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| IALA Guideline |

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IALA GUideline on integration and use of International Mobile Telecommunications2030 (IMT-2030) technologies for Marine AtoN – draft 2025-10

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|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

1 Introduction 6

1.1 Background 6

1.2 Scope 6

1.3 objectives 7

2 Use cases of maritime buoyage system (MBS) 7

2.1 use case on … 8

3 Use cases of positioning, navigation and timing (PNT) 8

3.1 use case on … 8

4 Use cases of vessel traffic services (VTS) 8

4.1 use case on … 8

5 Use cases of digital maritime services 8

5.1 use case on … 8

6 Conclusion and recommendations 9

7 Definitions 9

8 Acronyms 9

9 References 9

ANNEX A Use cases and potential requirements on MBS 10

A.1 Use case on … 10

A.X.1 Description 10

A.X.2 Pre-conditions 10

A.1.3 Service Flows 10

A.X.4 Post-conditions 10

A.X.5 Existing features partly or fully covering the use case functionality 10

A.X.6 Potential New Requirements needed to support the use case 10

ANNEX B Use cases and potential requirements on PNT 11

B.X Use case on … 11

B.X.1 Description 11

B.X.2 Pre-conditions 11

B.X.3 Service Flows 11

B.X.4 Post-conditions 11

B.X.5 Existing features partly or fully covering the use case functionality 11

B.X.6 Potential New Requirements needed to support the use case 11

ANNEX C Use cases and potential requirements on VTS 12

C.X Use case on … 12

C.X.1 Description 12

C.X.2 Pre-conditions 12

C.X.3 Service Flows 12

C.X.4 Post-conditions 12

C.X.5 Existing features partly or fully covering the use case functionality 12

C.X.6 Potential New Requirements needed to support the use case 12

ANNEX D Use cases and potential requirements on DIGITAL MARITIME SERVICES 13

D.X Use case on … 13

D.X.1 Description 13

D.X.2 Pre-conditions 13

D.X.3 Service Flows 13

D.X.4 Post-conditions 13

D.X.5 Existing features partly or fully covering the use case functionality 13

D.X.6 Potential New Requirements needed to support the use case 13

List of Tables

Table 1 Major system milestones for IMT (3GPP) technology 7

List of Figures

**No table of figures entries found.**

List of Equations

**No table of figures entries found.**

# Introduction

## Background

In November 2023, the International Telecommunication Union (ITU) released a comprehensive framework aimed at guiding the development of standards and radio interface technologies for the sixth generation of mobile systems. This framework is detailed in the Recommendation ITU-R M.2160, titled “Framework and overall objectives of the future development of IMT for 2030 and beyond.” The IMT-2030 Framework Recommendation delineates 15 capabilities essential for sixth-generation technologies, with nine capabilities building upon the existing infrastructure of 5G (IMT-2020) systems. Moreover, the IMT-2030 initiative is anticipated to significantly contribute to enhanced environmental, social, and economic sustainability. It is also designed to support the objectives of the Paris Agreement under the United Nations Framework Convention on Climate Change. The International Telecommunication Union (ITU) has published the framework for the development of standards and radio interface technologies for the sixth generation of mobile systems whose details are contained in Recommendation ITU-R M.2160 on the “Framework and overall objectives of the future development of IMT for 2030 and beyond” in November 2023. The IMT-2030 Framework Recommendation identifies 15 capabilities for the IMT-2030 technologies and nine of those capabilities are derived from existing 5G (IMT-2020) systems. IMT-2030 is also expected to help address the need for increased environmental, social, and economic sustainability, and also support the goals of the Paris Agreement of the United Framework Convention on Climate Change. [1]

For the development of IMT-2030, companies and industry associations are scheduled to submit proposals for the IMT-2030 Radio Interface Technology (RIT) for ITU-R consideration in early 2027. These submissions will then be evaluated against the agreed minimum requirements prepared by ITU’s expert group on IMT systems (ITU-R Working Party 5D), with the prospect of getting a final set of IMT-2030 technology standards approved by 2030.

Accordingly, 3rd Generation Partnership Project (3GPP), which produce the Reports and Specifications that define mobile systems including radio access, core network and service capabilities commenced the studies and works for the development of 6G system aligned with IMT-2030 framework within the context of 3GPP standardization [2].

Furthermore, 3GPP is expected to continue to cater to various industries’ demands for digital transformation through communication products and solutions based on 3GPP standards. These efforts will incorporate inputs stemmed from insights and market demands provided by those industries, integrating them into the 3GPP standardization process.

Hence, it is imperative to promptly formulate use cases and service requirements including regulatory aspects for Marine AtoN over IMT-2030. These inputs will play a vital role in the maritime sector’s involvement in 3GPP standardization efforts, aligning with the 3GPP timeline for studies and works starting from Release 20 onward for ITU-R IMT-2030.

## Scope

This Guideline defines use cases and service requirements, and relevant regulatory aspects for applying Marine Aids to Navigation (AtoN) over IMT-2030 (6G). The objective is to formulate inputs that reflect the demands of Marine AtoN-related stakeholders into 3GPP standardization for IMT-2030 (6G), with the aim of ensuring that these technologies are applicable to future maritime communication systems.

The scope of this Guideline focuses on transitional operational scenarios in which both legacy and advanced systems may coexist. The navigational environments and vessel types considered are illustrated in Figure 1, where the highlighted (orange) cells indicate combinations that fall within the scope. Specifically, this Guideline addresses the following:

* Only legacy type of vessels operating in a co-existence of legacy and new navigational environments
* Co-existence of legacy and new types of vessels operating in a legacy navigational environment
* Co-existence of legacy and new types of vessels operating in a co-existence of legacy and new navigational environments

Other combinations—such as fully new vessels operating exclusively in fully digital environments—are not considered within the scope of this Guideline at this stage.스크린샷, 라인, 직사각형, 텍스트이(가) 표시된 사진

AI 생성 콘텐츠는 정확하지 않을 수 있습니다.

1. Combinations of navigational environments and type of vessel types considered in this Guideline

In this document, the following terms are used to distinguish between types of vessels and navigational environments:

* Legacy type of vessel: A human-operated conventional ship that relies on traditional navigational methods and does not incorporate IMT-2030 communication capabilities.
* New type of vessel: A ship that seamlessly integrates with IMT-2030 communication technologies, enabling safe navigation and real-time situational awareness through continuous connectivity with shore-based and ship-based systems.
* Legacy navigational environment: A maritime domain where traditional aids to navigation (AtoN), voice communication (e.g., VHF), and non-integrated systems are used.
* New navigational environment: A digitally enhanced maritime domain where navigation is supported by infrastructure capable of leveraging IMT-2030 technologies for high-capacity, low-latency, and reliable communications to enable intelligent and automated vessel operations.

The classification of vessel types in this Guideline aligns with the IMO’s framework for Maritime Autonomous Surface Ships (MASS), which categorizes vessels based on their level of autonomy. However, this Guideline broadens the scope to include any vessel that incorporates IMT-2030-based communication and navigation functionalities—not limited to MASS, but including other smart or semi-automated vessels that benefit from the wireless connectivity based on IMT-2030 technologies.

Accordingly, this Guideline takes into account both legacy and digitalized maritime environments where Marine AtoN over IMT-2030 may be applied.

## objectives

The objectives of this Guideline are as follows to ensure the safety and efficiency of Marine AtoN within the IMT-2030 (6G) as maritime communication system.

1. Identify legacy use cases that must be supported by the Marine AtoN over IMT-2030.
2. Develop new use cases that are likely to find applicability in the Marine AtoN over IMT-2030.
3. Define potential service requirements, including regulatory consideration, for Marine AtoN over IMT-2030, drawing from both identified legacy use cases and newly developed use cases.
4. Formulate the input based on these use cases and potential service requirements to support the development of IMT-2030 for Marine AtoN.

# Use cases of maritime buoyage system (MBS)

## use case on intelligent connected buoys for real-time maritime awareness

As the maritime sector transitions toward digital infrastructure, buoys—traditionally used solely as physical aids to navigation—are increasingly being transformed into intelligent, connected nodes that support a range of advanced services. With the integration of IMT-2030 (6G) communication capabilities, buoys within the Maritime Buoyage System (MBS) can serve as edge devices in a distributed maritime data and communication network. These connected buoys can collect, process, and relay information in real time, enhancing navigational safety, environmental monitoring, and operational efficiency.

In this use case, buoys are equipped with sensors (e.g., GNSS, wave, weather, visibility, acoustic, AIS receivers) and connected via IMT-2030-capable modules—including satellite and terrestrial NTN systems. These smart buoys function not only as aids to navigation but also as multi-functional data nodes that:

* Transmit real-time environmental and positioning data to shore-based authorities and nearby vessels
* Relay dynamic AtoN status updates (e.g., light failure, drift detection) over low-latency, reliable communication links
* Participate in virtual AtoN generation by broadcasting safety messages in coordination with VTS or MASS systems
* Serve as localized anchor points for high-accuracy positioning reference, particularly in GNSS-denied environments
* Interface with Public Warning Service (PWS) systems for localized alert dissemination to nearby vessels via broadcast channels

By utilizing IMT-2030 technologies, these connected buoys enable low-latency, high-reliability communication that supports maritime domain awareness even in remote or congested waterways. Furthermore, their modular nature allows integration with autonomous surface vehicles, port management systems, and digital twin models for adaptive control of traffic separation schemes and risk-based AtoN placement.

This use case demonstrates how the MBS can evolve from a static, physical infrastructure into a smart, adaptive system that plays an active role in the future IMT-2030-based maritime communication ecosystem. It also highlights the importance of ensuring communication standardization, data format compatibility (e.g., S-200 series), and regulatory support for multi-role AtoN deployment.

# Use cases of positioning, navigation and timing (PNT)

## use case on POSITIONING

Positioning technology is a key enabler in the digital transformation of the maritime sector, supporting a wide range of applications including Marine AtoN and autonomous ship operations. With the maritime domain expected to integrate with the IMT-2030 (6G) communication system in the 2030s and beyond, substantial improvements in positioning precision, reliability, and resilience are anticipated. These advancements are expected to contribute to safer, more efficient, and more sustainable maritime navigation.

The ITU-R envisions considerable enhancements in positioning performance as part of the IMT-2030 framework. Specifically, it targets positioning accuracy in the range of 1 to 10 centimetres, aimed at supporting emerging use cases that demand high precision, such as autonomous transportation, advanced robotics, and immersive augmented or virtual reality. These requirements continue to evolve in alignment with ongoing technological advancements and the cross-sectoral needs of various industries.

In parallel, the 3GPP is actively working on the definition of positioning requirements for 6G. Through ongoing studies and technical evaluations, the objective is to detailed specifications that can support diverse application scenarios – including safety-critical and industrial use cases. As these standardization efforts mature, more concrete performance benchmarks will guide the development and implementation of positioning capabilities in future 6G systems, including their potential use in maritime contexts.

The IALA currently employs positioning systems such as DGNSS, SBAS, and R-Mode, with performance targets that typically range from sub-meter to tens of meters depending on application. For example, IALA Guideline G1128 specifies that sub-meter accuracy is required for berthing and pilotage, while 10-meter accuracy may be sufficient for coastal navigation, and oceanic navigation can tolerate accuracies up to 100 meters. These requirements are aligned with IMO Resolution A.1046(27) on World-Wide Radio Navigation System (WWRNS) and are designed primarily for manned navigation with moderate update rates and availability. However, such capabilities may not meet the future demands of data-driven and automated services.

To support the digital transition of Marine AtoN, new use cases requiring enhanced positioning are being explored, such as precision-based virtual AtoN deployment, autonomous inspection using unmanned systems, collaborative navigation, and MASS operations in complex environments. A preliminary gap analysis indicates that positioning services enabled by IMT-2030 have the potential to surpass current maritime requirements by an order of magnitude in accuracy, latency, and availability. This opens a path toward significantly expanding the scope and reliability of positioning-enabled maritime services.

This Guideline will be updated once 3GPP finalizes its Stage 1 service requirements on positioning for 6G. Further refinement of maritime use cases and positioning requirements is anticipated as part of the ongoing effort to align IALA’s future services with IMT-2030 capabilities.

# Use cases of vessel traffic services (VTS)

To be added.

## use case on …

*Editor’s note: The sub-sections will be further developed to capture the key points and description from IALA perspective.*

To be added.

# Use cases of digital maritime services

*Editor’s note: This section may be sub-categorized later depending on use cases introduced in this section.*

## use case on Public warning service (PWS)

Public Warning Service (PWS) is a standardized communication capability defined by 3GPP to deliver time-critical alerts—such as natural disasters, maritime accidents, or environmental hazards—to populations and systems at risk. While terrestrial implementations of PWS have matured under regulatory mandates for land-based mobile operators, the extension of this capability to the maritime domain is gaining importance as IMT-2030 (6G) evolves. The integration of IMT-2030-based non-terrestrial networks (NTNs)—including satellite constellations—opens new opportunities to provide real-time maritime PWS even in remote ocean areas far beyond the reach of coastal infrastructure. A key enabler of this advancement is the application of geo-fencing functionality, wherein virtual maritime zones can be dynamically defined to trigger the delivery of emergency alerts to vessels and offshore infrastructure within those boundaries. For example, when a ship enters a predefined alert zone such as a tsunami impact area, piracy hotspot, or hazardous spill region, authenticated PWS messages can be automatically delivered via IMT-2030 satellite links to onboard receivers in real time.

This geo-fencing-based PWS model enhances maritime safety by ensuring context-aware alerting regardless of terrestrial coverage, vessel nationality, or communication equipment heterogeneity. The technical requirements for such PWS deployments are largely consistent with existing 3GPP specifications, particularly those defined in TS 22.268 for PWS and TS 22.261 for IMT-2020 and beyond. These include the use of standardized message formats, such as the Common Alerting Protocol (CAP), which ensures interoperability across diverse systems and services, as well as compatibility with a wide range of terminal types, including conventional mobile devices, shipborne receivers, and future autonomous vessel systems.

While these technical standards remain valid for IMT-2030-based satellite applications, the application of PWS in the maritime domain introduces a set of new regulatory and policy considerations. Unlike terrestrial mobile operators operating under national authority, maritime PWS requires international coordination across jurisdictions, ship registries, and flag states. Therefore, additional regulatory requirements should be considered, such as:

* Clearly defined authorization structures for issuing PWS alerts in maritime zones (e.g., VTS authorities)
* Mandated terminal support for reception and presentation of PWS messages onboard SOLAS-class and high-speed craft vessels operating in IMT-2030 coverage areas
* Cross-border geo-fence coordination, especially for alerts affecting international straits or EEZ-adjacent waters
* Interoperability requirements with legacy maritime safety systems (e.g., GMDSS, Inmarsat SafetyNET)
* Message suppression or prioritization policies to avoid distraction during critical navigation while preserving safety-critical alerts

By combining IMT-2030-based NTN delivery and geo-fenced message targeting, maritime PWS can address critical communication gaps in current infrastructure and enable a globally harmonized emergency alerting capability for all classes of vessels, from conventional ships to MASS. To achieve this, cooperation between IALA, IMO, ITU-R, 3GPP, and national administrations will be essential to align message formats, authority structures, and receiver requirements. This use case supports the broader objective of digitalizing the maritime safety infrastructure and enhancing resilience in the face of increasing environmental and operational risks at sea.

# CONCLUSION

*Editor’s note: The section will be developed later..*

To be added.

# Definitions

The definitions of terms used in this IALA Guideline can be found in the International Dictionary of Marine Aids to Navigation (IALA Dictionary) at <http://www.iala-aism.org/wiki/dictionary> and were checked as correct at the time of going to print. Where conflict arises, the IALA Dictionary should be considered as the authoritative source of definitions used in IALA documents.

**IMT-2030** –The International Telecommunication Union Radiocommunication Sector (ITU-R) has officially defined IMT-2030 in Recommendation ITU-R M.2160, titled *“Framework and overall objectives of the future development of International Mobile Telecommunications (IMT) for 2030 and beyond.”* The Recommendation outlines the vision, usage scenarios, and key capabilities expected for IMT-2030, which forms the basis for what is commonly referred to as 6G. It builds upon IMT-2020 and expands the scope to support more advanced services including ubiquitous connectivity, intelligent network-native services, sustainable and resilient architectures, and integration of the physical and digital worlds [1].

**IMT-2020** – The International Telecommunication Union Radiocommunication Sector (ITU-R) has officially defined IMT-2020 in Recommendation ITU-R M.2083, titled *“Framework and overall objectives of the future development of IMT for 2020 and beyond.”* The Recommendation outlines the vision, usage scenarios, and key capabilities for IMT-2020, which forms the basis for what is commonly known as 5G. It describes three broad categories of usage scenarios: enhanced mobile broadband (eMBB), ultra-reliable and low latency communications (URLLC), and massive machine-type communications (mMTC) [2].

# Acronyms

Marine AtoN Marine Aids to Navigation

MBS Maritime Buoyage System

# References

1. [ITU-R](http://www.itu.int) M.2160 – Framework and overall objectives of the future development of International Mobile Telecommunications (IMT) for 2030 and beyond
2. ITU-R M.2083 – Framework and overall objectives of the future development of IMT for 2020 and beyond
3. [www.3gpp.org](http://www.3gpp.org)
4. IALA Guideline G1128 – The Performance and Monitoring of DGNSS Services in the Frequency Band 283.5–325 kHz
5. IMO Resolution A.1046(27) – World-Wide Radio Navigation System
6. IALA Recommendation R-129 – On R-Mode and Resilient PNT
7. IALA S-200 and S-100 Product Specifications (under development)
8. Use cases and potential requirements on MBS

This annex provides use cases and potential requirements on MBS to be formulated as inputs into 3GPP standardization for IMT-2030 based on use cases developed from IALA perspective which are introduced in Section 3.

## A.1 Use case on …

### A.X.1 Description

<Describe what the use case intends to achieve.>

### A.X.2 Pre-conditions

<List any pre-conditions that need to exist for this use case, preferably as a bulleted list, e.g. UE is registered to the network.>

### A. X.3 Service Flows

<Describe the sequence of events that explain what needs to happen, preferably as a numbered list, e.g. 1. User makes a voice call, 2. Called party receives alerting message.>

### A.X.4 Post-conditions

<Describe the end result e.g. Called party can decide whether to accept call based on information displayed on UE screen.>

### A.X.5 Existing features partly or fully covering the use case functionality

< Highlight existing features in the existing set of normative specifications that partly or fully cover this use case.>

### A.X.6 Potential New Requirements needed to support the use case

<Provide draft new requirements that are needed to realise the use case, and that are not yet covered in any normative specification.>

1. Use cases and potential requirements on PNT

This annex provides the example of use cases and potential requirements on PNT to be formulated as inputs into 3GPP standardization for IMT-2030 based on use cases developed from IALA perspective which are introduced in Section 4.

## B.X Use case on …

### B.X.1 Description

<Describe what the use case intends to achieve.>

### B.X.2 Pre-conditions

<List any pre-conditions that need to exist for this use case, preferably as a bulleted list, e.g. UE is registered to the network.>

### B.X.3 Service Flows

<Describe the sequence of events that explain what needs to happen, preferably as a numbered list, e.g. 1. User makes a voice call, 2. Called party receives alerting message.>

### B.X.4 Post-conditions

<Describe the end result e.g. Called party can decide whether to accept call based on information displayed on UE screen.>

### B.X.5 Existing features partly or fully covering the use case functionality

< Highlight existing features in the existing set of normative specifications that partly or fully cover this use case.>

### B.X.6 Potential New Requirements needed to support the use case

<Provide draft new requirements that are needed to realise the use case, and that are not yet covered in any normative specification.>

1. Use cases and potential requirements on VTS

This annex provides the example of use cases and potential requirements on VTS to be formulated as inputs into 3GPP standardization for IMT-2030 based on use cases developed from IALA perspective which are introduced in Section 5.

## C.X Use case on …

### C.X.1 Description

<Describe what the use case intends to achieve.>

### C.X.2 Pre-conditions

<List any pre-conditions that need to exist for this use case, preferably as a bulleted list, e.g. UE is registered to the network.>

### C.X.3 Service Flows

<Describe the sequence of events that explain what needs to happen, preferably as a numbered list, e.g. 1. User makes a voice call, 2. Called party receives alerting message.>

### C.X.4 Post-conditions

<Describe the end result e.g. Called party can decide whether to accept call based on information displayed on UE screen.>

### C.X.5 Existing features partly or fully covering the use case functionality

< Highlight existing features in the existing set of normative specifications that partly or fully cover this use case.>

### C.X.6 Potential New Requirements needed to support the use case

<Provide draft new requirements that are needed to realise the use case, and that are not yet covered in any normative specification.>

1. Use cases and potential requirements on DIGITAL MARITIME SERVICES

*Editor’s note: This annex may be sub-categorized later depending on use cases introduced in this annex.*

This annex provides the example of use cases and potential requirements on digital maritime services to be formulated as inputs into 3GPP standardization for IMT-2030 based on use cases developed from IALA perspective which are introduced in Section 6.

## D.X Use case on …

### D.X.1 Description

<Describe what the use case intends to achieve.>

### D.X.2 Pre-conditions

<List any pre-conditions that need to exist for this use case, preferably as a bulleted list, e.g. UE is registered to the network.>

### D.X.3 Service Flows

<Describe the sequence of events that explain what needs to happen, preferably as a numbered list, e.g. 1. User makes a voice call, 2. Called party receives alerting message.>

### D.X.4 Post-conditions

<Describe the end result e.g. Called party can decide whether to accept call based on information displayed on UE screen.>

### D.X.5 Existing features partly or fully covering the use case functionality

< Highlight existing features in the existing set of normative specifications that partly or fully cover this use case.>

### D.X.6 Potential New Requirements needed to support the use case

<Provide draft new requirements that are needed to realise the use case, and that are not yet covered in any normative specification.>