International Association of Marine Aids to Navigation and Lighthouse Authorities

Resilient Positioning, Navigation and Timing

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The General Lighthouse Authorities of the UK and Ireland

GRAD

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- IALA and resilient PNT
- The challenge of global coordination and harmonization
- Overview of the radionavigation services working group
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About IALA

International Association of Marine Aids to Navigation and Lighthouse Authorities

Aids to Navigation

IALA Constitution Art. 1

“A device, system or service, external to vessels, designed and operated to enhance safe and efficient navigation of individual vessels and/or vessel traffic"

Publications

Main result of the Committees' work

- **Standards** which can be referred to directly in IMO and other international conventions and in national maritime laws.
- **Recommendations** which advise what should be done.
- **Guidelines** which advise how to implement the recommendations as 'best practice'.
- **Manuals** which provide general reference materials (NAVGUIDE; MBS; VTS Guide; IALA Dictionary).
- **Model courses** which provide guidance on the training of VTS personnel, Aids to Navigation Managers and Aids to Navigation Technicians.

IALA Technical Committees

The “Power House” of IALA

- AtoN Requirements and Management (ARM)
- Engineering and Sustainability (ENG)
- Vessel Traffic Services (VTS)
- e-Navigation Information Services and Communications (ENAV)

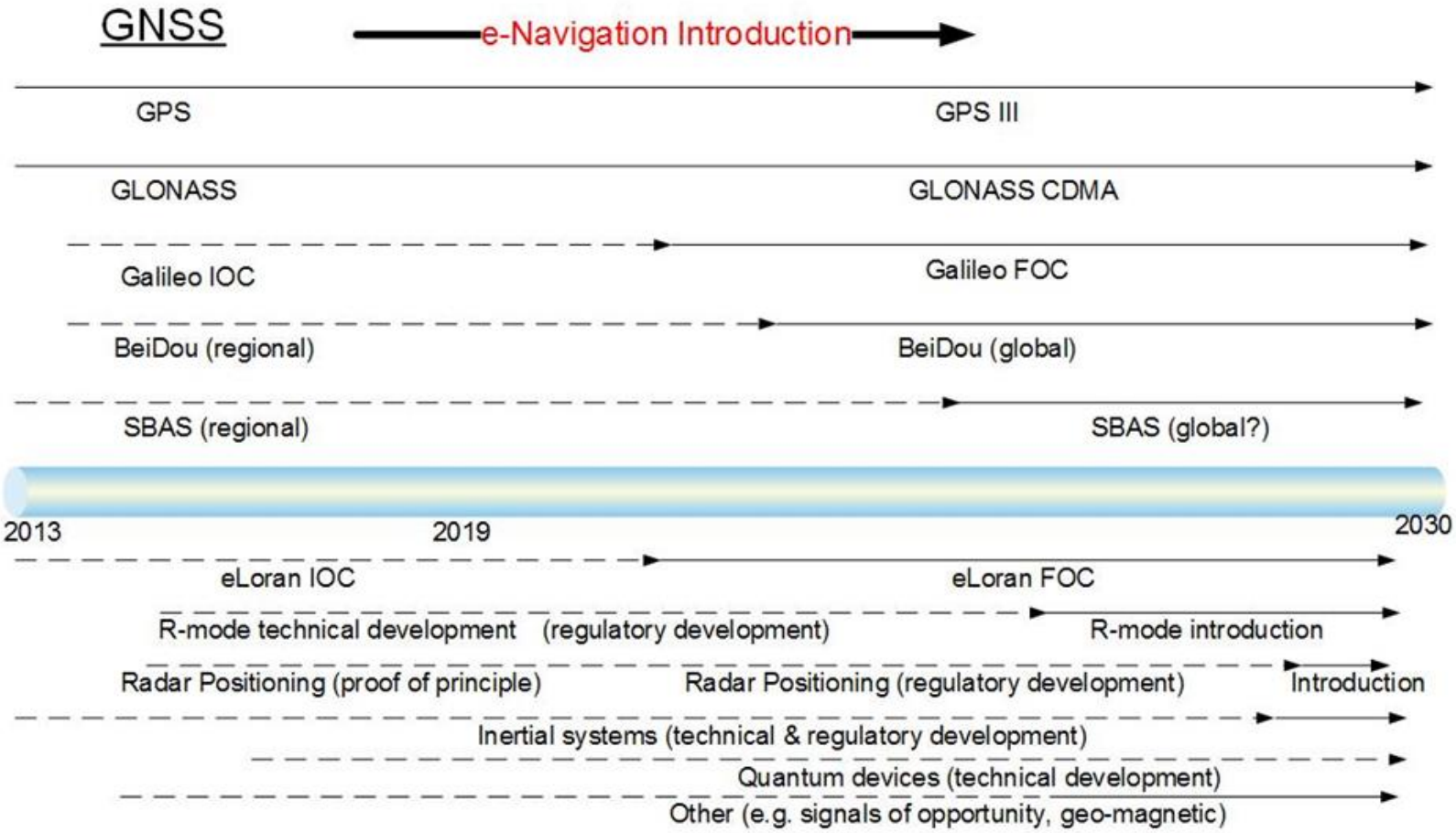
IALA and the future ships

- Shore services
- Resilient Position, Navigation and Timing (PNT)
- Data Modelling
- Connectivity

Increased dependence on automated systems

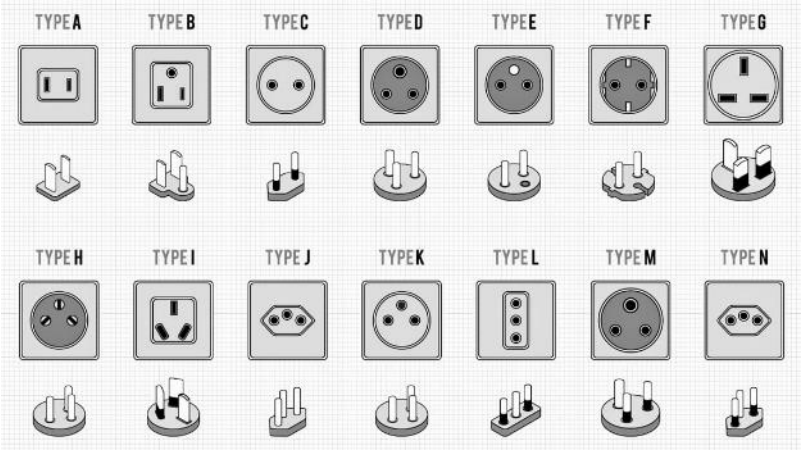
…combined with a decline in traditional skills gives rise to concern.

Timeline for Resilient PNT

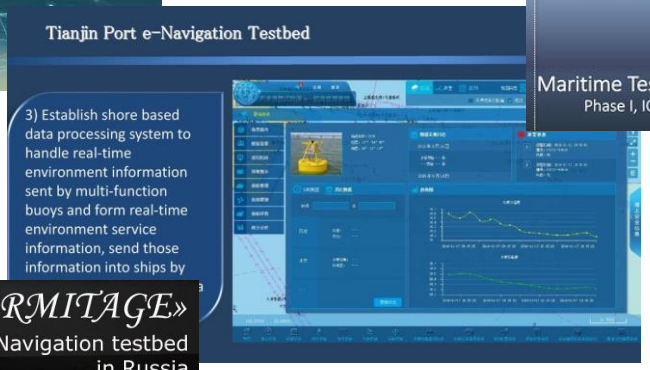


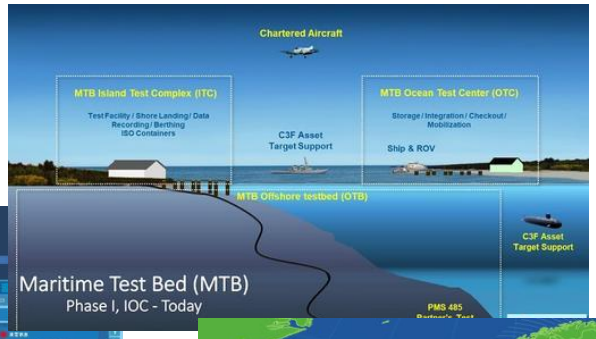
Complementary systems

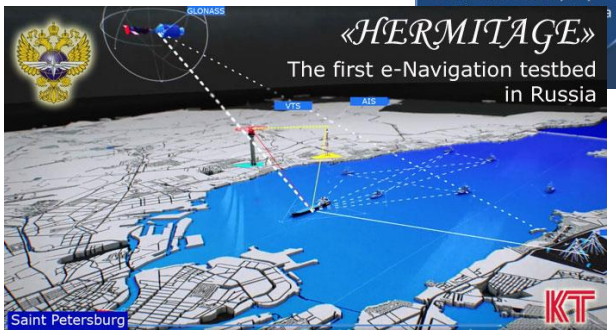
Developed and Harmonized



Regional and local solutions







SESAME
Solution II

complete
e-navigation


IMO


IEC


ITU


IALA


RESILIENT
NAVIGATION
and TIMING
FOUNDATION

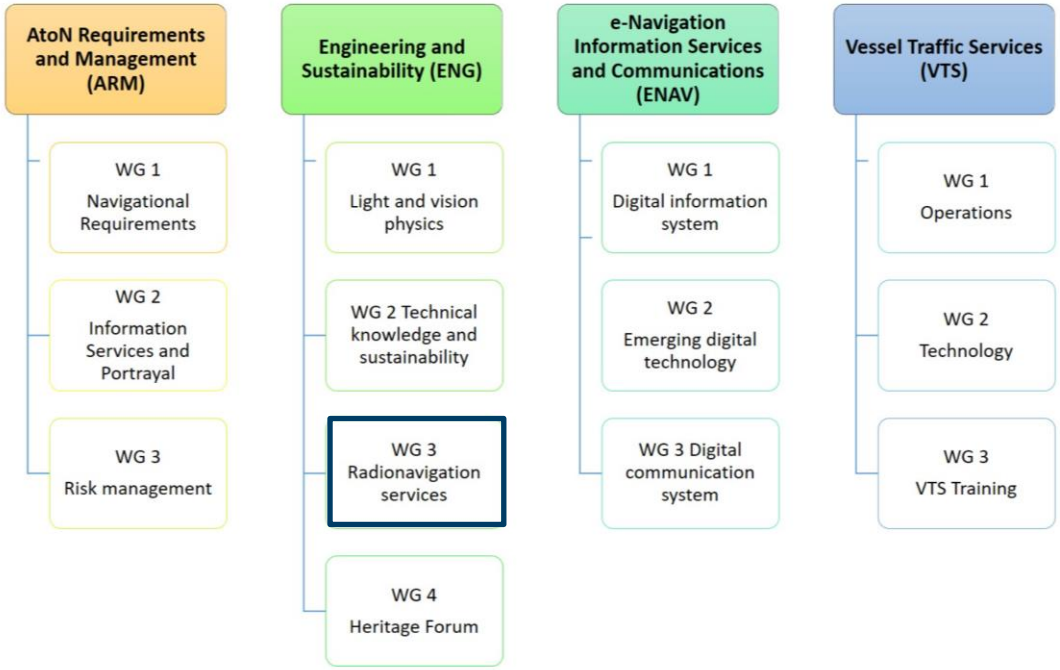
Radionavigation services WG

Reliable position-fixing (with redundancy) is a fundamental requirement for navigation and e-navigation.

Scope

All aspects of Positioning, Navigation and Timing systems including resilience, reliability and integrity.

Working with all other IALA Committees and sister organisations as required.



Need for Resilient PNT

GNSS is the primary source of PNT information today.

All GNSS are vulnerable to errors.

GLONASS

April 2014: ephemeris upload error, resulted in the constellation reporting significant position errors (~50km) before going off-air for 11 hours.

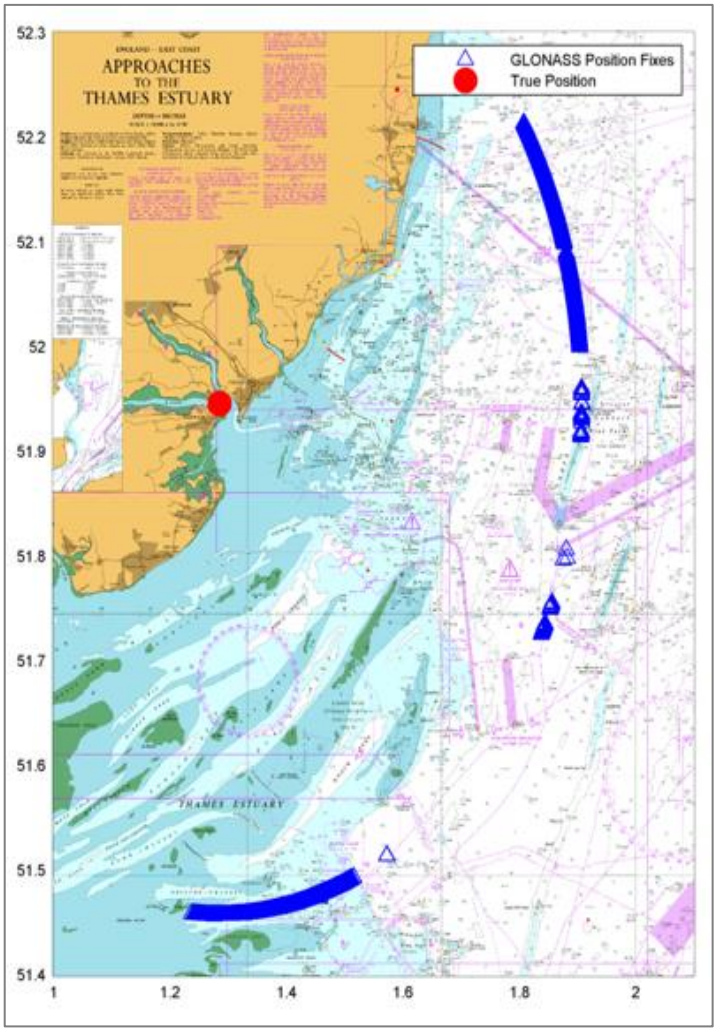
GPS

January 2004: a clock error in a satellite resulted in significant position errors.
January 2016: a 13 microsecond timing error affected most timing users and some position users.

Galileo

July 2019: a problem at the precise timing facility caused the system to be off-air for several days.
December 2020: the system was off-air for 6 hours due to time determination problem.

Position and timing information can be lost, or deteriorate, without warnings and can last a long time.



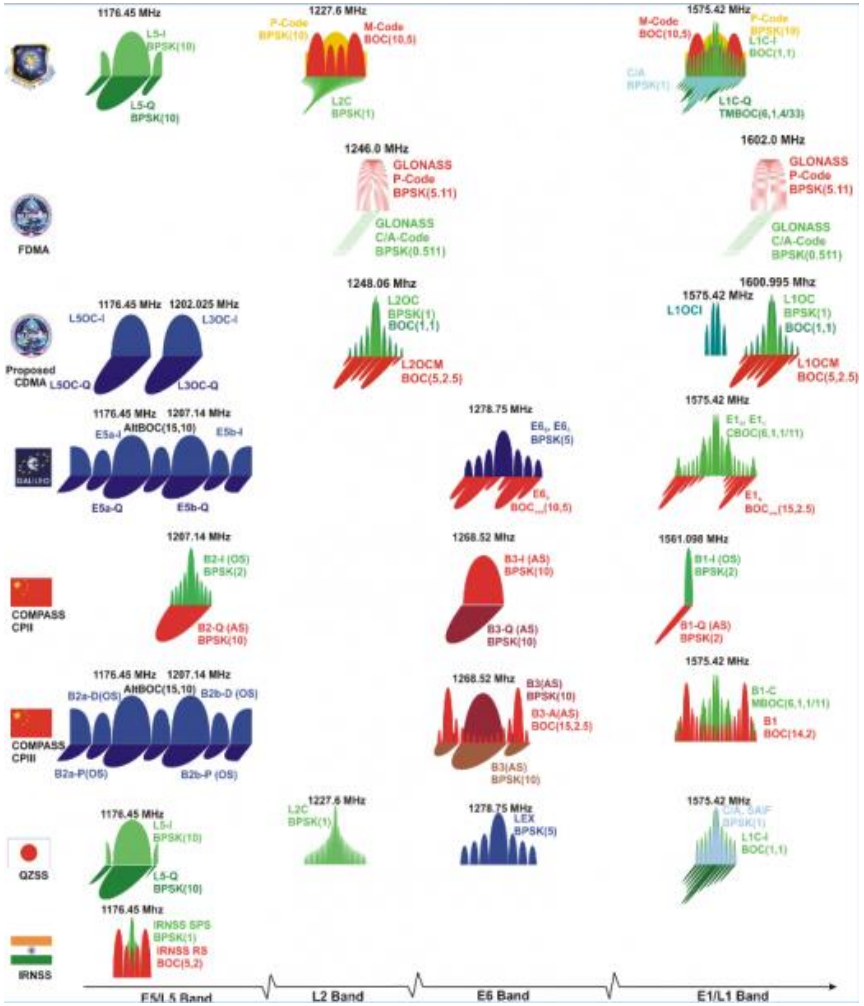
Source: General Lighthouse Authorities of the UK and Ireland

Need for Resilient PNT

Access to multiple GNSS can mitigate some of these, but does not protect against signal interference.

Interference can be caused by natural and man-made sources.

- Space weather
- Accidental signal jamming
- Deliberate signal jamming
- Spoofing



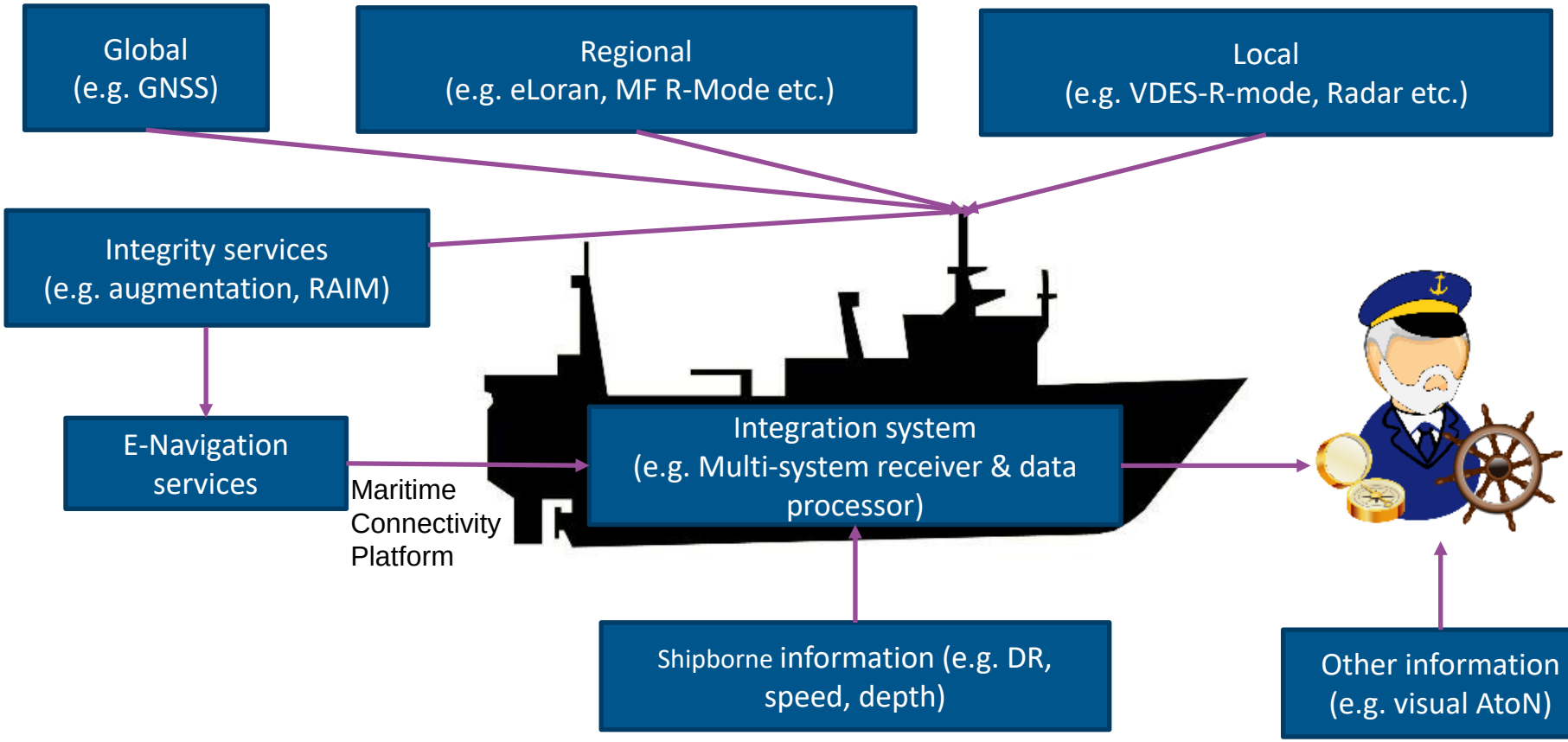
Source: https://gssc.esa.int/navipedia/index.php/GNSS_signal.

Actions within the working group

- Recommendation on Resilient PNT, raising awareness of the need and seeking the use of complementary systems.

System of Systems approach

- Recognising that one solution does not fit all requirements
- Strength and resilience is achieved through using multiple dissimilar systems in combination



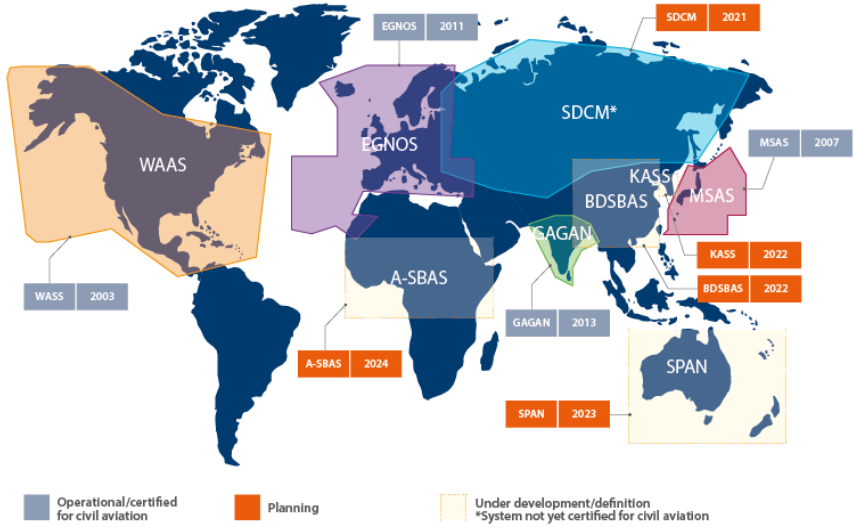
GNSS & augmentation

Source: www.everythingrf.com

Source: www.e-navigation.nl

Actions within the working group

- Recommendation on GNSS vulnerabilities and mitigation measures.
- Guidelines on the use, maintenance and future development of marine radiobeacon DGNSS.
- Guidelines on the maritime use of SBAS.
- Development of S-200 product specifications



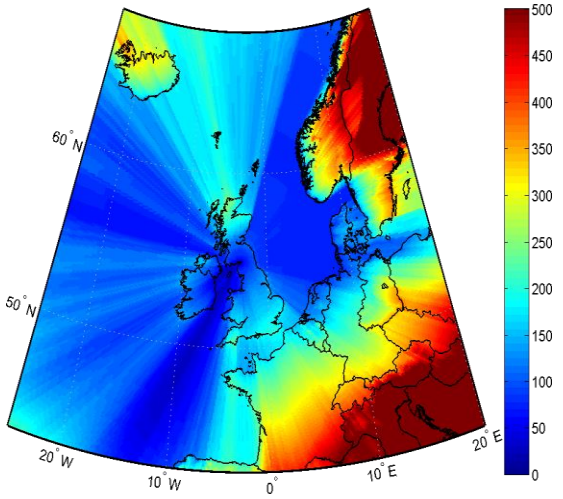
Source: www.gsa.europa.eu

eLoran

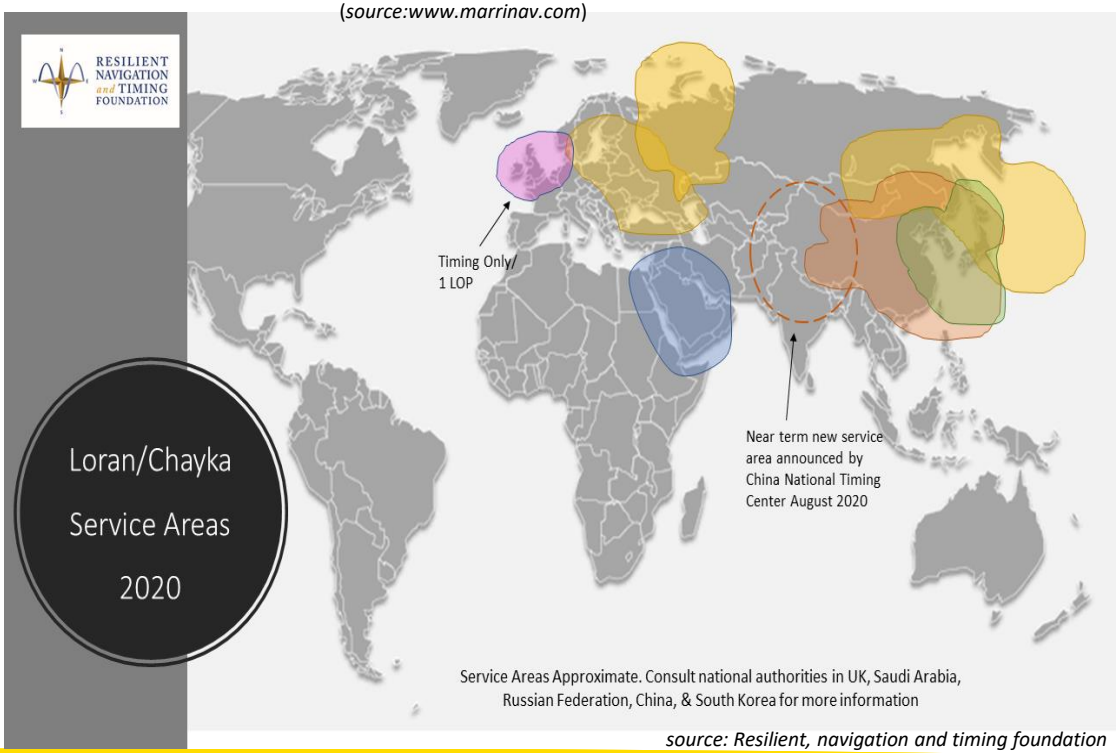
eLoran is a terrestrial, low frequency, high power signal, with dissimilar failure modes to GNSS.

It's a proven system, capable of meeting maritime accuracy, availability, integrity and continuity requirements.

Can provide position and time information.



Example of eLoran timing capability (in nanoseconds)
(*source:www.marrinav.com*)



source: Resilient, navigation and timing foundation

Actions within the working group

- Recommendation on the performance and monitoring of eLoran.
- Guideline on the implementation of eLoran services
- Development of S-200 product specifications

R-mode

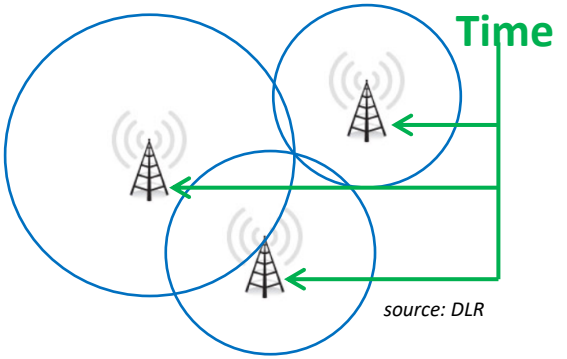
Addition of timing signals to existing maritime transmissions.

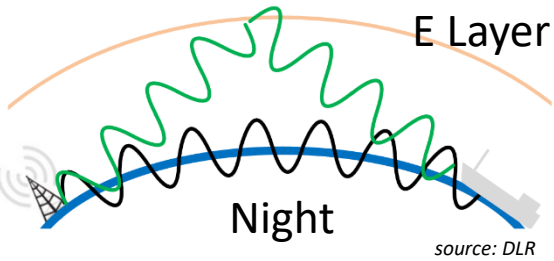
Marine radiobeacon and AIS/VDES base stations being considered at MF and VHF frequencies.

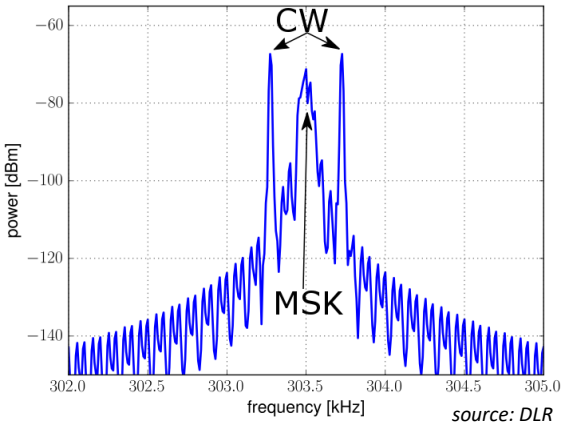
Phase measurements are needed for range estimation. Two continuous wave signals added to the legacy MSK signal.

WG receives updates from the R-mode Baltic sea project and others.

Technical development is ongoing.



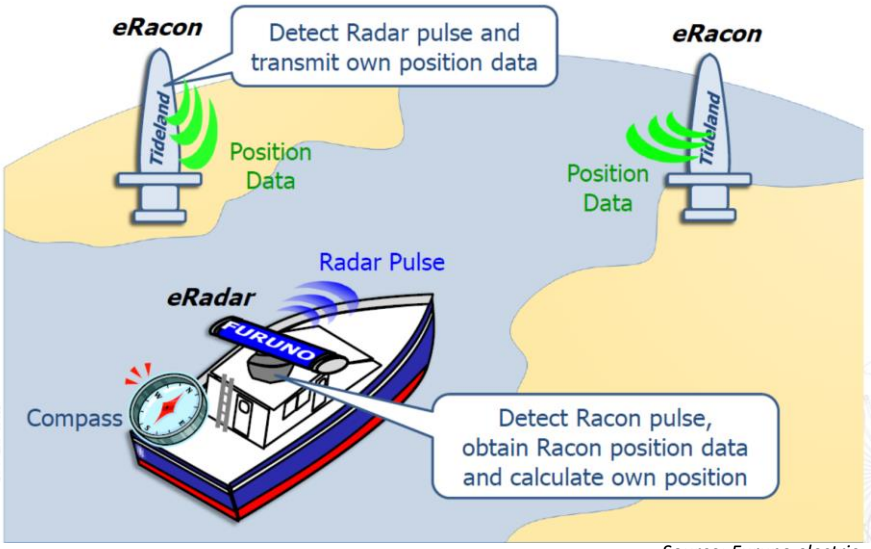




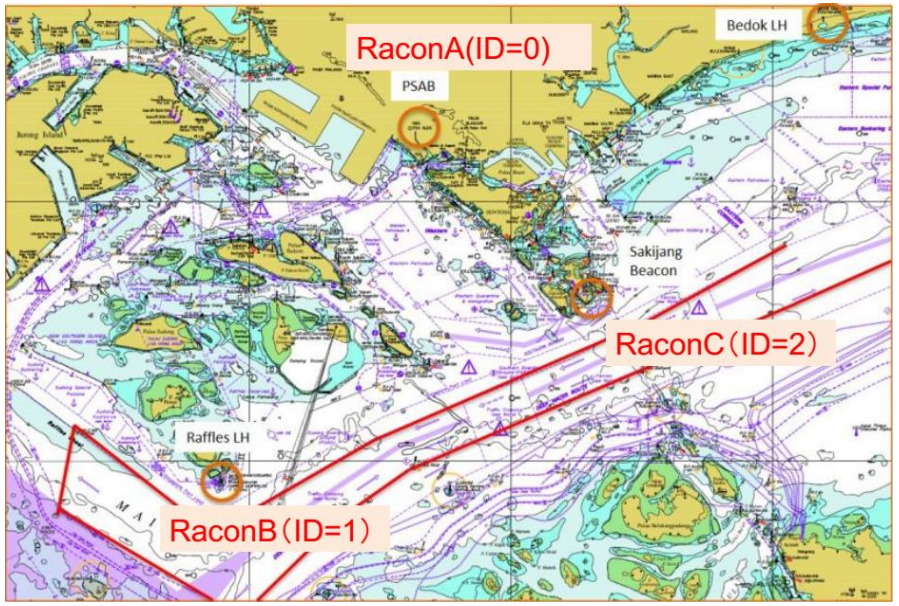
Actions within the working group

- Development of a Guidelines on the use of R-mode and the technical operation at medium frequency (MF).
- Close liaison with the IALA ENAV Committee which is leading the development of R-mode (VHF) .
- Sharing information on technical development and testbeds.

Enhanced radar positioning



Source: Furuno electric



source: Extracted from ENAV21-13.10

Actions within the working group

- Development of a Guideline on use of enhanced RACONs, in order to support consistent service and interoperability between manufacturers.
- Raising awareness of current radar/racon limitations, especially in busy harbour areas.
- Sharing information on technical developments and testbeds

Other

The working group also considers many other aspects, including:

- Technical developments with new systems
- Integrity approaches and solutions,
- Standards and associated developments

For example, the GLA have developed an ePelorus, called BinoNav®- a visual solution to obtain the vessel's position electronically through taking visual bearings.

The approach could be expanded for autonomous vessels with image recognition and fixed cameras.

Source: General Lighthouse Authorities of the UK and Ireland

Key considerations

All of the different systems that have been considered can provide a position, but knowing where you are is only one part of the problem.

It's important that the mariner (or autonomous vessel) knows that the information can be relied upon, that it's safe to use.

This is known as integrity, which is a very important aspect of resilient PNT.

We also need an approach that works for different combinations of PNT systems, so that one receiver works in all locations and can provide the required accuracy, integrity, availability, continuity etc.

User equipment

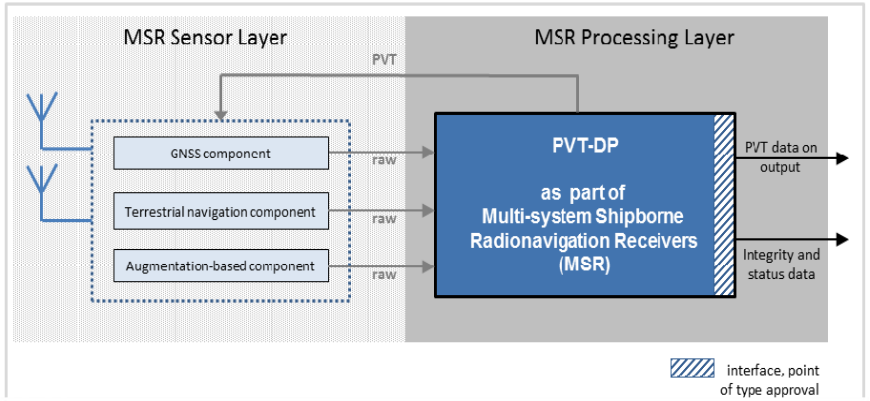
A multi-system radionavigation receiver performance standard (MSC.401 as amended) has been developed to:

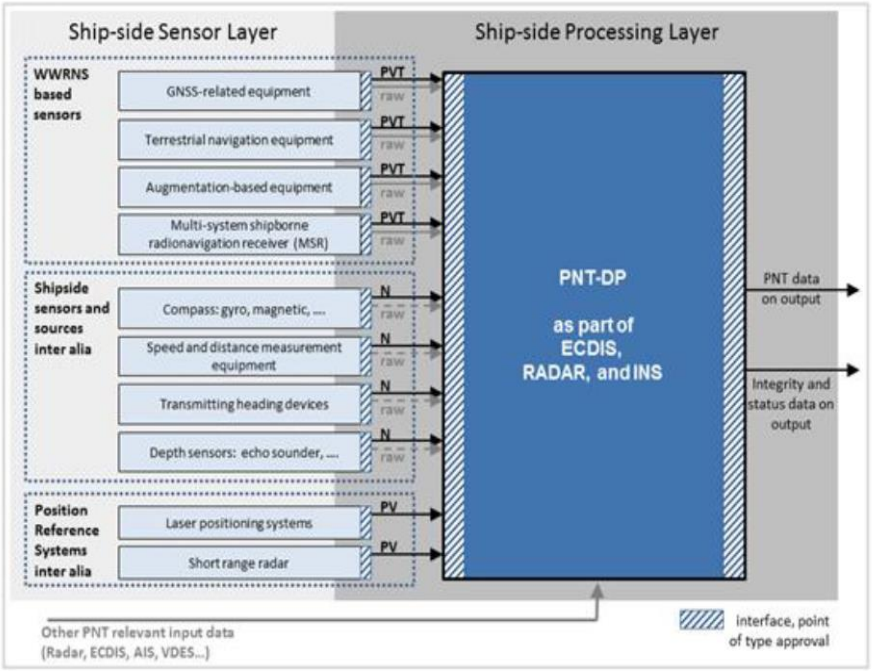
- Enable and support resilient PNT
- Define minimum performance requirements without defining systems to be used
- Enable further system development

Allows for use of:

- All GNSS (existing and future)
- All sources of augmentation (marine radiobeacon and SBAS)
- All terrestrial signals (existing and future)

Supported by IMO PNT Guidelines and the use of the PNT data processor.





Source: IMO MSC.1/Circ.1575

International standards

Lots of international standards do not consider the threats and hazards that are known today.

Resilient PNT systems are being developed, but no single system will meet all of the requirements at every location.

Therefore a dynamic, system of systems approach is required and this is a novel consideration from the point of standards.

The IMO MSR performance standard gives a starting point.

The next step is the development of an IEC test specification. This will require international support to get it on the IEC agenda and to complete the work.

Way forward

All radionavigation system have vulnerabilities, no system is perfect.

GNSS will continue to be the main source of PNT, supported by different PNT sources as appropriate for the location.

Resilient PNT is a requirement of future maritime navigation, it underpins safe navigation and enables e-Navigation services.

We have the opportunity to move resilient PNT from a nice theory to something available on vessels.

The next stage is the IEC test specification work for the MSR. This step needs your help, without a suitable receiver available on-board a manned or unmanned vessel, there is no resilience.

IALA can’t bring resilient PNT to the user on it’s own, we need to work together to make this happen.

THANK YOU

Contact: contact@iala-aism.org