IALA RECOMMENDATION (INFORMATIVE)

R0135 (R-135)
THE FUTURE OF DGNSS

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DOCUMENT REVISION

Revisions to this document are to be noted in the table prior to the issue of a revised document.

Date	Details	Approval
December 2006	1st issue	
December 2008	Edition 2 Full Revision Introduction of WWRNP concepts	
September 2020	Edition 2.1 Editorial corrections.	

THE COUNCIL

NOTING the function of IALA with respect to safety of navigation, the efficiency of maritime transport and the protection of the marine environment;

NOTING ALSO IMO Resolutions A.915 (22) on Maritime Policy for the Future Global Navigation Satellite System (GNSS) and A.953 (23) on the World Wide Radio-Navigation System;

NOTING FURTHER ITU-R Recommendation M.823-3 on the Technical Characteristics of differential transmissions for Global Navigation Satellite Systems (GNSS) from maritime DGNSS sites in the frequency band 285-325 kHz (283.5-315 kHz in Region 1);

RECOGNIZING the need to ensure that Differential GNSS (DGNSS) services in the frequency band 283.5-325 kHz continue to meet the minimum requirements set out in relevant ITU-R Recommendations and IMO Resolutions;

RECOGNIZING ALSO that the equipment providing the DGNSS service in several members' states requires replacement and that the present service will not provide for all the applications described in IMO Resolution A.915 (22);

RECOGNIZING FURTHER that some maritime applications are not fully met by the existing GNSS services;

HAVING CONSIDERED the revised proposals made by the e-Navigation Committee;

ADOPTS the updated strategy proposed for the Future of the IALA DGNSS, set out in the annexes to this Recommendation; and

RECOMMENDS that National Members and other appropriate Authorities providing or intending to provide DGNSS services in the band 283.5-325 kHz, implement the strategy set out in Annex 1 to this Recommendation.

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ANNEX A STRATEGY FOR THE FUTURE OF IALA DGNSS

1 GENERAL

The IALA DGNSS beacon system was developed in the 1990s and systems were installed in many countries over the period 1995-2000. The system was adopted as the international maritime standard for providing differential corrections to Global Navigation Satellite Systems (GNSS). IALA assessed the current and potential use of the system, and concluded in 2006 that there would be a requirement to recapitalise (i.e. replace) older systems. There is also potential to develop the system for the benefit of existing users and to enhance GNSS capabilities to take account of technical innovations, in accordance with IMO Resolution A.915 (22).

This strategy should be viewed in the context of the development by IALA of proposals for a World Wide Radio Navigation Plan (WWRNP) in support of e-Navigation. One key concept in this Plan is the possibility of separating the generation of correction data from the means of transmission, to facilitate broadcasting by a variety of methods. This could lead to the integration of terrestrial systems (DGNSS beacons, eLoran, AIS) to provide shared data channels and common correction sources. Additional ranging signals could also be provided, contributing to a redundant position-fixing solution, complementary to, but independent of GNSS.

2 SCOPE

This document outlines an updated strategy for the recapitalisation of DGNSS, setting out the requirements and options and identifying areas still needing further study.

3 ALTERNATIVE TECHNOLOGIES

There are potential alternatives to the IALA beacon system for the distribution of safety related differential services, in particular Satellite Based Augmentation Systems (SBAS) and the Automatic Identification System (AIS). SBAS, such as WAAS and EGNOS, are now becoming operational and SBAS-enabled receivers are being marketed to non-SOLAS users, although SBAS has not been designed or approved for maritime applications. The use of AIS as a means of broadcasting differential corrections has also been proposed and demonstrated. There are other ways of providing enhanced services, including Real Time Kinematic (RTK), eLoran and pseudolites. All these options have been considered and a subjective cost–benefit analysis carried out, a summary of which is presented in the table below.

Table 1 Performance Assessment

System	Accuracy	Coverage	Integrity/Continuity
IALA DGNSS	1-3 m	local/regional	Yes/High
SBAS	1-3 m	regional/global	Yes/High
AIS [1]	1-3 m	Local	Yes/Moderate
Pseudolites	sub-meter	Local	Yes/Moderate
eLoran	1-3 m	regional	Yes/High
RTK	sub-meter	Local	X/Low

Table 2 Cost Assessment

System	Provider cost	User cost	Marine Standard
IALA DGNSS	moderate	Low	Yes
SBAS	very high	Low	No
AIS	low	Low	Yes
Pseudolites	high	moderate	No
eLoran	Low 2	moderate	No
RTK	moderate	High	No

Notes

1 Implementation is covered in IALA Rec. R0124 (A-124 Annex) 16. International co-ordination is required to limit VDL loading

2 As a means of broadcasting DGNSS corrections only

X Level of integrity depends on the implementation technique

4 FACTORS AFFECTING THE FUTURE OF DGNSS

Taking all the above factors into account, modernisation of the IALA beacon DGNSS is the preferred option for regional maritime applications, particularly where existing infrastructure can be re-used.

Normal recapitalisation periods for such equipment would be 10 years. Budgetary requirements in most administrations dictate up to four years lead-time for planning re-equipment.

Driving factors for recapitalisation include age of the equipment, maintenance, developments in DGNSS, emerging technologies and RAIM. These are discussed in detail below.

4.1 AGE OF EQUIPMENT

The original computing and communications equipment has already become obsolete and been replaced in many cases. Some manufacturers of reference station and integrity monitor equipment have withdrawn from this market and maintenance of the equipment is no longer supported.

4.2 GNSS DEVELOPMENTS

Developments in GNSS (GPS L2C, L5, GLONASS M, Compass and Galileo) will require the introduction of new message types and new equipment. A concept of operations needs to be developed for the use of multiple frequencies for DGNSS services, to determine whether frequencies should be used separately or the data should be combined.

4.3 EMERGING TECHNOLOGIES

With the emergence of new technologies, the way in which the original DGNSS system was implemented needs to be re-evaluated. For example, instead of specialised, dedicated hardware units for reference stations and integrity monitors, it may be more cost-effective to consider off-the-shelf receivers with the reference station and integrity monitor functions implemented in software.

4.4 RAIM

Receiver Autonomous Integrity Monitoring, RAIM, is a method that provides GNSS integrity information on the user receiver without external augmentation. RAIM is not continuously available with the present GNSS satellite constellation and is not likely to be fully available until another GNSS is fully operational. The current IMO GNSS receiver performance standards call for fault detection (RAIM). Future standards for receivers using combinations of GNSS will almost certainly contain the same requirements. However, RAIM does not provide any improvement in accuracy.

5 APPLICATIONS

IMO Requirements for future GNSS cannot all be met by the existing differential system, e.g., 1m accuracy. New approaches could meet those requirements and provide greatly enhanced services but must preserve backward compatibility. Some new applications that could be served are hydrographic survey, port operations, berthing and AtoN management. Some new telematic applications may demand higher levels of integrity and accuracy than those set out in IMO A.915(22).

6 OPTIONS FOR FUTURE DEVELOPMENT

If no action is taken, the service from older systems will become unreliable, difficult to maintain and will no longer meet international requirements. Therefore, this is not an acceptable approach. Putting off a decision will make it more difficult and expensive to re-engineer or replace the system when it becomes essential to do so.

Systems could be modernised or replaced using the same architecture, but there are few potential suppliers and this is unlikely to meet future needs. This could lead to a proliferation of additional systems to meet specialised applications.

Development to meet future requirements and changes in the core GNSS would be the strategy most likely to result in a single integrated system meeting a wide range of applications, whilst maintaining backward compatibility and compliance with existing standards.

Discontinuing the service and replacing it with something else (SBAS, AIS, eLoran) could render existing user equipment obsolete and would require the development of new standards. It is unlikely that this would be acceptable to most administrations, providers and users.

7 RECAPITALISATION REQUIREMENTS

The baseline requirements and principles for the recapitalisation of the IALA DGNSS service are as follows:

1 Maintenance of legacy signals (backward compatibility).

2 Flexibility to support future service requirements e.g., multiple GNSS, ranging and communications functions.

3 Internationally applicable solution.

4 Life-time of at least 10 years.

8 RE-ENGINEERING OPTIONS

Action must be taken to prevent the service becoming unreliable and unable to meet international requirements.

Even if a decision is made to close down the IALA DGNSS at some point in time, an adequate period of notice is required to allow users to update to alternative technologies. Since this period could be several years, older systems have to be recapitalised to meet requirements in the medium term.

Recapitalisation offers the opportunity to provide enhanced performance to serve high integrity and high precision applications (IMO A.915 (22)). Furthermore, the system could be designed to support emerging and upgraded GNSS.

Having decided that re-engineering of IALA DGNSS is necessary, the following options are considered:

- Hardware Reference Stations and Integrity Monitors (RSIM)
- Software Reference Stations and Integrity Monitors (RSIM)
- Virtual Reference Station
- SBAS Integration

8.1 HARDWARE RSIM

Replacement of existing hardware with similar dedicated Reference Stations and Integrity Monitors (RSIM) would appear to be a low-risk option – the technology is known and procedures are in place. However, the choice of suppliers is limited and once this route is chosen, it will be difficult to develop the system to meet future needs. This could lead to the deployment of additional, non-standard systems to meet specialised applications.

8.2 SOFTWARE RSIM

An alternative already being implemented by some administrations is to replace the hardware-based Reference Station, Integrity Monitor, Communications and Control with software, using commercial, off-the-shelf GNSS receivers for position and time input. This has the potential advantage of flexibility as the hardware should be easy to replace and reconfigure.

However, the long-term maintenance of the software would be a concern. This might be partially alleviated by using software modules developed in a widely-used application language. This would also facilitate continuing development of the system to meet changing needs.

8.3 VIRTUAL REFERENCE STATION

Another option is to develop a Virtual Reference Station (VRS) network. In this case, the corrections and integrity messages are computed at a central site using data fed from remote receivers. This would offer performance advantages since accuracy could be uniform over the coverage area. However, the availability of the service would then be dependent on the communication links, which would also introduce extra running costs. Provision of backup systems for generation of corrections and/or communication links would need to be considered. Using data from an existing network such as those implemented by national survey organisations would be a possibility, although dependence on third-party providers and security implications would need to be taken into account.

This option would allow the separation of the generation of corrections from the means of transmission.

8.4 SBAS INTEGRATION

Integration with an existing SBAS, such as WAAS or EGNOS could offer a low-cost solution to service providers. This could be achieved in a variety of ways ranging from the use of SBAS receivers on each site to direct data links with the SBAS control centre.

The service would then be dependent on the SBAS provider so that a Service Level Agreement would be needed. Provision of backup systems for generation of corrections and/or communication links would again need to be considered. Performance would be limited to that provided by the SBAS - accuracy of a few metres at present. There are also limitations in coverage, especially at high latitudes, and there may be time to alarm (TTA) implications from this approach.

There are two ways to use SBAS data. The first is to reprocess the data at the beacon site and transmit legacy beacon messages. In this case the user’s receivers would not have to be changed.

The second way to use SBAS data would be to re-broadcast it in its existing format. In this case the IALA DGNSS stations would become terrestrial alternatives to the geo-stationary satellites. The data capacity of the channel would need to be increased and the user's beacon receiver would have to be changed to accommodate this new transmission, but the GNSS receiver's software could perform the normal SBAS operations.

9 ENHANCED PERFORMANCE

The recapitalisation solution should be able to enhance the level of service. Enhanced performance would include the ability to transmit additional messages, to cater for multiple GNSS and give better than 1m accuracy, meeting harbour navigation, docking and other specialised requirements.

The capability of providing messages for Galileo, Compass, GLONASS M and GPS L2C and L5 would be required, even though these signals will not be fully available for some years.

9.1 REAL TIME KINEMATIC (RTK)

A Real Time Kinematic solution using carrier-phase corrections would have the most potential for enhanced accuracy, but there are constraints imposed on data rates by the bandwidth of the present datalink. New modulation techniques could be used to broadcast additional messages, which are too long to fit into the existing low rate data stream. Alternative MF frequencies capable of providing RTK observables are also being investigated.

9.2 ADDITIONAL CHANNEL CAPACITY

The legacy DGNSS signal typically broadcasts RTCM SC-104 type 9-3 messages regularly to provide timely corrections and to provide integrity to meet the IMO requirement of 10 second time to alarm. Typically, DGNSS sites broadcast Type 9-3 messages for 12 satellites every 8.4 seconds at 100 bps. The repetition rate of these corrections was partially based on the dynamics of selective availability (SA). With SA removal in 2000, the latency of the signal may be increased to meet the same accuracy standards. Present standards allow the use of transmission rates up to 200 bps. With the availability of additional capacity in the DGNSS data channel, detailed troposphere and ionosphere models, precise orbit data and emergency messages could be broadcast.

9.3 PRE-BROADCAST INTEGRITY CONCEPT

Reducing the frequency of type 9 message transmissions will affect the system ability to meet the legacy integrity time to alarm (TTA) requirements. This concern may be mitigated by allowing the type 9 messages to have priority to interrupt other broadcasts as necessary to meet TTA requirements. Additionally, messages may be checked prior to transmission to ensure quality. This pre-broadcast integrity concept may reduce the potential interrupts to near zero.

9.4 CORRECTIONS FOR INDIVIDUAL GNSS ERROR COMPONENTS

Over the next several years, additional GNSS signals will be available to the public. These signals include Galileo, Compass, GPS L5, GPS L1C, GPS L2C and GLONASS M.

There may be merit in broadcasting corrections for the individual GNSS error components instead of only providing a single pseudorange correction encompassing all error components. Error components such as the tropospheric and ionospheric errors are common to all GNSS systems and may be broadcast independently of components specific to the individual GNSS systems. Independent error components such as precise orbits and precise time change slowly and may be broadcast infrequently for each GNSS satellite.

This approach would require a number of new message types.

9.5 RANGE RATE CORRECTIONS

Range Rate Corrections (RRC) should be removed as in some conditions the error may become larger by using RRC. With new message types, this could reduce data link loading by 20% thereby reducing data latency and improving position accuracy.

9.6 NEW MESSAGE TYPES

New message types, such as message type 27 for improving station selection, should be implemented. A new, short integrity message is also under consideration in RTCM SC-104, as a means of meeting the TTA requirement, while extending the correction update interval to release datalink capacity.

9.7 RANGING SIGNALS

Differential signals could also be used for ranging if a stable timing source is provided at the broadcast station. With suitable receiving equipment these signals could be used to provide redundant position-fixing, independent of GNSS. Where appropriate such ranging could also be integrated with eLoran and/or AIS.

10 INTERNATIONAL STANDARDS

Any solution proposed must meet international requirements, since the present service is the maritime standard. The roles of the relevant organisations are explained in appendix 2. The technical characteristics of the system and any changes to spectrum allocations must be agreed by ITU; message formats are generally developed and approved first in RTCM and then the ITU Recommendation is revised accordingly. The operational requirement and receiver performance standards must be approved by IMO.

System performance standards and operating procedures are dealt with by IALA and IEC produces receiver specifications. A lead-time of several years must be allowed for the regulatory process if any substantial change is planned to the existing system.

Future standards for DGNSS should be considered in the context of position-fixing requirements for e-Navigation. DGNSS is likely to be an essential part of the WWRNP being developed by IALA.

These matters should be considered in parallel with the recapitalisation of the system, but it is important to note that as long as international standards are met, the exact method of implementation remains a decision for the individual administration.

11 RECOMMENDED STRATEGY

It is recommended that:

1 Members should consider re-engineering their DGNSS to ensure required levels of service.

2 The intended performance levels should be specified (accuracy, availability, integrity, continuity and coverage).

3 The results of investigations of alternative development routes for IALA DGNSS e.g., software RSIM, VRS and SBAS integration should be considered, in terms of cost, technical and regulatory suitability.

4 Data link capacity required for an enhanced DGNSS service should be determined.

5 The merit of pre-broadcast integrity should be assessed, together with the rules for integrity interrupt and any additional integrity messages or RTCM integrity message headers that may be required.

6 The message types and transmission schemes for individual error components should be considered for new and existing GNSS signals.

7 Alternative data channels and alternative uses of the DGNSS broadcast channel should be investigated, noting the concepts discussed earlier of separating the functions of generating and broadcasting corrections.

8 The probable need to provide additional messages relating to Galileo, Compass, GPS L2C/L5 and GLONASS M should be taken into account.

9 The feasibility of providing sub-metre accuracy should be investigated.

10 The feasibility of providing ranging signals giving redundant position-fixing, independent from GNSS, should be investigated.

11 The advantages of Virtual Reference Station Networks should be explored, including networks established for land users (but capable of being used by maritime users).

12 The requirement for additional integrity messages or message header flags should be investigated.

13 There are significant advantages in sharing technical developments and administrations should be encouraged to make the results of their studies available through IALA.

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APPENDIX 1 ABBREVIATIONS AND TERMS USED

AIS	Automatic Identification System
Compass	GNSS under development by the People's Republic of China
EGNOS	European Geo-stationary Navigation Overlay Service (SBAS)
eLoran	Enhanced Loran
Galileo	GNSS being developed by the European Commission, European Space Agency and other partners.
GLONASS M	Second generation GNSS deployed by Russian Federation
GNSS	Global Navigation Satellite System
Pseudolites	Ground-based transmitter broadcasting signals with the same format as a satellite system.
RAIM	Receiver Autonomous Integrity Monitoring
RSIM	Reference Station/Integrity Monitor
RTCM	Radio Technical Commission Maritime
RTK	Real Time Kinematic
SBAS	Satellite Based Augmentation System
TTA	Time To Alarm
VRS	Virtual Reference Station
WAAS	Wide Area Augmentation System (SBAS)
WWRNP	World Wide Radio Navigation Plan
WWRNS	World Wide Radio Navigation System

APPENDIX 2 INTERNATIONAL ORGANISATIONS

IMO: International Maritime Organisation. A specialized agency of the United Nations, IMO's main task is to develop and maintain a regulatory framework for shipping. Its remit includes navigational safety, environmental concerns, legal matters, technical co-operation, maritime security and the efficiency of shipping. Requirements for radio-navigation systems and performance standards for receiving equipment are formulated by the IMO Sub-Committee on Safety of Navigation and ratified as resolutions of the IMO Maritime Safety Committee or Assembly.

ITU: International Telecommunication Union. The UN specialised agency responsible for telecommunications, in particular for spectrum management and technical characteristics of systems. Recommendations on radio-navigation systems are prepared by ITU-R Study Group 8 for approval by a Radiocommunications Assembly.

IEC: International Electro-technical Commission. The IEC prepares and publishes international standards for all electrical, electronic and related technologies. These serve as a basis for national standardization and as references when drafting international tenders and contracts. IEC Technical Committee 80 deals with maritime navigation and communications equipment.

RTCM: Radio Technical Commission for Maritime Services. A US based organisation that develops standards and recommendations for marine systems and equipment. In particular RTCM Special Committee 104 has produced the recommendations for the data formats used in differential GNSS.