eLoran – The Way Forward

Dr Sally Basker & Dr Nick Ward
General Lighthouse Authorities of the United Kingdom and Ireland
Prof David Last
Consultant to General Lighthouse Authorities of the United Kingdom and Ireland

BIOGRAPHY

Dr Sally Basker was appointed Director of Research and Radionavigation for the General Lighthouse Authorities of the United Kingdom and Ireland in 2005 and she is responsible for the research and development of physical and radio aids to navigation, support systems and their integration. Between 1997 and 2005 Dr Basker provided business and technology consultancy support to public and private sector clients. During this period, her responsibilities included: leading multi-national, multi-disciplinary teams; sales and marketing; programme management; and strategy development From 1990 to 1997, Dr Basker was involved in research and development in academia and industry including work on the US (GPS), Russian (GLONASS), and European (Galileo) satellite navigation systems and their augmentations. Dr Basker holds Ph.D and B.Eng(Hons) degrees from the University of Nottingham. She is a Fellow of the Royal Institute of Navigation, a Member of the US Institute of Navigation, a Director of the International Loran Association, a Member of the European eLoran Forum and a Member of the UK Department for Transport's e-Navigation Strategy Group.

Dr Nick Ward is Research Director for the General Lighthouse Authorities of the UK & Ireland, with responsibilities for radio-navigation and communications projects, including e-Navigation, as well as research & development strategy. He has been closely involved with the international standardization of Differential GNSS and AIS, is vice-chair of the IALA e-Navigation Committee, a Chartered Engineer and a Fellow of the Royal Institute of Navigation.

Prof David Last is a Consultant with the General Lighthouse Authorities of the UK & Ireland. He is a Professor Emeritus in the University of Wales, Immediate Past-President of the Royal Institute of Navigation and a Past-President of the International Loran Association.

1. INTRODUCTION

The International Loran Association (ILA) has summarised eLoran succinctly in the following three paragraphs [1]:

Enhanced Loran is an internationally standardized positioning, navigation, and timing (PNT) service for use by many modes of transport and in other applications. It is the latest in the longstanding and proven series of low-frequency, LOng-RAnge Navigation (LORAN) systems, one that takes full advantage of 21st century technology.

eLoran meets the accuracy, availability, integrity, and continuity performance requirements for aviation non-precision instrument approaches, maritime harbor entrance and approach manoeuvers, land-mobile vehicle navigation, and location-based services, and is a precise source of time and frequency for applications such as telecommunications.

..eLoran is an independent, dissimilar, complement to Global Navigation Satellite Systems (GNSS). It allows GNSS users to retain the safety, security, and economic benefits of GNSS, even when their satellite services are disrupted.

eLoran is a high-power (250kW transmitters), low-frequency (100kHz), terrestrial system. It is interoperable with the Russian Federation's *Chayka* system. Fifteen countries across the northern hemisphere currently deploy Loran or Chayka transmitters that can readily be upgraded to eLoran. From a maritime perspective, 72% of the World's 50 busiest freight ports (with 78% of goods by weight) are in areas with existing Loran systems

This paper presents the way forward for eLoran.

Section 2	Considers the new requirement for resilient or secure PNT taking into account the growing market for GPS jammers, critical infrastructure, new applications and securing current benefits.
Section 3	Outlines the role for eLoran.
Section 4	Presents the way forward based on the commercial opportunity and the investment indicators that need to be satisfied to encourage investment and market growth.
Section 5	Outlines high-level conclusions

2. THE NEW REQUIREMENT FOR RESILIENT OR SECURE POSITIONING, NAVIGATION AND TIMING (PNT)

2.1 GNSS VULNERABILITY

The vulnerabilities of GNSS are well known and have been documented by the US Department of Transportation's Volpe Center [2] and the General Lighthouse Authorities of the United Kingdom and Ireland (GLAs) [3] among others.

In 2008, the European eLoran Forum set out the strategic importance of positioning, navigation and timing systems (PNT) [4] that underpin the European critical infrastructure (e.g. power systems, telecommunications, transport and finance) and stressed the need for three PNT systems for making European critical infrastructure robust and resilient: GPS, Galileo and eLoran.

Before 2008, GNSS vulnerability assessments generally considered unintentional interference as being the major culprit because there was little evidence of deliberate interference in the civil sector.

This is no longer the case.

2.2 THE MARKET FOR JAMMERS

The impact of GNSS denial whether by intentional or unintentional interference is well understood.

The GLAs' trials have shown how significantly GPS jamming adversely impacts on the safety of navigation on a modern vessel and this is a major concern for e-Navigation and maritime situational awareness based on the Automatic Identification System (AIS) [5].

The San Diego jamming incident (there are others) showed the effect of jamming on telephone switches, cellular phones and hospital paging systems [6].

One of the most significant developments in 2008/9 has been the exponential increase in the number of low-powered GNSS jammers deployed maliciously in the civil sector [7].

The GLAs now await their deployment in the maritime environment with the potential of chaos at maritime pinch-points around the World like the Dover Straits.

In February 2008, the US Department of Homeland Security (DHS) announced that it was starting to deploy eLoran based on the need for a GPS backup and eLoran's ability to mitigate any safety, security or economic effects of a GPS outage or disruption [8]. This decision remains valid and is as applicable in Europe as it is in the US.

2.3 THE NEW REQUIREMENT

An increased awareness of GNSS vulnerability, jamming and its impact means that new markets for resilient, robust or secure PNT are emerging: telecommunications; general aviation; professional and recreation use as well as search and rescue in the maritime sector; and defence, homeland security and law enforcement.

In many sectors, this new requirement for resilient, robust or secure PNT will secure a wide variety of GPS-enabled industrial and user benefits worldwide that have resulted from new applications and services.

A key cross-sector benefit has been manning efficiency savings arising from system integration and automation. In many cases, automation has resulted in a change of operational concept where reversion to the previous operational concept is almost impossible without increasing the number and skill of the people involved. Secure PNT will protect these manning efficiencies when GPS is unavailable. The immediate benefit is economic and for some applications (e.g. maritime domain awareness) there are also safety and security benefits.

3. THE ROLE OF eLORAN

Over the last two decades, the availability, utility and quality (performance) of GNSS (GPS) has led to the decommissioning of many other radionavigation systems (e.g. TRANSIT, DECCA, OMEGA).

An increased awareness of GNSS vulnerability and jamming means that many sectors may each deploy their own backup solutions. However, this is likely to lead to a situation described as the *Tragedy of the Commons* (see [9] [10] [11]): a dilemma in which multiple individuals acting independently in their own self-interest can ultimately destroy a shared limited resource even when it is clear that it is not in anyone's long term interest for this to happen.

Loran in its enhanced format (eLoran) is one of the few terrestrial systems remaining that is both multi-modal and independent of GPS while being compatible with GPS in terms of meeting the performance requirements of many positioning and timing applications.

4. THE WAY FORWARD

4.1 THE COMMERCIAL OPPORTUNITY

The February 2008 US DHS announcement proved what had always been expected: the lack of eLoran users and investment was due to a lack of positive policy rather than a lack of demand.

Following this announcement, there has been investment by nations, public sector and private sector organisations in infrastructure, the development of new transmitter technology and the development of new receivers:

- the UK Technology Strategy Board has part-funded a Loran-based project called GAARDIAN led by Chronos Technology;
- a new transmitter has been launched by Nautel and UrsaNav with time and frequency equipment from Symmetricom;
- a new joint GPS / eLoran receiver has been announced by CrossRate Technology;
- new Loran systems for signal propagation measurement and differential Loran have been announced by Reelektronika – a Loran receiver manufacturer.

4.2. INVESTMENT INDICATORS

Moving forward with eLoran requires *trust* to be established to allow the public sector to invest in transmitters, the private sector to invest in the development of products and users to buy and install products. It is important to note that eLoran receivers will not generally be separate products, but integrated tightly with GNSS in a common receiver.

This trust requires the following:

- a *positive policy statement* from public sector service providers with a long-term commitment (e.g. 15-20 years);
- *continuity of funding* guaranteed to support the long-term commitment;
- *continuity of service* that builds confidence with users and service providers;
- an open, published and realistic *plan* with a commitment to delivery;
- an open, published *performance specification*; and
- an open, published *signal-in-space interface control document* that allows receiver/chip manufacturers, application developers and users to experiment and develop innovative applications and services.

It should be noted that these trust-builders are generic, i.e. they are as true for eLoran as they were for GPS … or remain for Galileo.

4.3 CHALLENGES

The challenges at this point are many, but achievable:

- *political* – make the positive policy statements and create structures that promote objectivity and stability;
- *regulatory* – develop multi-lateral or bi-lateral agreements that ensure global interoperability and ensure continuity of funding to support the policy statements and ensure delivery;
- *financial* – build the business cases to support investment by the public and private sectors and users;
- *operational* – publish service plans, deliver the service on time and ensure continuity of service;
- *technical* – support eLoran simulators and develop processing schemes; and
- *user* – work with existing user groups to encourage market penetration.

5. CONCLUSIONS

An increased awareness of GNSS vulnerability, jamming and its impact means that new markets for resilient, robust or secure PNT are emerging.

eLoran is an independent, dissimilar, complement to GNSS that allows users to retain the safety, security, and economic benefits of GNSS, even when their satellite services are disrupted.

The response to the 2008 US DHS announcement has demonstrated that public and private sector

organisations are prepared to fund and supply eLoran services and equipment and that there is demand from users if there is a positive policy statement.

Creating sustainable supply and demand for eLoran services are predicated on trust based on policy, continuity of funding, continuity of service provision, realistic plans, a relevant performance specification and a signal in space interface control document.

The challenges are many but achievable, addressing all aspects of service provision: political, regulatory, financial, operational, technological and user.

Finally, it follows from the *Tragedy of the Commons* discussion that eLoran has the potential to save money for those organisations (e.g. governments) that can engage in a mature and rational debate about GNSS vulnerability which recognises both the benefits of having two satellite navigation systems (e.g. GPS and Galileo) as well as the benefits of system diversity based on a common backup system - eLoran.

REFERENCES

[1] International Loran Association, *eLoran Definition Document*, v1.0, October 2007. (http://www.loran.org/news/eLoran Definition Document 0 1 Released.pdf)

[2] John A Volpe National Transportation Systems Center, *Vulnerability Assessment of the Transportation Infrastructure relying on the Global Positioning System*, Final Report, August 29 2001. (http://www.navcen.uscg.gov/GPS/geninfo/vulnerability_assess_2001.pdf)

[3] General Lighthouse Authorities of the United Kingdom and Ireland *The Case for eLoran*, May 2006. (www.nlb.org.uk/news/PR2006/eLoran Press Release.pdf)

[4] European eLoran Forum, *eLoran: Securing Positioning, Navigation and Timing for Europe's Future*, April 2008. (http://www.nlb.org.uk/news/pdf_eloran_pnt.pdf)

[5] Grant A, Williams P, Ward N and Basker S (2009). *GPS Jamming and the Impact on Maritime Navigation*. Journal of Navigation, 62 , pp 173-187

[6] Jewell D, *Ubiquity and the Joint Navigation Conference*, GPS Insights, GPS World, April 2007 (http://mg.gpsworld.com/gpsmg/article/articleDetail.jsp?id=418420)

[7] Last J.D., 'Silent Witness', Navigation News (Royal Institute of Navigation), pp10-13, January/February 2009 (www.professordavidlast.co.uk/cms_items/f20090402085322.pdf)

[8] US Department of Homeland Security, Statement from DHS Press Secretary Laura Keehhner on the adoption of national backup system to GPS, February 7, 2008. (http://www.piersystem.com/posted/786/LORAN_FINAL_Release.191614.pdf)

[9] Wikipedia, *Tragedy of the Commons*, http://en.wikipedia.org/wiki/Tragedy_of_the_commons

[10] "The Tragedy of the Commons," Garrett Hardin, Science, 162(1968):1243-1248.

[11] Senge P M, *The Fifth Discipline: The Art & Practice of the Learning Organization*, 1st edition, 1994 - paperback edition, xxiii, 413 p., ISBN 0-385-26095-4.