updates, SAR Sources)</td>
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<tr>
<td>• Route Monitoring</td>
<td>• Ship/Shore Radio Communications Network Router to automate wireless digital information exchanges via any network</td>
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<tr>
<td>• Route Planning/UrgentAircraft/Weather/Fuel</td>
<td>• Ship/Shore Network Connection Status Updates for all available communication networks</td>
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<td>• Conning (Mooring/AnchorIning etc.)</td>
<td>• Security Key Manager for encrypted communications</td>
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<td>• Alert Management</td>
<td>• Any Data Base Management System and any other Application Services</td>
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<tr>
<td>• Systems Monitoring/Trouble Shooting</td>
<td>• Engine (Service Broker, Port, Context, HAL, UI Framework)</td>
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<tr>
<td>• Ship Reporting to Authorities (FAL Reports)</td>
<td>Middleware (Any Operating System, Containers, Discovery &amp; Peering, Communications, Load Balancing, other generic services)</td>
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<tr>
<td>• Information Subscription Management</td>
<td>Private e-Navigation Computing Cloud</td>
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<tr>
<td>• DBC including equipment familiarization materials</td>
<td>Hardware</td>
<td></td>
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<tr>
<td>• Database Search Engine that allows geo-referenced and other searches</td>
<td>Redundant Physical Servers (Any CPU, Any Storage Hardware or Device)</td>
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<td></td>
<td>Networking &amp; 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).</td>
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<td></td>
<td>Data Center Mechanical &amp; Uninterruptable Power Supply (UPS)</td>
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</tbody>
</table>

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\footnote{http://en.wikipedia.org/wiki/Search_and_rescue} incident management and managing MSE\footnote{http://savi.avsi.aero/} 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, 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 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 decision support 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 computing resources 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 technological improvements and the direction of industry innovation as much as possible to mitigate ‘future proof’ problems.

In other industries the trend towards industry-wide reference system architecture (RSA) standards is clear (for instance AUTOSAR\footnote{http://www.autosar.org/} in the automobile industry and SAVE\footnote{http://en.wikipedia.org/wiki/IEC_61162} 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 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 more reliable and less expensive technology without having to wait for a major refit, because all components will be ‘Plug-n-Play’\footnote{http://icaci.org/files/documents/ICC_proceedings/ICC2009/html/nonref/3_26.pdf} (see IEC 29541-1/94), and 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 smartphone 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 a 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.

If industry experience shows that more than half of the effort to develop an application is spent on adapting it to the computing environment, it is less than half the effort to develop an application that performs 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 seller’s market to a buyer’s 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\footnote{http://www.enavsolutions.org} to encourage the CG to adopt an RSA for e-Navigation.

References: