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MARITIME RESILIENCE AND INTEGRITY OF NAVIGATION

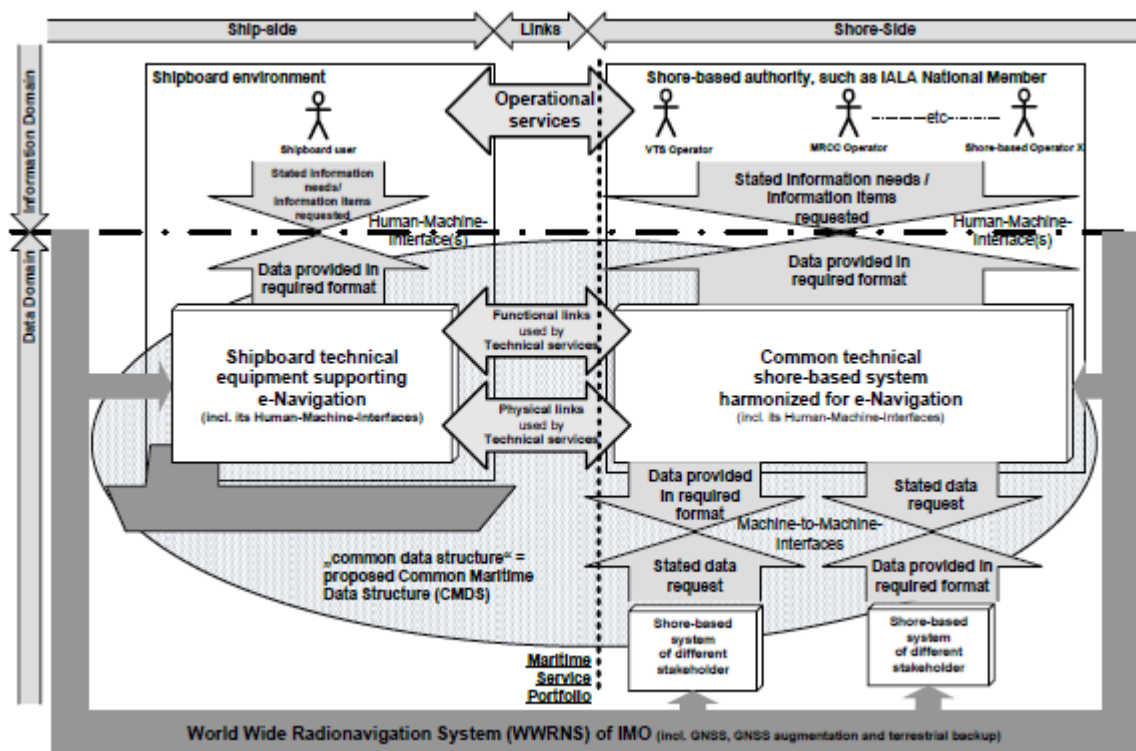
Resilient high-integrity PNT in a future maritime service environment

Service-based approach

To meet the increasing navigation challenges of the growing complexity of sea areas around the UK and Ireland and to take advantage of digital technology, the IMO has developed its e-Navigation strategy for the benefit of maritime safety, security and protection of the marine environment, reducing the administrative burden and increasing the efficiency of maritime trade and transport. e-Navigation is defined by the IMO and IALA as:

'The harmonised collection, integration, exchange, presentation and analysis of maritime 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.'

e-Navigation is based on the overarching architecture illustrated in Figure 1 below. This architecture is based on the Common Maritime Data Structure (CMDS) that spans the whole of the horizontal axis and the World Wide Radio Navigation System (WWRNS), which includes GNSS, GNSS augmentation and terrestrial backups.



Source: MSC.1/Circ.1595, 25 May 2018, e-navigation strategy implementation plan – update 1
Figure 1: e-Navigation architecture



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As well as making the best use of digital technologies to the benefit of maritime transport, e-Navigation is moving the focus of AtoN providers from infrastructure operations and maintenance to the provision of services. IMO's initial identification of services has been listed, but it should be noted that the final set of e-Navigation services is likely to be much wider than this initial list.

A number of initiatives worldwide are building core e-Navigation technologies, and developing, prototyping and demonstrating e-Navigation services. These initiatives include:

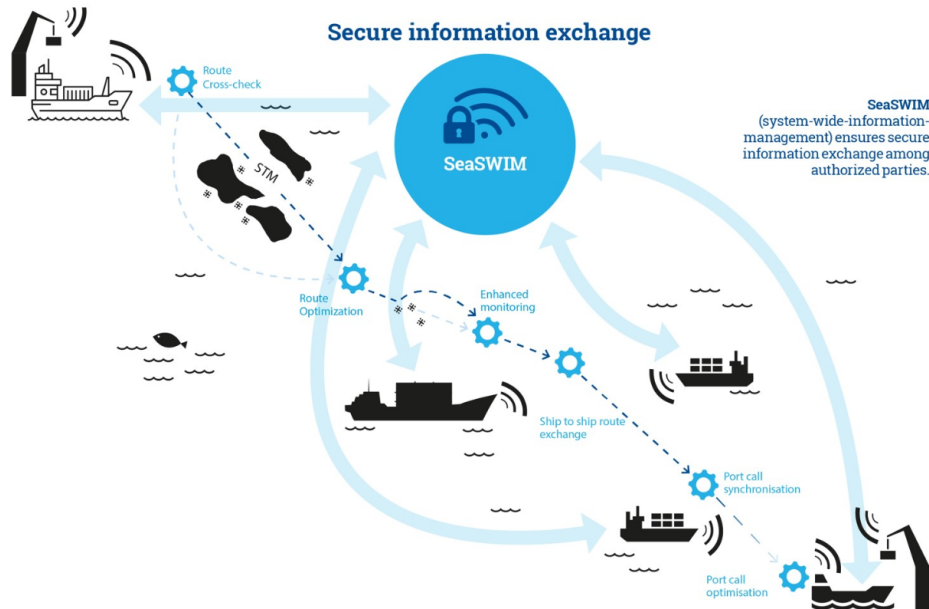
- the **EfficienSea2** project, led by the Danish Maritime Authority. This project ran for three years, finishing in April 2018. It had 32 partners from 12 countries and an overall budget of €11.5M. The overall aim was to create and implement innovative and smart solutions for efficient, safe and sustainable traffic at sea through improved connectivity for ships.
- the **Sea Traffic Management (STM)** series of projects, led by the Swedish Maritime Administration with 39 partners from 13 countries. STM ran from 2015 to 2018 and had a budget of €21M. STM's aims were:
 - to enable efficient exchange of information between maritime stakeholders through common standards
 - establish a decentralised service ecosystem for ships, ports and authorities
 - facilitate secure and authenticated access to authorised parties.
- the **SMART-Navigation** project, funded by the Ministry of Oceans and Fisheries of the Republic of Korea. This project is running from 2016 through to 2020. This project is developing core technologies for e-Navigation services; developing an e-Navigation operating system and digital maritime communication and developing the maritime digital communications standard for e-Navigation.

The following figure illustrates STM's set of services underpinned by secure, system-wide information management.



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Source: <https://www.stmvalidation.eu/image-gallery/>
 Figure 2: STM services and infrastructure

System-of-systems

As a consequence of technological development and the move to a service-based rather than infrastructure-based philosophy, e-Navigation is based on a system-of-systems as illustrated below.

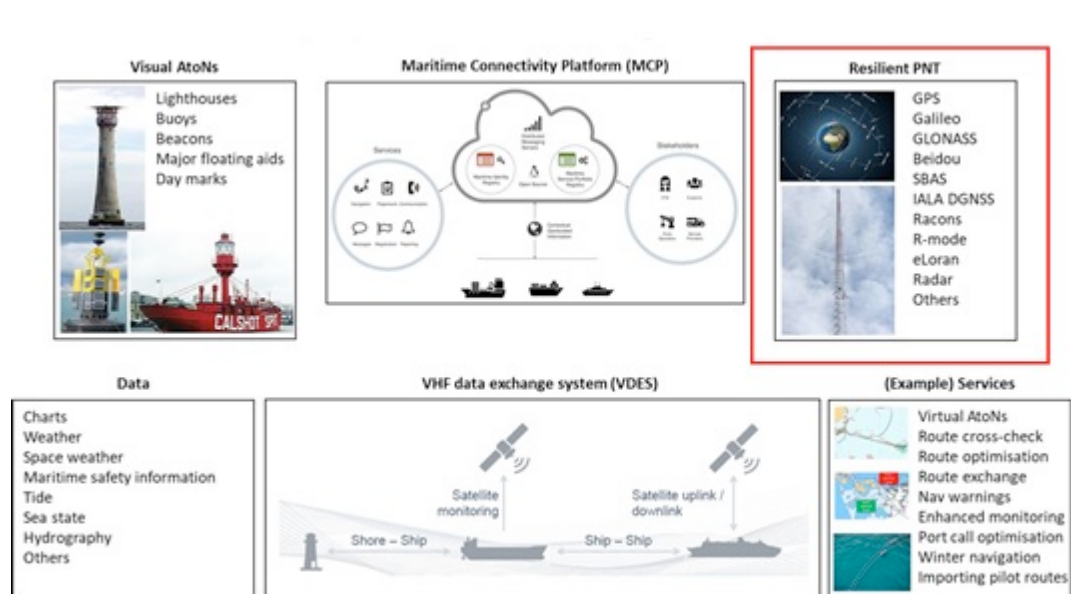


Figure 3: e-Navigation system-of-systems

This system-of-systems comprises:



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- traditional **visual AtoN**, such as lighthouses, buoys, beacons, etc. These are already in place and will continue to be required and operate for the foreseeable future
- the Maritime Connectivity Platform (**MCP**), which essentially serves as an “App Store”, pointing to the location of instances of the services that are advertised, and providing documentation on the specification and design of services for potential providers to implement.
- **resilient PNT**, as indicated by IMO, based on core GNSS, GNSS augmentation and terrestrial back-up. Given the evolution of the core GNSS systems and augmentation systems as it is currently understood, the identification of the optimal suite of terrestrial back-up systems to provide resilience (and integrity) in PNT is the MarRINav project’s principal objective
- a **service portfolio**, derived from and building on the services identified by IMO and the e-Navigation projects, such as EfficienSea2, STM and SMART-navigation, introduced above. This service portfolio is just starting to emerge and will likely be developed continuously as new services emerge both to meet requirements (user pull) and to take advantage of technological advancement (technology push)
- the VHF data exchange system (**VDES**), which is a concept developed by IALA and ITU, supported by IMO, in order to:
 - overcome the capacity shortcomings of the Automatic Identification System (AIS)
 - provide data exchange capability to enable e-Navigation applications
 - support modernisation of the Global Maritime Distress and Safety System (GMDSS)
 - ensure the effective and efficient use of the maritime VHF band.
- the **data** needed to support e-Navigation.

