Document Revisions (Title style)

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**IALA Guideline No. ####**

**on**

**Systems for high accuracy positioning services in critical areas**

**Edition 1**

**[Date issued]**

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

|  |  |  |
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| **Date** | **Page / Section Revised** | **Requirement for Revision** |
| 03/02/2016 |  | Draft document structure |
| 17/03/2016 | - Title changed to “Systems for high accuracy positioning services in critical areas”  - Document was spited of into main document for generic description and appendices for certain services.  - |  |
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# Introduction

## Purpose and scope of document

Critical areas…

Absolute and relative…

Not provided by IMO WWRNS…

Port and harbours have to be considered as essential hubs for the worldwide trade and shipping. Specific applications or manoeuvres, as for example automatic docking but also the passing of vessels in narrow bands, require very accurate and precise positioning information for their safe and efficient execution.

The purpose of this guideline is the harmonization between service provision and their utilisation at shipside. Therefore, the guideline is providing information concerning applicable systems, services and techniques as well as dedicated applications, with an exclusive focus on high-precision applications.

The document also summarizes recommendations of service providers, such as when and how the provided service data should be used. This forces the clarification of responsibilities and dependencies between shore-side and ship-side parts of such systems under consideration of the possible diversity on performance requirements.

This document use references to existing and future recommendations and guidelines from IALA dealing with the development, deployment and operation of PNT-relevant services including technical specification of communication interfaces between services and users.

## Structure of document

Chapter 2 refers the requirements on high accuracy systems including dedicated definitions.

Chapter 3 gives a general overall about systems and services.

In Chapter 4 the basic architecture (concept and hardware) of each system is described.

Chapter 5 informs about the applied methods and techniques implemented by algorithms and software as essential part of the systems.

Chapter 6 deals with interface specifications in relation to communication channels, data protocols, messages, and formats.

In Chapter 7 the utilization of the system and services for the user (on-board) is explained.

Chapter 8 is giving information about utilization policies, data exchange, intelligent access on independent services.

At the end the following annexes are included:

* Annex A: Abbreviations
* Annex B: Definitions
* Annex C: References

# Requirements

In this Guideline, high accuracy is defined to be accuracy better than 0.1 meters for horizontal, and in some applications, vertical, measurements.

IMO Resolution A.915(22) ‘Revised Maritime Policy and Requirements for a Future Global Navigation Satellite System (GNSS)’ describes the accuracy requirements for a number of applications. While A.915 does not define the term “high accuracy”, it does offer some guidance on high accuracy applications as shown in the following table.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | System Level Parameters | | | | |  |
| Usage | Accuracy | | Integrity | | | Position Fix Interval Needed (s) |
|  | Horizontal (m) | Vertical (m) | Alert Limit (m) | Time to Alert (s) | Integrity Risk (3 hours) |  |
| Automatic Docking | 0.1 | NA | 0.25 | 10 | 10-5 | 1 |
| Dredging | 0.1 | 0.1 | 0.25 | 10 | 10-5 | 1 |
| Construction | 0.1 | 0.1 | 0.25 | 10 | 10-5 | 1 |
| Cargo Handling | 0.1 | 0.1 | 0.25 | 1 | 10-5 | 1 |
|  |  |  |  |  |  |  |
| And other such as bridge clearance, lock, and inland water way, etc |  |  |  |  |  |  |

User demands

* Low latency and knowledge about latency: need source? Latency is the time lag between the navigation observations and the presented navigation solution. In applications with dynamic characteristics, both the service provider and the service user should be aware of the effects of latency. The service provider may need to consider changing some parameters of the service, such as the update rate, to minimize the impact of latency.
* Availability/Continuity – service level – for all high accuracy applications described here, availability of 99.8% and continuity over three hours of 99.97 is required.
* Coverage – service level – is generally local.

Calibration of services using other available services – we are not sure what the intent is here

Absolute and relative measurement of position or distance – due to user requirements, some applications require accurate absolute position measurements, others require accurate distance (relative position) measurements. Note that when doing absolute position applications, published reference locations must also meet the minimum accuracy requirement. [how many decimal places is 2 cm?]

Poll the committee membership for papers and other sources of user requirements for high accuracy services

# Systems for High accuracy services

## System overview

Reference guideline 1113 figure 2

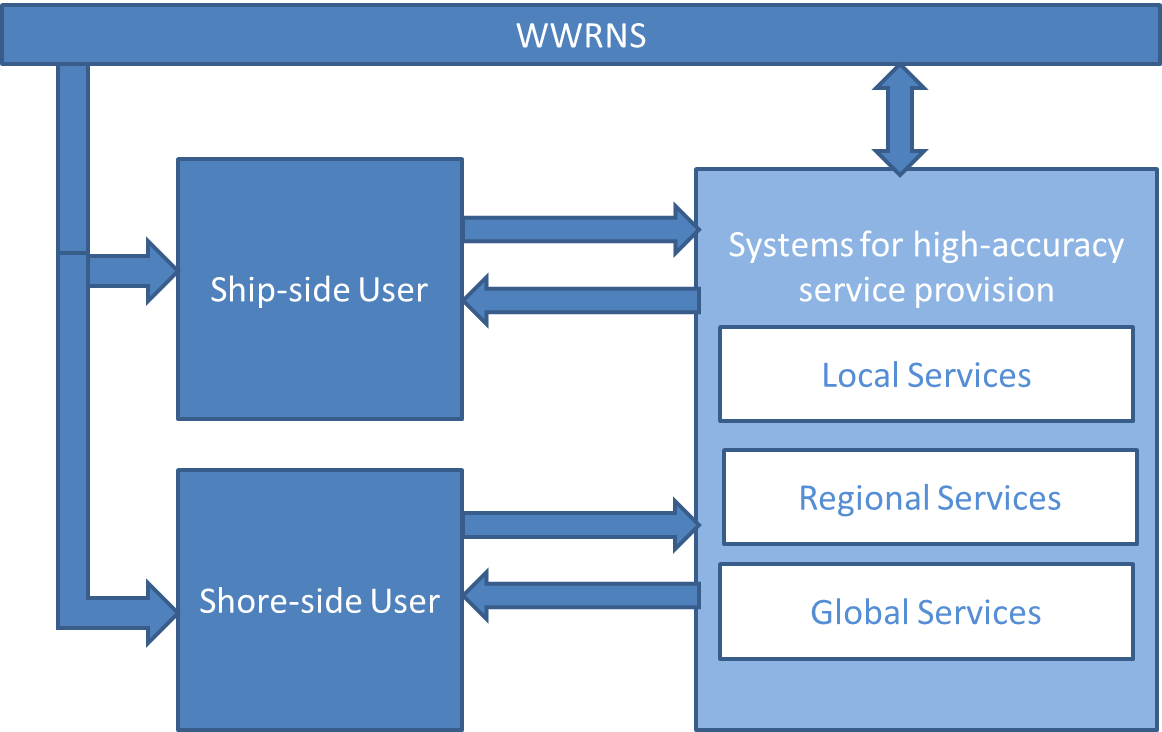
The following chart shows a schematic view of relationships between maritime users and shore providers of high accuracy positioning services. This chapter assumes that communications services are available as needed and are not shown in the chart. GNSS are shown as utility services available to maritime users and shore service providers.

On the shore side are shown some of the systems used to provide needed services:

* Information System – a system that provides information on currently available high accuracy services.
* Augmentation System – a system using techniques that provide enhancement to GNSS in order to provide improved navigation performance to the user.
* Distance Measurement System – a high accuracy distance measurement system for measuring relative position.
* Shore-based Processing Systems – provide position solutions based on measurements and information from both the user and the shore side.

The user side shows facilities that are needed in order to take advantage of the services provided by the shore side:

* Measurement Instruments – devices used to provide information needed to calculate position solutions.
* Position Processing – calculates position solution.



## Laser distance measurement system

## Augmentation systems for radio navigation

### Local Systems

### Regional and worldwide systems

# High accuracy services

>> Gives a short overview about possible services (the following table contains first examples and has to be extended in case of additional systems). May be it make sense to generalize the systems in that section and to give examples in an additional annex (Annex D).

Table with columns

Name of system

Services

Description

Reference implementation / Use Case

Appendix service is described

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Type | Description | Installations / Testbeds / Examples | Ref |
| Laser and other distance measurement systems | Device | Reflectorless distance measurement | ASTECH LDM301A | [1] |
| GNSS Ground based augmentation system | System and Service | Position augmentation by phase based GNSS correction data as well as integrity information | Research Port of Rostock;  GMV magicVRS (Spain, SouthAfrica, Argentina trials) | [2] |
| High precision RT services of Land Survey Offices | System and Service | Position augmentation by phase based GNSS correction data | SAPOS HEPS;  GMV magicPPP | [3] |
| Commercial High Precise RT services | System and Service | GNSS augmentation by PPP technology | FUGRO Starfix G2/G4  NavCom StarFire;  GMV magicPPP | [4]  [5] |
| Other radio based services |  |  |  |  |
| … |  |  |  |  |

# Use Cases

Per 915

Automatic Docking

Dredging/Construction/Maintenance

Cargo Handling

Port Approach

Restricted Waters

Pilotage

Position Keeping

## ANNEX A Abbreviations

|  |  |  |
| --- | --- | --- |
| GNSS | - | Global Navigation Satellite System |
| IALA | - | International Association of Marine Aids to Navigation and Lighthouse Authorities |
| IMO | - | International Maritime Organisation |
| PNT | - | Position, Navigation, and Timing |
| PPU | - | Potable Pilot Unit |
| RT | - | Real Time |

## ANNEX B Definitions

|  |  |
| --- | --- |
| Accuracy | [verify all terms are in IALA dictionary and we are using the same definition] |
|  | |
| Precision |  |
|  | |
| Integrity |  |
|  | |
| Time to Solution | |
|  |  |
|  | |
|  |  |
|  | |

## ANNEX C References

[1] <http://www.astech.de/en/produkt.html?name=LDM301A>

[2] Engler, Evelin und Noack, Thoralf und Beckheinrich, Jamila und Hirrle, Angelika und Schlüter, Stefan und Reimer, Roland und Klähn, Dietmar (2008) GNSS based solutions for maritime “Safety of Life” Application with increased Accuracy Requirements. ISBN 978-3-937655-18-5.

[3] <http://www.zentrale-stelle-sapos.de/heps.html>

[4] <http://www.starfix.com/positioning-systems/>

[5] <http://www.navtechgps.com/navcom_starfire_subscription_service/>

Overview Main Document

Per service an additional APENDIX (Structur )

*It follows a draft for Appendix 1 which describes MGBAS service.*

International Association of Marine Aids to Navigation and Lighthouse Authorities

**IALA Guideline No. YYYY**

**APPENDIX 1**

**Performance and Monitoring of**

**Maritime Ground Based Augmentation Systems (MGBAS) for high-accurate positioning in ports**

***AISM*** Association Internationale de Signalisation Maritime ***IALA***

**Edition 1**

**Month Year**



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| **Date** | **Page / Section Revised** | **Requirement for Revision** |
| 17/03/2016 |  | Draft version |
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**Performance and Monitoring of Maritime Ground Based Augmentation Systems (MGBAS) for high-accurate positioning in harbours**

# INTRODUCTION

This appendix to the Guideline “Systems for high accuracy services in ports and harbours” provides the design and implementation principles of Maritime Ground Based Augmentation Systems usable in harbor environment for high-accurate absolute and/or relative positioning. High-accurate positioning means that the absolute and/or relative position accuracy (95%) is 0.1 m or better.

## 1.1 Scope of document

Global Navigation Satellite Systems (GNSS) are space-based systems providing navigation signals and information, whose use enables world-wide the determination of positioning, navigation and time data. GPS and GLONASS are the first GNSS available. Modernised GNSS include enhanced GPS and GLONASS along with new core constellations such as Galileo and BeiDou.

Differential GNSS (DGNSS) are means to provide augmentation services to improve the accuracy of GNSS-based positioning and to monitor the integrity. DGNSS involves having reference stations, at precisely known locations that provide real-time corrections and integrity information for GNSS signals. Therefore DGNSS is not a stand-alone radio navigation system. DGNSS systems provide shore-to-ship services.

This existing IALA Guideline G-1121 describes the generation and broadcast of code based corrections with a focus on the maritime domain. The application of code-based DGNSS services enables that position accuracies of few meters up to few decimeters can be achieved depending on distance between reference site and user. IALA recommendation R-135 introduced alternative technologies such as Real Time Kinematic (RTK) under consideration of technical progress of last decades. RTK has been identified as service supporting the application of phase-based differential positioning algorithm to achieve position accuracy of 0.1 m or better.

Neither GNSS nor DGNSS do inherently provide integrity information. However, code-based as well as phase-based DGNSS services are in the position to provide also integrity information in relation to used GNSS and provided DGNSS service. System failures as well as disturbances can result into significant errors for extended periods of time, without notifying the user. Maritime augmentation services should provide the user with integrity information to support the situation awareness of mariners in relation to current reliability and usability of applied navigation aids. The service provider should publish that they follow IMO and IALA Recommendations for the provision of DGNSS services, giving emphasis to the provision of integrity information. In addition to these Guidelines the following recommendations from IALA should be taken into account:

* + - Future DGNSS options are captured in R-135 [2]
    - Vulnerability of GNSS systems is discussed in R-129 [3]
    - Recommendation to National Members to provide DGNSS is captured in R-115 [4].

1 IEC 61108-4

## 1.2 Structure of document

Chapter 2 …..

Chapter 3 …..

Chapter 4 ……

Chapter 5 ……

Annexes include abbreviations and various technical settings for evaluation and indication of GNSS and DGNSS status and integrity. The following annexes are included:

* + - Annex A: Abbreviations
    - Annex B: Technical settings for GNSS and DGNSS evaluation
    - Annex C: Technical settings for integrity indication
    - Annex D: ….

# PERFORMANCE REQUIREMENTS

#### Definitions

System performance is characterized by a number of different aspects, including Accuracy, Integrity, Continuity, Availability and Coverage as defined in [IALA G-1121] and

#### 2.2 Positioning Performance Requirements

IMO Resolution A.1046 (27) details the minimum requirements on worldwide radio navigation systems considering vessels operating in ocean and harbour entrances, harbour approaches and coastal waters. The requirements are described by accuracy, integrity, availability, and continuity for positioning……

Table 1 Performance levels of RTK services enabling high-accurate positioning in harbours

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

RTK Service providers should consider the appropriate number, and location, of reference stations to achieve sufficient coverage to ensure that these requirements are met in selected and/or complete harbor areas.

# SHORE SITE ARCHITECTURE

This chapter deals with the shore site architecture of phase-based DGNSS services and follows the generalized DGNSS architecture introduced by [G-1112]. Therefore a phase-based DGNSS is composed by 2 subsystems:

* subsystem for the generation of GNSS augmentation service and
* the subsystem realizing the transmission service.

#### GNSS Augmentation Service

* + 1. GNSS Data Acquisition

#### Single site Approach:

….

#### Network based Approach:

….

* + 1. GNSS Data Processing

Figure 1 Main stages of GNSS data processing during service provision

* + 1. Composition of Service data products
    2. Performance Aspects

#### Accuracy Aspects:

#### Integrity Aspects:

#### Continuity Aspects:

#### Availability Aspects:

#### 3.2 Transmission Services

* + 1. tbd
    2. tbd
    3. tbd
    4. tbd
    5. Performance Aspects
       1. Latency
       2. Availability
       3. Continuity
       4. Monitoring of transmission

#### Technical Implementation

**Figure 5: Implementation of a phase-based DGNSS service taking into account supported transmission**

* + 1. Components of GNSS augmentation services

**Reference Stations**

**Monitoring Stations**

**Communications**

* + 1. Components of Transmission services

**Transmitter**

**Transmission Monitors**

**Communications**

* + 1. Components for Remote Control
    2. Components for enhanced Monitoring

# 4 OPERATIONAL ASPECTS

**Operation and Maintenance:**

**Performance Verification:**

**Publication of information:**

#### Operation and Maintenance

#### Performance verification

* + 1. Availability in the coverage area
    2. Continuity
    3. Verification of integrity monitoring
    4. Verification of Accuracy

#### Publication of information

## 5 REFERENCES

[1] IALA Recommendation R-135 “On the Future of DGNSS”, Edition 1, December 2006.

[2] IALA Recommendation R-129 “On GNSS Vulnerability and mitigation measures,”, Edition 3, December 2012.

[3]

## ANNEX A ABBREVIATIONS

|  |  |  |
| --- | --- | --- |
| DGNSS | - | Differential GNSS |
| DOP | - | Dilution of Precision |
| FI |  | For Information |
| FFM | - | Far Field Monitor |
| GLONASS | - | Глоба́ льная навигацио́ нная спу́ тниковая систе́ ма, Globalnaya Navigatsionnaya Sputnikovaya Sistema |
| GNSS | - | Global Navigation Satellite System |
| GPS | - | Global Positioning System |
| HF | - | High Frequency (3 – 30 MHz) |
| IALA | - | International Association of Marine Aids to Navigation and Lighthouse Authorities |
| IEC | - | International Electrotechnical Commission |
| IMO | - | International Maritime Organization |
| IM | - | Integrity Monitoring Station |
| ITU | - | International Telecommunication Union |
| MF | - | Medium Frequency (0.3 – 3 MHz) |
| MSC | - | Maritime Safety Committee (IMO) |
| MSI | - | Maritime Safety Information |
| PNT | - | Position, Navigation, and Timing |
| PVT | - | Position, Velocity and Timing |
| RAIM | - | Receiver Autonomous Integrity Monitoring |
| RS | - | Reference Station |
| RTCM | - | Radio Technical Commission for Maritime Services |
| VRS | - | Virtual Reference Station Technique |

## ANNEX B DGNSS BROADCAST SETTINGS