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| IALA Guideline |

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SBAS MARITIME SERVICE

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

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CONTENTS

1. Introduction 4

1.1. Scope of the document 4

1.2. Structure of the document 4

2. Reference Requirements 4

2.1. IMO Resolution A.1046 (27) on Worldwide Radionavigation Systems 4

2.2. Other reference requirements 5

3. SBAS Architecture 6

3.1. Existing SBAS 6

4. SBAS Service Performance Parameters 7

5. User Segment Approach 9

5.1. SBAS Type approved receivers 9

6. SBAS Service Provision Scheme 9

6.1. SBAS Maritime Service Provision Scheme 9

6.2. SBAS Service Assurance 11

7. Acronyms 11

8. References 11

List of Tables

[Table 2‑1: IMO Resolution A.1046 operational Requirements 4](#_Toc536089794)

[Table 4‑1: Performance parameters to assess SBAS according to IMO maritime requirements 7](#_Toc536089795)

List of Figures

[Figure 3‑1: Basic SBAS architecture 6](#_Toc536089796)

[Figure 3‑2: Existing SBAS (in operation and under development) 7](#_Toc536089797)

[Figure 6‑1: SBAS Maritime Service Provision Scheme 9](#_Toc536089798)

List of Equations

*No table of figures entries found.*

# Introduction

GNSS have become the primary means of obtaining Position, Navigation and Timing (PNT) information at sea. Most of the ships in the world (even in the recreational and leisure field) are equipped with GNSS receivers (SOLAS carriage requirement [1]).

Moreover, nowadays the users can take advantage of the use of the **Satellite Based Augmentation Systems (SBAS)**, which provide enhanced performance over the current capabilities of the GNSS core constellations (GPS, Galileo, GLONASS and Beidou). SBAS improves the accuracy and reliability of GNSS information by correcting signal measurement errors and by providing information about the accuracy, integrity, continuity and availability of its signals.

GNSS supplemented by SBAS can provide accurate high-integrity positioning for coastal and harbour navigation. Thus, SBAS services will become increasingly used in the maritime sector in the near future and clear guidance of how and when to use SBAS in maritime is required, so as to make the most of the SBAS services for the benefit of safety of navigation.

## Scope of the document

This guideline provides the description of all the elements of SBAS system and service provision (direct reception of SBAS L1 Signal in Space (SiS) onboard the vessels), including reference requirements, description of the service and the operational chain and equipment.

## Structure of the document

To include the structure of the document.

# Reference Requirements

The reference requirements for the implementation of SBAS Service for maritime navigation are gathered hereafter.

## IMO Resolution A.1046 (27) on Worldwide Radionavigation Systems

IMO Resolution A.1046(27) on Worldwide Radionavigation Systems [1] establishes the requirements that a certain radionavigation system shall fulfil to be recognized by IMO as a component of the WWRNS, which means that the system is recognized to be able 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.

The resolution establishes the operational requirements that a system shall fulfil, which are summarised in the table below:

Table 2‑1: IMO Resolution A.1046 operational Requirements

|  | **Ocean waters** | **Harbour entrance, harbour approach and coastal waters** |
| --- | --- | --- |
| Accuracy  (95% HNSE) | 100 m | 10 m |
| System Integrity\* | As soon as practicable by Maritime Safety Information | Within 10s |
| Signal Availability | 99.8% | 99.8% |
| Continuity | N/A | 99.97% (over 15 min) |

\*Integrity warning of system malfunction, non-availability or discontinuity should be provided to users within 10s.

* For ocean waters: the system should provide positional information with an error not greater than 100 m with a probability of 95%. Signal availability should exceed 99.8%. 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.
* Navigation in harbour entrances, harbour approaches and coastal waters: positional information with an error not greater than 10 m with a probability of 95%. Signal availability should exceed 99.8%. When the system is available, the service continuity should be ≥99.97% over a period of 15 minutes. An integrity warning of system malfunction, non-availability or discontinuity should be provided to users within 10s.

It should be noted that, according to existing documentation [3] the signal availability and continuity requirements could be relaxed to 99.5% and 99.95% respectively when the augmentation system is used in combination with other back-up system (for areas of overlapping coverage).

Therefore, this IMO resolution is states the minimum operational requirements that the maritime community requires from any navigation system in order to be accepted and used for maritime navigation.

Note that this document considers the integrity at “system level”, this means that in case a failure is detected in the system, the user is warned to not use it. Therefore this approach does not consider potential performance degradations at user level due to local and non-system-related errors such as multipath and interferences (there are no Protection Levels or Integrity risks).

Moreover, the governments or organizations owning and operating the radionavigation systems should comply with the following points:

* The government or organization providing and operating the system has stated formally that the system is operational and available for use by merchant shipping.
* The continued provision of the service is assured.
* The system is able to provide position information within the declared coverage area with a performance not less than that established in the present resolution.
* Adequate arrangements have been made for publication of the characteristics and parameters of the system and of its status.
* 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.

## Other reference requirements

To complete with other reference documentation.

# SBAS Architecture

The main elements of a basic SBAS architecture are:

* **Space segment**: Includes the satellites with payloads aimed to transmit the corrections to the GNSS core constellations L1 (1,575.42 MHz) and integrity information.
* **Ground segment**: Includes all the ground elements in charge of the provision of the SBAS navigation message.
* Monitoring Station Network.
* Processing Facility Centre.
* Satellite Control Centre.
* Communication Layer.
* **User segment**: Includes the user equipment needed to receive and use the SBAS information.

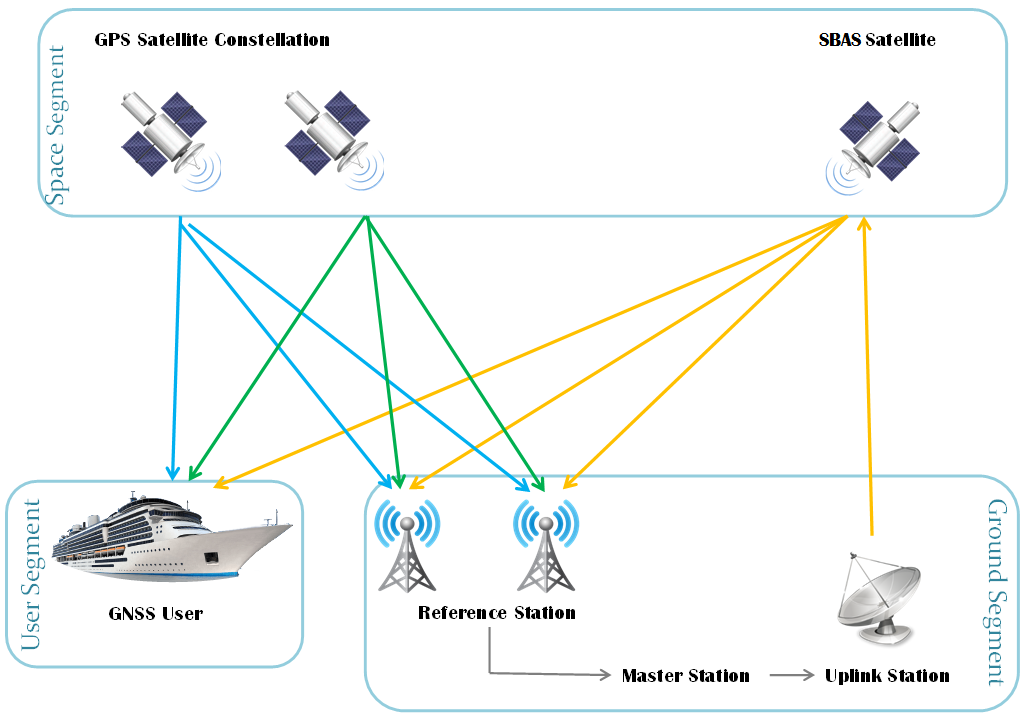


Figure 3‑1: Basic SBAS architecture

## Existing SBAS

Several countries have implemented their own Satellite-based Augmentation System.

* **Europe**: European Geostationary Navigation Overlay Service (EGNOS)
* **USA**: Wide Area Augmentation System (WAAS)
* **Japan**: Multi-functional Satellite Augmentation System (MSAS)
* **India**: GPS and GEO Augmented Navigation (GAGAN)
* **China**: Satellite Navigation Augmentation System (SNAS) (in development)
* **South Korea:** Korea Augmentation Satellite System (KASS). (in development)
* **Russia**: System for Differential Corrections and Monitoring (SDCM) (in development)

All of these systems comply with a common global standard and are therefore:

* **Compatible:** they do not interfere with each other;
* **Interoperable:** a user with a standard receiver can benefit from the same level of service and performance, regardless of what coverage area they are located in.

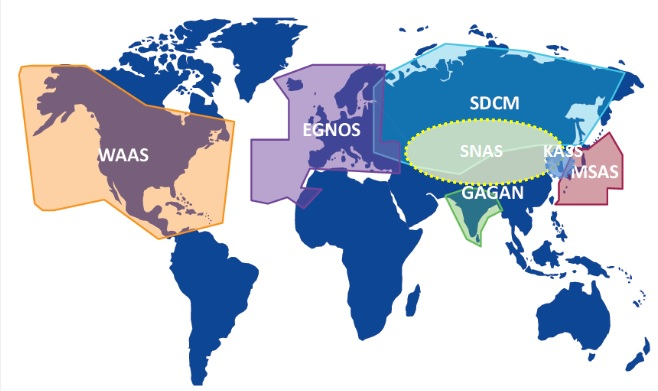


Figure 3‑2: Existing SBAS (in operation and under development)

# SBAS Service Performance Parameters

The list of service parameter required for a complete characterization of an SBAS Maritime Service are derived from the list in IMO Resolution A.1046(27), summarised in Section 2.1. Additionally to IMO parameters, a new parameter is required to characterize SBAS service for maritime because of the particularities of this radionavigation aid. This parameter is Service Availability which indicates the percentage of time a position calculated using certain SBAS is available in a specific location. To sum up, SBAS Signal Availability as defined by IMO Resolution does not differ users, within the GEO footprint, capable of obtaining an SBAS navigation solution for a particular epoch from those users that are not capable; while SBAS Service Availability takes into account that difference computing, as previously mentioned, the percentage of time in which that solution is obtained.

This section proposes a list of service parameters to characterize SBAS for maritime use which are different for “ocean waters” and for “harbour entrances, harbour approaches and coastal waters”.

According to IMO maritime requirements for “ocean waters” and for “harbour entrances, harbour approaches and coastal waters” and EGNOS particularities as radio navigation aid several parameters have been identified as required:

Table 4‑1: Performance parameters to assess SBAS according to IMO maritime requirements

|  |  |
| --- | --- |
| **Ocean Waters** | **Harbour entrances, harbour approaches and coastal waters** |
| **Signal Availability**  **Service Availability**  **Horizontal Accuracy 95%**  **Position update rate**  **Service Coverage** | **Signal Availability**  **Service Availability**  **Service Continuity**  **Horizontal Accuracy 95%**  **Position update rate**  **Time To Alarm**  **Service Coverage** |

The required parameters come directly from IMO Resolution A.1046(27). Neither IMO recommendation detail how these performance parameters are understood nor their values calculated. The paragraphs below detail how these parameters can be understood and measured.

* **Signal Availability**

Signal is considered available when the signal is provided according to its specification within the area of service.

For maritime SBAS Signal Availability would be the percentage of time the SBAS SiS is provided by the GEOs according to messages that can be processed by an SBAS receiver aligned with the IEC Test specifications throughout all points within the specified maritime coverage area.

Therefore the signal availability is calculated as the combined signal availability of the operational EGNOS GEOs. SBAS receivers are expected to be capable of instantaneous GEO switching without impacting the user.

* **Service Availability**

(Service) Availability is the probability that a user is able to determine its position with the specified accuracy and to monitor the integrity of its determined position at the initiation of an operation at any location within the coverage area.

* **Service Continuity**

It is defined as the probability that a user will be able to determine its position with the specified accuracy and is able to monitor the integrity of the determined position over the time interval applicable for a particular operation within the coverage area.

Every transition from a service available to unavailable is a service continuity event. SBAS Service Continuity is calculated as follows:

Service Continuity=1-CTI/MTBF

Where: CTI is 15 min, MTBF is the “Mean Time Between Failures” over the corresponding period, e.g. for period of two years, computed (over a period P) as: MTBF= P/n, where “P” is the 24 months period (in minutes), and “n” is the number of discontinuity events in P.

* **Horizontal Accuracy 95%**

In the present context, accuracy is a statistical value and is defined as the degree of conformance between the measured position and the true position of the user at a given level of confidence at any given instant in time and at any location in the coverage area. Accuracy is specified as the position error at 95% confidence level.

The Horizontal position accuracy is the 2D radial error of the instantaneous measured position in respect to the true instantaneous position.

* **Time To Alarm**

The Time to Alarm (TTA) is defined as the maximum acceptable time starting when an alarm condition occurs to the time that the alarm is displayed at the user interface. The time to detect the alarm condition is included as a component of this requirement.

* **Position update rate**

SBAS receivers must be designed to meet the 2s update rate required by IMO Resolution A.1046(27). The compliance to this parameter shall be demonstrated by the receiver/equipment manufacturers.

* **Service Coverage**

The service coverage is a designated geographical area where, taking into account the radio frequency environment, SBAS is adequate to provide required performance throughout a phase of navigation.

# User Segment Approach

This section describes the SBAS Service compatible equipment, including requirements for standardization of user equipment and needed equipment upgrades.

## SBAS Type approved receivers

To benefit from the SBAS L1 Maritime Service enhanced performance, including integrity at system level, the vessels must be equipped with SBAS type-approved receivers compliant with IEC-XXXXX (SBAS Receivers Test Specifications).

Upgrade to future versions of SBAS systems

# SBAS Service Provision Scheme

## SBAS Maritime Service Provision Scheme

This section aims at describing the high-level SBAS L1 Maritime Service Provision scheme, with the different stakeholders involved, including the interfaces and the provision of SBAS related Maritime Safety Information (MSI) to the end users.

The picture below presents schematically this High level Service provision model:

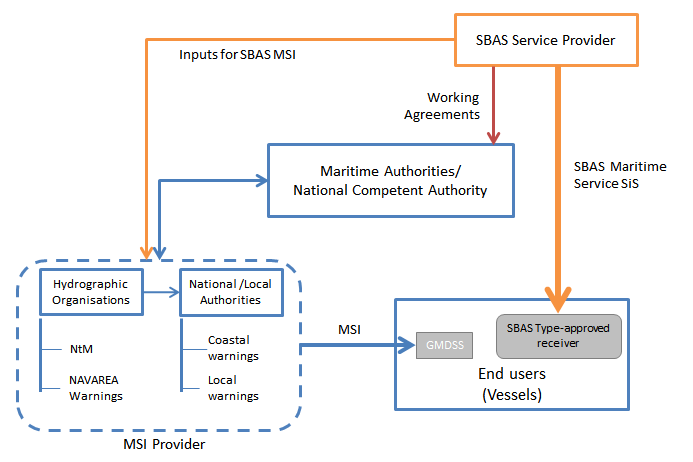


Figure 6‑1: SBAS Maritime Service Provision Scheme

This model considers the reception of the of the SBAS L1 SiS directly on-board the vessels equipped with type approved receivers, thus allowing the end users (mariners vessels) to benefit from SBAS L1 Maritime Service enhanced performance.

The actors involved in this high level service provision model, including their expected roles and responsibilities are described below:

* **The SBAS Service Provider**

The SBAS Service Provider will be the entity which provides the SBAS L1 Maritime Service. The SBAS Service Provider will also be responsible for establishing and supporting all required operational interfaces, as per the corresponding maritime operational chain, including the generation the SBAS MSI proposals to be distributed by the Hydrographic organisation (MSI providers) to the end users of the service.

The SBAS Service Provider will be responsible for the transmission of SBAS L1 SiS to the final users and to deliver the service under the terms, conditions and performance committed. The SBAS Service Provider responsibilities may be structured in four main blocks, as follows:

1. **Operation and Maintenance:**

The SBAS Service Provider should continuously monitor the service to detect and manage service disruptions and degradations and inform users. The information on the SBAS service degradations and unavailability’s is to be delivered to the MSI provider. An unscheduled outage or degradation of the SBAS service should be communicated to the users as soon as practicable to the MSI provider.

1. **Performance Verification:**

The SBAS service provider should verify that the service is performing according to specifications committed.

1. **Publication of information:**

The SBAS service provider should provide a description of the service (service characteristics, performances, coverage area, etc.), provide information of scheduled maintenance activities & planned unavailability, and service performance reporting and support to the users.

1. **Working agreements:**

The formalisation of SBAS Service Provider commitment to provide the service and the engagement with National Competent Authorities could be done by establishing working agreements, detailing at least:

* + - Roles and responsibilities and Liability[[1]](#footnote-1) scheme
    - Commitment about the long term operation of the SBAS service
    - Service offered and its characteristics
    - Reliability/continuity/quality of the service
    - SBAS MSI proposals (generation and distribution procedure)
    - Costs of the service – (i.e. free of charge)
    - Legal data recording needs
* **Maritime Authorities/ National Competent Authorities**

The SBAS Service Provider will engage with National Competent Authorities. The body designed as Competent Authority may vary for each individual State (for example: Coast Guard, Aids to Navigation Authority, etc.).

For the different matters related to the SBAS Maritime Service the National Competent Authority role and relationship will be one of mutual cooperation and support and will not entail any additional responsibility or liability for the Authority involved, beyond the existing ones.

For Maritime Safety Information (MSI), existing internationally agreed procedures will be followed. The Maritime Authorities may be involved in the MSI process, according to the common existing practices[[2]](#footnote-2).

* **End Users**

The end users are the mariners/vessels actually using the SBAS L1 Maritime Service SiS with a type approved receiver. The end users are also the recipient of the Maritime Safety information (MSI) related to SBAS.

The end users have the responsibility to ensure the correct maritime user equipment is used on their vessel, in this case type approved receivers, and that the resulting data is used in the appropriate manner. The end user is also responsible for the reception of the SBAS related safety information and to use these advises/warnings in the appropriate manner.

* **MSI provider (Hydrographic organisations):**

The Hydrographic organisations (in particular de NAVAREA coordinators) are the bodies responsible for the transmission of Maritime Safety Information to the final users. The MSI provider is responsible of promulgating to the final users, using the established communication channels, the Maritime Safety Information based on the information provided by the SBAS Service Provider on the SBAS Service status and degradations.

The way to provide this information takes as reference the existing procedures for the generation and distribution of Maritime Safety Information. The SBAS Service Provider is expected to send the SBAS MSI proposals (e.g. service performance degradations) to the NHO. These inputs will be provided in a format agreed between these parties. The NHO will use the procedures and channels already in place for the transmission of MSI to the vessels. Depending on the specific characteristics of the SBAS MSI, the National Hydrographic Office (NHO) will distribute the information as NAVAREA warning[[3]](#footnote-3) or Notices to Mariners (NtM)[[4]](#footnote-4), or will forward it to the National Authorities to be distributes as coastal or local warnings[[5]](#footnote-5) by the established mechanism.

SBAS as an AtoN

## SBAS Service Assurance

The continued provision of the service is to be assured by the governments or organizations owning and operating the different SBAS systems.

# Acronyms

SBAS 🡪 Satellite Based Augmentation Systems

MSI 🡪 Maritime Safety Information

AtoN 🡪 Aids to Navigation

SiS 🡪 Signal in Space

# References

1. IMO International Convention for the Safety of Life at Sea (SOLAS), Chapter V (Safety of navigation), 1974 (as amended).
2. IMO Resolution A.1046 (27) on the World Wide Radio Navigation System (WWRNS), November 2011.
3. IALA Guideline No. 1112, Performance and Monitoring of DGNSS Services in the Frequency Band 283.5 –325 kHz, Edition 1, May 2015
4. Preliminary Performance Analysis

To include performance analysis results (available for EGNOS).

1. Including technical, operational and legal aspects [↑](#footnote-ref-1)
2. Some states may also monitor the MSI at point of delivery to the mariner. [↑](#footnote-ref-2)
3. NAVAREA warning is the MSI of temporary nature applicable to one of the 21 navigational areas in the world. [↑](#footnote-ref-3)
4. Notices to Mariners (NtM) is the MSI permanent information published by the National Hydrographic Office. [↑](#footnote-ref-4)
5. Coastal or local warnings are the MSI of temporary nature applicable to a coastal or local area. [↑](#footnote-ref-5)