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GENERAL LIGHTHOUSE AUTHORITIES
United Kingdom and Ireland

The General Lighthouse Authorities' Loran Programme and Current Status in Europe

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Professor David Last

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The General Lighthouse Authorities

The General Lighthouse Authorities of the United Kingdom and Ireland are focused on the needs of our users

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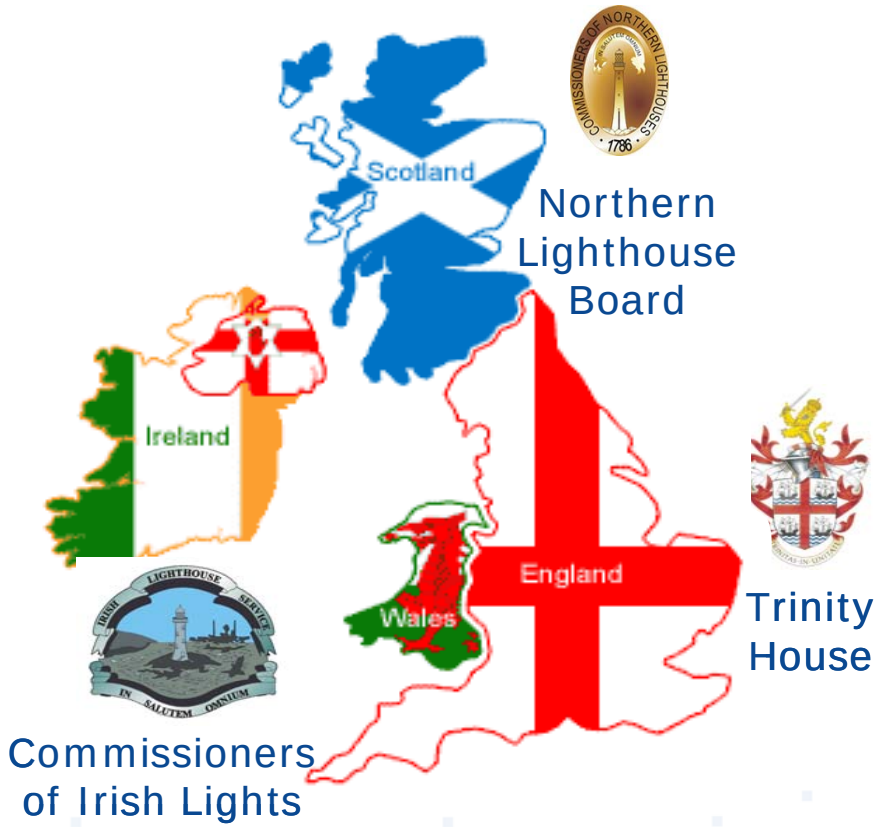
- **Our mission** is the delivery of a reliable, efficient and cost effective AtoN service for the benefit and safety of all mariners
- Funded by **Light Dues**
  - User pays, cost recovery
  - Reduced by 50% in real terms over the last decade
- **Our users** want better services for lower cost in a more litigious environment while maintaining safety standards
- Taking this further means delivering a **radionavigation dividend**



The Research & Radionavigation directorate works for all three GLAs

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Motivation for the eLoran Programme

The changing service provision environment

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Key Issues

- Larger & faster vessels
- Congestion at pinch-points
  - Dover Straits, Mallaca Straits …
- Trend to one/two man bridges
- Ubiquity of GPS and waypoint navigation
- Concern over ability to revert from electronic to traditional techniques
- In some cases safety may worsen
  - Electronic systems encourage a false sense of security
  - Human factors

Key Statistics

- Largest Container Ship
  - Maersk *Emma* launched 1st September 2006
  - *397m long, 56m wide, >11000 containers, >25knots, 13 crew*
- Fastest Ferry
  - SuperSeaCat II
  - 100m long, 17m wide, 690 passengers & crew, 147 cars, 38 knots (cruising) & 40 knots (max)
- Oil Spills 1974 - 2005[1]
  - Collisions and groundings accounted for 44% of intermediate spills (7 – 700 tonnes) and 63% of large oil spills (>700 tonnes)
- 80% of all accidents at sea are due to human error[2]

e-Navigation - making safe navigation easier and cheaper …

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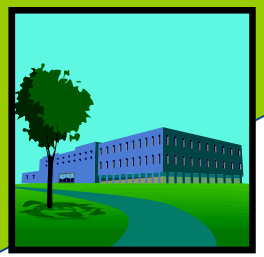
- The collection, integration and display of maritime information onboard and ashore by electronic means, to enhance berth-to-berth navigation and related services, for safety and security at sea, and protection of the marine environment[3]
- Structural components (many already exist on some vessels)
  - Electronic Navigation Charts
  - Integrated displays using Electronic Chart Display Information Systems
  - Electronic Positioning Systems
  - Vessel route and status information
  - Transmission of positional and navigational information using AIS
  - Information prioritisation and alarm management

IMO – International Maritime Organisation
IALA – International Association of Aids to Navigation Service Providers and Lighthouse Authorities

VTS

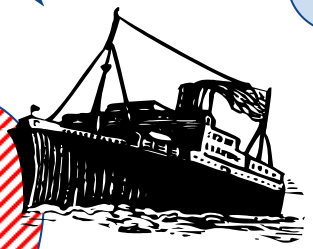
4. VTS communicates with ship to confirm warning and advise best route for safe passage

AtoN Service Provider

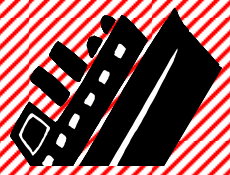


5. At 01.15 the AtoN service provider vessel lays wreck marking buoys in the exclusion zone that remains in place until wreck dispersed

2. From 21:30 Service provider broadcasts virtual AtoNs to ships and VTS to create exclusion zone using AIS. These appear automatically on ECDIS



3. At 21:45 a ship enters the exclusion zone. Collision warning alarms are sounded on the bridge and send to VTS



1. Shipwreck occurs at 21:08 and authorities are notified

The role of GPS in e-Navigation (with Galileo in the longer-term)

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- GPS will be the primary e-Navigation sensor for navigation
  - current GPS and DGPS will remain the mainstay for many years
  - L1 and L5 will offer GPS/Galileo interoperability
- GPS positioning and timing will underpin situation awareness through AIS
  - ship borne and shore-based situational awareness
  - used as an Aid to Navigation (AtoN)
  - also long-range identification and tracking
- GPS will be used for synchronised and sequenced lights

GPS/GNSS is vulnerable and is part of our critical infrastructure [4,5,6]

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	Vulnerability Examples	Possible Mitigation
System	**Satellite clock failures** (e.g. SVN23, 1 Jan 2004)	**Second system or augmentation** (e.g. Galileo, eLoran, SBAS)
	Poor signal quality (e.g. evil waveforms)	**Second system or augmentation** (e.g. Galileo, eLoran, SBAS)
	Design flaws (e.g. Block IIR ranging code interruptions)	**Second system or augmentation** (e.g. Galileo, eLoran, SBAS)
Signal	**Intentional interference** (e.g. potential terrorism)	**Second dissimilar system** (e.g. eLoran)
	Unintentional interference (e.g. Moss Landing)	**Second dissimilar system, GNSS freqs** (e.g. e-Loran, L2C, L5)
	Ionospheric effects (e.g. scintillation at high latitudes or equator)	**Second dissimilar system** (e.g. e-Loran)
User	**Receiver malfunction** (e.g. Royal Majesty, 1995)	**Redundant GPS receivers**
	Signal occultation (e.g. Urban canyons)	**Second dissimilar system &/or more SVs** (e.g.Galileo, SBAS, eLoran)
	Local Interference (e.g. Manatoulin TV set)	**Second dissimilar system &/or improved siting**

Impact of loss of GPS

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- Safety
  - May worsen because of lack of familiarity when reverting from e-Navigation to physical AtoNs
- Security
  - Both AIS and Long-range Identification & Tracking rely on GPS for positioning and, to some extent, timing
  - On-board new technology radar does not have to trigger existing racons
- Protection of the marine environment
  - E-Nav virtual exclusion zones will not trigger alarms possibly leading to collisions and groundings
- Economic
  - Direct loss at Southampton port is $6M per day not including knock-on supply-chain costs
  - Oil spill clean-up costs are $11k/tonne - Exxon Valdez $2B cleanup + $5B fines
  - UK Average cost is $16M per accident

e-Navigation needs a dissimilar, complementary, multi-modal & independent source of PNT

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Service	PNT	Multi-Modal	Independent wrt GPS		
			System	Signal	User
Galileo	✓	✓	✓	×	×
eLoran	✓	✓	✓	✓	✓
DGPS	×	✓	×	✓	×
SBAS	× ✓	✓	× ✓	×	×
Radar	×	×	✓	✓	✓

eLoran is the only option and this is driving the GLA's eLoran activity

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The GLA eLoran Programme

Objective

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- The provision of an international, globally-standardised eLoran PNT (position, navigation and time) multi-modal service, based on interoperable multi-regional components both as a complement to GNSS and as a stand-alone backup in case of failure, by 2012

Loran Evolution

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	Loran-C	Modernised Loran	eLoran
Transmitters	Valve/tube	Solid state	Solid state, messaging and frequency steering
Propagation ASFs	Printed/limited	Computed predicted, not necessarily integrated in receiver	Measured or modelled and integrated in receiver
DLoran	N/A	N/A	Reference Stations
Receivers	Hyperbolic with chains	Time of emission with all-in-view	Time of emission with all-in-view
Accuracy	460m (95%)	100m (95%)	10-20m (95%)
Notes	2 Med, 4 Chayka	9 former NELS	The Future

Harwich Port Approach Trial, April 06

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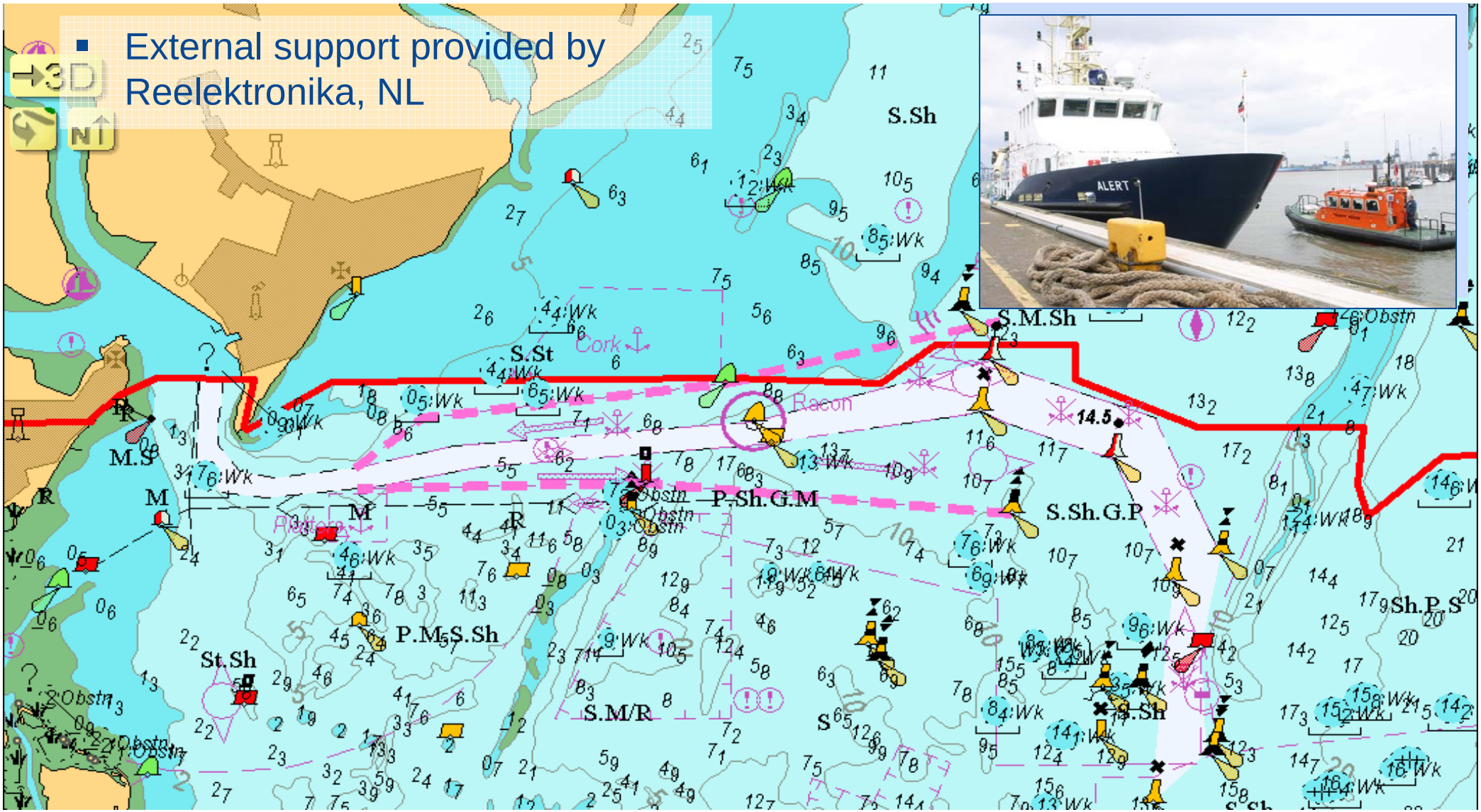

Harwich Port-Approach Results

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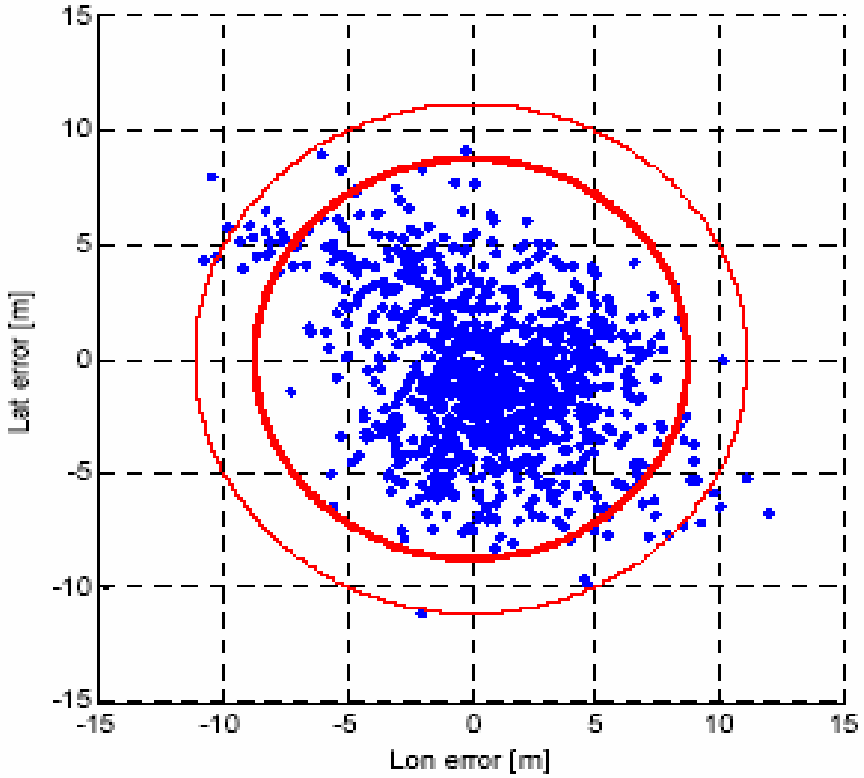
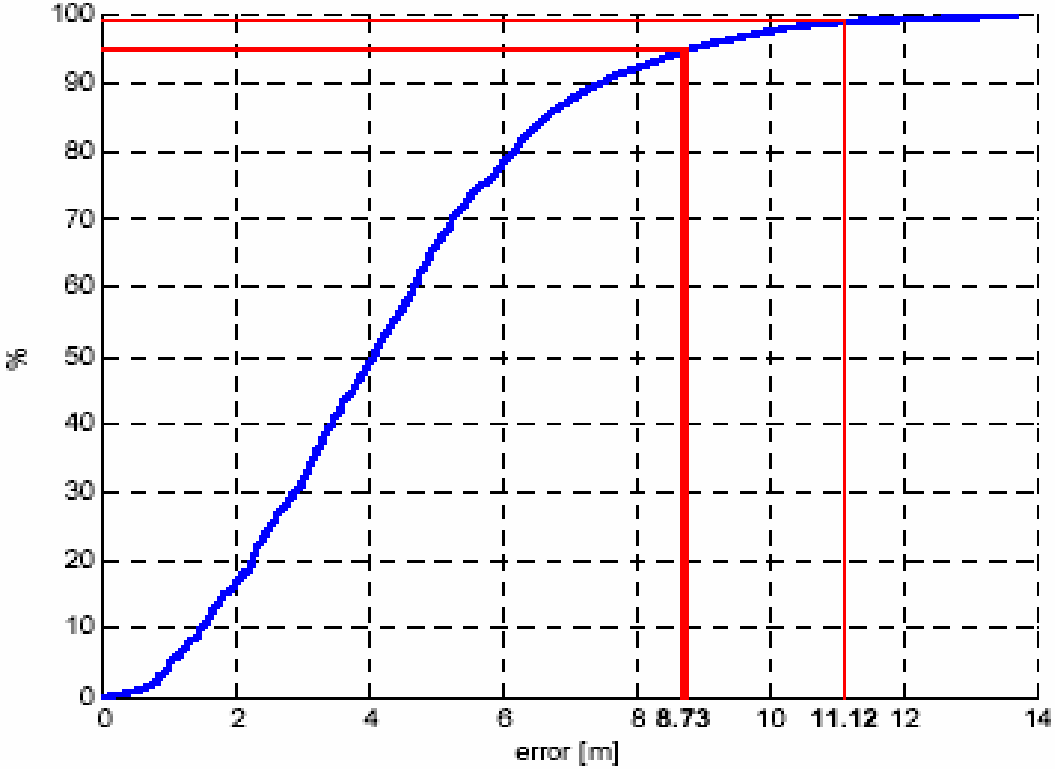


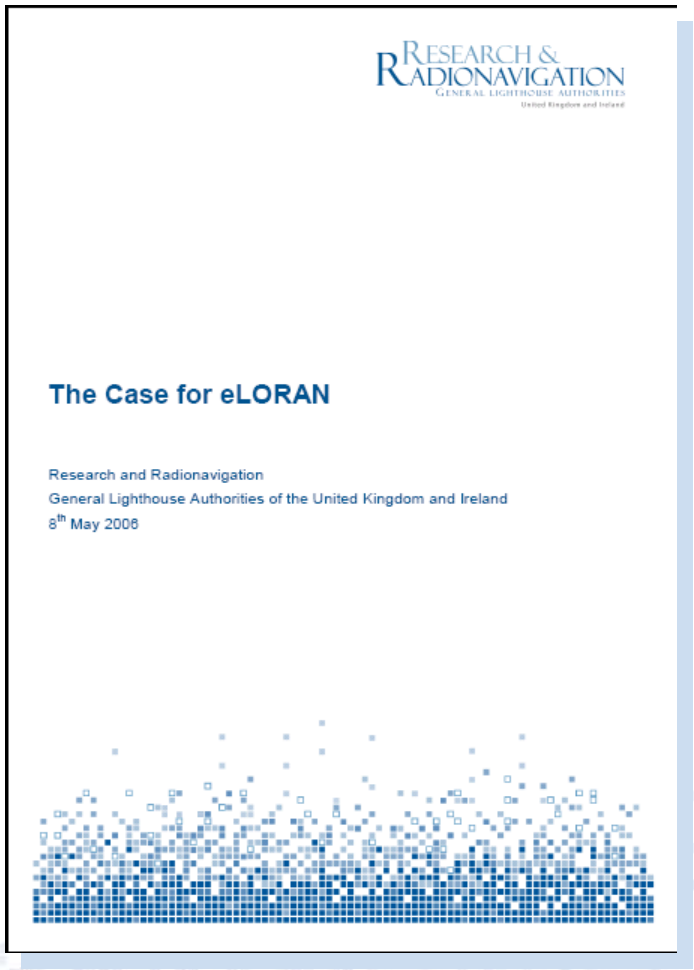


Resulting dLoran positioning accuracy

8.73 m (95%) **11.12 m (99%)** **97.51% < 10 m**

Economic Analysis – The Case for eLoran

- External support from a team led by Booz Allen Hamilton, London, with Helios Technology and Prof. David Last
- The Case for eLoran published in May 2006
  - eLoran enabling e-Navigation that embodies safety, security and protection of the maritime environment together with the delivery of a radionavigation dividend to our users



Cost/benefit analysis ongoing reporting Q4 2006

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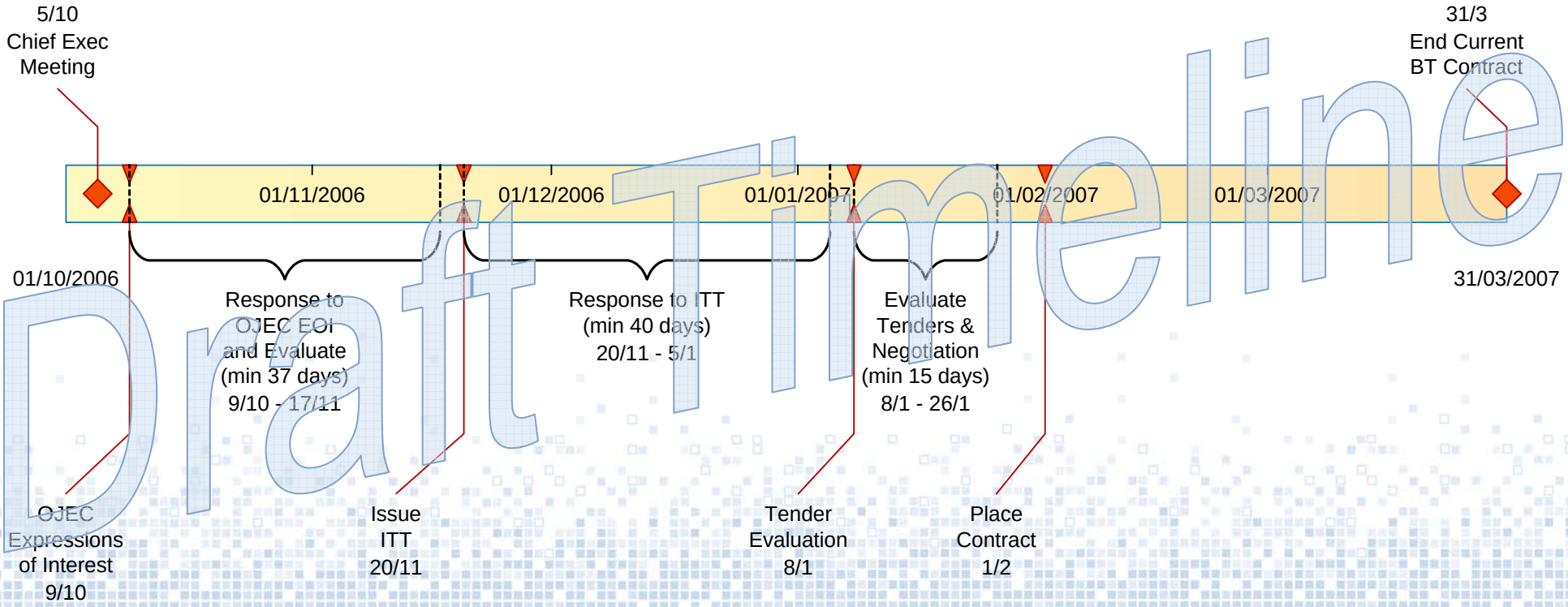
- Preliminary results
  - Positive NPV over 20 years based on certain assumptions
  - Enough to extend GLA activity for three years
  - Reporting shortly following internal GLA review
- $1.1M US initial cost estimate for converting an automated solid state transmitter (e.g. Rugby) to eLoran
  - Transmitter control (timing suite)
  - UPS
  - Monitor Receiver
- $2.5M US initial cost estimate to provide dLoran at 34 major ports in the UK and Ireland
  - 21 reference stations
  - 34 ASF surveys

The Rugby Transmitter

- Current trial due to end March 2007
- The GLAs are proposing to extend the current eLoran service by three years to March 2010 with an option to extend for 15 – 20 years
- Future service to include a messaging capability for UTC and differential Loran corrections



Further eLoran activity in 2006/7

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- Timing with Chronos technology in Q4 2006
  - Testing is going to evaluate suitability in the time domain
  - From a maritime perspective this is focused on the timing needs for AIS and synchronised/sequenced lights
- Real-time differential at Harwich in Q4 2006 / Q1 2007
  - The main aim of this project is to repeat the April 2006 Harwich Approach Trial in real time
  - Demonstration of the re-use of the ASFs measured in April 2006.
  - Measurement of new absolute ASFs along the route (if viable)
- Recruiting
  - Up to two people to support the GLAs' eLoran programme

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Current Status in Europe

European Loran Stations – a huge leap forward in 2006

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	December 2005	October 2006
Vaerlandet Boe Berlevag Jan Mayen	Close 31/12	Operational until December 2009
Ejde	Uncertain	Now operated by France
Lessay Soustons	Operational until 2015	Operational until 2015
Rugby	Operational until March 2006	Extending operations until March 2010
Sylt	Close 2 January 2006	Arrangements in place to maintain operations

European Radionavigation Plan

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- Meeting 30 June 2006 – mainly focused on eLoran
- Galileo Joint Undertaking indicated that other enough systems will be needed to complement GNSS in order to mitigate disruptions on GNSS signals
- Netherlands – will Galileo be sufficiently robust in the presence of interference?
- Italy – re-activate Selia Marina provided that eLoran is in ERNP
- eLoran needs to be investigated at European level
- ERNP update in Q4 2006 with possibility to issue Q1 2007

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The Way Ahead

Setting eLoran on firm foundations

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- eLoran needs the equivalent of the GPS “Red Book” ***FAST***
  - System description
  - Signal specifications
  - Performance specifications including error budgets
  - DLoran
- Some of this needs to be owned at a global level – ILA?
- Some of this needs to be owned at a regional level – EU, North America?
- Some of this needs to be owned at a national level

Possible Long-term European eLoran Programme

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R&D & Proof of Concept 2004 - 2007	Preparation for Initial Services 2007 - 2010	eLoran Initial Service Provision (ISP) 2010 – 2012	European eLoran Service Roll-out 2012 -2015
Aim: Keep eLoran alive and extend R&D in order to prepare for initial services	**Aim**: Trigger long-term investment and initial services in Europe through ERNP	**Aim**: Launch initial services and transition to European eLoran	**Aim**: Roll-out eLoran services across Europe
Task: Identify where eLoran may be needed, high-level cost/benefit analysis and technical proof of concept.	**Task**: Programme of work for all transport modes: institutional, regulatory, commercial, operational, technical and user. This includes education and PR to build broad support through ERNP.	**Task**: Transition from current to future institutional and commercial arrangements. Upgrade existing system if needed, deploy dLoran and make ASF maps.	**Task**: Roll-out multi-modal eLoran services across Europe

What is the equivalent in the US and elsewhere?

Preparation for Initial Services (2007 – 2010) – Work Areas

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- Institutional: identify appropriate long-term arrangements
- Regulatory: standardise eLoran at a global level
- Commercial: identify appropriate long-term funding for operations and build the long-term business case
- Operations: operate the current infrastructure on a research basis and bring current R&D to an initial service provision capability (ASF measurement and dLoran) with long-term trials
- Technical: risk analysis that shows the need for a second, dissimilar radionavigation service for e-Navigation etc. Develop and cost architecture for the future e-Loran service. Encourage the development of user equipment.
- User: trials to demonstrate how eLoran delivers benefits in different user environments

References

1. International Tanker Owners Pollution Federation. *ITOPF Handbook 2006/7*
2. Squire, D. *The Human Element in Shipping*. www.he-alert.com, January 2005
3. IALA Definition of e-Navigation
4. John A Volpe National Transportation Systems Center. *Vulnerability Assessment of the transportation infrastructure relying on the Global Positioning System*. August 29th, 2001
5. Helios Technology Ltd. *Recommendations towards the development of a European Radionavigation Plan (ERNP)*. October 2004
6. European Commission. *Green paper on a European programme for critical infrastructure protection*. Brussels, 17.11.2005, COM(2005) 576 final