General Lighthouse Authorities
The United Kingdom and Ireland

The General Lighthouse Authorities
Marine Navigation Plan has been undertaken by:

Commissioners of Irish Lights
Northern Lighthouse Board
Trinity House

MARINE NAVIGATION PLAN
2016 to 2030

MARINE NAVIGATION PLAN 2016 – 2030

The General Lighthouse Authorities

The General Lighthouse Authorities (GLA) of the UK and Ireland are:

• the Commissioners of Irish Lights, known as Irish Lights, for all of Ireland

• the Commissioners of Northern Lighthouses, known as the Northern Lighthouse Board (NLB), for Scotland and the Isle of Man (IoM)

• the Corporation of Trinity House, known as Trinity House (TH), for England, Wales, the Channel Islands and Gibraltar.

The GLA provide marine Aids to Navigation (AtoN) and have a shared mission statement:

To deliver a reliable efficient and cost effective AtoN service for the benefit and safety of all mariners.

The GLA are separate corporate entities with statutory responsibilities given to them by Parliament through the Marine Shipping Acts (MSAs) 1995 and 1894, as amended. They are independent in their executive decision-making in accordance with those statutory responsibilities. For administrative purposes the GLA are treated as executive Non-Departmental Public Bodies (NDPBs) by agreement and only to the extent that this does not conflict with their respective statutory positions and legal status.

The GLA operating costs are met from the General Lighthouse Fund (GLF). The income to the GLF comes mostly from light dues that are charged at UK, IoM and Republic of Ireland (RoI) ports and a contribution from the Government of Ireland, with commercial income from use of reserve capacity. Charges are in direct proportion to the costs of the services provided. This cost-recovery system is regulated by the UK Secretary of State for Transport who has a duty to ensure the effective management of the GLF to enable the GLA to provide adequate Aids to Navigation at the optimum cost. An advisory body, known as the Lights Advisory Committee, which is made up of shipping and ports' representatives, is consulted by the Department for Transport on certain financial matters relating to the GLF.

MARINE NAVIGATION PLAN 2016 - 2030

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EXECUTIVE SUMMARY

This document describes the GLA plan for the overall marine Aids to Navigation (AtoN) service provision mix. This plan covers electronic and visual AtoN and is a consolidated version of the separate plans that have been produced in the past.

The document presents the GLA plan in respect of lighthouses, beacons, major floating aids, buoys, day-marks and other forms of visual AtoN required for safe navigation in their areas of responsibility. These visual AtoN and existing electronic AtoN are likely to remain at the core of the overall system mix, reflecting the level of service the GLA will provide to all users, taking advantage of technological and operational improvements forecast in AtoN service provision.

The plan has been created in the context of the introduction of e-Navigation, which will change the way that operators (mariners in the traditional sense, as well as future conceptual operators in cases of remotely-operated or autonomous vessels) react to information that is presented to them. The human factors aspect is critical in all cases. The plan also considers and supports the expansion and increasing take up of Global Navigation Satellite System (GNSS) infrastructure and technology, shortly to comprise four satellite constellations – GPS, Galileo, GLONASS and BeiDou – as well as the recognition of these systems by IMO. The Plan recognises the vulnerability of all these systems to disruption and therefore includes both current systems and investigation of potential future systems that may be needed to ensure the resilience of navigation.

Visual aids to navigation will continue to be an essential component of the AtoN system mix both as principal aids used by traditional navigators and as a resilient complement to GNSS and other electronic aids for manned and autonomous vessels using more advanced navigation techniques.

The GLA radiobeacon differential GNSS (DGNSS) service will be maintained until at least 2025. Its continuation beyond that will depend on user needs (including possible new uses) and alternatives that are or may become available. Notable alternatives may include the European Geostationary Navigation Overlay Service (EGNOS) in Europe and, potentially, other space-based augmentation systems (SBAS) elsewhere in the world.

Support will be given to the development and international harmonisation of Automatic Identification System (AIS) AtoN, including virtual AtoN. The implementation of an international strategy for the future of Racons will be supported, taking account of changes in Radar technology and potential developments in coastline matching of Radar images.

The plan also highlights that the GLA need to maintain a close watch on the development of future technologies to anticipate new requirements and ensure that the AtoN mix remains efficient and effective. In particular, the implementation strategy for e-Navigation will be supported and GLA applications and services will be developed and demonstrated as elements within Maritime Service Portfolios (MSPs).

The Marine Navigation Plan 2016 - 2030 is the principal supporting document
of the GLA Strategy '2030 – Navigating the Future'
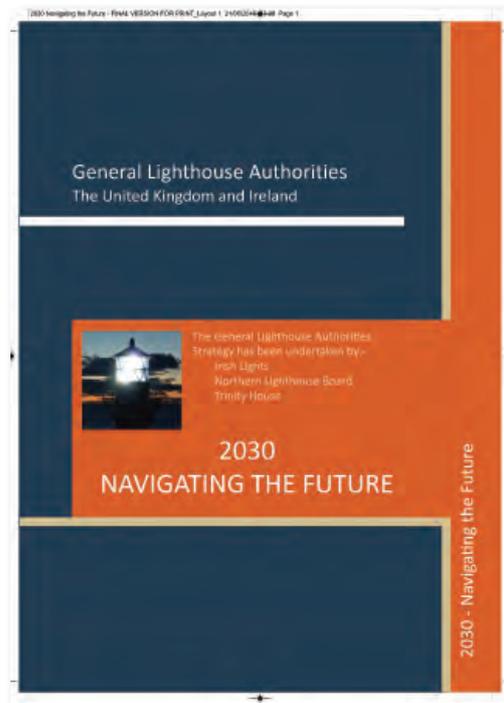
1. INTRODUCTION

1.1 Background

The three General Lighthouse Authorities (GLA) - Trinity House (TH), the Northern Lighthouse Board (NLB) and Irish Lights, provide marine Aids to Navigation (AtoN) to the mariner in the interests of general navigation. The GLA have a shared mission statement:

To deliver a reliable efficient and cost effective AtoN service for the benefit and safety of all mariners.

Changes in traffic patterns, the proliferation of high-speed and larger craft and their interaction with marine leisure activities all place new demands on Aids to Navigation (AtoN) service providers. It is recognised that the widespread reliance on Global Navigation Satellite Systems (GNSS) as the primary means of position fixing has encouraged some mariners to navigate in areas and conditions which they would not previously have attempted - for example, close inshore, at night and in reduced visibility. More generally, the recognised vulnerabilities of GNSS to interference, which are not well understood by some users, must be taken into consideration to ensure resilience when determining future AtoN provision.

AtoN provision also needs to take into account the evolving shipboard practices, training, skill levels and experience of seafarers. Traditional navigational skills sometimes appear to be superseded by over-reliance on new technological advances, for example, the Electronic Chart Display Information System (ECDIS) and Integrated Bridge Systems (IBS). Indeed, some mariners are now using portable devices for navigation. AtoN service providers must continuously review the level of requirements and delivery to take account of these changes.

It is clear from in-depth consultation with users in both the commercial and leisure sectors that lighthouses, buoys and beacons will continue to play a vital role in the balanced AtoN mix. In addition, the role of AtoN is often understated when considering the protection of trade, the marine environment, marine coastal industries and the general public.

Taking these factors into consideration, the GLA Marine Aids to Navigation Strategy between 2015 and 2030, described in the GLA document '2030 Navigating the Future', is to:

• continue to provide an appropriate mix of AtoN for general navigation for all mariners

• continue to provide a timely and effective response to wrecks, new dangers and AtoN failures

• continue to undertake superintendence and management of all Aids to Navigation in accordance with international standards, recommendations and guidelines

• work with users, partners and stakeholders nationally and internationally, to continuously improve the safety of marine navigation through harmonised international standards, recommendations and guidelines

• improve reliability, efficiency and cost-effectiveness while ensuring the safety of navigation

- introduce new services and infrastructure in line with user requirements and technological developments, including lights, electronic systems, e-Navigation and the Maritime Connectivity Platform

- keep abreast of technological developments and undertake research and development on new AtoN technologies

- protect and exploit our intellectual property where appropriate.

Previously, the GLA have published two separate volumes – the GLA Visual Aids to Navigation Plan (VANP) and the GLA Radio Navigation Plan (GRNP) – to translate the Strategy into tangible action plans. Since the publication of the GLA Strategy '2030 – Navigating the Future', the two separate plans have been consolidated into this single GLA Marine Navigation Plan (GMNP), reflecting the ever-more integrated nature of the overall AtoN systems mix in the context of e-Navigation.

1.2 Scope and objectives

This document reaffirms the GLA commitment to maintain UK and Irish waters as amongst the safest to navigate in the world. This plan will inform GLA partners, at home and abroad, and provide a basis for fostering continued co-operation. These partners include the UK, Scottish and Irish Transport Departments, the Maritime and Coastguard Agency (MCA), the Irish Coast Guard (IRCG) and international partners, principally the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA).

This plan has been formulated in the context that the Governments of the UK and Ireland are signatories to the International Maritime Organization's (IMO) Safety of Life at Sea (SOLAS) Convention with the associated obligations, inter alia:

> "...provide…such Aids to Navigation as the volume of traffic justifies and the degree of risk requires..."
> "...take into account the international recommendations and guidelines..."
> "...arrange for information relating to Aids to Navigation to be made available to all concerned..."

Through the Merchant Shipping Acts (MSA) and other legislation, the UK and Irish Governments have empowered the GLA to meet their Aids to Navigation obligations under the SOLAS Convention and to carry out other functions in relation to wreck. The GLA responsibilities apply equally to all types of mariner and vessels: from the highly-trained professional navigator on board large, sophisticated ships through to the amateur leisure user sailing small boats.

This plan provides a snapshot of the overall mix of AtoN available to the user and highlights those AtoN – electronic and visual – that need to be provided by the GLA to meet the requirements of all users, efficiently and effectively, in the context of the gradual evolution towards e-Navigation. As the marine navigation terrain is not static, this plan will necessarily be subject to periodic review and update. However, it enables the GLA to move forward with confidence in the delivery of their vision and means that they can plan ahead in what promises to be a varied, dynamic and challenging environment.

1.3 Structure of the document

This document is structured as follows:

- Section 1 describes the background to and scope and objectives of the GLA Marine Navigation Plan (GMNP)

- Section 2 provides a description of the environment in which the GLA have to provide their services

- Section 3 introduces the plan, summarizing the currently available system mix used in marine navigation, highlighting those systems provided by the GLA, those operated on board the vessel or provided externally by third parties

- Section 4 considers current GLA systems and presents the plan for their continued operation and evolution

- Section 5 describes the trends in on-board systems and the potential implications for future AtoN service provision. It highlights the role of the GLA in ensuring that AtoN services continue to support mariners' use of the future on-board navigation systems

- Section 6 describes the potential evolution of external systems and their likely impact on the GLA AtoN service provision. It highlights the role of the GLA in monitoring external developments and evolving the mix of AtoN to adapt to changes in external systems

- Section 7 presents aspects of GLA research and development that address the mix of future AtoN in the changing operational environment as e-Navigation evolves

- Section 8 addresses wider issues (international, co-operative, standards and regulatory) of implementing the GMNP

- Section 9 confirms the GLA commitment to users.

The changing service provision environment

2.

2. THE CHANGING SERVICE PROVISION ENVIRONMENT

2.1 Introduction

The service provided by the GLA is coming under increasing pressure from a variety of drivers. User requirements are becoming more demanding and complex. The marine navigation technology market is expanding and becoming more diverse with the proliferation of mobile and hand-held devices and the advent of e-Navigation services. This step-change in technology is taking place against the backdrop of changing patterns of worldwide shipping traffic and the drive for increased efficiency of AtoN services.

Through co-operation between the GLA and their international partners, the environment in which they operate can be influenced - particularly from a technical and operational perspective. However, at the same time, there are several external drivers over which they have little or no influence; in these areas the GLA will work to anticipate change and develop a proactive plan accounting for these external drivers. The key external drivers (detailed below) are regulatory and institutional, user and societal, commercial, operational, technical and environmental.

2.2 Regulatory and Institutional Drivers

The SOLAS Convention and Merchant Shipping Acts (MSA), as amended, form the basis for the GLA service provision mandate and therefore play a crucial role in driving implementation. The GLA also need to consider the legal implications of the Nairobi Wreck Convention (NWC), enacted through the Wreck Removal Convention Act 2011. The NWC provides the legal basis for the GLA mandate for removal of shipwrecks that may have the potential to affect adversely the safety of lives, goods and property at sea, as well as the marine environment. The GLA co-operate closely with each other to minimise overlap in the provision of AtoN and to ensure consistent levels of service provision. Each GLA takes into account appropriate international directives, requirements, recommendations and guidelines, including those of IALA.

Standardisation and global interoperability, such as performance standards for the multi-system shipborne radionavigation receiver, should enable the earliest possible uptake of new services and technology. Major changes in technical approach, such as that required by the introduction of the e-Navigation concept, will affect how the GLA operate under the existing regulatory framework. In particular, under the SOLAS convention, the GLA have a role in providing Radio Navigation services; whether these responsibilities will increase under e-Navigation has yet to be determined, but the need for resilience in these services has been recognised by IMO from an early stage. e-Navigation will also encompass physical AtoN.

The standardisation of electronic AtoN is increasingly driven at a supranational level, with development co-ordinated principally through IALA. IMO will continue to be the governing body setting on board carriage requirements, while IALA has the role of harmonising onshore infrastructure and services, such as vessel traffic services (VTS) and Aids to Navigation.

The roles of regional bodies such as the European Commission and its executive agencies, such as the European Maritime and Safety Agency (EMSA) and the European GNSS Agency (GSA), alongside other pan-European bodies, such as the European Space Agency (ESA), are growing in prominence.

European Directives could increasingly impact the equipment operated both on shore and at sea in terms of the performance requirements of the shore-based equipment to support international traffic. Collaboration with other service providers should be considered, to identify opportunities for sharing infrastructure and utilising common technologies. GLA collaboration with neighbouring administrations will increase over the medium term, a current example being support to the definition of maritime EGNOS services in Europe.

The International Telecommunication Union (ITU) allocates the global radio frequency spectrum and develops technical standards for ICT, applicable to maritime communications/navigation, and the International Hydrographic Organisation (IHO) co-ordinates standards for nautical charts, hydrographic documents and maritime data, including Maritime Safety Information (MSI). The Radio Technical Commission for Maritime Services (RTCM) and the International Electrotechnical Commission (IEC) are tasked with technical standardisation and type-approval of equipment. Comité International Radio-Maritime (CIRM), the international association for marine electronics companies, promotes the application of electronic technology to the safety of life and efficient conduct of vessels at sea, representing the global base of equipment suppliers/manufacturers. It is important to recognise that development, regulatory and type-approval processes can be very lengthy, particularly for the introduction of new systems, involving carriage requirements.

As a result, the GLA recognise the importance of such bodies and the need to support their proceedings to ensure that key technologies are developed in accordance with the needs of both the marine user and the service provider. Of particular importance is the need to resolve spectrum issues associated with frequency congestion while making best use of the available resource through a fair, equitable and transparent management structure.

2.3 User & Societal Drivers

The GLA in fulfilling their statutory responsibility for superintendence and management of marine Aids to Navigation must continue to provide effective AtoN services recognising an e-Navigation concept of operations, which must support an increasing use of automated systems. AtoN services should meet the needs of all users, from tankers, cargo, passenger and container ships through to fishing vessels and small leisure craft, and including autonomous vessels in the future; services must not just be driven by emerging technological solutions. The GLA recognise that the needs of maritime users vary considerably and the range of requirements and diversity of users is only likely to increase as, for example, remotely piloted and autonomous vessels become more common.

On-board Navigation Aids and associated equipment carried by the users differ with size, age and classification of vessels, affecting the ability of those vessels to make best use of available technology. The GLA will continue to consider the user base when making decisions for the future deployment or changes to AtoN, case by case, based on the degree of risk.

The GLA exercise their Superintendence and Management duties for Local AtoN in a manner that ensures that users experience a consistent level of service between General and Local AtoN. The requirement under the UK's Port Marine Safety Code to maintain casualty response data and submit periodic availability reports to the GLA represents recognised best practice. This requirement has already been extended to other authorities responsible for the maintenance of local AtoN and will be further extended for the maintenance of AtoN on offshore renewable energy and aquaculture sites.

The role of the GLA in ensuring the integrity, reliability and accuracy of its GNSS-aided AtoN services, when coupled with the increased dependence by marine navigators upon GNSS, will become more critical in future. GNSS is vulnerable to jamming, spoofing and other external threats, such as space weather. The resilience of navigation will not be fully addressed by the availability of multiple constellations, and complementary systems will be needed to provide more than one means of navigation.

In co-operation with partners such as the Maritime and Coastguard Agency (MCA), the Irish Coast Guard (IRCG), the UK Hydrographic Office (UKHO) and the Irish and UK Meteorological Offices, the incidence of threats to GNSS availability and information on their possible impact must be communicated effectively to mariners. In particular, the consideration of backup systems for GNSS, to provide continuity of service in the event of disruption, is likely to be driven by the needs of society and the attitudes and abilities of users to cope with that disruption.

2.4 Commercial Drivers

There are key trends in the global shipping industry that are already having, and will continue to have, a large effect on the services the GLA deliver:

- The range of ship sizes is increasing – the container vessel MSC Oscar is 396m long with a capacity of 19,224 twenty-foot equivalent units (TEU) whereas the cruise ship Harmony of the Seas is 361m long and 226,000 Gross Tonnes. While further increase in size may not be at the same pace, very large vessels will feature throughout the period of this plan

- The United Nations Conference on Trade and Development (UNCTAD) 'Review of Maritime Transport Report 2016' (Table 2.2)[1] indicates that, at the start of 2016, the average age of commercial ships had reached 20.3 years, a slight increase over the previous year. The current average age remains low, compared with previous decades

- Revenue generated from light dues will continue to rise and fall as shipping traffic fluctuates. Further, as central governments look to protect the interests of users of AtoN services, regulatory pressure will continue to be applied to increase GLA cost efficiency. GLA AtoN services must therefore be cost-effective to both the user and service provider – with the GLA adopting a flexible and user-centric approach to service provision. AtoN, whilst essentially providing the necessary risk mitigation measures, should offer good value for money and evolve in a manner that optimises the cost of service provision whilst maintaining safety obligations.

The GLA must be prepared for fluctuations in demand for shipping movements in line with general economic trends in the UK and Ireland, in Europe and globally. The GLA must therefore consider scenarios and develop contingency plans that will enable them to meet their service commitments.

The pressures on service provision will increase as a result of these changes. The size, age and capability of the international fleet is becoming more varied and this has an impact upon the GLA plans that are complementary to the introduction of new on-board equipment. Essentially, the GLA must meet the demands of 30-year-old cargo ships with basic bridge and navigation equipment as well as brand-new container ships with fully integrated bridge systems.

[1] UNCTAD/RMT/2016 http://unctad.org/en/PublicationsLibrary/rmt2016_en.pdf

2.5 Operational Drivers

The GLA must provide such Aids to Navigation as deemed practicable, necessary and justified by the volume of traffic and the degree of risk. From an operational perspective, reliability of service provision is the key. Comprehensive risk management processes will still need to be followed to ensure that adequate resilience is built into the system. In addition, the way that ships operate is changing. For example, shore-based management systems and shared way marks/routing used for fuel efficiency can lead to increased density of traffic with potential mutual conflicts with other vessels and with floating AtoN.

For the GLA, this means providing AtoN services that guarantee a seamless, high integrity, 'always-on' positioning capability for seafarers. An integrated approach to electronic AtoN services should ensure high levels of safety, integrity, reliability and resilience. Diversity across the AtoN mix and infrastructure should avoid single points of failure in service provision.

The introduction of e-Navigation will change the way that operators react to information that is presented to them and getting the human factors part of this right is critical. Increasing take up of this technology will, over time, impact on the AtoN infrastructure provided. However, e-Navigation requires resilience, therefore it is essential to understand what happens when key e-Navigation components fail or their services are denied to users. The manner in which AtoN services and related Maritime Safety Information will be included in Maritime Service Portfolios is yet to be determined but is likely to be developed in the period of this plan.

In addition to e-Navigation there are many evolving elements in the operational environment that present new challenges to service provision in terms of cost, risk and service level, including:

- The increasing recognition of economic dependence on commercial on-time shipping – disruption of traffic can have direct and immediate effects on industry and consumers

- The widespread and growing reliance upon GNSS as the primary means of position fixing and the lack of widely available electronic backup systems

- The increasing deployment of Traffic Routing Schemes to cope with changes in traffic patterns, such as those associated with offshore renewable energy installations

- The balance between traditional navigation skills and the role of technological advances such as ECDIS and Integrated Navigation and Bridge Systems (INS/IBS)

- The potential to provide additional services such as meteorological and hydrological (Met/Hydro) data.

2.6 Technical Drivers

In the visual AtoN domain, new systems and services provide an ever-increasing array of options through which to optimise service levels, whilst reducing risk and cost. At the same time, the need for co-ordination through IALA and key stakeholders such as IMO has never been more important in the endeavour to ensure consistent levels of service provision on an international basis.

Through co-operation between the GLA and international partners, it is possible to influence and determine the technical service provision environment. However, there are several external drivers which the GLA need to anticipate and respond to. Those that will directly influence the AtoN system mix until 2030 include:

- Introduction of new GNSS services: Galileo, modernised GPS, the modernisation of GLONASS and BeiDou; along with the use of EGNOS and other satellite-based augmentation systems (SBAS)

- Multi-system receivers, for which the performance standard has been approved by IMO, with IEC standardisation work to be completed circa 2019 and equipment expected on the market circa 2020

- Possible addition of complementary technologies for resilience of the vessel's Integrated Navigation System and PNT data processing, including:
    - Potential development of terrestrial backup systems to GNSS, such as ranging mode (R-Mode) and eLoran internationally
    - Absolute Radar positioning, with Coherent Radar and enhanced Racons
    - Maritime version of Advanced Receiver Autonomous Integrity Monitoring (ARAIM), with multi-constellation GNSS including Galileo
    - Integration of on-board navigational aids such as inertial measurement units.

- Cybersecurity aspects of AtoN provision and associated services

- New maritime communication and information systems, such as:
    o The development of the VHF Data Exchange System (VDES)
    o The Maritime Connectivity Platform
    o Broadband communications in their potential role as an e-Navigation component
    o The emergence of the Internet of Things.

- Autonomous vessels

- The development and use of "apps" that will affect type-approval of bridge systems and equipment and will make updating of Electronic Navigation Charts (ENCs) even more important.

Examples of technical developments in visual Aids to Navigation include:

- Large Light Emitting Diode (LED) arrays for lights on fixed stations, particularly sector lights

- Improvements in the efficiency and colour characteristics of LEDs

- Introduction of "smart" lighting strategies, such as synchronisation, sequencing and increased conspicuity

- LEDs as direct replacements for traditional light sources.

The GLA will need to monitor and assess a number of emerging on-vessel capabilities, including the response to emerging IMO guidelines for Positioning, Navigation and Timing (PNT), encompassing the Multi System Receiver (MSR) in the ship's Integrated Navigation System (INS), to ensure that the AtoN service is tailored to the needs of the user. These include:

- Growing deployment of ECDIS and INS/IBS

- Improvements in RAIM and emergence of Advanced RAIM

- Improved inertial navigation, potentially using Quantum Technologies

- New receiver techniques for detecting and mitigating the effects of GNSS interference

- Availability of consumer-grade multi-constellation GNSS receivers and their proliferation amongst non-regulated vessels and smaller craft.

An optimised mix of electronic and visual AtoN systems must maintain the ability for the GLA (and other users) to respond effectively and quickly in the event of an emergency.

2.7 Environmental Drivers

As environmental drivers gain prominence in the UK and Ireland, the GLA act not only to preserve the marine environment within which the ships operate but also with a wider economic and climate conscious mind-set. Shipping will need to adapt both to operating in a changing climate as well as navigating the marine-based renewable energy infrastructure put in place to counter these changes (such as wind-farms, tidal and wave power systems). There is also pressure to reduce the emissions, including greenhouse gases, sulphur and nitrogen oxides and particulates generated by ships. Efficient routing has a role to play in emission reductions alongside more efficient engines and fuels.

The impacts of regulations on other sectors will also affect the GLA as their implementation leads to the proliferation of off-shore equipment and a subsequent requirement for a safe navigation service in their vicinity. Wind, wave and tidal energy generation projects are likely to increase significantly during the period of this plan. Visual AtoN are exhibited on offshore wind farms for both maritime and aeronautical users. The different AtoN requirements of each sector sometimes conflict and the management of such shared zones needs careful consideration.

Whilst overall marine spatial planning responsibility lies with other bodies, the GLA are statutory consultees in the planning process and must take responsibility for ensuring that safe navigation and AtoN requirements are included. In partnership with other organisations, it is GLA strategy to ensure that the principles of safe and efficient navigation are recognised and maintained in national and regional marine plans.

At an institutional level, a range of environmental measures are at an advanced stage of preparation in IMO. These include: NOx and SOx controls and the use of low sulphur fuels (January 2020); additional measures for enhancing the Energy Efficiency of International Shipping (EEDI)[2]; and measures to reduce the emission of Green House Gases from ships and associated Market Based Measures (MBM)[3], that may bring in more directional routing. In addition, there is potential for the introduction of further regional measures within the EU.

Climate change is forecast to give rise to an increase in frequency and severity of the winter storms in UK and Irish waters and ice-free summers in higher latitudes opening up previously un-navigable, but more efficient, shipping channels around the globe. In the longer term, rising sea levels could render some ports unusable and change the navigable approaches to others.

The GLA will therefore need to ensure that they are able to:

• Maintain an appropriate level of SOLAS and non-SOLAS service, even under extreme weather conditions

[2] EEDI https://www.marpol-annex-vi.com/eedi-seemp/
[3] IMO MBM http://www.imo.org/en/OurWork/environment/pollutionprevention/airpollution/pages/market-based-measures.aspx

- Mark the most direct route possible between origin and destination (including engaging in international initiatives such as Motorways of the Sea with such aims)

- Service and mark high density sea-lanes, such as the Dover straits, with special measures such as rapid response and virtual AtoN, to ensure high levels of safety and efficiency

- Ensure that the role of AtoN in marine spatial planning is properly recognised

- Continue joint work with IALA to ensure clear international approaches.

3. GLA MARINE NAVIGATION PLAN

3.1 Optimising the mix

In order to meet the varied user requirements, GLA AtoN provision must be considered in the context of an overall system of AtoN available in any particular area. The mix of AtoN provided within the system must meet user needs in differing weather and other environmental conditions, considering the type and density of traffic, the complexity of navigation, as well as technological developments.

The diversity of users must be considered. The mariner navigating using basic means will have totally different needs to that of a watch-keeper on the bridge of a modern cruise ship. The variety of navigation equipment and skills in use requires the GLA to ensure that the risk control measures provided by AtoN are comprehensive. The disparity between on-board equipment fit and competence amongst users is increasingly evident.

To meet obligations to deliver a reliable, efficient and cost effective AtoN service, the GLA must take account of the performance, vulnerabilities and likely evolution of external systems and on-board navigation aids relied on by each type of user. This includes monitoring and influencing developments in these external systems to resolve and manage potential future uncertainties, for example by providing integrity warnings. GLA furnished systems and services are provided as part of an optimised AtoN mix to ensure that the GLA meet their statutory obligations to provide services to all users as the volume of traffic justifies and the degree of risk requires.

This plan is based upon the GLA supporting the full range of AtoN available to deliver a flexible service that meets the needs of all users. This approach is the only way that service levels can be maintained in the context of a changing service provision environment. GLA systems will be deployed in particular areas in a way that balances cost, risk and service levels, taking into account external services and on-board systems.

GLA Marine Navigation Plan

3.

3.2 The overall mix

The following chart shows the overall AtoN system mix currently available to maritime users (green text) around the coasts of the UK and Ireland. It also shows future systems (red text) that have reached a high level of technological maturity and are expected to become available in the short to medium term. The systems are classified as electronic or visual aids; as GLA-provided, external or on-board. External systems are those not provided or operated by the GLA, although the GLA has an interest or involvement in some cases to promote mariners' effective use complementary to AtoN services.

	GLA systems	On-board systems	External systems
Electronic aids	Radiobeacon DGNSS AIS as an AtoN Racons Radar reflectors Virtual AtoN eRacons Met/Hydro Navigation data provision Maritime Service Portfolios	Radar ECDIS S Mode AIS Astro-navigation Dead reckoning via speed log & gyrocompass Bathymetry Multi-system receiver VDES Inertial navigation ePelorus	GNSS • GPS • GLONASS VTS Further Constellation GNSS • Galileo • BeiDou EGNOS Maritime Connectivity Platform Communication infrastucture eLoran
Visual aids	Lighthouses Beacons Major floating aids Buoys Day marks	Paper charts Pelorus Sextant	Visual Aids provided by Local Lighthouse Authorities • Lighthouses • Beacons • Major floating aids • Buoys • Day marks

GREEN: Current systems
RED: Potential future systems currently technically proven or with a high level of technical maturity for marine AtoN applications

Descriptions and the status of the main systems listed above are provided and regularly updated on the GLA Research and Radionavigation Directorate (R&RNAV) website [4.]

4. GLA SYSTEMS

The AtoN systems currently provided by the GLA, by means of physical infrastructure (such as lighthouses and major floating aids) and electronic infrastructure (such as radiobeacon transmissions), are:

- Lighthouses – lights; many also include other aids
- Major floating aids (MFA), including light vessels (LV)
- Buoys
- Sectored lights and Precision Directional Lights (PDL), horizontally de-limited to mark safe passage limits
- Beacons
- Day Marks
- Audible (sound) signals – for hazard warning
- Radiobeacon DGNSS
- AIS as an AtoN (including transmissions of Synthetic AIS AtoN from another location, and of virtual AtoN for temporary marking of a hazard) and AIS transmission of Met/Hydro data
- Radar Beacons (Racons), actively responding to ship's Radar
- Radar reflectors (passive) - included with some other physical AtoN.

In addition to their direct AtoN role, there is potential for the GLA AtoN platforms, infrastructure and communications networks to contribute to coastal monitoring, communications and other services.

4.1 Lighthouses

Lighthouses are currently a vital part of the mix of AtoN provided by the GLA. They will continue to play an essential role in providing:

- inshore and channel navigation
- spatial awareness
- back-up for GNSS
- marking of dangers
- hosting sector/leading/directional lights, AIS base stations and other AtoN.

User consultation indicates that for some mariners the use of lighthouses for landfall and waypoint navigation will continue to change. Over the period of this plan, some lighthouses will have an enhanced role in future, providing a platform for additional services, including:

- environmental data collection
- electronic navigation services.

4.2 Beacons

Beacons range from pole beacons to substantial, lighted structures providing leading lines, hazard and channel marking. They remain important for local and inshore channel marking. User consultation indicates that with increased leisure traffic the demand for beacons will grow.

4.3 Major floating aids

Traffic separation schemes, offshore to hazards (such as shoals) and areas of high traffic density may require AtoN of enhanced range and conspicuity. This will continue during the period covered by this plan. Currently, enhanced range and conspicuity are provided by Light Vessels (LV) and Light Floats.

Advances in technology and equipment design may eventually allow the phased replacement of these aids with more efficient and cost-effective alternatives, but not in the period covered by this plan. Whilst progress has been made in this area, a gap still exists between the level of service provided by major floating aids (MFAs) and the largest buoys available. With investment in research and development, it is believed that the operational performance of buoys may, in the longer term and in some cases, meet user needs. Consideration must be given to the visual conspicuity of MFA and the effectiveness of alternatives as a daymark.

4.4 Buoys

Buoys are essential in providing the mariner with visual orientation, spatial awareness and waypoint, channel and hazard marking. This requirement will not change significantly in the near term. The GLA are committed to light, or discontinue, unlighted buoys (with the exception of a few minor floating aids) during the period of this plan.

Taking into account the requirements of users, additional equipment can be added to buoys to provide enhanced services such as the synchronisation and sequencing of lights, transmission of AIS and Met/Hydro, and environmental data collection.

4.5 Day marks

An important property of visual AtoN is their ability to assist distinction and identification during daylight hours. This may be provided by painting areas of structures conspicuously, by providing recognisable shapes, patterns, signage or other means of identification. The requirements for day marks will change when considering the range from which the AtoN needs to be recognized.

4.6 Audible (sound) signals

In accordance with IALA policy, GLA may provide audible signals (also referred to as sound signals) only for hazard warning and if justified by the rate of occurrence of low visibility conditions. These hazards are certain man-made structures (such as offshore installations) and isolated AtoN. Audible signals should have a range of at least 2 nautical miles and a backup audible signal may be provided (for which a usual range of 0.5 nautical miles is considered adequate).

GLA role relating to lighthouses, MFAs, beacons, buoys, day marks and sound signals
- Monitoring the evolving user requirements for lights
- Evaluating emerging technology and potential solutions including power generation and storage
- Supporting the international standardisation processes
- Keeping effective maintenance records to monitor life of light sources and their degradation
- Maintaining effective measurement systems
- Exploiting developments in light sources (especially LEDs) to improve the performance and cost effectiveness of visual AtoN
- Monitoring possible developments in optics for cost-effective performance
- Modelling the properties of visual AtoN to select appropriate solutions for enhancing conspicuity, taking into account atmospheric conditions and background lighting
- Improving the environmental impact of our AtoN
- Continuing a common, risk-based approach to service levels for visual AtoN
- Contributing to continuing national and international discussions on the development of visual AtoN, their deployment and measurement.

4.7 Radiobeacon DGNSS

Radiobeacon DGNSS remains the accepted means of providing immediate system-level integrity warnings of GNSS malfunction to maritime users. It is defined internationally with global standards and regional harmonisation of frequencies through IALA and ITU.

The GLA are likely to continue to provide a DGNSS service over the period of this plan. In addition to monitoring the performance of GPS, DGNSS may eventually be developed to monitor Galileo, GLONASS and BeiDou. Consideration should also be given to the potential for integration of EGNOS information into the existing DGNSS infrastructure to offer users increased service levels at little additional overall cost to the maritime industry.

However, the requirements of the GLA DGNSS service will likely be affected by developments in other GNSS integrity sources for mariners, such as Advanced Receiver Autonomous Integrity Monitoring (ARAIM) and future versions of EGNOS. To ensure that the GLA DGNSS service continues to provide comprehensive and cost-effective augmentation, the GLA will examine carefully whether the availability of multiple GNSS constellations, together with GNSS integrity sources, provides an opportunity for rationalisation of the DGNSS network beyond 2025.

GLA role relating to radiobeacon DGNSS
- Review the long term programme of radiobeacon DGNSS system development and upgrade, taking into account the availability of new GNSS signals/services and the evolution of user equipment
- Seek opportunities for potential radiobeacon DGNSS system rationalisation from 2025 onwards whilst keeping pace with the evolving user requirements for reliability and integrity and considering other potential uses - such as R-mode (if technically feasible)
- Determine the technical feasibility, policy implications and commercial business case supporting the integration of radiobeacon DGNSS and EGNOS.

4.8 AIS as an AtoN

AIS technology can significantly enhance and complement existing AtoN. In particular, AIS technology can be used in the following ways:

- To provide AtoN identity, position and AtoN status confirmation to the mariner

- As Real AIS on an existing AtoN

- A Real AIS AtoN may also be transmitted on behalf of an existing AtoN from another location (synthetic)

- As Virtual AIS AtoN, where no physical AtoN exists, for example for use in emergency wreck marking prior to deploying buoys

- To broadcast AtoN monitoring information to the service provider

- To facilitate traffic analysis by AtoN providers to assist in the provision of the appropriate level of service and mix of AtoN

- To provide Met/Hydro information or other data to the mariner or service provider.

As AIS develops as an integral component of the VHF Data Exchange System (VDES), the GLA will seek to exploit all AIS potential benefits to enhance their service delivery to the mariner by applying AIS technology to selected AtoN. The use of AIS as an AtoN should have a direct and positive impact on the efficiency of service provision. Under certain circumstances, AIS may provide an appropriate alternative to permanent or temporary physical AtoN.

GLA role relating to AIS as an AtoN
- Employ AIS as an important component of the AtoN mix
- Liaise with other stakeholders to reduce the risk of misuse
- Liaise with other AIS stakeholders on AIS infrastructure, operation and service provision and, in particular, work closely alongside the MCA and IRCG to maintain the necessary inter-agency service level agreements
- Enable an operational AIS virtual AtoN service
- Continue involvement in the development of relevant standards through IMO, IALA, IEC and ITU
- Provision of additional data through AIS
- Monitor the development of new and evolving AIS and related technologies, such as VDES and assess their ability to support new value added AtoN services to the user.

4.9 Racons

Users continue to place a high importance on Racons as an integral part of any AtoN system particularly at night, in reduced visibility and adverse weather conditions. In response, the GLA recognise the importance of Racons in the overall service provision mix and their role in satisfying the needs of specific users. The GLA understand that the requirements for Racons are likely to evolve if Radar positioning using map-matching emerges and Racons are used as inputs to the position solution, especially in featureless areas, and as an integrity check.

The GLA consider Racons a very important element of the AtoN system mix since they provide an independent means of identifying and locating marks in poor visibility and without reliance on GNSS.

IMO MSC79 approved new Radar performance standards in Resolution 192(79) that removed the requirement for S-Band Radars to trigger Racons. This was intended to facilitate the introduction of so-called "new technology" (NT) to improve detection of small targets, performance in clutter and to enable future Radars to meet the more stringent limits being imposed on spurious and out of band emissions.

GLA trials have shown that an improved specification of Racon could operate satisfactorily with an NT Radar and that specification has now been adopted internationally. Racons fully compatible with new Radar technologies could be developed, but there are currently no industry standards or recommendations for these "new technologies".

GLA role relating to Racons
- Continue to deploy and operate Racons where required
- When providing new or replacement Racons, use specification compatible with NT Radar
- Continue to monitor developments in radar technology and support specific studies or trials as required
- Continue to liaise with appropriate national and international bodies and Racon manufacturers, as required, to investigate solutions and ensure that the mariners' requirements are met
- Explore the potential for absolute positioning using enhanced radar AtoN and additional processing facilities on radars, including map matching. In particular, monitor the developments in radar position fixing to understand the impact on Racon requirements both in terms of capability and the number and geometry of Racons required
- Encourage implementation of the international strategy for the future of Racons agreed by IALA (based on GLA input).

5. ON-BOARD SYSTEMS

A number of on-board navigation systems are currently available or could be envisaged over the time period to 2030. In addition to traditional navigation instruments, such as the magnetic compass, sextant, the pelorus and paper charts, there are several on-board electronic systems currently in use:

- Radar, used as a collision avoidance tool and also for navigation by taking range and bearing, parallel indexing or triangulating Radar responses, from objects of known position

- Gyrocompass and GNSS heading device to provide heading, bearings and an indication of the rate of turn

- Speed log, which together with the above, provides an established means of Dead Reckoning

- ECDIS, capable of continuously portraying a vessel's position in relation to land, charted objects, Aids to Navigation and unseen hazards. ECDIS also incorporates a Dead Reckoning (DR) facility to "coast" for short periods during outages of other navigation systems. The Radar overlay function is an essential feature of the ECDIS system which may be used to cross check ECDIS position accuracy.

- AIS, as an on-board system operated independently of or in conjunction with shore-based AIS base-stations that provides information on vessels/AIS targets within the vessel's vicinity aiding situational awareness. Met/Hydro information can be transmitted to vessels by shore-based AIS.

- Bathymetry, where echo soundings are taken from the sea bed and matched to charts to contribute to the determination of position. This type of navigation requires there to be suitable features on the sea-bed for recognition and for the sea bed terrain to be relatively static (e.g. free of highly dynamic shifting shoals).

In order to provide the optimum AtoN mix and to understand how on-board systems will continue to impact on this mix, the GLA need to maintain a watching-brief on the developments of on-board systems and technology, including:

- Multi-system receiver, combining multi-constellation GNSS with complementary backup (including terrestrial) positioning systems

- Inertial navigation (and its integration with positioning systems), including low-cost Inertial Measurement Units and, in the longer term, Quantum Technology inertial devices

- VHF Data Exchange System (VDES), extending VHF communications to and from ships with data rate capability up to 32 times that of AIS

- ePelorus, providing digital visual fixes and their integration into electronic bridge systems.

GLA role relating to on-board systems
- Monitor the on-board use of AIS as an AtoN
- Understand and influence how GLA data are used in and with on-board systems (including ECDIS, inertial navigation and e-Navigation services) to avoid the risk of misuse and to expand GLA data provision, as needed
- Influence the development of the multi-system receiver and ensure that GLA services are consistent

6. EXTERNAL SYSTEMS

6.1 GNSS

GNSS currently comprises GPS and GLONASS. The European constellation, Galileo, achieved initial operational services in 2016; it and the Chinese system, BeiDou, are expected to be fully operational by 2020. These four systems have been recognised as components of the World-Wide Radio Navigation System (WWRNS) by the International Maritime Organization (IMO) and will ultimately provide signals from over 100 satellites, for use within suitable receivers.

At present, GPS is the principal means of position fixing used by all classes of mariner in ocean and coastal navigation. The GLA believe that this will remain true until at least 2020, when other systems such as Galileo may become more common parts of the mix. General reliance on GPS leads to a single point of failure. In the longer term, even though more satellites and signals will be available, an increase in the number of available GNSS systems will only partially mitigate the risk of jamming, spoofing or interference, as all are subject to the same failure modes. GNSS vulnerability, therefore, remains a concern.

In addition, the provision of integrity information is important to allow the user to have confidence in GNSS positioning and navigation. In theory, this can be achieved through receiver autonomous integrity monitoring (RAIM) and in the future through a maritime version of Advanced RAIM (ARAIM) at the user level but there is uncertainty around the implementation of this in future receivers. There is a continuing role, therefore, for the GLA to monitor GNSS performance to understand the impact on their systems and provide warnings to users when AtoN performance is degraded. This role will be influenced in scope and timescale by the emergence of GNSS signals on additional frequencies and EGNOS maritime integrity services.

GLA role relating to GNSS
- Monitor the development and specification of new and emerging GNSS services in order to ensure that they meet the needs of the mariner
- Test and demonstrate these services when available to confirm that their performance is in line with expectations
- Continue to support the immediate development of GNSS on-board equipment standards, including the multi-constellation receiver, through IMO, IALA, CIRM, IEC and ITU. These should include generic software GNSS receivers that will enable an accelerated and more cost-effective uptake amongst users
- Monitor GNSS performance (possibly extending to additional frequencies beyond L1) and influencing factors, such as space weather, to provide timely integrity warnings of service degradation
- Co-operate with other UK & Irish critical infrastructure stakeholders to examine the feasibility of a common GNSS performance monitoring network by 2020.

6.2 EGNOS

EGNOS is the European Satellite-Based Augmentation System (SBAS) and is one of a set of similar regional systems providing services globally, albeit with some coverage gaps. EGNOS provides system integrity information on the health of the GPS constellation in real-time and corrections for improved GPS position accuracy. The information may be accessed directly from geostationary satellites via the signal in space or via the web-based EGNOS Data Access Service (EDAS), although there may be increased latency associated with the EDAS data.

The existing EGNOS was developed primarily as an aviation service, having been certified and declared operational for aviation use in 2011. A maritime service provision scheme using the existing system is being investigated by the EU agencies to provide integrity at system level for maritime GPS-based navigation. A future maritime EGNOS service may eventually also provide integrity at user level and extend the augmentation to dual frequency, multi-constellation GNSS. While EGNOS provides coverage of Europe, including the GLA service area, any development of maritime services and user equipage should be considered in conjunction with the other SBAS internationally.

EGNOS could have significant implications for the GLA DGNSS service, potentially reducing the requirement for beacon infrastructure but, conversely, providing opportunities for co-operation, collaboration and integration of EGNOS and DGNSS.

GLA role relating to EGNOS
- Monitor and contribute to the development and specification of EGNOS maritime services in order to ensure that they take into account and meet the needs of the mariner
- Co-operate with the EGNOS authorities and service provider to support its use in the maritime sector
- Work with international partners and standards bodies to support the wider use of SBAS in the maritime sector
- Determine whether at some point EGNOS could remove the requirement for Radiobeacon DGNSS or if there is a requirement for both systems
- Determine the technical feasibility, policy implications and commercial business case supporting the integration of DGNSS radiobeacons and EGNOS or their future complementary use.

6.3 Communications infrastructure

Future maritime communications infrastructure will likely include

- VDES, which will enhance maritime communication applications, based on robust and efficient digital transmission at a much higher rate of up to 32 times that achieved by current AIS
- NAVDAT, which in addition to NAVTEX information, will enable the transmission of digital forecast data, detailed VTS information, chart corrections and other enhanced services
- Terrestrial coastal broadband or satellite broadband.

GLA role relating to communications infrastructure
- Influence and demonstrate potential future components of the maritime communications backbone, notably VDES, as bearers for AtoN information and GLA e-Navigation MSPs.

6.4 Maritime Connectivity Platform

The Maritime Connectivity Platform (MCP) is defined as a carrier-independent communication framework enabling efficient, secure, reliable and seamless electronic information exchange between all authorised maritime stakeholders across available communication systems. If it is adopted, it could underpin e-Navigation and support the sharing of all types of maritime information, including navigation information.

GLA role relating to the Maritime Connectivity Platform
- Monitor and influence the development of the MCP.

6.5 eLoran

The prototype eLoran system operated by the GLA up to the end of 2015 was a technical success, meeting IMO navigation standards (for port and harbour approach) of accuracy, integrity, availability and continuity. It was shown to be a valid complement to GNSS, with suitably equipped ships reverting seamlessly to navigation by eLoran upon the loss of GNSS. As by-products, the service also successfully delivered prototype precise timing and a secure data channel, plus land navigation. However, the GLA activity to inform neighbouring countries' considerations of funding and delivering an eLoran maritime service was not successful. Those countries switched off their transmissions at the end of 2015 and some announced the dismantling of their stations.

As a system external to the GLA, the UK government continues to keep UK eLoran transmissions on the air and it is still providing a service in the UK, with the caveat that its current use is only for timing and data services, not position. A commercial entity has entered into negotiations with representatives of the North-West European countries with existing Loran sites: the UK, Norway, Denmark, Germany and France. As a result, some key transmitter sites in Europe may be preserved. The principal commercial driver for eLoran as an external system is understood to be the delivery of highly-precise timing for telecommunications, broadcasting, aviation, financial services and other applications. This will also include a secure data channel. Such an eLoran system, if further established with multiple transmitters, could eventually deliver a commercial maritime navigation service for UK and Irish waters, with a capability similar to that demonstrated by the GLA prototype system.

GLA role relating to eLoran
- Maintain contact with potential commercial operators and UK government in order to monitor the development of the eLoran business
- Be prepared to respond to an invitation to negotiate an agreement to participate in an eLoran maritime navigation service. Those negotiations could cover a range of degrees of involvement, especially in respect of differential Loran operation of coastal reference stations
- Seek to maximise the return on the investment the GLA has made in eLoran technology. One way to do so may be to provide commercial operators with GLA technical consultancy services for eLoran, gaining commercial income from use of GLA reserve capacity.

7. POTENTIAL FUTURE SYSTEMS AND RESEARCH

There are potential future AtoN systems, on-board systems and external systems that may influence the future components of the AtoN mix. The following chart outlines these technologies and systems. Many are currently immature and require considerable research. All need a level of technology monitoring by the GLA to determine their possible contribution to, or impact on, future AtoN.

	GLA systems	On-board systems	External systems
Electronic aids	Radiobeacon DGNSS eRacons/Enhanced radar AtoN Navigation data provision AtoN applications of VDES Maritime Service Portfolios R-mode Other terrestrial systems	Astro-navigation Calibrated DR via speed log & gyrocompass Automated bathymetry Multi-system receiver Inertial & integrated navigation ePelorus Autonomous vessel systems Maritime ARAIM Radar image map-matching Quantum Technologies	Multiconstellation GNSS Satelite Timing and Location (STL) Space Weather Alerts Maritime EGNOS Version 3 Maritime Connectivity Platform Communication infrastructure ARAIM Integrity Support R-mode (international service provision) Terrestrial signals of opportunity
Visual aids	Improved visual AtoN	Response of Autonomous vessels to visual AtoN	

GREEN: Evolution of current systems
RED: AtoN applications (or impact on AtoN) of potential future systems currently with a high level of technical maturity
BLACK: AtoN applications (or impact on AtoN) of possible future systems currently with the lower level of technical maturity

Potential Future Systems and Research

7.

7.1 GLA Systems

7.1.1 Improved Visual AtoN

Changing requirements for marking and developments in lighting technology include advanced visual AtoN, sometimes called 'smart' lights. These may be:

*   responsive – switching on or increasing intensity when visibility reduces, vessels are detected or vessels send a request

*   sequenced and/or synchronised lights - indicating direction or improving spatial awareness in channels

*   enhanced conspicuity characters, including different flash shapes and flickering

*   light communications to provide additional information via the light itself.

GLA role relating to improved visual AtoN

*   Support and monitor the development of improved visual AtoN
*   Evaluate new technologies as they become available
*   Participate in the standardisation of improved visual AtoN.

7.1.2 Enhanced Radar AtoN

The GLA will consider the need for the deployment of enhanced Radar AtoN in support of on- board Radar image map-matching as a contribution to coastal navigation. This will possibly include enhanced Racons (introducing unique identification to their Radar response) to support the determination of the vessel's absolute position from the Radar image, in naturally featureless littoral areas where position-fixing would otherwise be difficult.

GLA role relating to enhanced radar AtoN

*   Contribute to and support the development of Radar map-matching navigation to determine the requirement for enhanced radar AtoN
*   Consider the availability of Radar mapping data (potentially provided using crowdsourcing), the provision of passive reflectors (possibly in groups to provide identification) and investigate the relationship between Radar map-matching and enhanced Racons.

7.1.3 R-mode

The GLA will co-operate with other interested nations in assessing and developing ranging mode (R-mode) technology, using AIS base stations and (if feasible) MF beacons.

GLA role relating to R-mode
- Co-operate internationally with other maritime authorities to develop and evaluate R-mode technologies.

7.1.4 Maritime Service Portfolios

The GLA will work with their international partners to define Maritime Service Portfolios (MSP) that will set out the operational and technical characteristics of e-Navigation services. This will help to match services to user requirements and identify the progression path and potential system design.

GLA role relating to Maritime Service Portfolios
- Support Government and IMO in e-Navigation development and standardisation for the benefit of all users
- Ensure that resilience of positioning, navigation and timing information is recognised as an essential element of e-Navigation and that its provision is addressed as part of the implementation strategy
- Investigate what AtoN information is required for e-Navigation to work correctly and determine the necessary role of the GLA
- Monitor and support the development of new communications technologies and assess their suitability to meet the GLA requirements in respect of e-Navigation
- Investigate additional benefits of e-Navigation for the GLA, including the provision of value added services to specific groups of maritime users
- Develop the GLA content of Maritime Service Portfolios in collaboration with other interested parties
- Contribute to the development of a Common Maritime Data Structure and the standardisation of data exchange through S-200
- Participate in the development and standardisation of information systems, such as the Maritime Connectivity Platform.

7.1.5 Navigation data provision

Future navigation (including e-Navigation MSPs) will be underpinned by the provision in real-time of supporting data, such as charts, route-planning decision support and weather data. Data exchange specifications are likely to be based on the International Hydrographic Office (IHO) S-100 Standard for geo-spatial information, leading to a Common Maritime Data Structure (CMDS). IALA is building a database of product specifications within the Registry. This data will be an important part of the future AtoN service mix and the GLA may have a contributory role in data gathering, data bundling into products and transmission of relevant products to the user.

GLA role relating to navigation data provision
- Identify data opportunities
- Contribute to a vision for navigation data service provision
- Co-operate in developing and managing AtoN data product specifications.

7.2 On-board Systems

The performance standard for the Multi-System Receiver (MSR) includes SBAS and Type Approved user equipment and is expected to become available around 2020. The future addition of multiple dissimilar systems (including terrestrial signals) in the MSR will further add to the resilience of maritime navigation.

In combination with multi-constellation GNSS and maritime ARAIM, integration of developments in individual technologies, such as inertial navigation, astro-navigation, bathymetry, calibrated traditional dead reckoning and, ultimately, quantum navigation, will likely contribute to high integrity and resilient navigation within the MSR. Fully autonomous vessels will be heavily reliant on such a capability, which could include the on-board systems that could provide appropriate responses to visual AtoN inputs.

GLA role relating to on-board systems
- Support the longer-term development of GNSS on-board equipment standards, including autonomous high-integrity operation (e.g. maritime ARAIM), reducing the need for augmentation systems
- Undertake horizon scanning, technology watch and performance assessment activities on developing technologies, including: bathymetric navigation, inertial navigation systems, astro-navigation and e-Pelorus within the context of the vessel's Integrated Navigation System (INS) and Multi-System Receiver.

7.3 External Systems

7.3.1   Maritime services of future EGNOS

In order that future EGNOS may provide maritime services with GNSS-based integrity at user level, research is needed to characterise the GNSS signals in the maritime operational environment and to establish the contribution of EGNOS integrity to the integrated navigation solution of the MSR.

GLA role concerning future maritime EGNOS service
* Influence the development of maritime services of future EGNOS in regard to the concept of integrity at user level when integrated in the MSR
* Support the characterisation of GNSS in the maritime environment, including effects of multipath and interference.

7.3.2 ARAIM

Maritime ARAIM, which could provide ships with ground measurements of GNSS clock and ephemeris errors in a rapidly updated ARAIM integrity support message, has the potential to realise high integrity maritime navigation.

GLA role concerning ARAIM
* Influence the development of maritime ARAIM including the use of ground measurements transmitted an integrity support message
* Investigate the transmission mechanisms for ARAIM potentially including Radiobeacon infrastructure.

7.3.3 Satellite Timing and Location

Satellite Timing and Location (STL) is a commercially available service which uses Iridium satellite signals to provide measurements related to the ship's position and velocity, which may contribute to the navigation solution through the vessel's Integrated Navigation System (INS).

GLA role concerning STL
* Support the investigation of STL measurements as a contribution to the vessel's INS, recognising the effects of vessel dynamics on STL performance

7.3.4 Terrestrial signals of opportunity

Navigating by using terrestrially broadcast signals of opportunity may determine position by making use of the hundreds of different signals that are available, such as digital audio broadcast (DAB), digital video broadcast (DVB), mobile telephone, WiFi and WiMax. This type of technology is under development and, if substantial technical challenges can be overcome, could find an application over the next ten years in the maritime domain, at least for navigation near the coast and in ports. Although it does not require any investment in shore-based infrastructure, it does require suitable on-board equipment and potentially suffers from some disadvantages, such as poor geometry in determining the position solution and lack of independence from GNSS, which is used to synchronise the broadcast systems. eLoran may also provide a terrestrial signal of opportunity should it be developed for other purposes and it could provide a source of UTC Time synchronisation of signals (independent of GNSS) for a number of terrestrial backup systems (e.g. R-Mode).

GLA role relating to terrestrial signals of opportunity
- Monitor developments in signals of opportunity technology and encourage research into the maritime use of digital TV (DVB-T2) signals, possibly alongside AIS R-mode ranging.

7.3.5 Space weather alerts

Space weather can severely disrupt GNSS navigation and AtoN service provision. Space weather 'nowcasting' services are likely to develop further in continuing to provide effective alerts to the mariner.

GLA role relating to space weather alerts
- Investigate the capability of space weather alerts to maximise their benefit to mariners and GLA services

7.3.6 Evolution of the MCP and communication infrastructure

Although early implementation of the MCP is ongoing, there will likely be long-term development and evolution over many years that may radically impact maritime operations and AtoN service provision.

GLA role relating to the long-term development of the MCP and communication infrastructure
- Monitor and influence the development of the MCP
- Encourage industrial participation in the provision of the MCP for the UK and Ireland
- Explore the possible contribution of future GLA infrastructure to the provision of comprehensive maritime communications.

8. DELIVERING THE PLAN

8.1 Implementation

This plan will be delivered through:

- Co-operation between the GLA – at all stages of the AtoN lifecycle (covering concept, requirements, design, development, test, operation, disposal, etc.) to ensure the provision of the required level of service

- Strategic participation in IALA – to ensure continuous representation of national interests whilst working alongside international partners

- Continuous Aids to Navigation Review - to ensure that the Aids to Navigation system effectively supports user needs, taking into account all potential changes in the service provision environment. This includes trends, types, volume and mix of traffic, local hazards, areas of traffic convergence/separation, environmental considerations and changes to other risk mitigation measures

- Consultation with User Groups - to ensure the level of service continues to meet their requirements, considering the balance between electronic and visual navigation and on-board systems

- International agreement on IMO e-Navigation – the GLA will work through IALA, MCA, IRCG, DfT, Transport Scotland, DTTAS, IMO and others to give their input and support to the e-Navigation initiative

- Application of the Risk Assessment principles - as laid down in IALA Guidelines - to understand better the vulnerabilities of the system mix and the redundancy required in systems and operations, incorporating explicit assessment and mitigation of evolving cyber security risks

- Participation in international projects – in order to ensure that the GLA actively influence and monitor those activities that directly impact upon their strategy.

- Continuing contribution to developments in maritime technology – to ensure future and current Aids to Navigation service provision remains relevant and compliant with international standards where appropriate

- Continuing contribution to the development of international standards and recommendation for AtoN

- Continued and closer co-operation with the MCA and IRCG

- Promotion and communication of the GMNP – to ensure that users, national stakeholders and international partners are fully aware of future service provision up to 2030.

8.2 Planning for Change

This plan reflects the level of service the GLA will provide to all users, taking advantage of technological and operational improvements anticipated in Aids to Navigation service provision. However, there are other developments in the external environment, many of which have been discussed in Section 2 that will directly impact the level of service in the future.

As outlined in the GLA Marine Aids to Navigation Strategy "2030 – Navigating the Future", this overall plan will evolve to reflect progress made at international and national level in any or all of the following areas:

• Inter-body agreements between IMO, IHO, IALA, ITU and other organisations on e-Navigation and any subsequent changes to mandatory carriage requirements

• Anticipated timescales for the implementation and operation of new GNSS services

• Development and implementation of terrestrial backups to GNSS

• A network of AIS stations around the coast that facilitates implementation of AIS as an AtoN, and as an emergency wreck marking system by stakeholders such as the GLA; as well as providing the all-important traffic data to inform the risk management process that determines the deployment of AtoN

• Potential consideration of measures that direct traffic in high density and high-risk areas, potentially leading to some degree of sea-traffic control, with consequent changes in the provision of AtoN and Vessel Traffic Services accordingly

• The carriage of multi-system navigation receivers by SOLAS and non-SOLAS Vessels to ensure that all mariners have an improved position-fixing capability, with the required availability of complementary electronic and visual AtoN.

9. OUR COMMITMENT TO THE USERS

The GLA will:

- Work closely with each other to maximise benefit and positive impact
- Consult regularly with users through the Joint User Consultative Group, individual consultative committees and local user groups, to understand their needs, inform them about developments and consider their views, to improve services for all classes of mariner
- Engage with other maritime service providers in the UK and Ireland to ensure a co- ordinated approach to safety of navigation in GLA areas of responsibility
- Work with local lighthouse authorities and neighbouring littoral states to ensure that users receive an effective and seamless service
- Provide a stable and resilient AtoN service for general navigation that meets international standards, recommendations and guidelines
- Respond to wrecks, new dangers and AtoN casualties in a timely fashion to minimise the risk to users
- Engage with international organisations, government and other bodies to promote the harmonisation and standardisation of AtoN services
- Explore new developments that may improve the effectiveness and efficiency of the service provided
- Ensure that through constant review the AtoN mix is relevant, reliable and cost effective
- Conduct their activities in a way that minimises impact on the environment.

This GLA Marine Navigation Plan describes how the GLA will adapt in the face of a changing service environment, thereby optimising service provision in terms of cost, risk and service level.

When delivered, this Plan will mitigate risk in providing for the safety of navigation, the protection of life, property and the marine environment.

As this Plan is implemented, the GLA will continue to provide services cost-effectively, maintaining their track record of success and delivery of their shared mission statement:
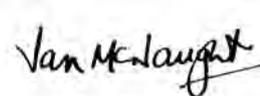
"To deliver a reliable, efficient and cost-effective Aids to Navigation Service for the benefit and safety of all mariners"

....
IRISH LIGHTS

....
NORTHERN LIGHTHOUSE BOARD

....
TRINITY HOUSE

Girdle Ness Lighthouse - ONE OF THE UK DGPS REFERENCE STATIONS

GLOSSARY

AIS	Automatic Identification System
ARAIM	Advanced Receiver Autonomous Integrity Monitoring
AtoN	Aid(s) to Navigation
CIRM	Comité International Radio-Maritime
CMDS	Common Maritime Data Structure
DAB	Digital Audio Broadcast
DfT	Department for Transport (UK)
DGNSS	Differential Global Navigation Satellite System
DGPS	Differential Global Positioning System
DR	Dead Reckoning
DTTAS	Department of Transport, Tourism And Sport (RoI)
DVB	Digital Video Broadcast
ECDIS	Electronic Chart Display and Information Systems
EDAS	EGNOS Data Access Service
EEDI	Energy Efficiency Design Index
EGNOS	European Geostationary Navigation Overlay Service
eLoran	enhanced LOng RAnge Navigation System
ENC	Electronic Navigation Chart
ESA	European Space Agency
EU	European Union
GLA	General Lighthouse Authorities of the UK and Ireland
GLF	General Lighthouse Fund
GLONASS	GLObal NAvigation Satellite System
GMNP	GLA Marine Navigation Plan (This Document)
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GRNP	GLA Radio Navigation Plan
GSA	European GNSS Agency
IALA	International Association of Marine Aids to Navigation & Lighthouse Authorities
IBS	Integrated Bridge System
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IHO	International Hydrographic Organization
IMO	International Maritime Organization
INS	Integrated Navigation System
IoM	Isle of Man
IRCG	Irish Coast Guard
ITU	International Telecommunication Union
LED	Light Emitting Diode

LV	Light Vessel
MBM	Market Based Measures
MCA	Maritime and Coastguard Agency
MCP	Maritime Connectivity Platform
MFA	Major Floating Aid
MNP	Marine Navigation Plan
MSI	Maritime Safety Information
MSP	Maritime Service Portfolio
MSA	Merchant Shipping Act
NAV	Navigation
NAVDAT	NAVigation DATa
NAVTEX	NAVigational TelEX
NDPB	Non-Departmental Public Body
NLB	Northern Lighthouse Board
NT	New Technology
NWC	Nairobi Wreck Convention
PNT	Position, Navigation & Timing
R&RNAV	(GLA) Research and Radionavigation Directorate
Racon	RAdar BeaCON
RAIM	Receiver Autonomous Integrity Monitoring
R-Mode	Ranging Mode
RoI	Republic of Ireland
RTCM	Radio Technical Commission for Maritime Services
SBAS	Space-Based Augmentation System
SOLAS	Safety Of Life At Sea
STL	Satellite Timing and Location
TEU	Twenty foot Equivalent Unit
TH	Trinity House
UK	United Kingdom
UKHO	UK Hydrographic Office
UNCTAD	United Nations Conference on Trade and Development
UTC	Universal Time Coordinated
VANP	Visual Aids to Navigation Plan
VDES	VHF Data Exchange System
VHF	Very High Frequency
VTS	Vessel Traffic Services
WiMAX	World-Wide Interoperability for Microwave Access
WWRNS	World-Wide Radio Navigation System
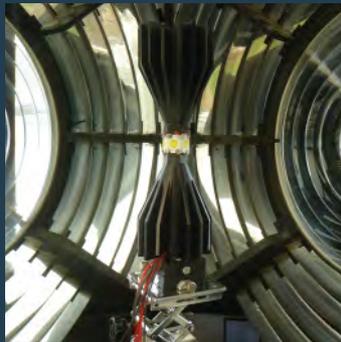
MARINE NAVIGATION PLAN
2016 to 2030

Produced by the
General Lighthouse Authorities of the
United Kingdom and Ireland

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