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Resilient Position, Navigation & Timing (PNT)

Summary of Business Case considering options for alternative positioning

Introduction

This document summarises the results of a study by the General Lighthouse Authorities of the United Kingdom and Ireland (GLA) on options for Resilient PNT, their effectiveness and the economic benefits that will derive from the improved management of maritime Aids-to-Navigation (AtoN).

Study of options identified for alternative positioning

Options for the future of maritime AtoN within an e-Navigation environment have been developed for a study in the British Isles, through a series of workshops with prominent national experts in the fields of maritime systems and navigation.

Four options were identified, which were credible within the timescale for the introduction of e-Navigation and these are described in the following sections.

The number of physical AtoN required to support each option was based on existing navigational requirements. It was recognised that changing traffic patterns could result in an increase in the number of short range aids to navigation.

Option 1 'Do Minimum'

The first option represents a broad continuation of the current AtoN provision, using existing approaches and technologies to mark hazards, channels and traffic separation schemes. In this option IMO's e-Navigation concept is assumed to be implemented as expected by 2018-2020 and is predicated upon existing technologies. It is expected that the majority of SOLAS vessels will be equipped with standards-compliant ECDIS by 2018 and will, over time, install New Technology (NT) radar systems and multi-constellation GNSS receivers, as their existing equipment needs replacing. This approach will provide minimal improvements to PNT resilience.

Option 2 'Maximise Current Infrastructure'

The second option recognises the current trends in maritime radar equipage and assumes an expansion or enhancement of the physical AtoN infrastructure to support a fallback mode based on radar positioning. It is assumed that e-Navigation is implemented by 2018-2020; all SOLAS vessels are equipped with ECDIS by 2018 and multi-constellation GNSS receivers over time. NT radar systems will be installed by 2018 and will be capable of supporting vessel absolute positioning in the coastal and harbour environment, providing position to the ECDIS for use in the event of a loss of GNSS position. This would require some cooperative action on the part of radar manufacturers, possibly stimulated by regulatory changes.

Recognising the dependence of users upon GNSS-based navigation, some initiatives would be taken by shore-based authorities to mitigate the risk as the mariner navigates closer to danger due to misplaced confidence in vulnerable GNSS:

1. The first would be to deploy an enhanced infrastructure of radar AtoN (corner reflectors or target enhancers) at appropriate charted points around the coastline, to support NT radar positioning as a key component of integrated navigation that provides resilient PNT for e-Navigation.

2. The second activity would be to extend the introduction of new physical AtoN such as synchronised lights and to take measures to enhance the conspicuity of lights.

As well as additional marks for expanding offshore installations for renewable energy, marking of new channels, hazards and traffic separation schemes may be necessary. Position-fixing resilience may be improved by this approach; however the timing element of the PNT service, which is a critical input for many on board systems and for some AtoN, remains vulnerable and it is noted that the use of GPS time stamping continues to grow.

Option 3 'Hardened GNSS'

The third option represents a concerted effort to reduce the risks of complete dependence upon GNSS by the maritime community for the implementation of e-Navigation. Actions would be undertaken to protect the GNSS infrastructure against the effects of interference (so-called 'hardening'). This would include installation of multi-constellation GNSS receivers, incorporating more robust testing for the effects of interference, with alerting when interference is detected. Anti-spoofing methods would also need to be developed.

Recognising this dependence on GNSS based navigation, the infrastructure would need upgrading, enhancing the capabilities of augmentation systems to support multiple GNSS systems/additional frequencies. There would also need to be support for the standardisation of more robust user GNSS receiver equipment and its safe integration into future bridge systems.

This option would require action from maritime authorities and telecommunications regulators to ensure adequate means to deter, detect and respond to GNSS interference events. Reversionary procedures would need to be developed by maritime authorities, VTS operators and shipping organisations, through IMO, for mariners in the event of potentially hazardous GNSS interference. PNT resilience would be significantly improved in the longer term.

Option 4 'Implementation of a terrestrial PNT (in this case eLoran)

The fourth option represents the provision of an alternative terrestrial position-fixing system by maritime authorities, complementing GNSS to ensure resilient PNT. This option assumes that the IMO's e-Navigation concept would be implemented as expected by 2018-2020 predicated upon robust PNT sourced from GNSS and eLoran. It is also assumed that all SOLAS vessels will be equipped with multi-system (integrated eLoran/GNSS) receivers by 2020.

eLoran implementation activities would lead to Full Operational Capability in 2018. This would ensure a resilient PNT service for harbour and coastal operations around all coastlines where 'the volume of traffic justifies and the degree of risk requires' (SOLAS Chapter V).

The study assumes that, as a consequence of the reliability of PNT and the resulting robustness of e-Navigation, Option 4 makes it possible for shore-side authorities to rationalise their lights infrastructure. Any lights selected for withdrawal would be based on sound navigational principles. Remaining lights would be replaced using low cost technology, independently mounted, or mounted on existing structures if a day mark is required. These changes could result in substantial income and savings.

Economic appraisal of options

The approach taken to the economic appraisal was to perform a discounted cash flow analysis of the costs and benefits of each individual option. Comparisons were then made to the 'do minimum' option (Option 1). This required the identification and valuation of all of the relevant costs and benefits that fall to all of the maritime stakeholders within each option.

The economic appraisal includes costs for the upgrade and extension of the existing eLoran infrastructure in the British Isles.

A conservative approach was taken to evaluate the economic case so that the results were credible for all options. In this connection, the main economic benefits were assumed to be the possibility of reducing the provision of physical AtoN (lighthouses and buoys) as a result of confidence in the resiliency of electronic position-fixing (Option 4). Estimates of savings associated with the removal of lights incorporate the conservative assumption that the overall cost of provision of lights (capital, operational and overhead costs) would be subject to efficiency savings (2.5% p.a.) irrespective of the option pursued. In some of the options, the primary benefits arise from avoided expenditure. These costs and benefits were valued over the transition to, and the minimum lifetime of, the eLoran service. The timing of the costs and benefits was established and the resulting figures discounted.

Subsequently the Net Present Value (NPV) of each option was ascertained. This enabled comparison with the ‘do minimum’ option. A number of parameters (costs, benefits and timing) were varied in order to understand the sensitivity of the results to specific assumptions.

General assumptions

It was assumed within a number of options that the maritime users equip with new capabilities in order to receive the benefits of e-Navigation. It was assumed that only those costs incurred specifically due to each option were to be valued. For example, ECDIS equipage was assumed across all scenarios (including the ‘do minimum’ option) and was therefore not valued.

Widespread fitting of enhanced equipment was assumed, in order to enable the full benefits of e-Navigation. In practice this would mean that most vessels transiting the waters in which e-Navigation is implemented as well as those making port calls, would have the required equipment. The appraisal has not attributed the costs of equipage of all international maritime users in this study, which was carried out for a limited region.

In addition, the full cost of new equipment was not attributed. Instead, the analysis used the cost delta between the basic capability that the vessel owner would ordinarily equip with and that of the more advanced receiver. The cost delta per receiver was estimated to be £200 for multi-constellation GNSS and £500 for eLoran/GNSS on SOLAS vessels and £100 and £250 respectively on non-SOLAS vessels. This figure was assumed to decrease over time until in 10 years’ time there would effectively be no cost delta as the new receiver becomes the de facto standard. This model is based on experience of the cost profile of GPS receivers as new capabilities are introduced.

Preferred option on economic grounds

The economic analysis of the four options developed within the business case process resulted in only one option (Option 4) that produced a positive NPV over the duration of the analysis. Furthermore, neither of the other options resulted in a better NPV than the ‘do minimum’ option.

The study concluded that the preferred option on purely economic grounds would be Option 4 (Maritime eLoran). The benefit-to-cost ratio of the preferred option was in excess of 2:1. Sensitivity analysis of Option 4 showed that the benefits are robust to significant changes in its underpinning assumptions. It is not particularly sensitive to variations in the cost of implementing eLoran, either the core system or the necessary vessel equipage. In addition, the likely extension of the system life beyond 10 years greatly enhances the overall benefits of the option.

Study Outcome

On the basis of the economic analysis, the net financial benefits and ongoing savings of implementing eLoran in the case of the British Isles would be substantial.