

SUB-COMMITTEE ON NAVIGATION,  
COMMUNICATIONS, AND SEARCH AND  
RESCUE  
12th session  
Agenda item 8

NCSR 12/8  
Day Month 2025  
Original: ENGLISH  
Pre-session public release: ☒

## WORK PROGRAMME

### DEVELOPMENT OF PROCEDURES AND REQUIREMENTS FOR THE RECOGNITION OF AUGMENTATION SYSTEMS IN THE WORLD-WIDE RADIONAVIGATION SYSTEM (WWRNS)

Submitted by (TBC)

#### SUMMARY

*Executive summary:* This paper contains a proposal for draft procedures and requirements for the recognition of augmentation systems in the World-Wide Radio Navigation System (WWRNS).

*Strategic direction, if applicable:* SD2

*Output:* TBC

*Action to be taken:* Paragraph 0

*Related documents:* MSC 107/17/7 and MSC 107/20 paragraph 17.58. Resolutions A.1117(33), A.1174(33), A.915(22), A.1046(27), A.577(14), MSC.112(73), MSC.113(73), MSC.114(73), MSC.115(73), MSC.233(82), MSC.379(93), MSC.401(95), MSC.432(98), MSC.449(99), MSC.480(102) and MSC.74 (69). SN/Circ.182, SN/Circ.187, SN/Circ.329, SN/Circ.334, SN.1/Circ.340 and SN.1/Circ.341.

#### Introduction

1. This document is submitted in accordance with the provisions of the *Organization and Method of Work of the Maritime Safety Committee and the Maritime Environment Protection Committee and their Subsidiary Bodies* (MSC-MEPC.1/Circ.5/Rev.5) and contains a proposal for draft procedures and requirements for the recognition of augmentation systems in the World-Wide Radio Navigation System (WWRNS).

## **Background**

2. Following consideration of a proposal from Australia et.al (MSC 107/17/7), MSC 107 agreed to include in its post-biennial agenda (MSC 107/20 paragraphs 17.58.1 and .2 refer):

.1 an output on "Development of procedures and requirements for the recognition of augmentation systems in the World-wide radionavigation system", with one session needed to complete the item; and

.2 an output on "Development of performance standards for dual frequency multi-constellation satellite-based augmentation systems (DFMC SBAS) and advanced receiver autonomous integrity monitoring (ARAIM) in shipborne radionavigation receivers", with two sessions needed to complete the item,

and assigned NCSR as the associated organ.

3. The Committee also agreed the performance standards for DFMC SBAS and ARAIM in shipborne radionavigation receivers should be developed only after the approval/adoption of the necessary procedures and requirements for the recognition of augmentation systems. NCSR 11 subsequently prepared the provisional agenda for NCSR 12 containing the output on "Development of procedures and requirements for the recognition of augmentation systems in the World-wide radionavigation system", which was approved by MSC 109.

## **Global Navigation Satellite Systems (GNSS)**

4. Since their introduction some decades ago, the use of Global Navigation Satellite Systems (GNSS) has grown globally, in almost every sector. The maritime industry is no exception. Global availability, high accuracy and fast position updates has meant GNSS has become the primary means of obtaining Positioning, Navigation and Timing (PNT) information for the maritime sector.

5. The Organization has, over the years, recognised different GNSS constellations (e.g. GPS, GLONASS, Galileo, Beidou) and Regional Navigation Satellite Systems (RNSS) (e.g. Indian Regional Navigation Satellite System (IRNSS), Quasi-Zenith Satellite System (QZSS)) as components of World-Wide Radionavigation System (WWRNS).

6. PNT services from GNSS and RNSS are now used widely by the international ships to fulfil carriage requirements for radionavigation, as required by SOLAS chapter V, Regulation 19-2.1.6.

7. Increased reliance on GNSS has also led to concern for the integrity of the navigation information, the continuity of service and the vulnerability of systems to external influences.

## **Augmentation systems**

8. GNSS and RNSS meet the requirements (e.g. accuracy, availability, integrity) for navigation in ocean waters, in accordance with the operational requirements in resolutions A.1046(27) and A.915(22). However, without augmentation, standalone systems do not meet the more stringent operational requirements for navigation in harbour entrances, harbour approaches and coastal waters (e.g. horizontal accuracy, integrity warning and service continuity).

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9. The main concern is their lack of ability to meet IMO requirements for navigation in harbour entrances, harbour approaches and coastal waters, due to lack of assurance of continuity (99.97% over the required 15 min period).

10. IMO resolution A.915(22) foreshadowed different augmentation techniques and their evolution by early 2000s; either local, wide area (e.g. SBAS) or receiver-based augmentation. Resolution A.915(22) makes the following references to augmentation systems.

*.1 Without augmentation, GPS accuracy does not meet the requirements for navigation in harbour entrances and approaches or restricted waters (para 2.1.1.4);*

*.2 Without augmentation, GLONASS accuracy is not suitable for navigation in harbour entrances and approaches (para 2.1.2.4);*

*.3 Augmentation provisions should be harmonised worldwide to avoid the necessity of carrying more than one shipborne receiver or other devices (para 3.1.3).*

11. Over the years, IMO has already agreed performance standards for shipborne receiver equipment, for individual GNSS and for multi-system receivers (resolution MSC.401(95)), which identify augmentation systems and Receiver Autonomous Integrity Monitoring (RAIM).

12. However, with the approval of this output, IMO has identified the need to recognise augmentation systems as components of the World-Wide Radionavigation System (WWRNS).

13. There are several augmentation systems (ground-based and satellite-based) presently being used by the maritime community, notably Radiobeacon Differential GNSS (DGNSS), SBAS (Satellite Based Augmentation System) and RAIM (Receiver Autonomous Integrity Monitoring). Others are under development (e.g. PPP (Precise Point Positioning) and Advanced RAIM). More information on augmentation systems is available in Chapter 6 of the IALA NAVGUIDE Edition 9.

### **Performance standards for augmentation systems**

14. Over the years, the Organization has developed performance standards for shipborne receiver equipment for individual GNSS and, more recently, for multi-system receivers. These performance standards apply to radio navigational equipment ships carry, to comply with SOLAS V/19-2.1.6.

15. The Organization also recognises in some of these performance standards (e.g. resolution MSC.401(95)), the capability of the receiver to use current and future radionavigation systems, as well as augmentation systems, for the provision of position, velocity and time data.

16. Additionally, there are performance and test standards publicly available that allow manufacturers to build shipborne equipment capable of using ground-based and/or satellite-based augmentation systems. These standards, recognized internationally by the Maritime community, have been developed either by the Organization, or by other international standardisation bodies (e.g. RTCM, ITU, IEC...), are referred in paragraphs 17 and 19. However, these standards are not based on any IMO performance standard.

17. The Organization has also developed performance standards for shipborne GNSS receiver equipment (e.g. MSC.113(73), MSC.114(73), MSC.115(73), MSC.233(82),

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MSC.379(93)) that can use augmentation data provided by Radiobeacon DGNSS. They also refer to the internationally accepted data transmission standards for DGNSS defined by RTCM SC-104, as well as ITU-R M.823-3 recommendations.

18. Regarding SBAS, although the Organization has not developed a specific performance standard for such augmentation systems, it recognizes its use (resolution MSC.401(95)) as a system to augment GNSS, once the relevant standard is in place.

19. IEC has recently developed and published the 61108-7 *Maritime navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS) – Part 7: Satellite Based Augmentation System (SBAS) L1 – Receiver equipment – Performance standards, methods of testing and required test results*.

20. Additionally, IALA describes all elements of an SBAS relevant to maritime Administrations in their publications *G1152 SBAS Maritime Service* and *G1129 The Retransmission of SBAS corrections using MF-Radio Beacon and AIS*.

21. RAIM is already considered by the Organization as a mechanism to provide integrity monitoring, being identified in the performance standards developed for each GNSS system/constellation, as a minimum capability for the receiver (resolutions MSC.232(82), MSC.379(93), MSC.401(95)).

### **Need for IMO recognition of augmentation systems**

22. The cosponsors of this proposal consider the lack of IMO recognition of augmentation systems, particularly SBAS, to be a major impediment to its uptake for the many new and emerging maritime activities that could be made safer by using augmentation services.

23. The increasing use of electronic navigation on board ships, growing needs for high accuracy in some operations (e.g. large cruise ships needing highly precision positioning to manoeuvre in confined harbours), increased competition for limited water space due to the proliferation of offshore renewable electricity infrastructure and the introduction of ship operations performed autonomously, all demand high levels of position accuracy and assurance of continuity and integrity.

24. This increasing reliance on GNSS highlights the importance of resilient PNT and an objective consideration of areas of vulnerability and measures to reduce or mitigate such effects. Resilient PNT means, among other things, recognition by the Organization of different PNT sources and associated vulnerabilities, and their corresponding augmentation systems.

25. Without augmentation, a GNSS standalone navigation solution does not meet the operational requirements for navigation in harbour entrances, harbour approaches and coastal waters. It also does not provide near-instantaneous integrity warning of system malfunction.

26. Without recognition by the Organization, there is risk of lack of harmonization and interoperability among these augmentation systems, with an impact on shipboard equipment.

27. EGNOS, the European Union's SBAS, has been providing Safety of Life (SoL) services to maritime users since March 2024. Thus, EGNOS declared their services to IALA (<https://www.iala-aism.org/gnss-register/>) as recommended by normative IALA Recommendation *R-1022 provision of GNSS augmentation services for maritime navigation applications*.

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28. Thus, there is a need for augmentation systems to be recognised by IMO and internationally accepted. This recognition, as stated in IMO resolution A.1046(27), would mean that *“the Organization recognizes that the system is capable of providing adequate position information within its coverage area and that the carriage of receiving equipment for use with the system satisfies the relevant requirements of the 1974 SOLAS Convention”*, providing assurance to the maritime community on the use of these systems and related services provided.

### **Proposal**

29. For IMO to adopt procedures and requirements for the recognition of augmentation systems in the WWRNS, the co-sponsors envision two potential options: to issue a new resolution or to revise the current resolution A.1046(27).

30. Annex A provides procedures and requirements for the recognition of augmentation systems in the WWRNS addressing a new resolution as a first option. The format aligns with the current procedures and requirements identified in IMO resolution A.1046(27).

31. Annex B proposes additions to current procedures and requirements for the recognition of radionavigation systems to include augmentation systems as well by revising IMO resolution A.1046(27) as a second option.

### **Action requested of the Sub-Committee**

32. The Sub-Committee is invited to consider these proposals and take action, as appropriate.

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## **ANNEX A**

### **DRAFT RESOLUTION MSC.509(105)/REV.1 PROVISION OF RADIO SERVICES FOR THE GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM (GMDSS)**

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO that the Assembly, at its twenty seventh, adopted resolution A.1046(27) on *Worldwide radionavigation system*,

RECALLING FURTHER ... ,

TAKING INTO ACCOUNT ...,

NOTING ... ,

HAVING CONSIDERED, at its ...th session, the recommendation made by the Sub-Committee on Navigation, Communications and Search and Rescue at its twelfth session,

HAVING ALSO CONSIDERED ... ,

1 ADOPTS the *Recommendation on procedures and requirements for the recognition of augmentation systems in the WWRNS*, set out in the annex to the present resolution;

2 RECOMMENDS Governments to ensure that provision of augmentation systems in the WWRNS established on or after the date of adoption of the present resolution conforms to criteria not inferior to that set out in the annex to the present resolution;

3 INVITES Governments to ...

## **ANNEX**

### **RECOMMENDATION ON PROCEDURES AND REQUIREMENTS FOR THE RECOGNITION OF AUGMENTATION SYSTEMS IN THE WWRNS**

#### **PURPOSE**

Radionavigation and augmentation systems share common technical features (e.g. signal frequencies) but they are different and separate systems.

A radionavigation system as a standalone system allows a user equipped with the appropriate receiver to compute a PNT solution. On the contrary, an augmentation system cannot be used alone to do so but, as per the functionalities offered (e.g. provision of corrections, integrity

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information and alerts), complements the radionavigation system by enhancing the accuracy of the PNT solution computed as well as providing integrity warnings.

Those nuances that differentiate the radionavigation and augmentation systems advocate to define new procedures and requirements for the recognition of augmentation systems in the worldwide radionavigation system. Thus, the text proposed mostly replicate the Annex included in resolution A.1046(27) but slightly modified to introduce into the procedures and requirements described there the particularities of augmentation systems compared to the radionavigation ones for their recognition in the WWRNS.

### **SCOPE**

This annex includes procedures and requirements for the recognition of augmentation systems in the WWRNS.

The operational and navigation requirements have been defined to emphasize the augmentation systems shall be used in combination with radionavigation systems to comply with the operational requirements.

The values considered for the navigation performance requirements are identical to the ones identified in resolution A.1046(27).

## **PROCEDURES AND REQUIREMENTS FOR THE RECOGNITION OF AUGMENTATION SYSTEMS IN THE WORLD-WIDE RADIONAVIGATION SYSTEM (WWRNS)**

### **1. PROCEDURES AND FUNCTIONS OF IMO**

- 1.1. IMO should recognize or should have recognised, based on resolutions A. 1046(27)<sup>1</sup> and A.915(22), the radionavigation system(s) which will be augmented by the augmentation system(s) which are the object of these procedures.
- 1.2. IMO recognition of an augmentation system at worldwide level means the Organization recognizes the system is capable of providing information to improve accuracy and provide integrity warning to enhance the positioning, navigation and timing performance of a radionavigation system already recognised by the Organisation. And the carriage of receiving equipment for use with the system satisfies the relevant requirements of the 1974 SOLAS Convention, as amended.
- 1.3. IMO should not recognize an augmentation system without the consent of the Government or organization which has provided it and is operating the system.
- 1.4. In deciding whether to recognize an augmentation system, IMO should consider whether:
  - 1.4.1. the Government or organization providing and operating the system has formally stated that the system is operational and available for use by merchant shipping;
  - 1.4.2. its continued provision is assured;
  - 1.4.3. it is capable of providing augmentation information within the coverage area declared by the Government or organization operating and providing the system with performance not less than that in Appendix "Operational Requirements"; and
  - 1.4.4. adequate arrangements have been made for publication of the characteristics and parameters of the system and of its status, including amendments, as necessary.
- 1.5. If there are any changes to a recognized system, the criteria listed in previous paragraph should be applied when deciding whether the system should continue to be recognized.

### **2. RESPONSIBILITIES OF GOVERNMENTS OR ORGANIZATIONS**

- 2.1. The provision and operation of an augmentation system is the responsibility of the Governments or organizations concerned.
- 2.2. Governments or organizations desirous of having their augmentation system recognized by IMO, should formally notify IMO that the system is operational and available for use by merchant shipping. They should also declare the coverage of the

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<sup>1</sup> Or Even though in previous resolutions A.815(19) or A.953(23) already revoked by A.1046(27)

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service area of the system and provide as much other information as practicable, to assist IMO in its consideration of the factors identified in previous paragraph 1.4.

- 2.3. Augmentation system operators should provide the Organization with at least the following information:
  - 2.3.1. A description of the service being offered.
  - 2.3.2. Confirmation that the service offered is operational and available for use by maritime users.
  - 2.3.3. Confirmation that the service will be provided continuously, until further notice.
  - 2.3.4. Identities of GNSS/ RNSS augmented by the system.
  - 2.3.5. Confirmation that any future changes in the GNSS augmentation service should not affect legacy users of the service.
  - 2.3.6. Expected or planned changes to the services are to be notified to maritime users in advance (two years notice is recommended whenever possible).
  - 2.3.7. Identification and contact details of the GNSS augmentation service provider.
  - 2.3.8. Advice on where information relating to the service can be found, along with relevant references to standards and specifications that the service complies with.
  - 2.3.9. Any terms and conditions to access the service.
- 2.4. Governments or organizations that have an IMO-recognized augmentation system should not make changes to the operational characteristics of the system without notifying IMO (see resolution A.577(14)).

### **3. SHIPBORNE RECEIVER EQUIPMENT**

- 3.1. To avoid the need to carry more than one receiving equipment, shipborne receiving equipment should be able to receive and process augmentation information from different service providers at worldwide level and within the coverage area of each system in which the ship trades.
  - 3.2. Shipborne receiving equipment should conform to relevant performance standards, not inferior to those adopted by the Organization.
  - 3.3. Augmentation systems should make it possible for shipborne receiving equipment to automatically select the appropriate components (either ground-based and/or satellite-based) for determining the ship's position, with the required performance.
  - 3.4. Shipborne receiving equipment should have at least one output from which position and integrity information can be supplied in a standard format to other equipment.
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## **APPENDIX**

### **OPERATIONAL REQUIREMENTS**

#### **1. INTRODUCTION**

- 1.1. The operational requirements for an augmentation system should be general in nature and capable of being met by a number of systems. All systems should be capable of being used by an unlimited number of ships.
- 1.2. The requirements should be met by a combination of radionavigation systems with augmentation systems, in the coverage area of the augmentation systems.
- 1.3. The augmentation systems are considered to be available when they provide the required integrity for the given accuracy level.

#### **2. NAVIGATION IN OCEAN WATERS**

- 2.1. Where an augmentation system is combined with a radionavigation systems both used to assist in the navigation of ships in ocean waters, the combined systems should provide positional information with an error not greater than 100 m with a probability of 95%. This degree of accuracy is suitable for purposes of general navigation and provision of position information in the GMDSS.
  - 2.2. In view of the fact that merchant fleets operate worldwide, the information provided by an augmentation system must be suitable for use for general navigation by ships engaged on international voyages in any ocean waters within the augmentation system coverage area.
  - 2.3. Taking into account the radio frequency environment, the coverage of the augmentation system should be adequate to provide, in combination with a radionavigation system(s), position-fixing throughout this phase of navigation. The minimum requirements of the system should be as follows:
    - 2.3.1. Permit an update rate of the computed position data not less than once every 2 s.
    - 2.3.2. Signal availability of > 99.8%.
    - 2.3.3. Provide an integrity warning of augmentation system malfunction, non-availability or discontinuity to users as soon as practicable by Maritime Safety Information (MSI) systems.
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**3. NAVIGATION IN HARBOUR ENTRANCES, HARBOUR APPROACHES AND COASTAL WATERS<sup>2</sup>**

- 3.1. Where an augmentation system is combined with a radionavigation system(s) both used to assist in the navigation of ships in such waters, the combined systems should provide positional information with an error not greater than 10 m with a probability of 95%.
- 3.2. Taking into account the radio frequency environment, the coverage of the augmentation system should be adequate to provide, in combination with a radionavigation system(s), position-fixing throughout this phase of navigation. The minimum requirements of the system should be as follows:
  - 3.2.1. Permit an update rate of the computed position data not less than once every 2 s.
  - 3.2.2. Signal availability of > 99.8%.
  - 3.2.3. Service continuity of  $\geq 99.97\%$  over a period of 15 minutes when system is available.
  - 3.2.4. Provide an integrity warning of system malfunction, non-availability or discontinuity to users within 10 s.
- 3.3. The augmentation system should be considered available when it provides the required integrity for the given accuracy level.

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<sup>2</sup> SOLAS regulation V/13 requires each contracting Government to provide, as it deems practical and necessary either individually or in cooperation with other contracting Governments, such aids to navigation as the volume of traffic justifies and the degree of risk requires

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## **ANNEX B**

### **CHANGES PROPOSED TO RESOLUTION A.1046(27)**

The following changes are proposed (in grey shading) to resolution A.1046(27) in order to allow the recognition of augmentation systems in the worldwide radionavigation system.

The revision of resolution A.1046(27) should not affect the current radionavigation systems recognized based on previous resolutions.

**Resolution A.1046(27)**

**Adopted on 30 November 2011  
(Agenda item 9)**

**WORLDWIDE RADIONAVIGATION SYSTEM**

THE ASSEMBLY,

RECALLING article 15(j) of the Convention on the International Maritime Organization regarding the functions of the Assembly in relation to regulations and guidelines concerning maritime safety,

RECALLING ALSO resolution A.953(23), by which it adopted, as the IMO policy on the recognition and acceptance of suitable radionavigation systems intended for international use, the "Revised Report on the Study of a Worldwide Radionavigation System" annexed to that resolution,

RECOGNIZING the need for a worldwide radionavigation system to provide ships with navigational position-fixing throughout the world,

RECOGNIZING ALSO the need of an augmentation system to provide ships with a higher accuracy than provided with worldwide radionavigation systems

RECOGNIZING ALSO that radionavigation and augmentation systems share common technical features (e.g. signal frequencies) but they are different and separate systems.

RECOGNIZING ALSO that a radionavigation system as a standalone system allows a user equipped with the appropriate receiver to compute a PNT solution.

RECOGNIZING ALSO that an augmentation system cannot be used alone to do so but, as per the functionalities offered (e.g. provision of corrections, integrity information and alerts), complements the radionavigation system by enhancing the accuracy of the PNT solution computed as well as providing integrity warnings.

RECOGNIZING ALSO the need to amend the aforementioned revised report,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its eighty-eighth session and the request from its one hundred seventh-session,

1. ADOPTS, as the IMO policy for the recognition and acceptance of suitable radionavigation or augmentation systems intended for international use, the "Revised Report on the Study of a Worldwide Radionavigation System", as set out in the Annex to the present resolution;
2. INVITES Governments to keep the Organization informed of the operational development of any suitable radionavigation or augmentation system conforming to the policy referred to above which might be considered by the Organization for use by ships worldwide;

3. INVITES ALSO Governments and organizations providing radionavigation or augmentation systems to consent to recognition of these systems by IMO;
4. REQUESTS the Maritime Safety Committee to recognize radionavigation and augmentation systems conforming with the requirements set out in the Annex to this resolution, and to publish information on such systems;
5. REQUESTS ALSO the Maritime Safety Committee to keep the above-mentioned revised report under review for adjustment as necessary;
6. REVOKES resolution A.953(23).

## Annex

### **REVISED REPORT ON THE STUDY OF A WORLDWIDE RADIONAVIGATION SYSTEM**

#### **1 INTRODUCTION**

1.1 Studies on a worldwide radionavigation system have been taking place since 1983. These studies have provided a basis on which chapter V of the 1974 SOLAS Convention has been amended to include a requirement for ships to carry means of receiving transmissions from suitable radionavigation systems throughout their intended voyage.

1.2 The operational requirements for worldwide radionavigation and augmentation systems are given in the appendix.

1.3 It is not considered feasible for IMO to fund a worldwide radionavigation or an augmentation system. Existing and planned systems which are being provided and operated by Governments or organizations have therefore been studied, in order to ascertain the conditions under which such systems might be recognized or accepted by IMO.

#### **2 PROCEDURES AND RESPONSIBILITIES CONCERNING THE RECOGNITION OF SYSTEMS**

##### **2.1 Procedures and functions of IMO**

2.1.1 The recognition by IMO of a radionavigation or an augmentation system would mean that the Organization recognizes that the system is capable of providing adequate position or augmentation information respectively within its coverage area and that the carriage of receiving equipment for use with the system satisfies the relevant requirements of the 1974 SOLAS Convention, as amended.

2.1.2 IMO should not recognize a radionavigation or an augmentation system without the consent of the Government or organization which has provided and is operating the system.

2.1.3 In deciding whether or not to recognize a radionavigation or an augmentation system, IMO should consider whether:

- .1 the Government or organization providing and operating the system has stated formally that the system is operational and available for use by merchant shipping;
- .2 its continued provision is assured;
- .3 it is capable of providing position or augmentation information within the coverage area declared by the Government or organization operating and providing the system with a performance not less than that given in the appendix;
- .4 adequate arrangements have been made for publication of the characteristics and parameters of the system and of its status, including amendments, as necessary; and
- .5 adequate arrangements have been made to protect the safety of navigation should it be necessary to introduce changes in the characteristics or parameters of the system that could adversely affect the performance of shipborne receiving equipment.

2.1.4 In deciding, in the light of any changes to a recognized system, whether the system should continue to be recognized, the criteria listed in paragraph 2.1.3 should be applied.

## **2.2 Responsibilities of Governments or organizations**

2.2.1 The provision and operation of a radionavigation or an augmentation system is the responsibility of the Governments or organizations concerned.

2.2.2 Governments or organizations willing to have a radionavigation or an augmentation system recognized by IMO should formally notify IMO that the system is operational and available for use by merchant shipping. The Government or organization should also declare the coverage area of the system and provide as much other information as practicable to assist IMO in its consideration of the factors identified in paragraph 2.1.3.

2.2.3 Governments or organizations that have a system recognized by IMO should not allow changes to the operational characteristics of the system under which the system was recognized without notifying IMO (see resolution A.577(14)).

## **3 SHIPBORNE RECEIVING EQUIPMENT**

3.1 To avoid the necessity of carrying more than one set of receiving equipment on a ship, the shipborne receiving equipment should be suitable for operating either with a worldwide radionavigation system, or with radionavigation systems or augmentation systems which cover the area in which the ship trades.

3.2 Shipborne receiving equipment should conform to the relevant performance standards not inferior to those adopted by the Organization.

3.3 Radionavigation or augmentation systems should make it possible for shipborne receiving equipment automatically to select the appropriate stations for determining the ship's position with the required performance.

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3.4 Shipborne receiving equipment should be provided with at least one output\* from which position information can be supplied in a standard form to other equipment.

\* Refer to the recommendation of the International Electrotechnical Commission, in particular, IEC publication 61162, *Digital interface for Navigational Equipment within a ship*.

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## APPENDIX

### OPERATIONAL REQUIREMENTS

#### 1 INTRODUCTION

1.1 The operational requirements for worldwide radionavigation and augmentation systems should be general in nature and capable of being met by a number of systems. All systems should be capable of being used by an unlimited number of ships.

1.2 The requirements may be met by individual radionavigation systems, by a combination of such systems or by a combination of radionavigation and augmentation systems.

1.3 The system is considered to be available when it provides the required integrity for the given accuracy level.

#### 2 NAVIGATION IN OCEAN WATERS

2.1 Where a standalone radionavigation system or a combination of a radionavigation and an augmentation system are used to assist in the navigation of ships in ocean waters, the system or the combined systems should provide positional information with an error not greater than 100 m with a probability of 95%. This degree of accuracy is suitable for purposes of general navigation and provision of position information in the GMDSS.

2.2 In view of the fact that merchant fleets operate worldwide, the information provided by a radionavigation or an augmentation system must be suitable for use for general navigation by ships engaged on international voyages in any ocean waters within the systems coverage area.

2.3 Taking into account the radio frequency environment, the coverage of the system should be adequate to provide position-fixing throughout this phase of navigation.

2.4 The radionavigation or augmentation system should permit an update rate of the computed position data not less than once every 2 s.

2.5 Signal availability should exceed 99.8%.

2.6 An integrity warning of system malfunction, non-availability or discontinuity should be provided to users as soon as practicable by Maritime Safety Information (MSI) systems.

#### 3 NAVIGATION IN HARBOUR ENTRANCES, HARBOUR APPROACHES AND COASTAL WATERS\*

3.1 Where a standalone radionavigation system or a combination of a radionavigation and an augmentation system are used to assist in the navigation of ships in such waters, the system or the combined systems should provide positional information with an error not greater than 10 m with a probability of 95%.

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\* SOLAS regulation V/13 requires each contracting Government to provide, as it deems practical and necessary either individually or in cooperation with other contracting Governments, such aids to navigation as the volume of traffic justifies and the degree of risk requires.

3.2 Taking into account the radio frequency environment, the coverage of the system should be adequate to provide position-fixing throughout this phase of navigation.

3.3 The radionavigation or augmentation system should permit an update rate of the computed position data not less than once every 2 s<sup>\*\*</sup>.

3.4 Signal availability should exceed 99.8%.

3.5 When the system is available, the service continuity should be  $\geq 99.97\%$  over a period of 15 minutes.

3.6 An integrity warning of system malfunction, non-availability or discontinuity should be provided to users within 10 s.

3.7 The system shall be considered available when it provides the required integrity for the given accuracy level.

<sup>\*\*</sup> This applies to the computed and displayed position data, but not to the update rate of any correction data, which may remain valid for 30 s or more.

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