UK eLoran - Initial Operational Capability at the Port of Dover

Dr. Paul Williams and Mr. Chris Hargreaves,
The General Lighthouse Authorities of the United Kingdom and Ireland

BIOGRAPHY (IES)

Dr. Paul Williams is a Principal Development Engineer with the Research and Radionavigation Directorate of The General Lighthouse Authorities of the United Kingdom and Ireland, based at Trinity House in Harwich, England. He is the technical lead of the GLA’s eLoran Work Programme, and is responsible for the ongoing roll-out of the GLA’s eLoran Initial Operational Capability (IOC). He holds BSc and PhD degrees in Electronic Engineering from the University of Wales, is a Chartered Engineer, and a Fellow of the Royal Institute of Navigation.

Mr. Chris Hargreaves is a Research and Development Engineer with the Research and Radionavigation Directorate of The General Lighthouse Authorities of the UK and Ireland, based at Trinity House in Harwich, England. His work is focused on the GLA’s eLoran project in particular measurement trials, software development and data analysis. He holds an MSci degree in Mathematics and Physics from the University of Durham, and an MSc in Navigation Technology at the University of Nottingham and is a member of the Institute of Navigation and the Royal Institute of Navigation.

ABSTRACT

The General Lighthouse Authorities of the United Kingdom and Ireland (GLA) provide marine aids-to-navigation (AtoNs) for the benefit and safety of all mariners within their waters. These AtoNs include traditional lighthouses, buoys and various radionavigation systems.

Visual signalling by lights and buoys has for centuries played a crucial role in marine navigation close to danger. Its role remains vital in the future world of e-Navigation, a concept driven by the International Maritime Organisation (IMO) to harmonise, integrate and exchange maritime information, to enhance berth-to-berth navigation. However, GNSS (effectively GPS) has become the primary Aid-to-Navigation (AtoN) used by all professional and most other mariners. The vulnerability of GNSS to space weather and interference (unintentional and criminal jamming) means that a backup system is needed to achieve resilient Position Navigation and Timing (PNT) for e-Navigation. Though the probability of losing GNSS may be low, the consequential impact could be very high and maintaining an appropriate balance of physical and radionavigation AtoNs is vital for e-Navigation.

The GLA’s Research and Radionavigation Directorate has adopted a strategic objective to:

‘Demonstrate, promote and justify the benefits of GLA implementation of Resilient Position, Navigation and Timing and implement into Marine Aid to Navigation provision by 2018.’

Enhanced Loran (eLoran) is the latest in the longstanding and proven series of low frequency, LOng-RAnge Navigation systems. eLoran evolved from Loran-C in response to the 2001 Volpe Report on GPS vulnerability. It vastly improves upon previous Loran systems with updated equipment, signals, and operating procedures. The improvements allow eLoran to provide better performance and additional services when compared to Loran-C. In recent years the GLA have been pioneering the introduction of eLoran in Europe.

eLoran is an independent, dissimilar and complementary backup to GNSS and is the only credible and cost-effective option that, in the time available, can deliver e-Navigation’s urgently needed benefits of safety and security at sea and protection of the marine environment through the provision of resilient PNT information, taking over seamlessly when GNSS fails.

The GLA have deployed a new eLoran transmitter station at Anthorn in Northwest England; conducted successful GPS jamming and eLoran trials; and continues to work with International colleagues to promote eLoran’s maritime and non-maritime benefits. The GLA’s eLoran strategy is to extend their current trials; to continue building a European consensus in favour of eLoran; and to move towards UK eLoran Initial Operating Capability (IOC) in limited UK waters by mid-2014.

eLoran IOC will comprise Port Approach accuracy (10m 95%) level eLoran at several major ports on the east coast of the United Kingdom. This will include one upgrade of the already existing prototype service at Harwich/Felixstowe and up to six new installations; Dover, the Thames Estuary to Tilbury, Humber (Immingham and Hull), Middlesbrough, Firth of Forth (to Grangemouth) and Aberdeen.
The work of installing IOC level eLoran includes performing surveys of Additional Secondary Factor (ASF) data within each desired coverage area and the installation of a Differential-Loran (DLoran) Reference Station in the locality of each port. DLoran corrections will be broadcast using the Loran Data Channel – employing the Eurofix modulation scheme – implemented on the UK eLoran transmitter at Anthorn.

IOC will also include a DLoran Reference Station Monitoring and Control Centre based in Harwich. As of the time of writing a European tender process has almost been completed for the Operational Level DLoran Reference Stations and Monitor/Control Station.

IOC eLoran will provide areas for demonstrations and trials so that mariners can gain experience in using the service and allow them to understand the benefits that eLoran can bring to the resilience and integrity of their operations. It is the aim of the GLA to complete IOC installation by the end of 2014.

This paper describes the work done by the GLA in installing IOC level eLoran at the Port of Dover and the northern part of the Traffic Separation Scheme (TSS) within the Dover Strait; a vital sea traffic pinch point allowing access to and egress from the North Sea Region via the English Channel.

Technical background is presented on the technology required for implementing eLoran in and around port approach areas. The overall architecture of the IOC level DLoran system is presented. We then focus on the implementation of eLoran in the Port of Dover approaches and the northern part of the Dover Strait TSS. The planning and performance of the Dover ASF survey is highlighted. Accuracy of the eLoran implementation is assessed through validation runs using a vessel passing through the region covered by the ASF map and served by the Dover DLoran reference station. A comparison is made between several ASF data post-processing methods using positioning accuracy performance as the quality measure. The processes outlined in this paper will be repeated at each of the other candidate eLoran IOC ports.

INTRODUCTION

The General Lighthouse Authorities of the United Kingdom and Ireland (GLAs) comprise Trinity House, The Commissioners of Irish Lights and The Northern Lighthouse Board. Between them, they have the statutory responsibility to provide marine Aids-to-Navigation (AtoNs) around the coast of England and Wales, all of Ireland and Scotland, respectively. AtoNs take many forms, from the more traditional lighthouse to radio navigation systems, including the use of new GNSS when they become available.

It is recognised that GPS, or more generally Global Navigation Satellite Systems (GNSS) have become the primary means of obtaining Position, Navigation and Timing (PNT) information at sea, and there is no doubt that GNSS will form the primary source of PNT for e-Navigation.

An aim of the International Maritime Organisation is to develop a strategic vision for e-Navigation, integrating existing and new navigational tools in an all-embracing system, contributing to enhanced navigational safety and environmental protection, while reducing the burden on the navigator. One of IMO’s requirements for e-Navigation is that it should be resilient - robust, reliable and dependable [1]. Requirements for redundancy, say the IMO, particularly in relation to position fixing systems, should be considered.

GPS/GNSS IS EVERYWHERE!

But GPS is vulnerable to intentional and unintentional interference [2, 3], while at the same time it is used in many ship’s systems, as shown in Figure 1.

![Figure 1 – GPS is used in many ship’s systems.](image)

Its output is displayed on the ECDIS; is transmitted to other vessels using AIS; is used to calibrate the gyro compass; in the RADAR; connected to the digital selective calling (DSC), its reported position transmitted at the push of the emergency button for search and rescue; the vessel data recorder; the dynamic positioning system; surveying equipment; the ship’s entertainment system for aiming the satellite dish and it even synchronises the ship’s clocks!

GNSS is also used in Aid-to-Navigation (AtOn) provision, for deploying buoys and lights, AIS transponders, AtOn position monitoring, and its precise timing capabilities are used to synchronise the lights along an approach channel to improve conspicuity [4].
SO WHAT TO DO?

In 2010 we followed the UK Treasury methods to produce the GLA’s eLoran Business Case [5, 6]. This comprehensive document presented and analysed various options for providing ‘Resilient PNT’ in UK and Irish waters. It was clear that if the GLA chose to implement eLoran it could rationalise its physical AtoN infrastructure, removing some lights and other physical aids, and on balance actually reduce costs by implementing eLoran. Indeed, compared to other possible resilient PNT options such as GNSS hardening, radar absolute positioning, increasing physical AtoN provision, eLoran would save the GLAs £25.6M over a nominal system lifespan of 10 years from the introduction of e-Navigation services in 2018 to 2028.

BUT LORAN IS OLD FASHIONED ISN’T IT?

What’s the difference between shiny new eLoran and the old, outdated, Loran-C system? Well, the core signal of eLoran is pretty much the same as Loran-C but tolerances have been tightened up. Things like carrier zero crossing points, half-cycle peaks, ECDs, transmission timing, signal power, signal availability, power supply resilience have all been upgraded taking advantage of improvements in technology allowing us to better appease the “four horsemen” of navigation: Accuracy, Availability, Continuity and Integrity.

SAM control is a thing of the past and eLoran transmitters are synchronised directly to UTC – this means that their times of transmission can be predicted. Having stations independently synchronised to UTC means that the mariner no longer has to rely on old fashioned hyperbolic navigation. Charts with hyperbolic lines of position on them are a thing of the past. A modern eLoran receiver works just like a GPS receiver, employing signals from all available transmitters in its position solution. With GPS those transmitters are moving in space, in eLoran the transmitters are fixed onto the surface of the earth.

Modern receivers are small (Figure 2), they use off the shelf, high performance processors; the receiver is written in software allowing a lot of flexibility.

Three transmitters are sufficient to give you position, 4 or preferably 5 signals are better for integrity. But for timing and frequency applications you only need one transmitter. The Anthorn station in the UK can cover the entire UK and Ireland with a radio signal that has stability enough to satisfy the Stratum 1 frequency source requirement for steering the clocks of telecom networks; and Anthorn has not even been upgraded to full eLoran standard yet!

One of the big differences between Loran-C and eLoran is that eLoran now has a data channel. Some of the Loran pulses of each pulse group are modulated so that data can be sent over the 100kHz signal. This allows service providers to send integrity alerts, and application specific data, like UTC time, and differential-Loran and DGPS corrections. In Europe this is implemented by the already internationally standardised Eurofix system [7]. A parallel can be drawn with GPS signals, which contain a navigation component (pseudorandom noise code and/or carrier phase) and modulated data. Some options for data channel technology are still evolving with 1500 bits per second demonstrated, and 3000bps possible. That may not sound very much to salt of the earth communications engineers, but for Loran it’s pretty impressive, especially when you consider prototype attempts at Loran data communications in the past have been limited to 30 to 250 bps.

MARITIME APPLICATION SERVICES

So, how do we apply eLoran to something like the maritime application of port approach? To do this it is important to remember that the receiver operates by measuring how long it takes a groundwave radio signal to travel over the surface of the earth. An eLoran receiver assumes that the world is made entirely of sea-water, for which it has a very accurate propagation model built-in. The receiver does not, and indeed cannot, know about any land along the propagation path; and land slows the signal down, perhaps by as much as a few microseconds over typical propagation distances.

So the service provider must survey the effects of the land masses in the area of coverage, the Additional Secondary Factors (ASFs) of all the stations, across the proposed service area are mapped. The ASF survey is a once-and-for-all task but it needs to be done, and the ASFs published. In the old days, hyperbolic lines would be “grid warped”, or tables would be published on paper for the navigator to enter values manually. But with modern eLoran receivers containing large amounts of memory, quite detailed ASF maps can be stored in the mariner’s receiver.

ASFs depend on the electrical conductivity of the surface over which the eLoran signal travels. The conductivity changes with the constitution and moisture content of the earth. This means that the ASF along a path varies over a period of time – perhaps by as much as a few hundred
nanoseconds over a year. Of course because the ASFs stored in a receiver are fixed a method is needed to correct for this temporal ASF variation. In order to monitor this variation, a reference station is installed close to the harbour, or point of use of the eLoran service. This differential-Loran (DLoran) reference station measures the temporal changes in the signals’ arrival times due to changing ASFs, transmitter variations and weather effects. The DLoran reference station performs the same task as a differential GPS reference station. Now, the phrase “reference station” conjures up images of expensive buildings, amenities, and hordes of personnel and associated support services. However, a DLoran reference station is a small box sitting in the corner of a room connected to a small eLoran receive antenna on the roof, and to the Internet. It sends differential corrections over the Internet to an eLoran transmitter, which then broadcasts them to the mariner’s receiver over the Loran Data Channel.

Note that a DLoran reference station does not transmit a radio signal, it does not need a transmitter itself, it uses the Internet and the eLoran signal to disseminate its real time data. The mariner uses the same eLoran receiver to receive both the navigation signal AND the differential corrections.

So the process is: map ASFs once; run a reference station; and broadcast corrections. That’s it! With good Signal to noise ratio and transmitter geometry 10m or better accuracy can be obtained.

MEASURING ASFS

The GLA have had the ability to measure ASFs for a number of years using a combination of commercial hardware (Figure 3) and bespoke software (Figure 4).

Figure 3 – Reelektronika ASF Measurement System.
*Picture courtesy Reelektronika.*

Figure 4 – GLA produced software for ASF survey, processing and validation.

The software, written in Matlab™, shows a real-time plot of the survey as it progresses. The ASF values are colour coded according to magnitude. The software can also process the ASF data once it has been measured, to get the best performance out of it. The real time capabilities of the software allow the determination of the quality of the data while aboard the ship, rather than having to wait until back in the laboratory. Statistical analysis of the data can also show where the ship should go to gather more data in a particular area.

Once the survey is complete, the software can be used to generate interpolated grids of ASF data – the most convenient and accurate form of ASF data storage.

It is important with any scientific or engineering measurement to establish the error on that measurement. The same can be said of ASFs, and so the software can calculate the error bounds on ASF measurements. This “ASF error” data can again be published in grid form alongside the ASF database. This allows it to be used as one component of an Integrity Equation, implemented within the mariner’s receiver, to calculate Horizontal Protection Levels (HPL).

After processing the ASF data should be validated by performing a harbour approach or other manoeuvre that requires a particular positioning accuracy. For this, the software can be switched to “Validation” mode. Once the validation is successful, the data can be output in a publication format (RTCM SC-127 format for example).

The plot in Figure 4 shows an ASF database for Harwich and Felixstowe, major ports on the east coast of the UK. Using this data and differential-Loran in the Harwich and Felixstowe approach provides 10m (95%) positioning accuracy.
UK ELORAN PROTOTYPE

This prototype eLoran system works alongside GPS. It has been in operation 24 hours a day since about May 2010. It is “prototype” since it demonstrates the concept of eLoran using signals from existing Loran-C stations in Norway, the Faroe Islands, Germany and France plus the UK’s station at Anthorn; see Figure 5.

These stations, together with ASF measurements and DLoran, can deliver a high-precision eLoran service in ports where 10-20 metre accuracy is needed, across the area enclosed by the green contour in Figure 6.

It is very impressive, yet the full availability and accuracy benefits of eLoran are still to come as these stations are eventually upgraded to full eLoran capability. And for the last year or so the GLA has begun to move beyond the confines of the Harwich and Felixstowe approaches and implement initial eLoran services in other regions around the GLA service area.

![Figure 5 – Relevant European Loran-C stations for prototype eLoran.](image)

INITIAL OPERATIONAL CAPABILITY

IOC involves upgrading the installation at Harwich and Felixstowe and installations in the approaches to another six of the busiest ports in the UK; Aberdeen, Grangemouth, Middlesbrough, Immingham, Tilbury and Dover. For each of these areas an ASF survey and a differential-Loran reference station will be required.

The corrections for these reference stations will be broadcast using the Anthorn Loran Data Channel. There is also the need for a Monitoring and Control System for the network of DLoran Reference Stations and it is envisaged that this will be based in Harwich. Figure 8 illustrates the architecture of the Initial Operational Capability system. The diagram shows the major components; eLoran transmitter; DLoran reference station network; monitor and control system. Also shown are the interfaces between the components, which provide not only operational data but also include the ability to monitor the integrity of the system. Also note that the Loran Data Channel is capable of supporting third party messaging applications using a client “logon” facility. This is already being done at Anthorn.

The European tender process for seven operational reference stations and the control system is almost complete.

The aim of IOC is to provide areas for demonstrations and trials, so that the mariner can gain experience of the system and its capabilities and provide feedback to the GLA on its performance.
ELORAN AT THE PORT OF DOVER

In the absence of the final operational reference stations it was decided by the GLA to perform an early implementation using prototype equipment that was already available at the GLA.

The choice for this early implementation was obvious, the iconic Port of Dover, a major port on the southeast coast of the UK, and the Dover Strait, is one of the busiest sea ways in the world – some 500 plus vessels travel through there each day on their way to or from the North Sea Region; Figure 10.

An ASF survey and a differential-Loran reference station would be required.
PORT OF DOVER ASF SURVEY

Planning the ASF survey started with a traffic analysis. Referring again to Figure 10, this is 28 days worth of historic AIS data in the Dover Strait, and the major traffic concentration areas can clearly be seen.

The next step is to prioritise the regions within that zone and estimate how much ship time will be required to perform the survey; Figure 12. For this early implementation interest was limited to the ferries travelling within this purple region, and the cargo and tankers travelling up and down the main parts of the channel. So the ferry routes, the harbour approach and the northern part of the traffic separation scheme (TSS) would be covered for IOC.

The next thing is to work out where to sail the survey ship. In order to make efficient use of ship time it is possible use knowledge of the physics of Low Frequency radio propagation and the expected spatial variations of the ASFs. So, for example, it was realized that the vessel could sail around the outer limits of the coverage area measuring raw data; see Figure 13. The middle of the area can be “filled in” by interpolating the measured data. This is possible in the region of the Dover Strait because the land surrounding the area and along the propagation paths from the transmitters to the prospective locations of the ASF measurement system is relatively flat and smooth and, therefore it is likely the ASF values also vary smoothly.

It is possible to obtain land-path data using an electronic coastline database. The amount of land along the propagation paths from the transmitters to the prospective locations of the ASF measurement system can be used to gain an estimate of the amount of surveying required. For example, in an area where the ASF value is expected to be flat over a wide region, the vessel perhaps only needs to visit one point within that area. On the other hand in a region of complex coastline variations like the west coast of Scotland or Norway, the spatial ASF variation is expected to be much greater and so more concentrated ASF surveying would be required. As the GLA moves towards Fully Operational Capability, effort will be put into resurrecting ASF computer modelling work [X], as the need for efficiency would become greater when implementing over a much larger area.

Figure 12 – Prioritising areas and calculating ship time.

Figure 13 – Proposed sailing routes for Port of Dover Approach ASF Survey.

Figure 14 shows the full set of ASF data the GLA collected for Anthorn. The ASF value varies from about 1.6μs in the north, to about 2.3μs in the southern part of this section of the Dover Strait. If ASFs were not used for Anthorn in this region, the mariner would experience a position error of about half a nautical mile or so.

ASF data is available for all of the transmitters likely to be used in the area; Anthorn, Lessay, Sylt and Soustons (see Figure 5).

The ASFs for Lessay, for example, are shown in Figure 15. They exhibit lower values than Anthorn because there is less land in the propagation paths from the transmitter at Lessay to Dover than there is for the paths from Anthorn to the area (of course the “type” of land also affects the ASF value, manifested by its electrical ground conductivity).

As a last example, Sylt’s ASFs are shown in Figure 16. Of course this is raw measured data. It was mentioned earlier that interpolation is employed to fill in the gaps within the ASF measurement tracks. Those tracks were designed to make the best use of ship time, taking into account the expected variations in the data and the knowledge that interpolation is possible.

The data therefore needs to be processed before it can be published and disseminated for use within eLoran receivers.
The interpolation and extrapolation method used is not a simple linear interpolation, however, as that would likely result in inaccurate data. An interpolation method is required that takes into account the physics of Low Frequency radio signal propagation and the statistics of the measured data.

Several forms of interpolation were investigated, but the GLA settled on the so called “radial filter method” as providing the best accuracy performance (at least in this particular region).

The method employs a “radial” filter, an example of which is shown in Figure 18. This filter is convolved with the raw measured data along a radial direction from the transmitter across the ASF measurement area.
The filter has the effect of weighting strongly the ASF data that appears along a radial propagation path from the transmitter and less strongly the data appearing on parallel radial paths. This interpolation works very well and we would expect positioning accuracy on the order of 10m within the yellow region shown in Figure 19.

Extrapolation of data occurs outside the measurement tracks (yellow polygon), but it should be borne in mind that extrapolation is inherently more error prone than interpolation because there is less information available to “bound” the resulting values. However, even extrapolated ASF data can provide better positioning accuracy than no ASF data at all, at least up to certain limits!

Despite the issues with extrapolated data it is still desirable to publish any two-dimensional data set in a friendly, uniform format rather than an odd polygonal shape such as that shown in Figure 19. It is much better to publish uniform, rectangular grids of data.

It is possible however to satisfy both the seemingly contradictory requirements of extrapolated data and uniform grids. The service provider is encouraged to advise the mariner about the ASF measurement error associated with each region of the grid. For example, anywhere within the yellow polygon of Figure 19 we expect a certain amount of measurement error. Anywhere outside the polygon, but still within the rectangular ASF grid we can reasonably expect that measurement error to be higher; but not as high as that error which would be observed outside the rectangular ASF grid.

The GLA propose therefore that as well as an ASF map, an “ASF Quality Map” should also be published; see Figure 20. It is published at the same time, and in exactly the same format, as the ASF data, and it contains an error estimate on the ASF measurement at each grid location. So receiver manufacturers would need to provide twice the small amount of memory required for each ASF map.

The ASF Quality Map can be employed as a component of an integrity equation implemented within the mariner’s receiver. The aim of an integrity equation is to take into account the error budget for positioning and provide the mariner with an alarm (or several levels of alarm) should a computed Horizontal Protection Level (HPL) breach a preset Horizontal Alert Limit (HAL).

Figure 21 shows a simplified view of integrity (HPL) and serves to illustrate the relationship between positioning error and the errors on components used to form that position solution.

**ACCURACY PERFORMANCE VALIDATION**

Once the ASFs had been measured and the prototype reference station installed the performance needed to be tested. This was accomplished through a validation run of the vessel through the area.

Figure 22 shows a screenshot of the GLA ASF Measurement software running in validation mode. The coloured track shows the path of the vessel, with the colour indicating the positioning error compared to differential-GPS. The vessel travels through an area of extrapolated and interpolated ASF data, so the positioning error at the northern end of the track is higher than the lower end of the track.

Figure 23 shows a comparison of eLoran positioning against DGPS positioning along the route as a scatter plot. The associated Cumulative Distribution Function (CDF) is shown on the right of the diagram. From this it can be
seen that the positioning accuracy obtained along this particular route was 12.5m (95%).

Figure 22 – Screenshot of GLA ASF Measurement software running in validation mode.

Figure 23 – eLoran positioning accuracy scatter plot and Cumulative Distribution Function of positioning error. Accuracy: 12.5m (95%)

DOVER TO CALAIS FERRY INSTALLATION

Further validation and demonstrations will take place aboard a cross Channel ferry. The GLA has made an agreement with P&O Ferries in the UK to install a receiver aboard their £157M vessel, “The Spirit of Britain”. This relatively new vessel is one of the largest passenger ships to operate along the iconic Dover to Calais route. Data will be collected and feedback obtained on the eLoran service’s performance over the coming months.

OTHER AREAS

The GLA continue their work towards IOC level eLoran. Dover is the first port of call for the GLA’s eLoran Initial Operational Capability– the ASFs have been mapped and a prototype differential-Loran reference station has been installed. The final operational DLoran reference stations should be available this time next year.

Figure 24 – Medway in the River Thames Estuary is shown as the green dot.

The next area the GLA has concentrated upon is the Thames Estuary up to Tilbury. Although the GLA has not yet installed a permanent DLoran reference station, the ASF survey was performed in November 2012 using a temporary reference station installed at Medway; Figure 24. Along the route shown in Figure 25, a validation trial demonstrated 8.3m (95%) accuracy; Figure 26.

Figure 25 – ASF map validation route from the port of Medway heading out of the River Thames estuary.

Figure 26 - eLoran positioning accuracy scatter plot and Cumulative Distribution Function of positioning error. Accuracy: 8.3m (95%).
STATUS AND NEXT STEPS

The next steps are to continue the implementation of IOC eLoran at the remaining port approaches for this phase. It is the aim that all ASF surveys will have been performed by the middle of 2014 in readiness for the installation of the operational differential-Loran reference stations at each candidate port. Licence agreements are being established with the various port authorities involved in order to allow this.

All ports that have been approached are positive and are keen to assist in the GLA eLoran implementations. eLoran noise surveys have been performed at all ports and locations for all DLoran reference stations have been found.

Port of Dover has prototype eLoran up and running and so far has demonstrated 12.5m (95%) accuracy during the limited validation performed so far, however further validation continues aboard the Spirit of Britain ferry.

The Thames Estuary ASF Survey has been performed and 8m (95%) accuracy has been demonstrated in the area.

IOC level DLoran reference stations should be available mid-2014 ready for installation.

The methods and processes employed during the progress of this work will be proposed for inclusion within the next version of the eLoran receiver Minimum Performance Specification as determined by Radio technical Commission for Maritime Services (RTCM) Special Committee (SC) - 127.

These include the techniques and algorithms used for ASF measurement processing, the preferred ASF file format, and guidelines on the usage of ASF data.

SUMMARY

This paper has presented an overview of the work of the General Lighthouse Authorities of the United Kingdom and Ireland on the implementation of eLoran Initial Operational Capability (IOC).

The Port of Dover implementation is complete in prototype form, and is available for use by mariners equipped with a suitable receiver and ASF data.

The GLA is making good progress at other port approaches.

ACKNOWLEDGMENTS

The GLA acknowledge the assistance of the crew of ‘THV Alert’, the Dover Harbour Board, Peel Ports (Medway), Associated British Ports (Humber), Aberdeen Harbour Authority, Forth Ports, PD Ports (Middlesbrough).

REFERENCES


