Multi-Constellation GNSS and Maritime Applications

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Outline

- General overview of maritime applications and requirements
- Benefits of multi-constellation GNSS for maritime applications
- Standardisation processes for maritime applications
- Status of standardisation of GNSS in maritime Community
- Recommendations to promote the introduction of multi-constellation GNSS to the maritime community

Overview of Requirements and Applications

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IMO operational positioning requirements

- Operational performance requirements according to IMO Res. A.953(23) on World Wide Radionavigation System (WWRNS)

Parameter	Area with high traffic/risk	Area with low traffic/risk	Ocean
Position accuracy (horizontal, 95%)	≤10 m	≤10 m	≤100 m
Coverage	Local	Local	Global
Availability	≥99.8% (2 years)	≥99.5% (2 years)	≥99.8% (30 days)
Continuity	≥99.97% (3 hours)	≥99.85% (3 hours)	NA
Time-to-alarm	≤10 s	≤10 s	As soon as practical by MSI

IMO future GNSS requirements

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IMO GNSS performance requirements for general navigation according to Res. A.915(22) on future GNSS

	System level parameters				Service level parameters			
	Absolute Accuracy	Integrity			Availability % per 30 days	Continuity % over 3 hours	Coverage	Fix interval (s)
	Horizontal (metres)	Alert limit (metres)	Time to alarm[2] (s)	Integrity risk (per 3 hour)				
Ocean	10 (100)[1]	25	10	10^{-5}	99.8	N/A	Global	1
Coastal	10	25	10	10^{-5}	99.8 (99.5)	N/A (99.85)	Global	1
Port approach and restricted waters	10	25	10	10^{-5}	99.8 (99.8)	99.97 (99.97)	Regional	1
Port	1	2.5	10	10^{-5}	99.8	99.97	Local	1
Inland waterways	10	25	10	10^{-5}	99.8	99.97	Regional	1

[1] Figures in brackets refer to operational requirements according to Res. A.953

In addition Res. A.915(22) lists more than 30 different marine applications and their proposed requirements ranging from 10 cm position accuracy (automated docking, cargo handling, construction work) to 10 m.

GNSS in maritime ship operations

Maritime sector is well advanced in exploiting the opportunities of GNSS

- All SOLAS ships are required to carry a GNSS receiver
- Both public and private augmentation systems in operation
- Increasing reliance on GNSS for ship operation
- Shift of focus from accuracy to reliability (integrity, continuity)

Integrated Bridge System (IBS)

Integrated Navigation System (INS)

Demanding applications

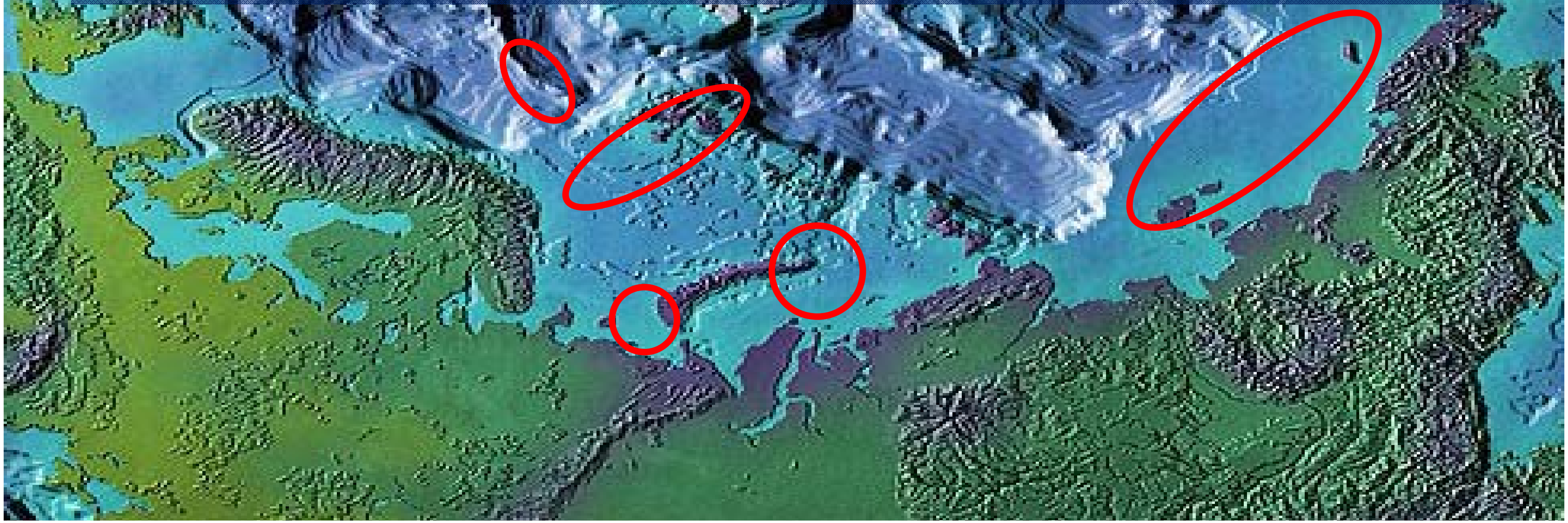
Dynamic Positioning (offshore loading, floating production)

Marginal ships operation (underkeel clearance, bridge clearance, narrow fairways, canals, etc

Inland waterways (barges and pushers, Locks)

The Arctic challenge –
Oil exploitation and transport

- Major oil & gas discoveries in critical ecological areas
- One of the most promising oil provinces remaining in the world
- Challenges: Safe and environmentally friendly oil & gas exploitation and transport
  Lack of ground infrastructure for navigation, communication and surveilance
- Technology gaps to be filled



The arctic challenge

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Conclusion from the MarSafeNorth-project, 2010

- GNSS will work fine in Arctic areas most of the time
- Some degradation due to ionospheric scintillations has to be expected but combining GPS, Galileo and Glonass in two (or multiple) frequency and orbit/clock solutions (PPP, “state space”) will minimise the problem
- Both public and commercial orbit/clock dGNSS corrections will apply to all Arctic areas but availability of the correction signals is limited

Benefits of multi-constellation GNSS for maritime applications

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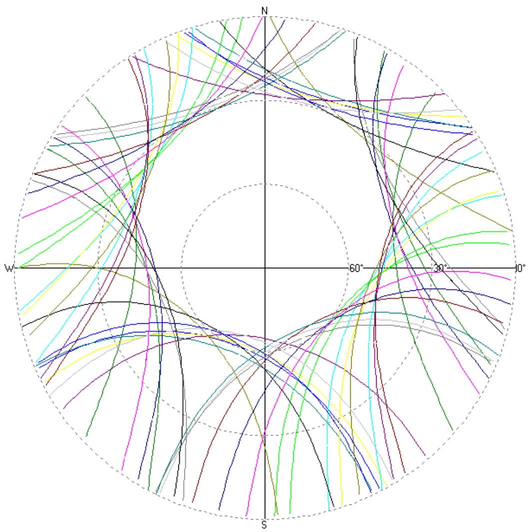
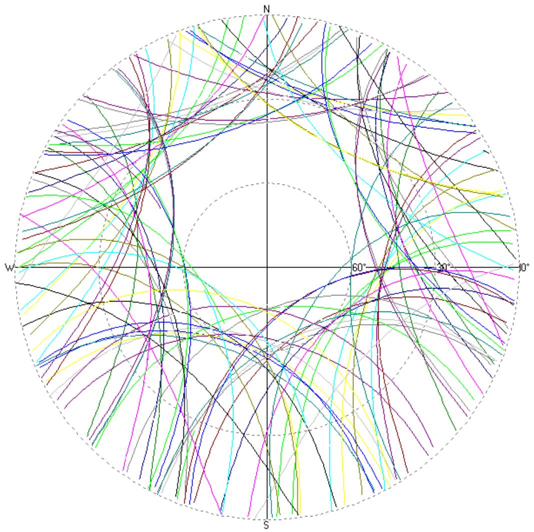
Benefits of multi-GNSS for maritime applications

Improved accuracy, reliability, continuity and availability

Example: GPS vs. GPS+Glonass Satellite Trajectories at high lattitude



GPS only,
Observer's Latitude: 75°N

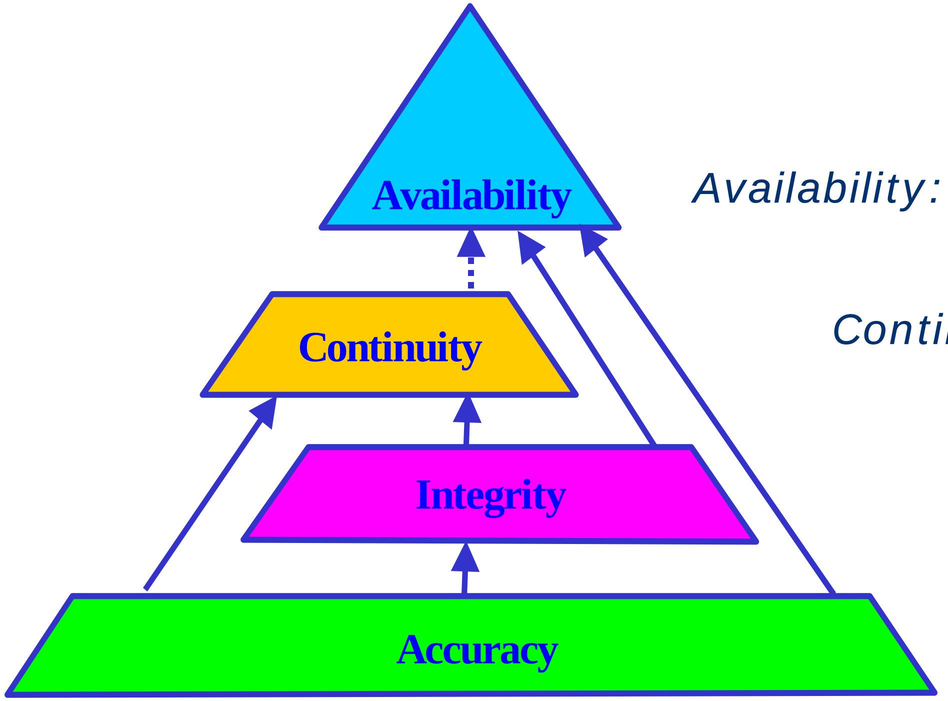


GPS + Glonass,
Observer's Latitude: 75°N
Filling in some of the "empty space" due to a higher Glonass inclination angle

Plots generated by use of GeoSky II (Fugro)

Service performance parameters

Required Navigation Performance (RNP) pyramid



Availability: of accuracy, integrity and continuity

Continuity: Continuity risk per operational time interval (3 hours)

Integrity : Integrity risk, Time to alarm (TTA), Horisontal alarm limit (HAL)

Accuracy: Horisontal absolute accuracy at 95 % confidence level (2 sigma)

Can IMO's GNSS requirements be achieved today?

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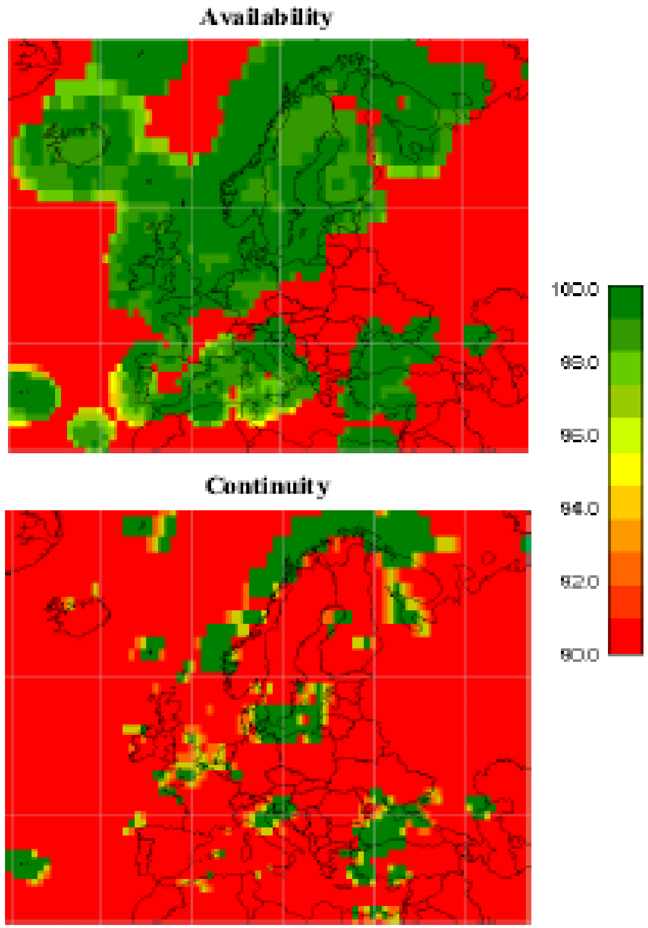
Several independent studies indicate that:

- Standalone GNSS (GPS, GLONASS, GALILEO) can only meet WWRNS requirements for ocean navigation, and do not meet any other requirements of the A.915
- IALA dGPS has the required availability of accuracy and integrity throughout the nominal beacon range, however, continuity requirements can only be met at a few discrete points
- SBAS (WAAS/EGNOS) may achieve the required availability and continuity, however, shadowing of GEO satellites may reduce availability and continuity at high latitudes and large ports. A Quasi-zenith (QS) solution over the central areas would be much preferred
- Multi-GNSS RAIM and ARAIM may fulfil IMO requirements for general navigation according to Res. A.915(22)



Standardisation processes for maritime applications

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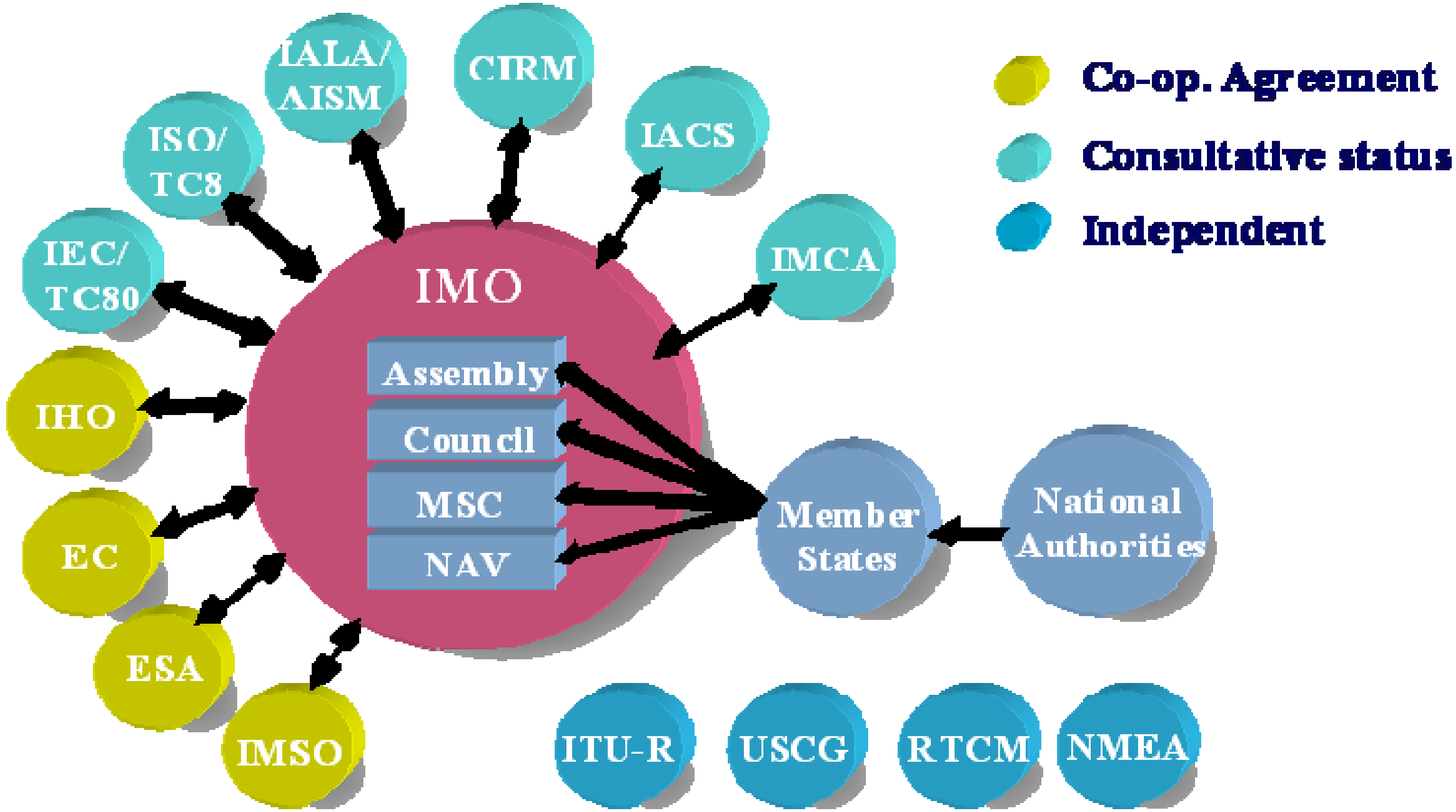
Maritime Standardization

Bodies involved in maritime standardisation



Key standardisation bodies involved in maritime standardisation (other than IMO)

ITU-R and WRC regulates allocation and protection of maritime radio bands and GNSS frequencies as well as recommendations on their use.

IEC TC80 develops test standards based on IMO performance standards for maritime equipment required on board SOLAS ships.

ISO TC 8 also develops test standards based on IMO performance standards. For historical reasons, test standards for ship's heading sensors (magnetic and gyro compass) has been the responsibility of ISO.

IALA/AISM administers the allocation of frequencies and ID numbers for dGNSS stations utilising the Maritime Radio Beacons. In general, all terrestrial and buoy-based aids-to-navigation is the responsibility of IALA/AISM. The organisation issues Manuals, Guides, Guidelines and Recommendations on the use of aids-to-navigations tools, notably VTS and AIS. The e-NAV and VTS committees serve as 'expert bodies' to IMO.

Key standardisation bodies involved in maritime standardisation (other than IMO)

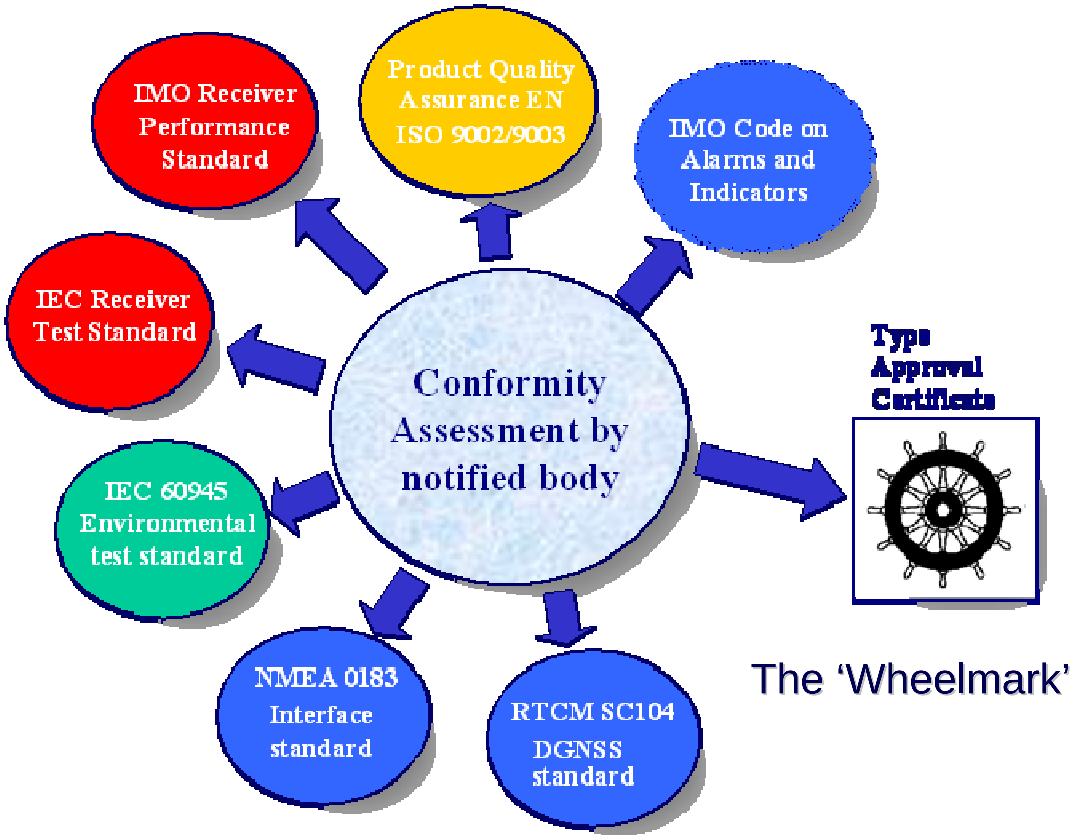
RTCM is an independent US organisation. The RTCM-SC 104 standards for Differential GNSS is a de-facto standard for transmission of differential corrections to GNSS, and is adopted by ITU-R (M.823-3).

NMEA is also an independent US organisation. The NMEA 0183 and NMEA 2000 are de-facto standards for interfacing marine electronic devices, and also adopted by IEC (61162-series).

CIRM (Comite International Radio-Maritime). CIRM is promoting marine electronics for efficient shipping and the safety of life at sea. CIRM represent the industry in developing international regulations and standards, and providing technical and industrial advice to the Organisations.

IMCA is the international trade association representing offshore, marine and underwater engineering companies. IMCA publishes good practice guidance, technical reviews; safety promotion materials and other documentation related to navigation requirements for offshore operations

Maritime equipment certification



All navigational equipments carried onboard ships in fulfilment of the carriage requirements must have a type approval certificate or other conformance certificate issued by a designated test laboratory.

In Europe this requirement is regulated through the 'Maritime Equipment Directive (MED)', through its latest amendment.

Maritime standardisation activities for Galileo

Kongsberg Seatex involvement in Galileo standardisation projects:

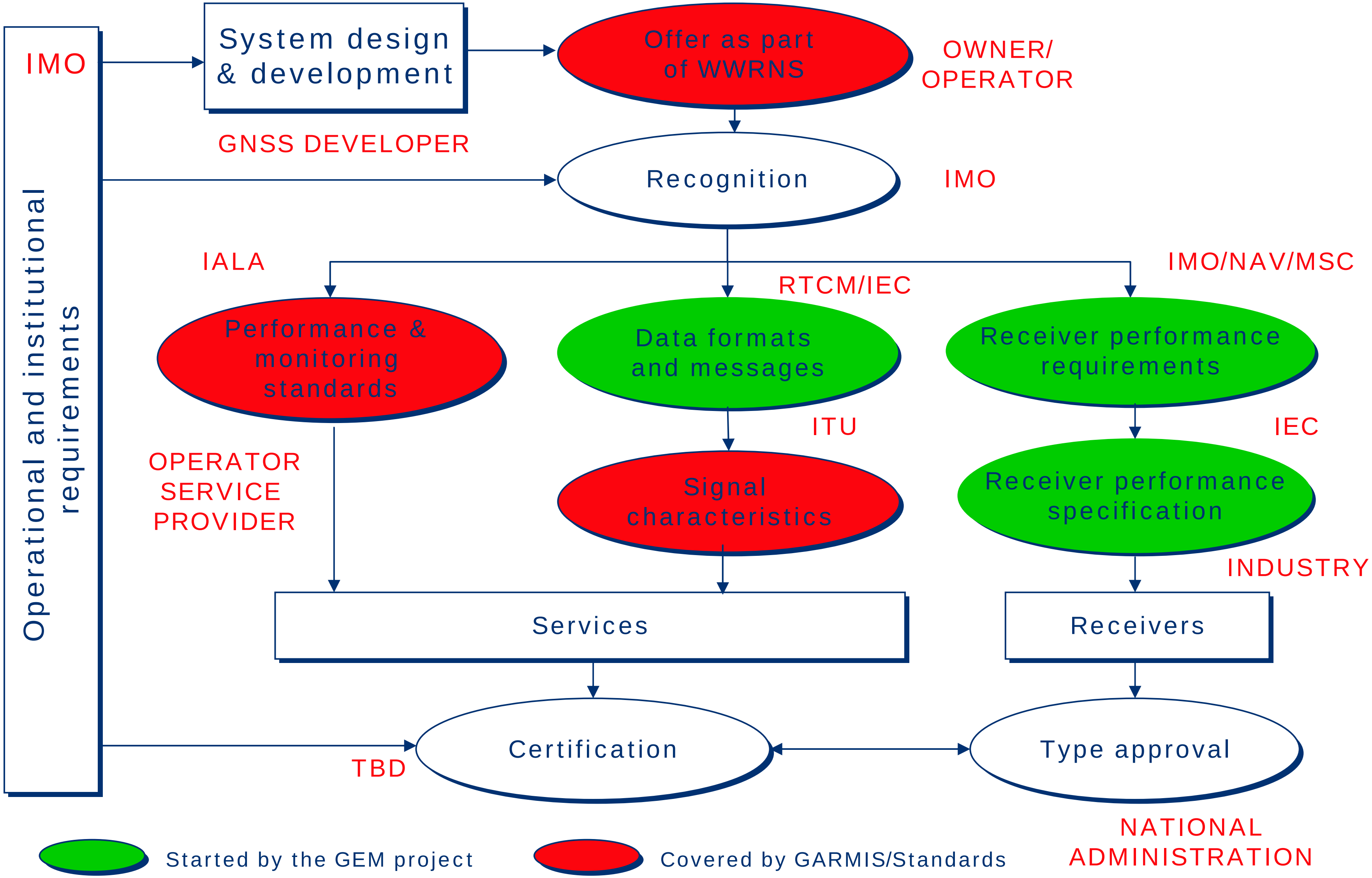
SAGA : Standardisation Activities for GAlileo, 2000-2004

GEM : Galileo Mission Implementation, 2004-2006

GARMIS : GAliileo Reference Mission Support, 2006-2008

STANDARDS : STANDardisation And Reference Documentation Support, [illegible]-2010

Maritime Standardisation Roadmap



Status of standardisation of GNSS in maritime Community

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Standards for Maritime GNSS Receivers

- IMO:
  - Minimum receiver performance standards adopted for
    - ❑ GPS (revised MSC.112(73), 1 Dec 2000
    - ❑ GLONASS (MSC.53(66), 30 May 1996)
    - ❑ Combined GPS/GLONASS (MSC.74(69, 12 May 1998)
    - ❑ GALILEO (MSC.233(82), 5 Dec 2006)

- IEC:
  - Performance standards, methods of testing and required test results adopted for:
    - ❑ GPS (IEC 61108-1, ed.2, 2003-07)
    - ❑ GLONASS (IEC 61108-2, Oct 1998)
    - ❑ GALILEO (IEC 61108-3, June 2010)

Standards for Maritime GNSS Receivers

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- IEC 61162-1 Serial Interface Standards
  - New revised version, IEC 61162-1, Ed. 4, 25 Nov 2010

- RTCM V2.4 dGNSS Standards
  - A new RTCM SC104 V2.4 DGNSS standard is under development. A new set of messages based on a generic approach is being developed. Expected adoption during 2012

- RTCM V3 RTK standards
  - A new RTCM SC104 V3.2 is under development. Includes a new Multiple Signal Message (MSM) which is intended to generate GNSS receiver observables in a universal manner to meet the coming reality when more and more GNSS and their signals will be available. Expected adoption during 2012

IEC 61108-3 Galileo Rx test standards – Whats new?

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Navigational status

The navigational status for different position accuracy levels shall be expressed in three navigational states; “Safe”, “Caution” and “Unsafe”.

The conditions for a “Safe” navigational state are:

1. the estimated error (95 % confidence) along the major axis of the error ellipse is less than the selected accuracy level corresponding to the actual navigation mode, and
2. integrity is available and within the requirements for the actual navigation mode, and
3. a new position has been calculated within 1 s for a conventional craft and 0.5 s for a high speed craft

IEC 61162-1, Ed.2 Serial Interface Standards – What's new

The sentences required for Galileo come in three categories:

1. New Galileo only sentences (GAL, almanac data)
2. Modified GNSS sentences, i.e. sentences are reused with modification and/or reinterpretation of fields when using GA talker. Navigational status included at the end for compatibility with former versions.
3. New GNSS sentences;

    GFA – Fix accuracy and integrity

Recommendations

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Recommendations

- Generic approach to IMO GNSS receiver performance standards as well as IEC 61108 series of testing standards

- Coherent identification of multi-GNSS signals;
  - IEC, NMEA, RTCM and RINEX may consider to agree on a consistent method of identification of signals, observables and systems
  - At present RINEX V3.01 seems to have the most comprehensive approach

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Thank you for your attention!

Any Questions?

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