e-Navigation Infrastructure Design Considerations

Fred Pot
Marine Management Consulting
fpot@enavsolutions.org

E-Navigation Underway Conference
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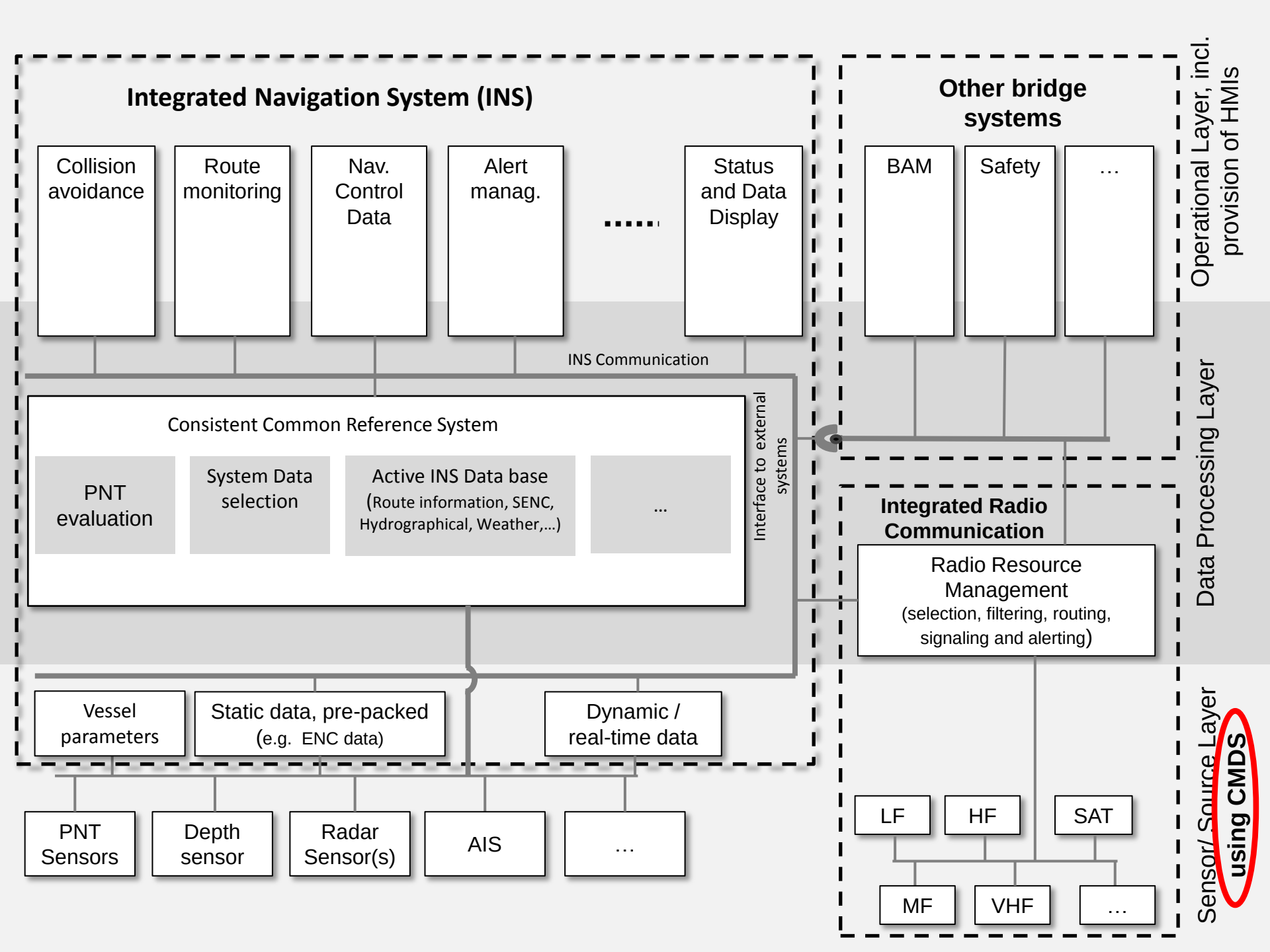
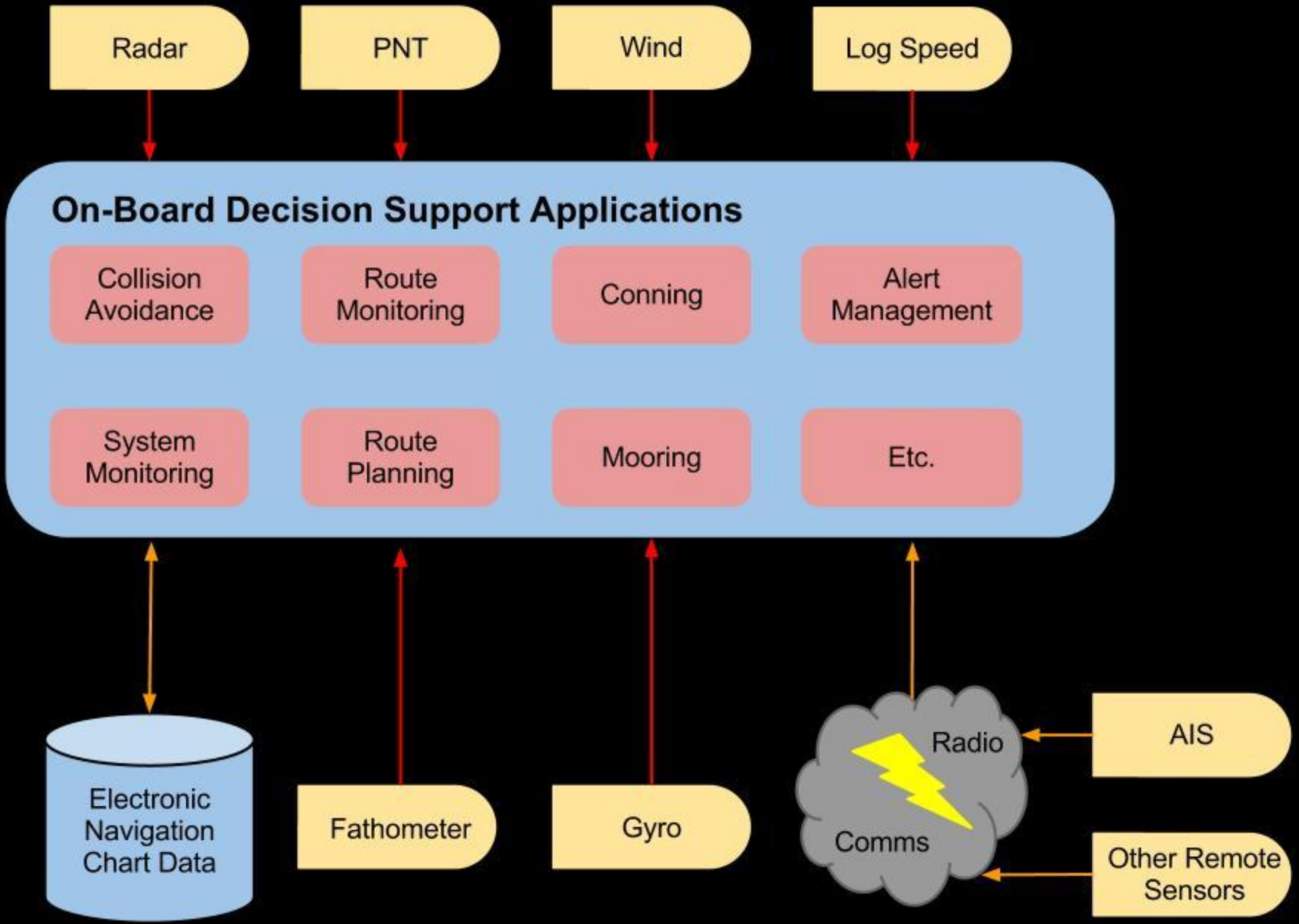
The Case for an Open Source Reference System Architecture

See also the article about this subject in the latest issue of The Digital Ship

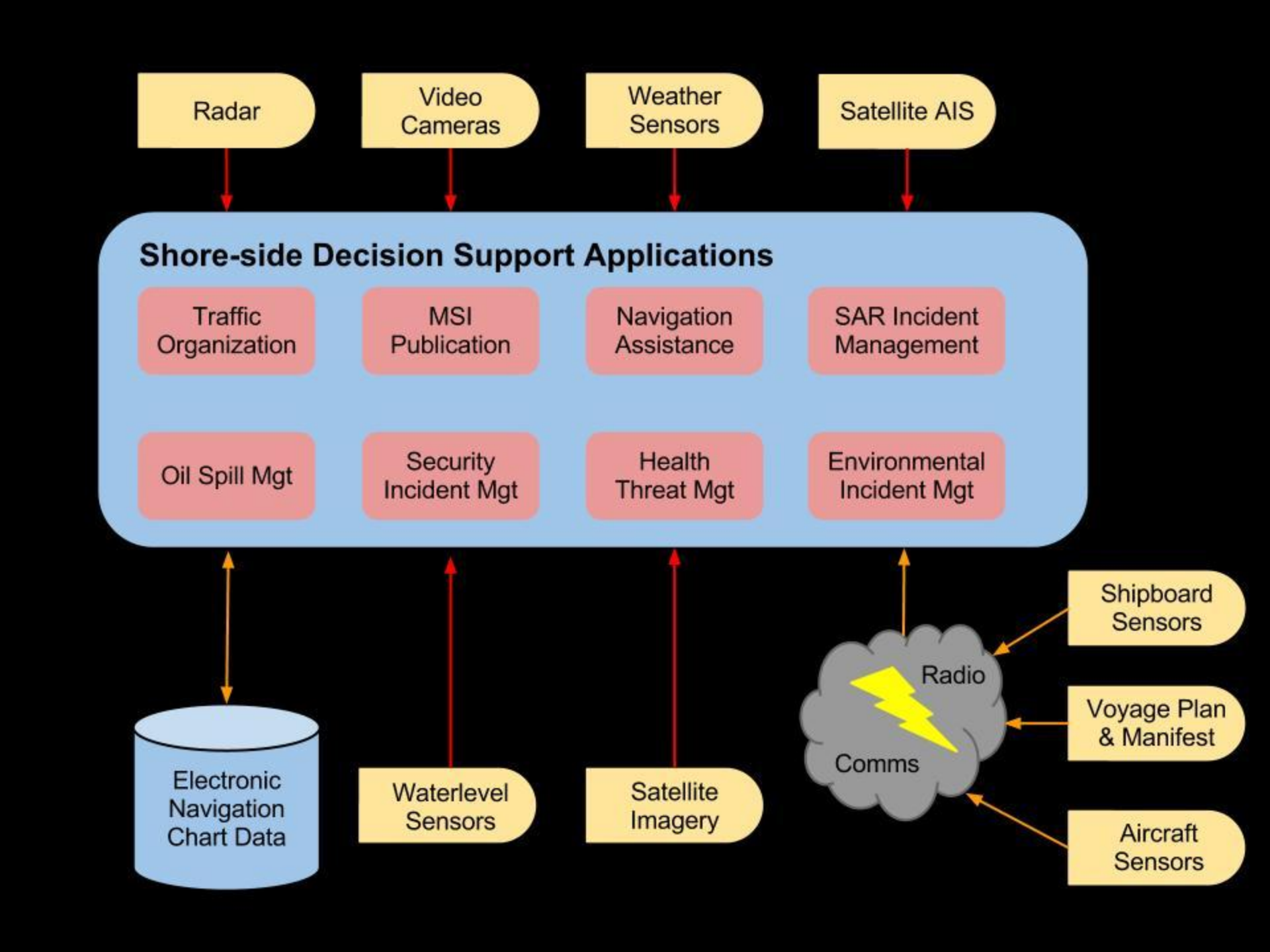
Example of an Integrated Navigation System (INS) on a Cruise Ship

Source: Sperry Marine

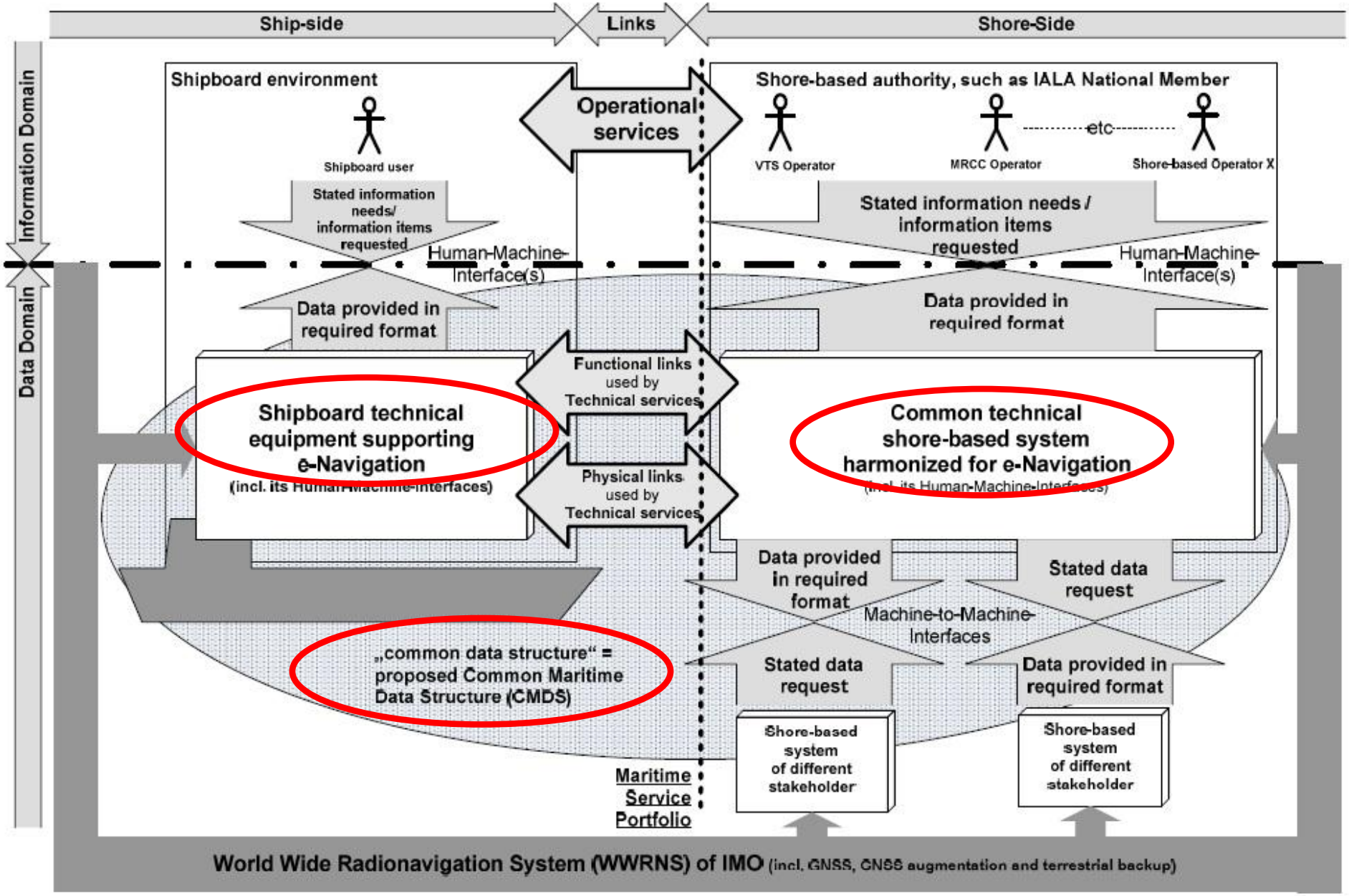

Integrated Navigation System (INS)
Collision avoidance
Route monitoring
Nav. Control Data
Alert manag.
.....
Status and Data Display
Other bridge systems
BAM
Safety
…
Operational Layer, incl. provision of HMIs
INS Communication
Consistent Common Reference System
PNT evaluation
System Data selection
Active INS Data base (Route information, SENC, Hydrographical, Weather,…)
…
Interface to external systems
Data Processing Layer
Integrated Radio Communication
Radio Resource Management (selection, filtering, routing, signaling and alerting)
Vessel parameters
Static data, pre-packed (e.g. ENC data)
Dynamic / real-time data
PNT Sensors
Depth sensor
Radar Sensor(s)
AIS
…
LF
HF
SAT
MF
VHF
…
Sensor/ Source Layer
using CMDS


Radar
PNT
Wind
Log Speed
On-Board Decision Support Applications
Collision Avoidance
Route Monitoring
Conning
Alert Management
System Monitoring
Route Planning
Mooring
Etc.
Electronic Navigation Chart Data
Fathometer
Gyro
Radio
Comms
AIS
Other Remote Sensors

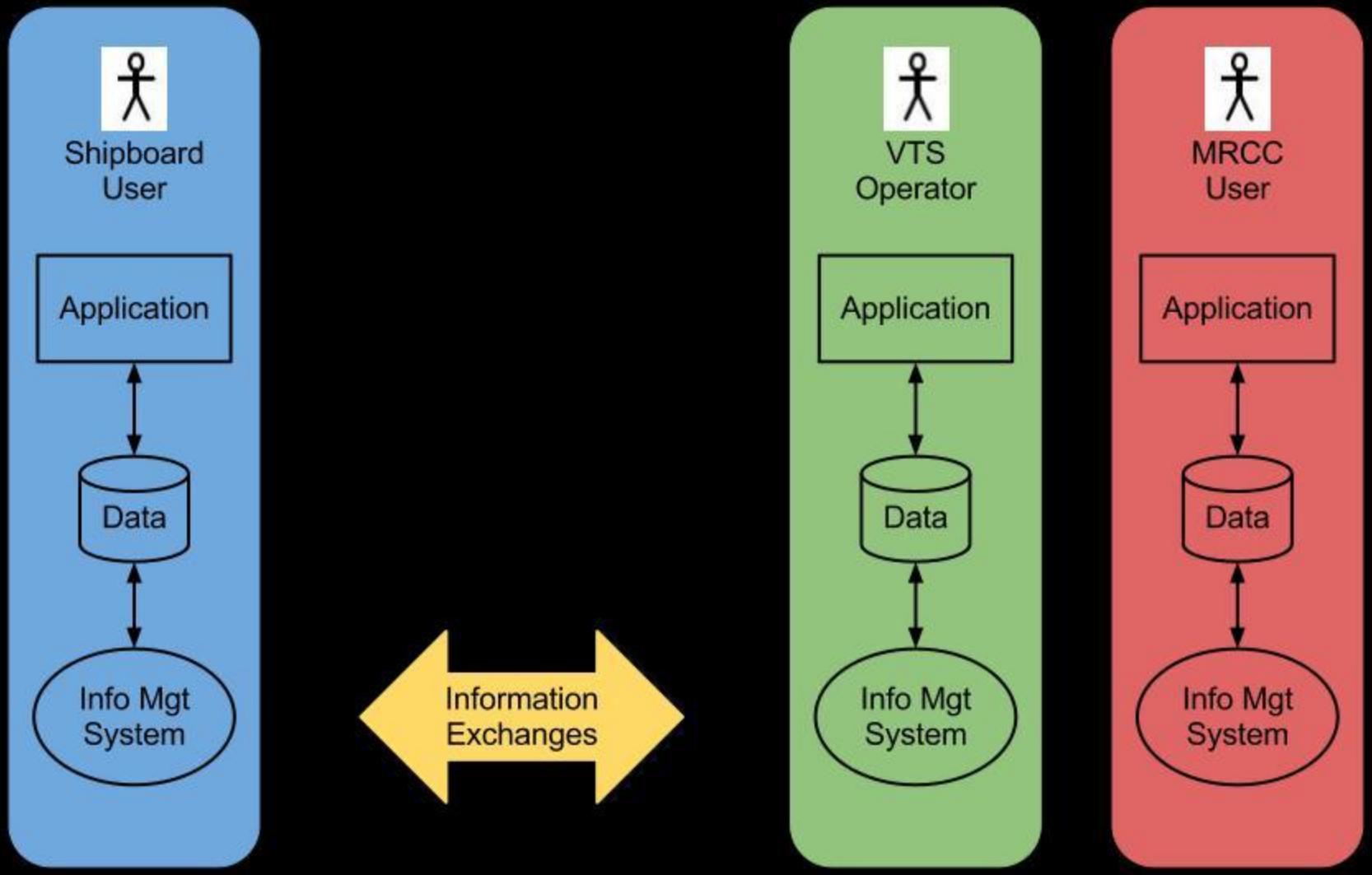

VTS


Radar
Video Cameras
Weather Sensors
Satellite AIS
Shore-side Decision Support Applications
Traffic Organization
MSI Publication
Navigation Assistance
SAR Incident Management
Oil Spill Mgt
Security Incident Mgt
Health Threat Mgt
Environmental Incident Mgt
Electronic Navigation Chart Data
Waterlevel Sensors
Satellite Imagery
Radio
Comms
Shipboard Sensors
Voyage Plan & Manifest
Aircraft Sensors

Overarching e-Navigation Architecture



Simplified Overall e-Navigation Architecture



What will e-Navigation Infrastructure Requirements be?

Solutions selected at NAV 59 will likely include:

- Automated Ship/Shore Information Exchanges (in S-100 format)
- Inter-operability between diverse computing environments (On-Board and Ashore)
- Health & Accuracy “Meta” Data for all Information Sources
- Region/Area Specific Solutions

Other Likely Requirements

- Redundancy with Automatic Fail-Over for all Critical Resources
- Use Existing Infrastructure/Technology where possible (On-Board and Ashore)
- Modular & Scalable
- Allow for Encryption of Information Exchanges (i.e. Transport Layer Security or TLS)
- Allow for Non-TCP/IP Protocols (NAVTEX, SafetyNet, DSC, AIS/IEC 61162)
- Must be Technology Agnostic to make it Future Proof (i.e. 3D Head’s Up Display, etc.)
- Technology Life Cycle Tools (Incl. Remote Trouble Shooting and Upgrading)
- Low Total Cost of Ownership (Acquisition, User Training and Maintenance Costs)
- Mix & Match Applications with sensors and other information sources
- Deploy an application on any computing platform without customization

E-Navigation Infrastructure Design should anticipate New Technology

E-Nav Implementation not until 2015-2025 Period

- Technology will change drastically in the meantime

Some Technology Trends are clear

- Cloud Computing is on the rise
- Open Source Reference System Architecture Standards (RSA) are adopted in many industries (Automobile, Aviation, Telecommunications, etc.)

Their effects have been well established

- Increased availability and quality of solutions while reducing their cost
- Marine Industry stands at the cusp of realizing the same benefits

Examples of Reference System Architectures in other Industries

AUTOSAR

AUTomotive Open System ARchitecture

BMW GROUP

BOSCH

Continental

DAIMLER

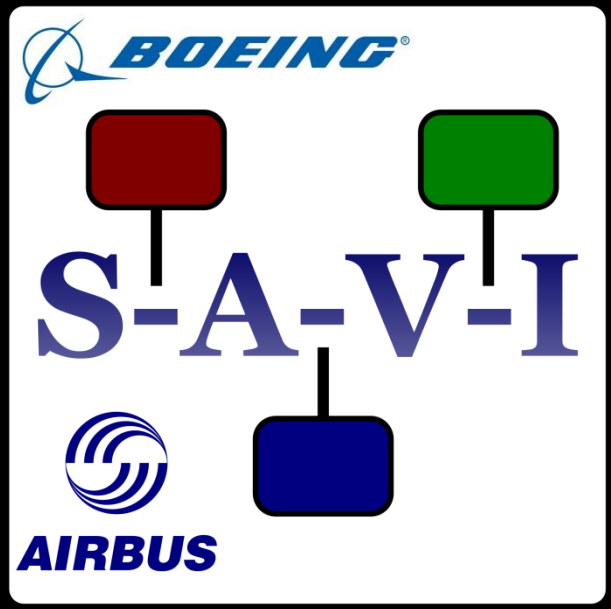
Ford

GM

PSA PEUGEOT CITROËN

TOYOTA

VOLKSWAGEN



System
Architecture
Virtual
Integration

Adoption of a Reference System Architecture Standard will

Enable Information Exchanges

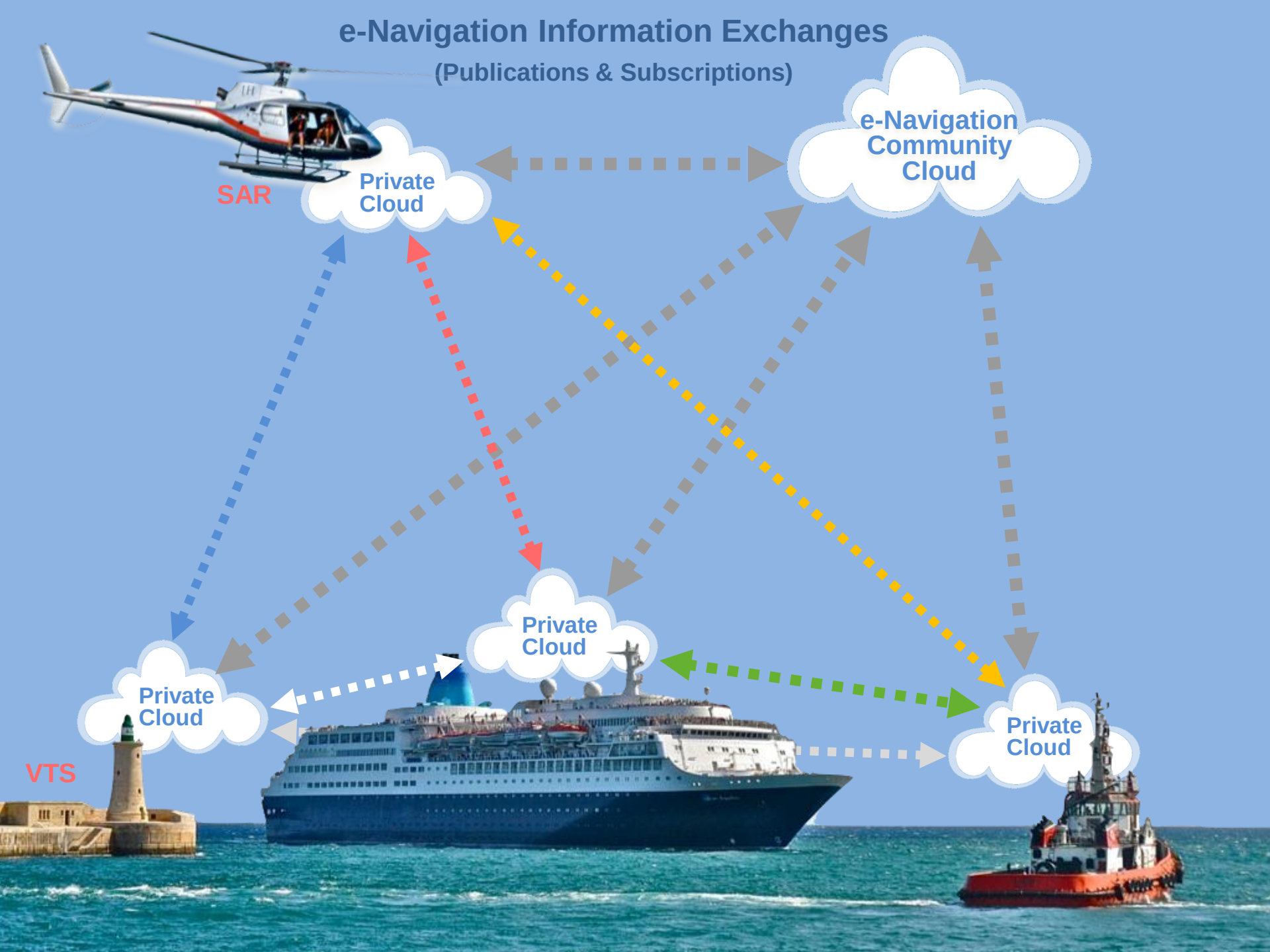
- Assure Interoperability between Shipboard and Shore-side Systems
- Provide the Framework for Automatic, Seamless and Secure e-Navigation Information Exchanges irrespective of the systems that are involved in the exchanges

Adopting Inter-Vendor Operability Standards

- Use well established interfacing standards
  - OpenGIS® Sensor Model Language Encoding (SensorML)
  - Universal Plug-n-Play (IEC 29431-1)
  - JSON (Java Script Object Notation)
  - Etc.

Allow use of existing Computing Environments

- An RSA can run alongside legacy applications on the same Platform
- An RSA is Platform Technology Agnostic
- An RSA can accommodate any Protocol on any Network


e-Navigation Information Exchanges
(Publications & Subscriptions)
SAR
Private Cloud
e-Navigation Community Cloud
Private Cloud
Private Cloud
Private Cloud
VTS

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

Security

Private e-Navigation Computing Cloud

Any Certified Instance of the **Open Source Reference System 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 and remote portfolio of sensors and other devices, they should comply with well-established interfacing standards (SensorML, UPnP, etc.) Sensors and devices 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.

E-Nav will likely require significant investments

Modify Decision Support Applications

- Process information received from remote sensors and other sources
- Receive and process health and accuracy information for all sources
- Present this information on-demand in an intuitive, task-oriented manner

New Applications

- Automatic message routing via available communications networks
- Information Management System
- Etc.

Modify Sensors, Information Sources and Network

- Built-In Integrity Testing (BIIT) and reporting of health status
- Accuracy Reporting
- IEC 61162 (NMEA) cannot handle these (or S-100 messages)

Ship Owners and Port & Coastal Authorities may be hesitant to embrace e-Navigation

They will likely be required to fund Implementation

- **Solution Carriage Requirements for new tonnage**
- **Solution Implementation Schedule for Port & Coastal Authorities**

Product Bundling and Vendor Lock-In are problems

- **Proprietary Apps with Proprietary Connections to Proprietary Sensors**
- **Inability to select best Application or Sensor (No Mixing and Matching)**
  - Inter-Vendor Operability using IEC 61162 (NMEA) is problematic
  - Impossible for video (Radar, Video Cameras, etc.)
- **Vendor sometimes charges a premium for Service & Upgrades**
- **Complete refit usually postponed until operational calamities occur**

Maintenance and Training Cost are Significant

- **Remote trouble shooting and upgrading software is still rare**
- **Additional, more complex equipment will increase maintenance costs**
- **Additional, more complex equipment will increase training costs**

Adoption of a Standard RSA could turn Ship Owners and Port & Coastal Authorities into e-Navigation Champions

Reduce Total Cost of Ownership

- Use (existing) Commercial Off The Shelf (COTS) computing environment
- Significantly reduce the need for proprietary, single function black boxes
- Allow trouble shooting and upgrading without traveling service engineers

Allow Mixing & Matching of Components

- Use well established interfacing standards (Universal Plug-n-Play, OpenGIS® SensorML, etc.) to eliminate Inter-Vendor Operability Problems and allow replacing Applications & Electronic Equipment On-The-Fly

Turn e-Nav Solution Market into a Buyer's Market

- Unbundle applications from computing platform and from sensors/sources of information
- Expand development of e-Navigation Solutions beyond Vendors of Electronic Equipment
- Increase availability and quality of solutions while reducing their cost

Recommended Next Steps

Specify e-Navigation Infrastructure Requirements

- Develop detailed CONOPS (aka “Use Cases”) for each Potential Solution
- Use FSA Criteria to select from Potential Solutions (NAV 59)
- Derive e-Navigation Infrastructure Requirements from Solutions’ CONOPS

Identify Alternative Infrastructure Options

- Ask a panel of Independent Software Engineering Experts from inside and outside the Maritime Industry to identify candidates
- Test candidates in ACCSEAS, Mona Lisa, MEH and others
- Use e-Navigation Objectives to evaluate candidates

Implement Selected Infrastructure Option

- Develop Minimum Shipboard Solution Portfolio
- Develop Minimum Performance Standards for the e-Navigation Shipboard and Shore-side Infrastructure
- Develop Infrastructure Implementation Plan

An Open Source RSA like MARSSA meets all requirements

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- ☑ • Health & Accuracy “Meta” Data for all Information Sources
- ☑ • Region/Area Specific Solutions

Other Likely Requirements

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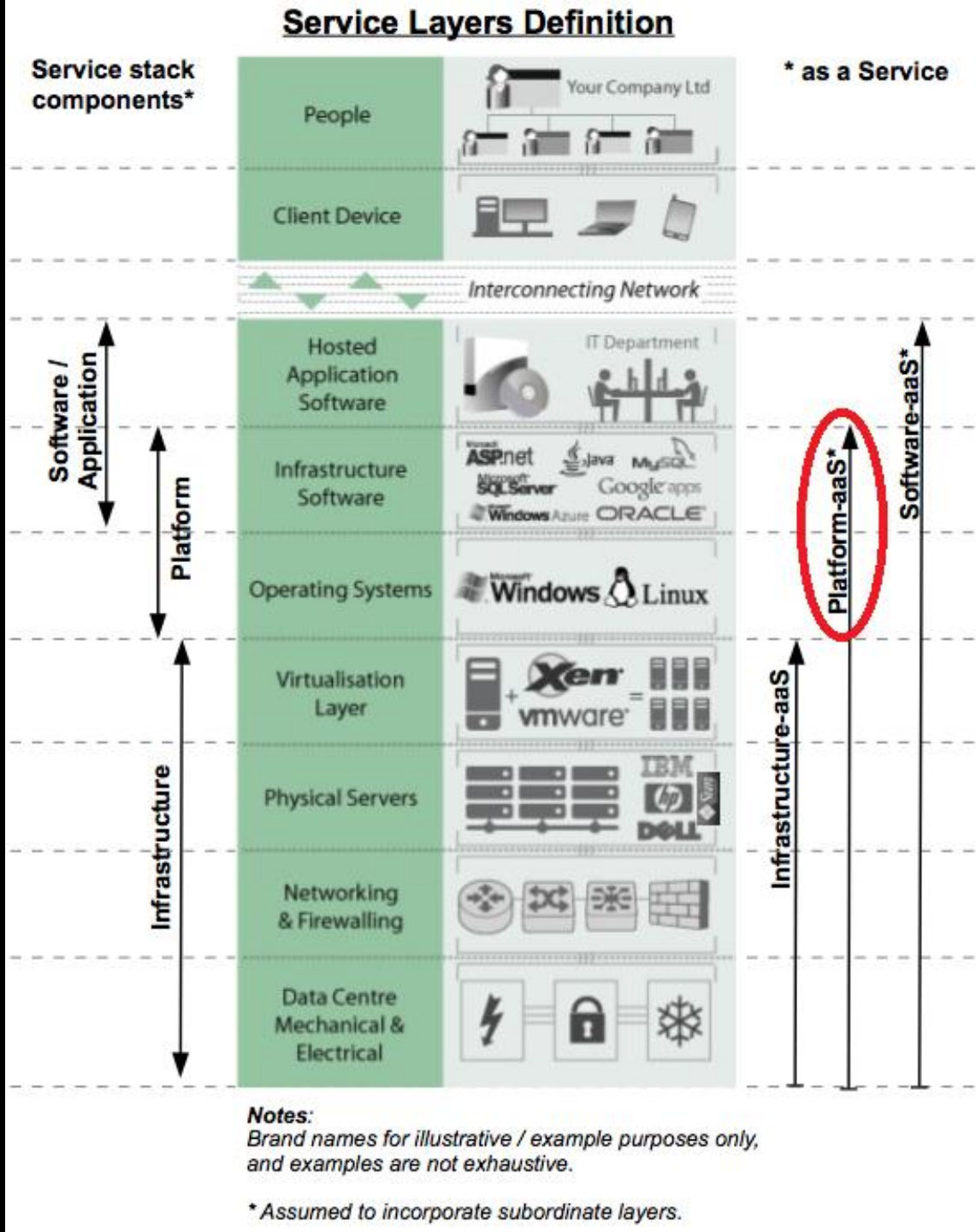
- ☑ • Must be Technology Agnostic to make it Future Proof (i.e. 3D Head’s Up Display, etc.)
- ☑ • Technology Life Cycle Tools (Incl. Remote Trouble Shooting and Upgrading)
- ☑ • Low Total Cost of Ownership (Acquisition, User Training and Maintenance Costs)
- ☑ • Mix & Match Applications with sensors and other information sources
- ☑ • Deploy an application on any computing platform without customization

Platform as a Service

PaaS



Source:
Ms. Craig-Wood
http://www.katescomment.com

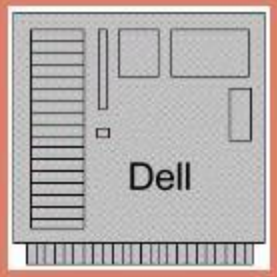
Shipboard Computing Environment

Ship A

Windows Applications

* e-Mail
* HR/Payroll/Time Keeping
* Stores Inventory/Purchasing
* Maintenance Planning
* Inspection Planning
* On-line forms
* Etc, etc.

MS Windows

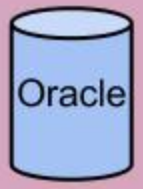


Ship B

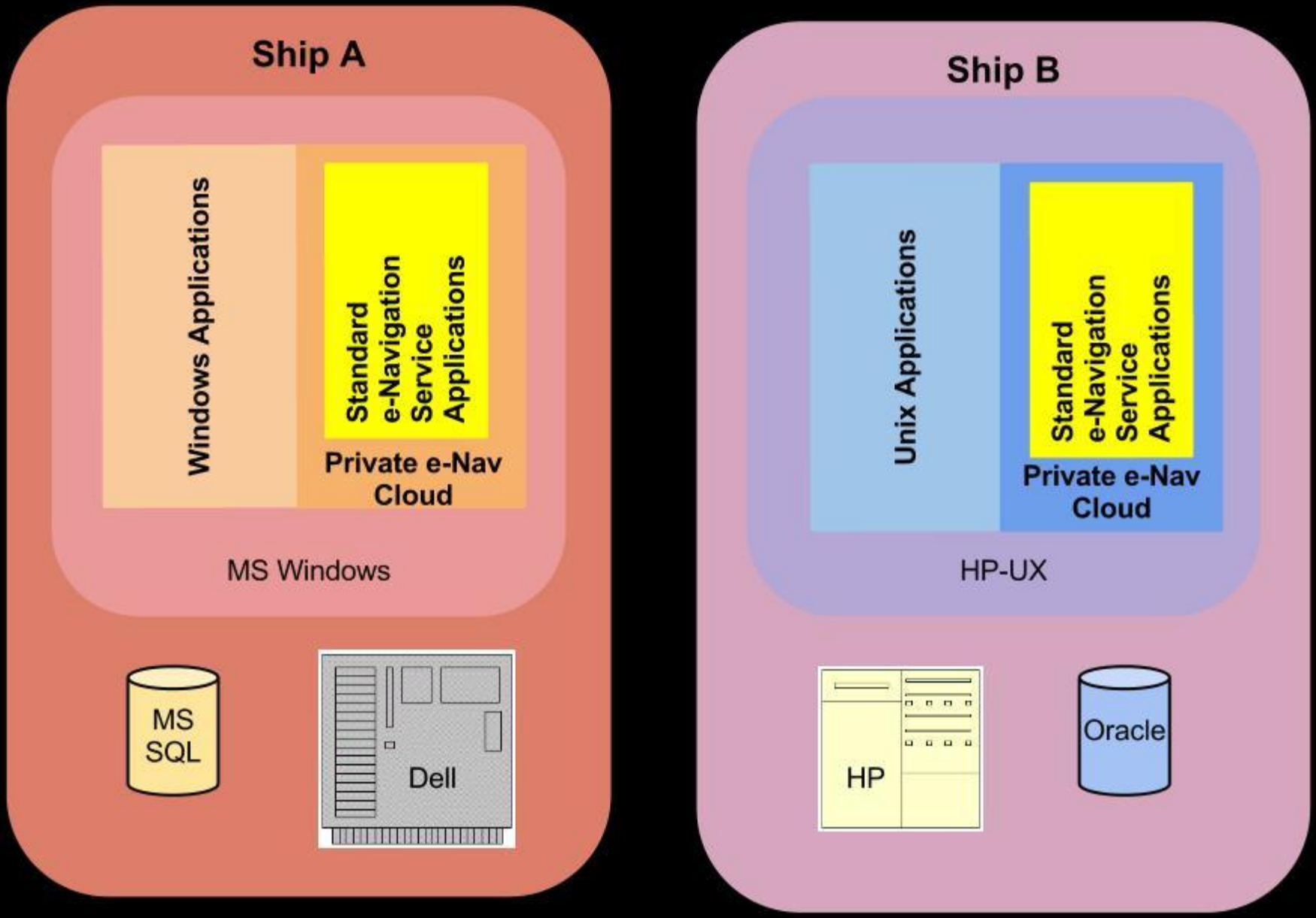
Unix Applications

* e-Mail
* HR/Payroll/Time Keeping
* Stores Inventory/Purchasing
* Maintenance Planning
* Inspection Planning
* On-line forms
* Etc, etc.

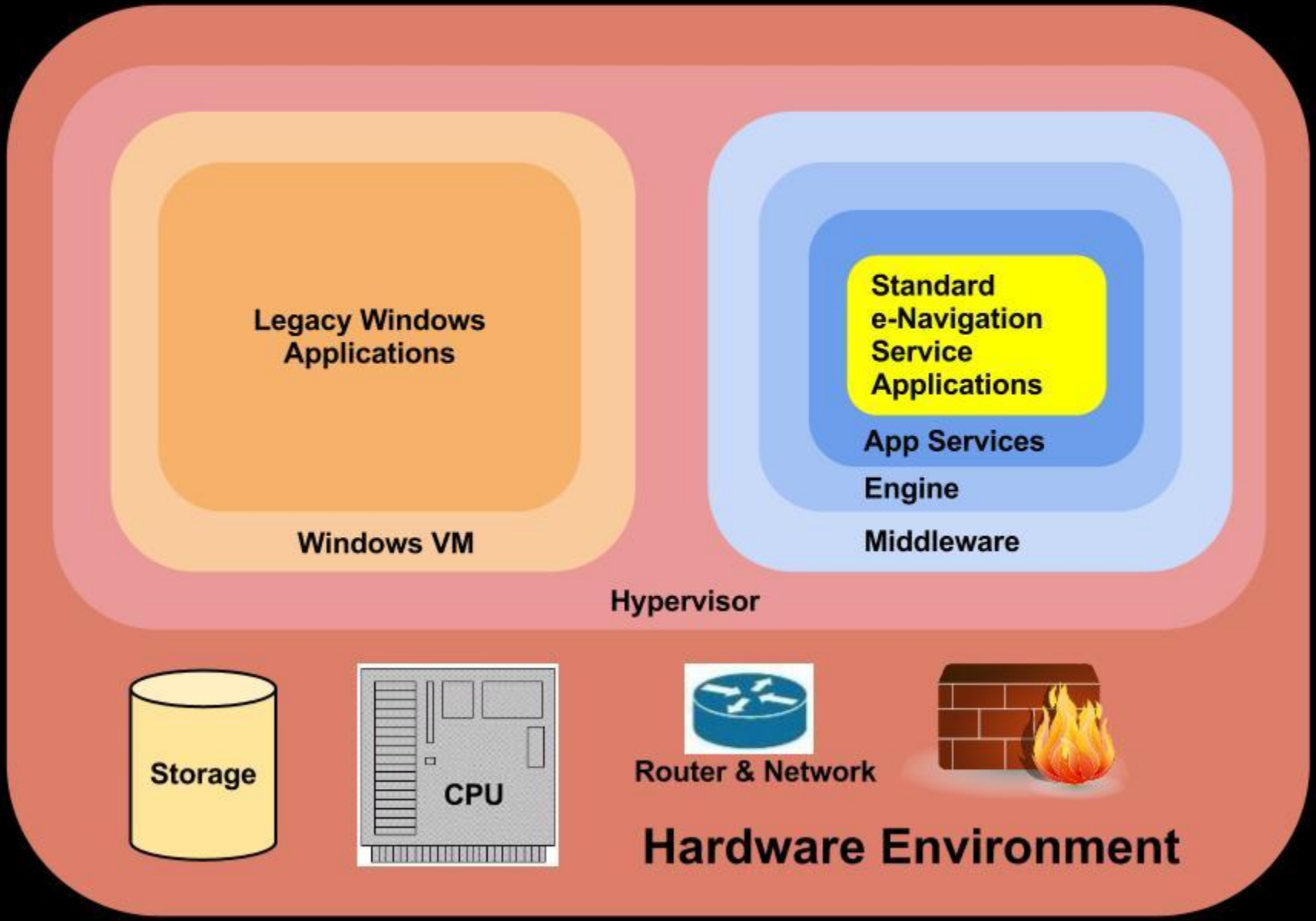
HP-UX



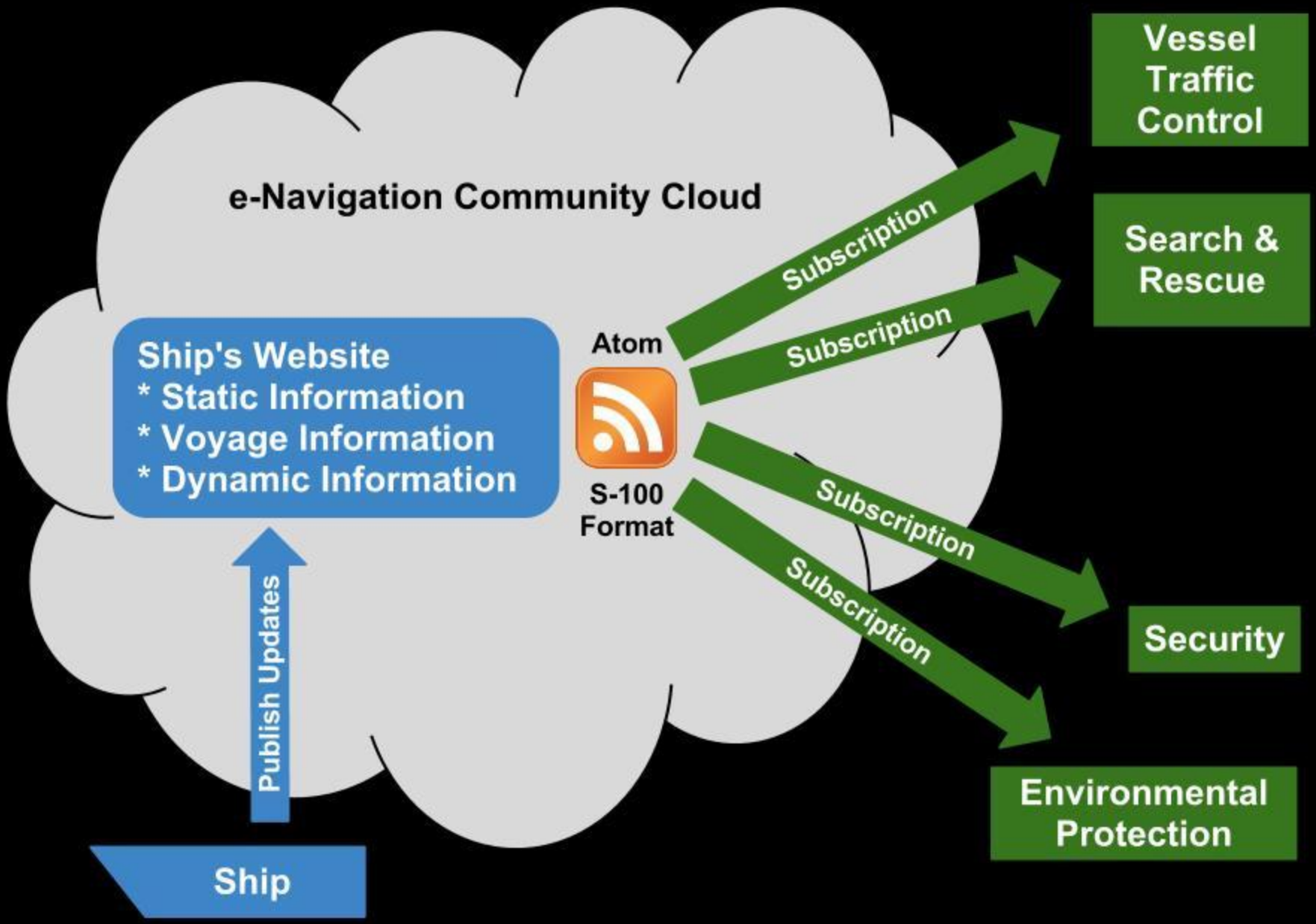
Shipboard e-Navigation Computing Environment

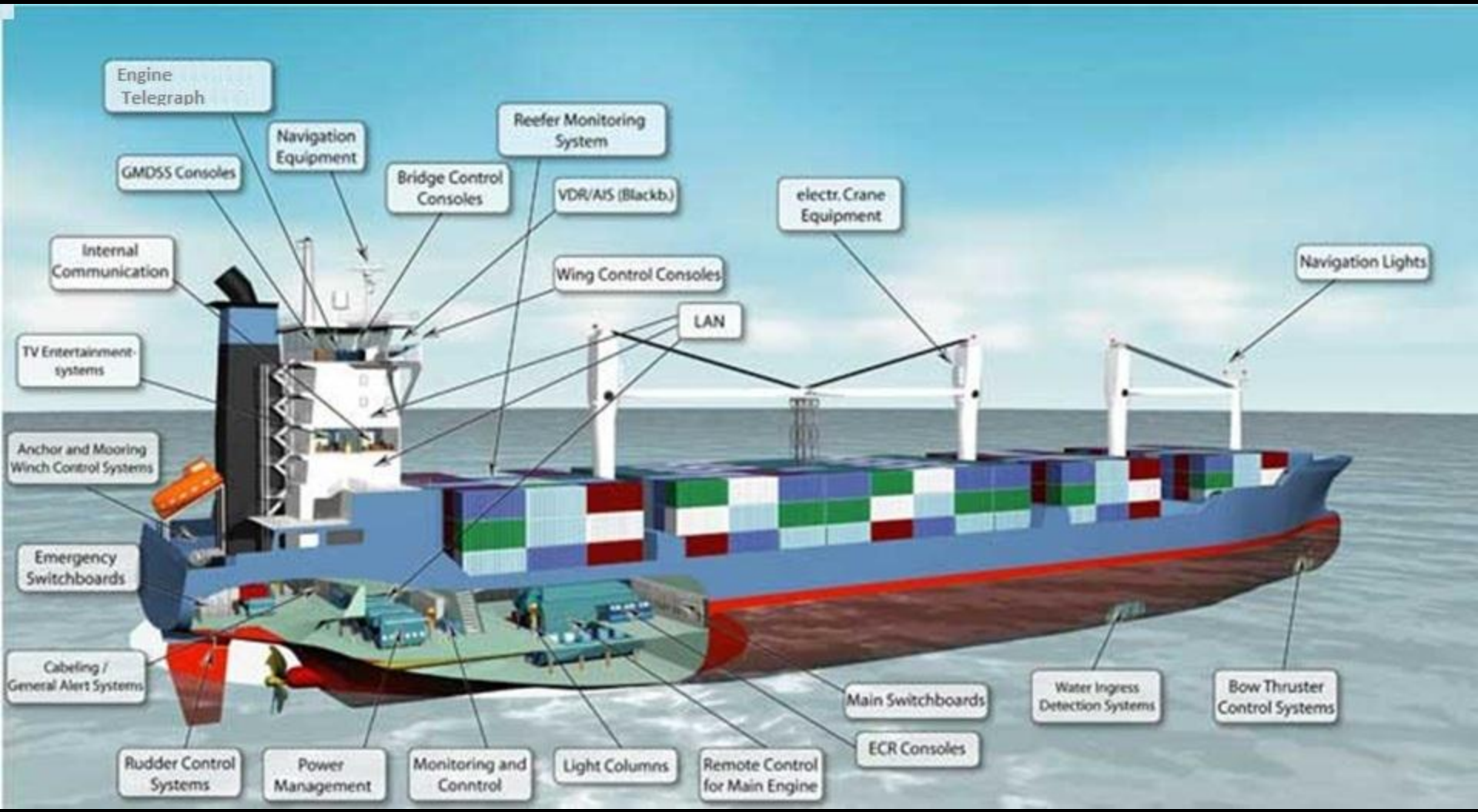


Private e-Navigation Cloud with Legacy Applications



Automate Ship Reporting to Authorities





Source: Shahabasa Int. Co.

ARCHITECTURAL FOUNDATIONS

Implementing e-Navigation

Copenhagen-Oslo-Copenhagen, 29-31 January 2013

Krystyna Wojnarowicz
Chair
MARSEC-XL

Geir Fagerhus
CEO
MARSEC-XL

WHO IS THIS GUY?
WHY ARE WE DOING THIS?

- **Geir Fagerhus, CEO & Co-founder MARSEC-XL**
- MARSEC-XL Foundation is a **not-for-profit** organization.
- We are **NOT** a vendor. We are **NOT** promoting any products.
- **Career-long work with software dependency:**
  - Maritime, Automotive, Aeronautics, Defense, Telecom.
- **Co-creator of MARSSA** (together with Krystyna & MARSEC-XL core team, 2007-2011)
- **Founder of Q-Labs**
- **Initiator & establisher of Carnegie Mellon's Software Engineering Institute - Europe.**
- **Mariner, commercially licensed**

WHAT WE STAND FOR

- Vision: MARSEC-XL shapes the digital future of the maritime industry and **contributes** to establishing **open standards**.

- Mission: To bring systems & software **engineering** competencies to the maritime industry and drive MARSSA **open architecture** adoption by the maritime industry.

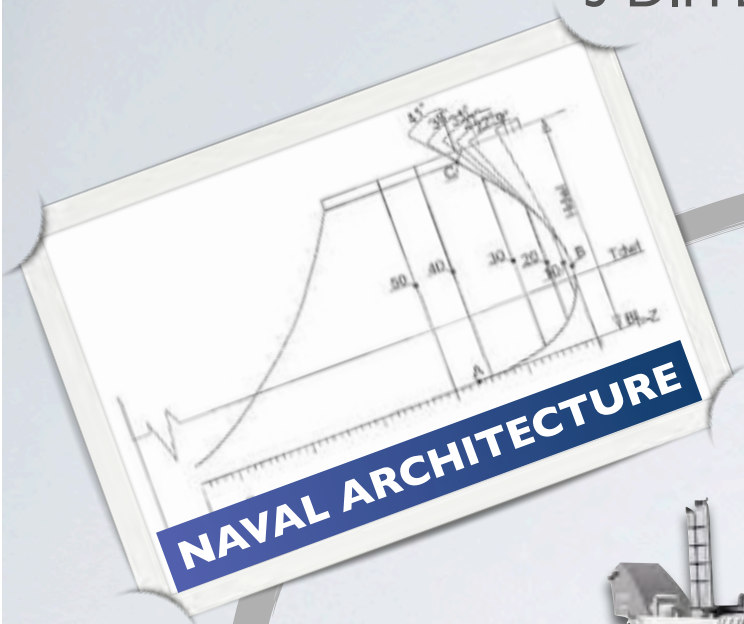
DEFICIENCIES IN THE MARITIME SECTOR

- **Integration and interoperability problems**
- **Too many proprietary systems, Too few standards**
- **Insufficient End-user orientation**
- **Far too high Total Cost of Ownership (TCO)**
- Insufficient innovation
- Missing competencies and focus on systems software engineering
- Lack of adequate industry acquisition processes and evaluation methods
- Old and inadequate business models
- Lack of "Living Labs": no continuous technology testing and validation off-board.

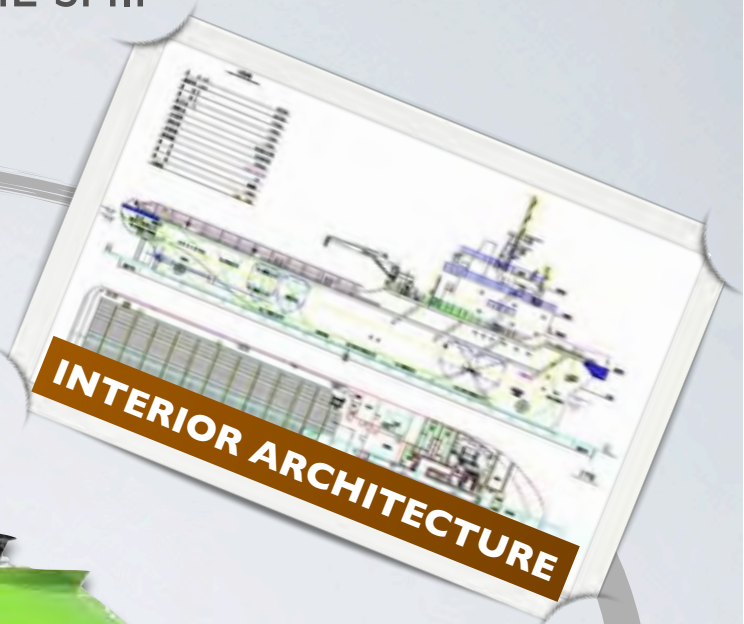
**Market Survey by MARSEC-XL 2007-2009*

3 ARCHITECTURES NEEDED

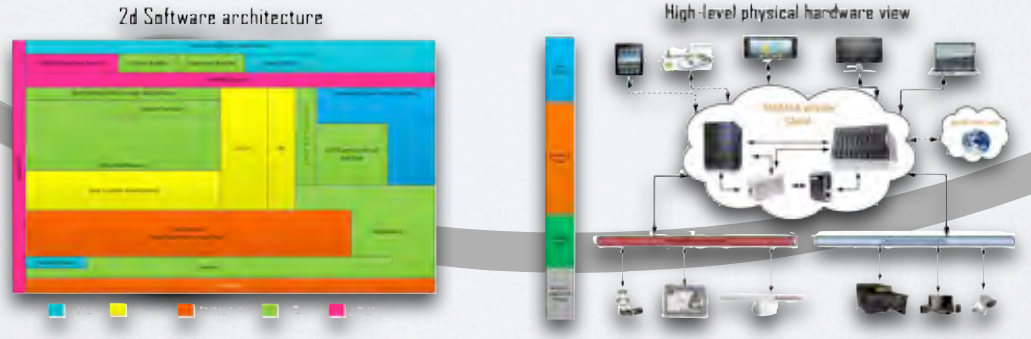
3 DIFFERENT VIEWS OF THE SAME SHIP



NAVAL ARCHITECTURE



INTERIOR ARCHITECTURE



MARINE SYSTEMS SOFTWARE ARCHITECTURE

www.MARSSA.ORG

- **MARSSA** = MARine Systems Software Architecture
  - First **Community Driven Open Reference Architecture** project in & for the maritime industry.
  - **Created** & **Hosted** by **MARSEC-XL**

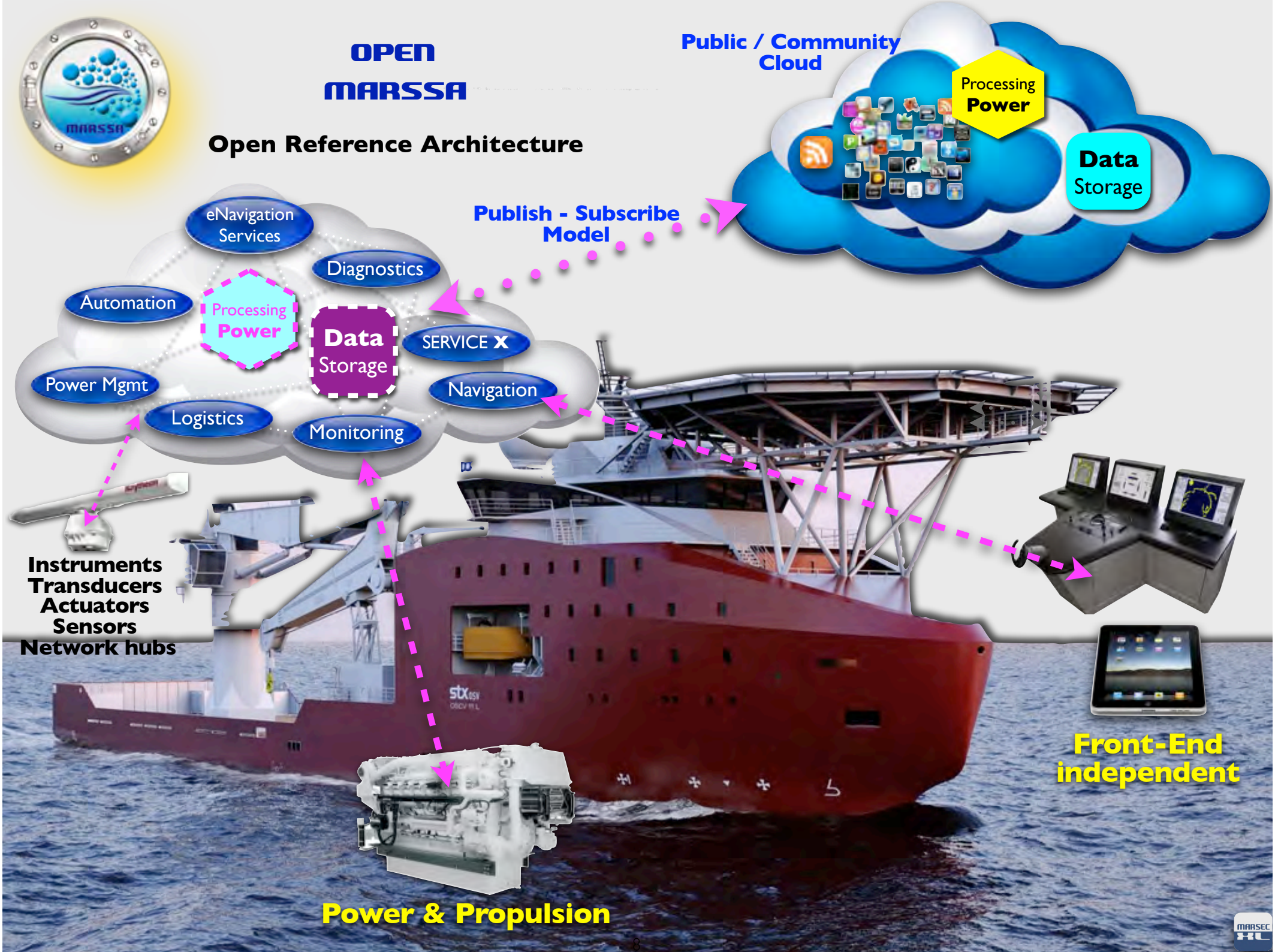
- **MARSSA mission**: To dramatically lower the **TCO** and at the same time increase the **quality** of marine electronic systems by providing an **Open Reference Architecture** facilitating **full interoperability** across all system components. MARSSA is the **quality enabler** facilitating **continuous technology insertion**.

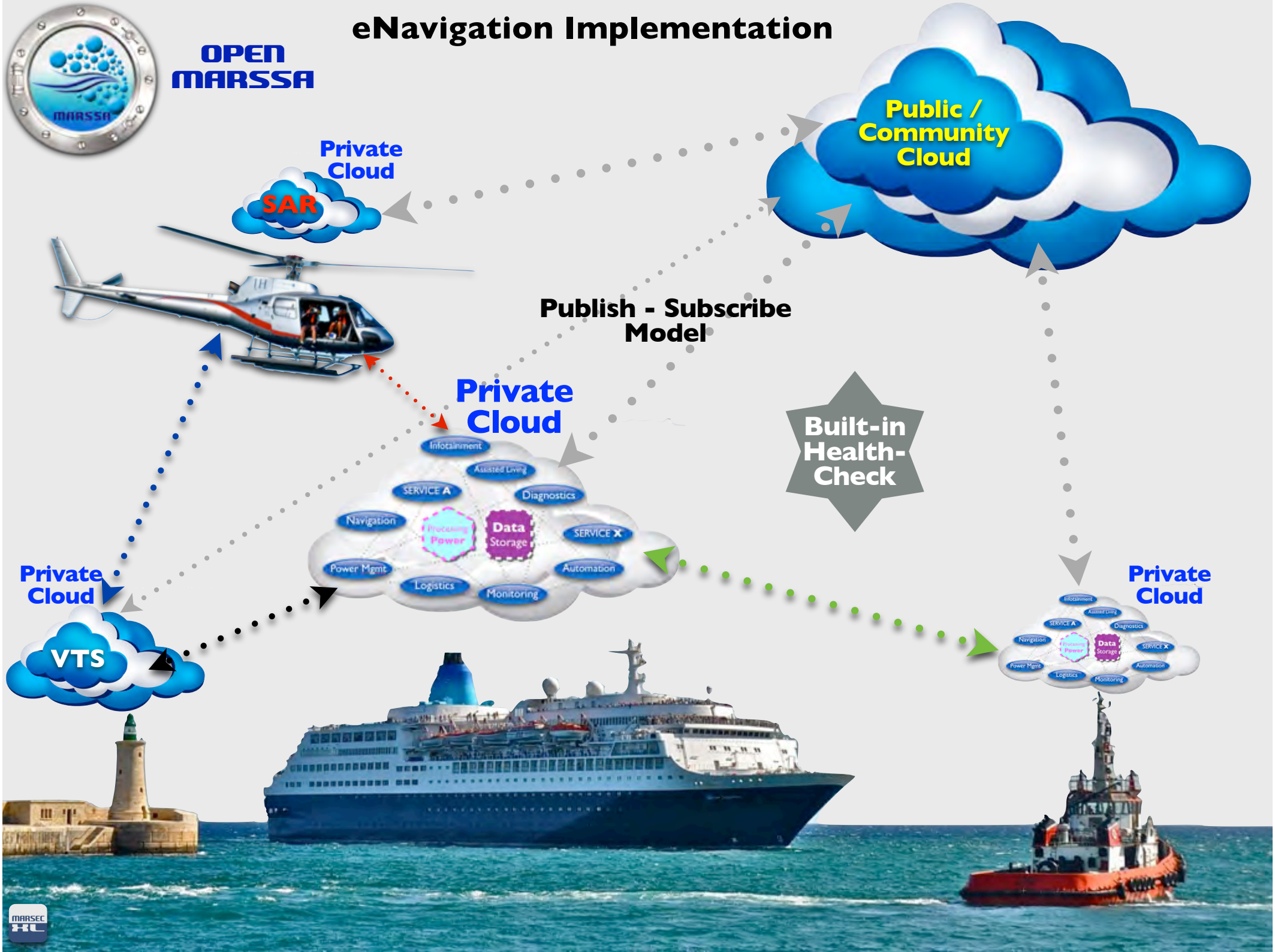
- **MARSSA vision**: MARSSA becomes a recognized & adopted **standard** across the maritime industry for **integration** of electronic systems.

- **MARSSA** is well suited to support the **implementation** of global **eNavigation**.

OPEN REFERENCE ARCHITECTURES

- **AUTOSAR Automotive, SAVI Avionics**
- **MARSSA - Maritime**
  - The MARSSA Open Reference Architecture: a **blueprint** for the design & implementation of software systems and their **integration** on marine vessels and related onshore maritime operations.
  - The blueprint will tackle the **non-functional properties** by providing a **platform** upon which **innovation** and **integration** can take place.
  - Open Reference Architecture ensures that **end users / owners** are **not locked** into a proprietary technology or a single-vendor solution. It is **future-proof**.
- **Collaborate** on **low-value add** - *P. Odence, Black Duck Software @ IOOI2012*
- **Collaborate** on **shared, domain-specific middleware** - *Prof. Conradi, NTNU*


OPEN
MARSSA
Open Reference Architecture
Public / Community
Cloud
Processing
Power
Data
Storage
Publish - Subscribe
Model
eNavigation
Services
Diagnostics
Automation
Processing
Power
Data
Storage
SERVICE X
Power Mgmt
Navigation
Logistics
Monitoring
Instruments
Transducers
Actuators
Sensors
Network hubs
Front-End
independent
Power & Propulsion

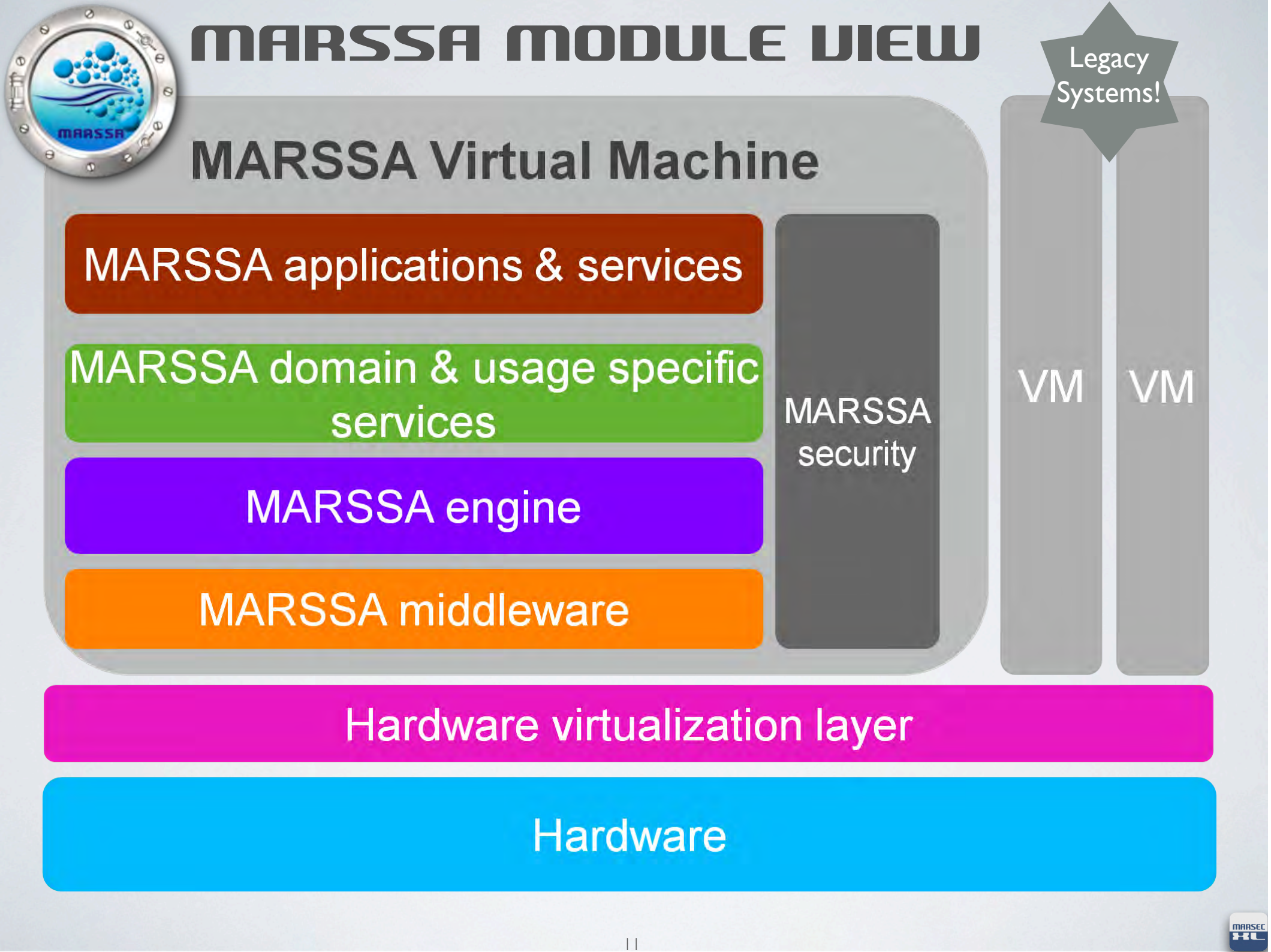

eNavigation Implementation
OPEN MARSSA
Public / Community Cloud
Private Cloud
SAR
Publish - Subscribe Model
Private Cloud
Infotainment
Assisted Living
SERVICE A
Diagnostics
Navigation
Processing Power
Data Storage
SERVICE X
Power Mgmt
Automation
Logistics
Monitoring
Built-in Health-Check
Private Cloud
VTS
Private Cloud
MARSEC XL

MARSSA BENEFITS

Radically Increased Quality

Full Interoperability
High Reliability
Redundancy
Robustness
Scalability
Flexibility
Radically Reduced TCO
Continuous Technology Refresh & Rapid Insertion
Can Improve & Ease Reporting (logistics, operations, performance, emissions)

MARSSA MODULE VIEW

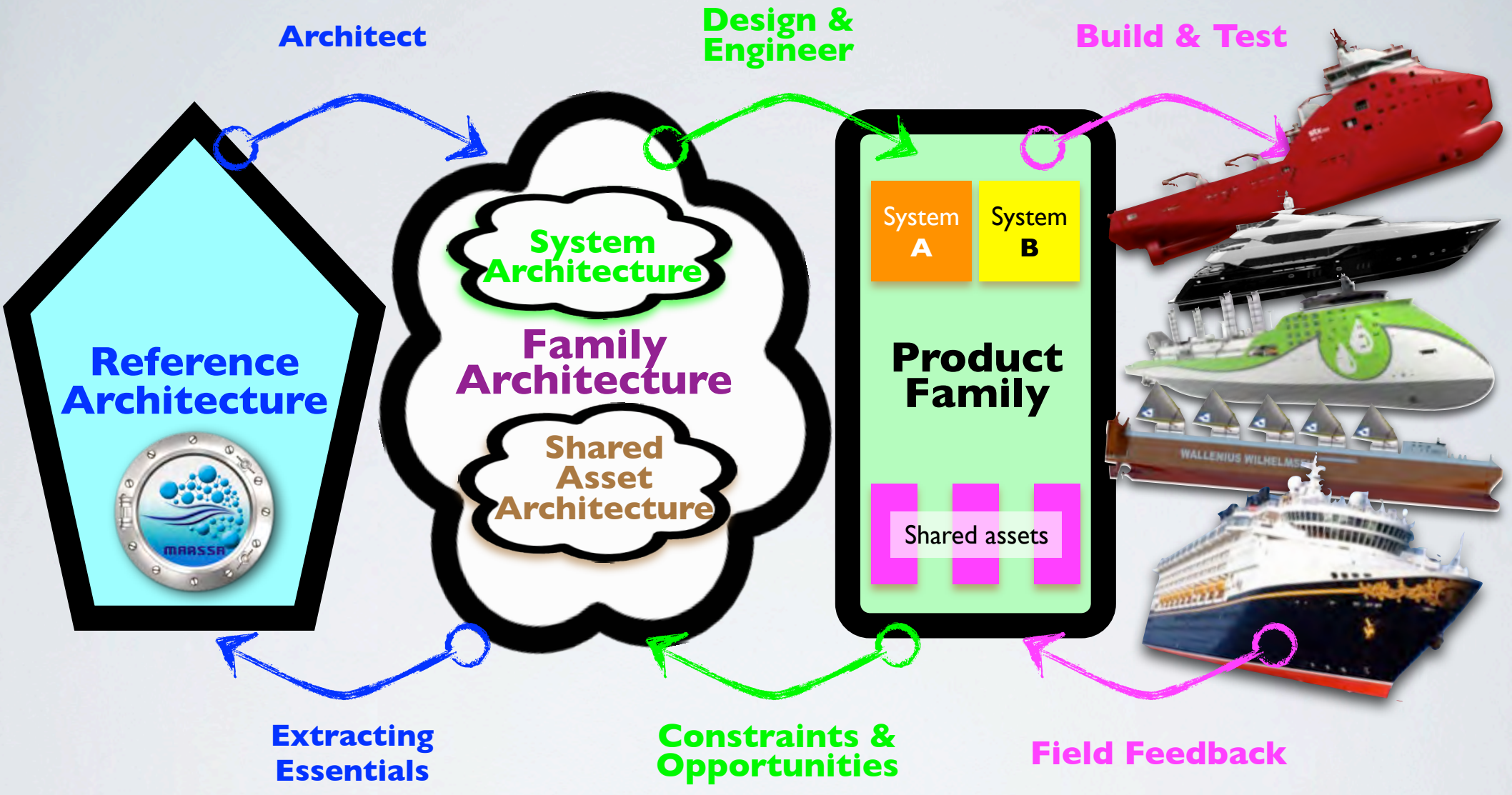


Openness always wins in the end!

- **Open Standards** can help **make a market** that goes **beyond** an **individual company.** They provide a **platform** in which vertical **applications** are built.

- US Navy Open Architecture program: up to **80%** reduction in Total Cost of Ownership (TCO). Continuous Technology Insertion: complete renewal of onboard electronic systems every 4th year.

MARSSA IN ONBOARD SYSTEMS



We are Open!

CONTACT INFO

MARSEC-XL

geir@marsec-xl.org

www.marsec-xl.org

www.marssa.org

twitter

@MARSEC_XL