

GPS-Free UTC TimeScale Using eLoran



ITSF 2015, Edinburgh, Scotland
4th November 2015

Charles Curry BEng, CEng, FIET
Chronos Technology Ltd

Presentation Contents

- Review of eLoran Research by Chronos
- Synchronising a Cs to eLoran
- Latest International eLoran Situation
- Latest UK eLoran Situation
- Recommendations & Conclusion

UK Research on eLoran



GAUL



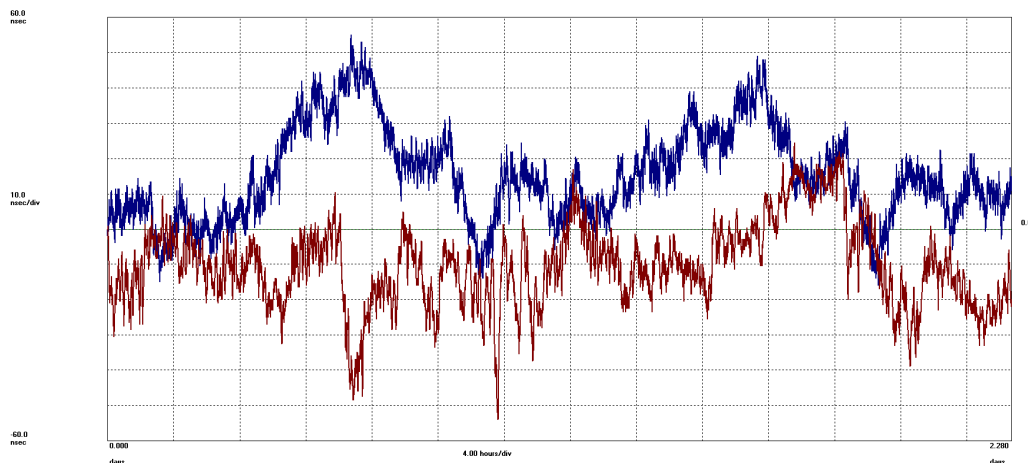
Research Tools



- SENTINEL Research Platform
- Combined eLoran and GPS PoC Timing Receiver CTL8200
- H-Field Antenna

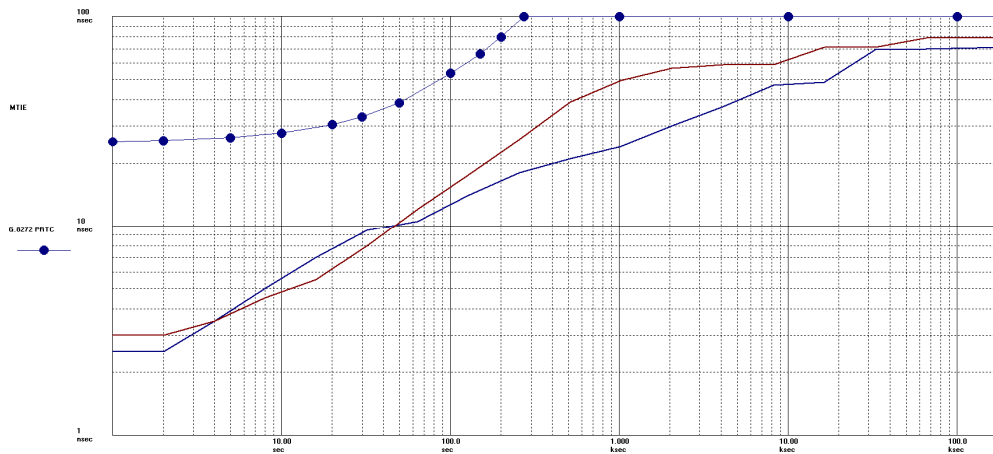


Some Results – TIE and MTIE



TIE Graphs
Blue: GPS
Red: Indoor eLoran
3 days, 10ns/div

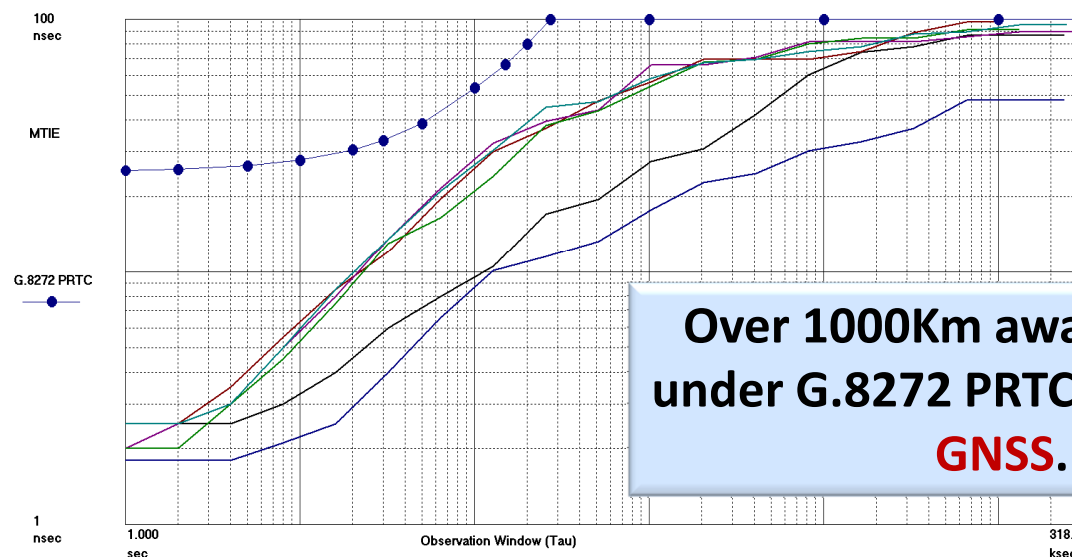
MTIE Plots
Mask: G.8272 PRTC
Blue: GPS
Red: Indoor eLoran
3 days



Distant Station Testing



Symmetricom TimeMonitor Analyzer
 MTIE; Fo=1.000 Hz; Fs=1.000 Hz; 2014/03/10; 18:51:14



**Over 1000Km away! indoors,
 under G.8272 PRTC, **no external
 GNSS.****

Colour	Station	Range	Location	Path
Red	Lessay	300km	Northern France	Land and Sea
Blue	Anthorn	350km	North-West England	Land
Cyan	Sylt	800km	North Germany	Land and Sea
Green	Soustons	900km	Southern France	Land and Sea
Magenta	Vaerlandet	1150km	South-West Norway	Land and Sea

GAUL – Galileo Assist Using eLoran



- Latest Innovate UK Grant – Oct 1st 2015
- Using Loran Data Channel
- Research Regional Differential UTC Corrections
- Broadcast Galileo (& GPS) Ephemeris Data
- Broadcast Local UTC corrections
- Broadcast System Health Information

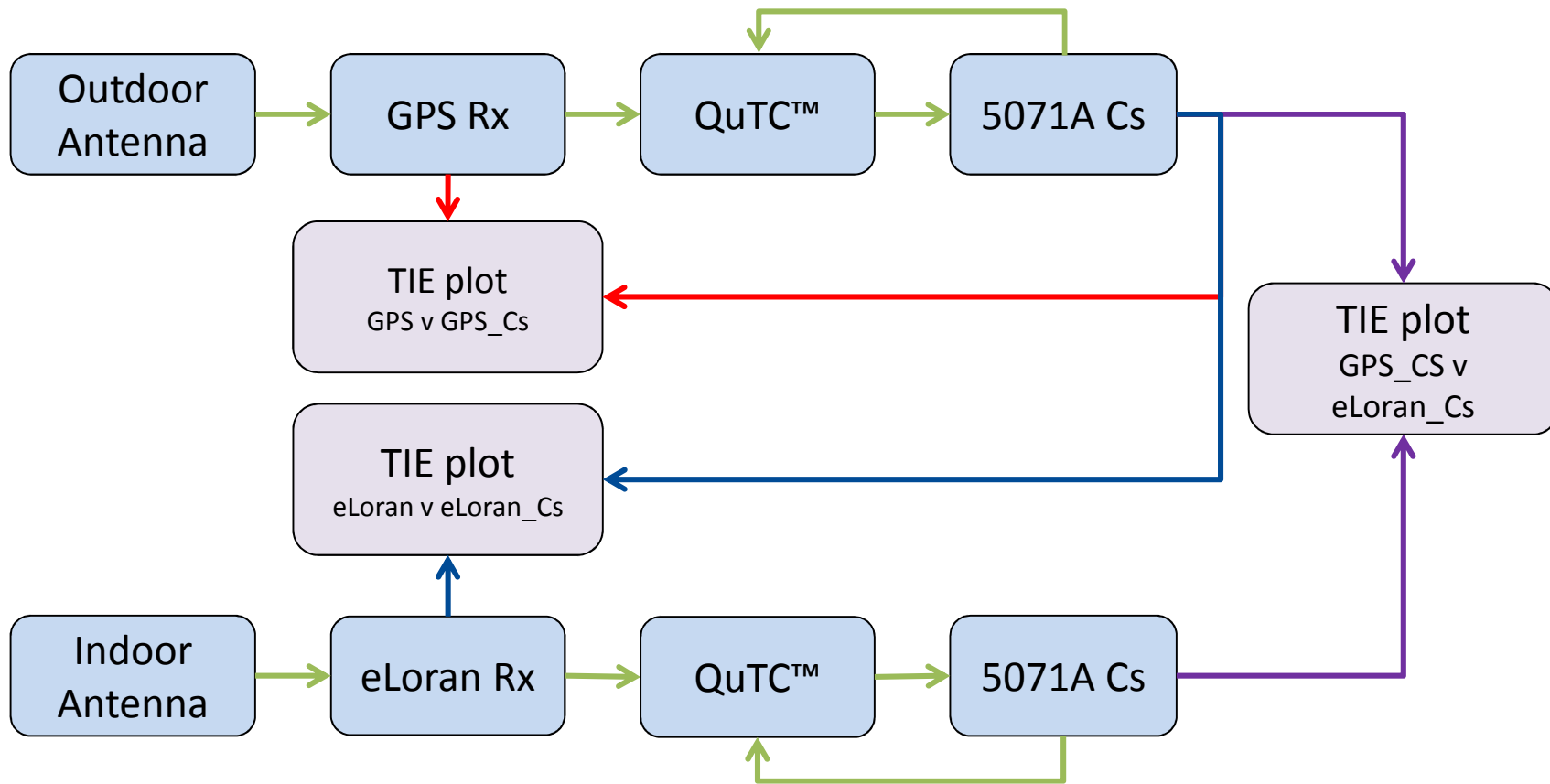
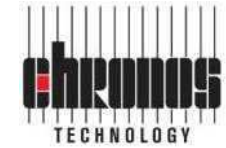
Loran Data Channel Structure

TABLE 2-3. EUROFIX MESSAGE DESCRIPTION AND STATUS

Message Type	Bits	Description	Status
1	0001	Eurofix DGPS correction (single sat)	Fixed
2	0010	Eurofix DGLonass correction (single sat)	Fixed
3	0011	Reserved	
4	0100	Eurofix Station ID/Health message	Fixed
5	0101	Short Message Service (SMS)	Fixed
6	0110	Loran UTC Message	Fixed
7	0111	Reserved	
8	1000	Reserved	
9	1001	Reserved	
10	1010	Differential eLoran Phase Corrections	Fixed
11	1011	Differential eLoran Almanac data	Tentative
12	1100	Third Party Data Client	Fixed
13	1101	Reserved	
14	1110	Reserved	
15	1111	Reserved	
16	0000	Reserved	

**LDC Message Type
13 Reserved for
ASF Differential
Corrections for the
Timing Community**

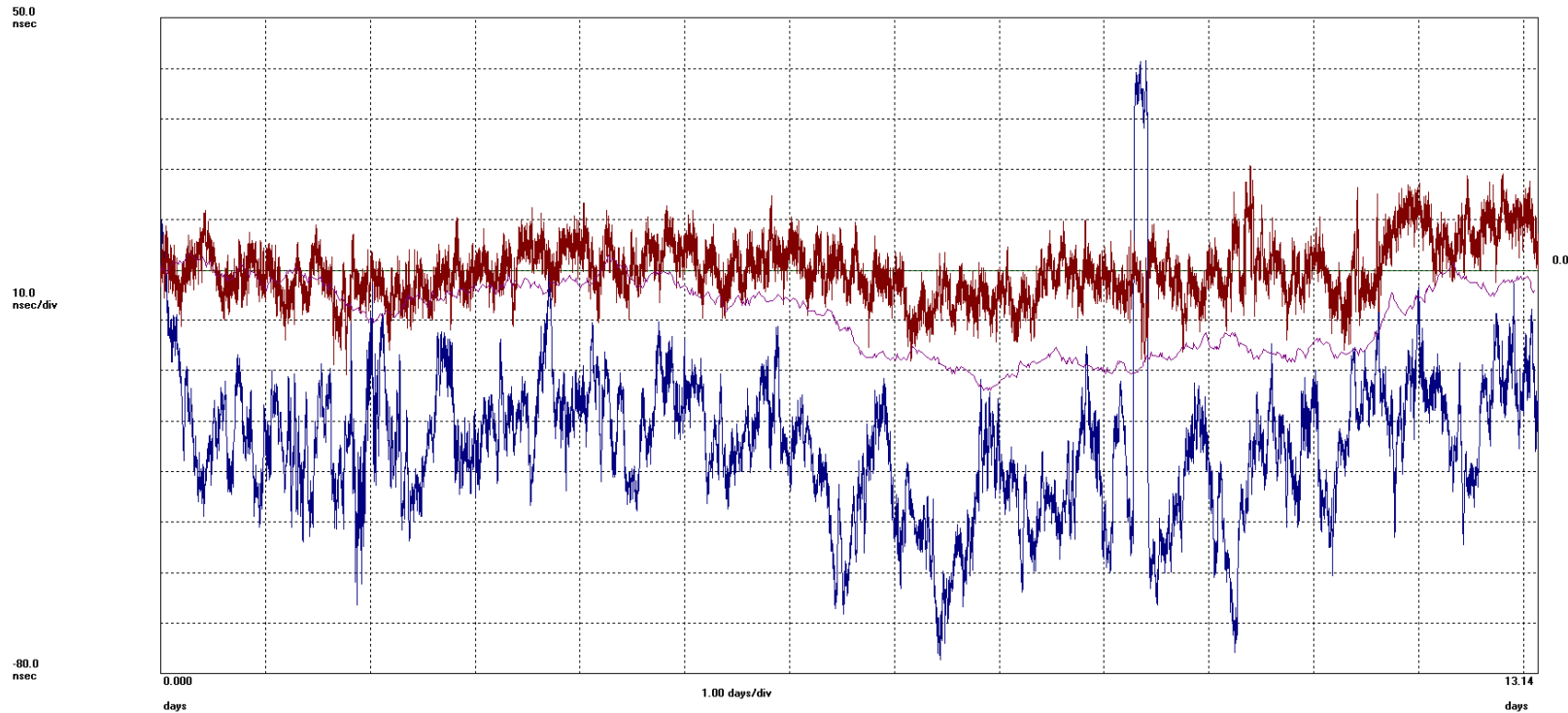
Synchronising Cs to eLoran



Results



Symmetric TimeMonitor Analyzer
Phase deviation in units of time: F₀=999.3 mHz; F₀-1.0000000 Hz; 2015/09/22; 04:38:11
1 (blue): Agilent 53220A; Test: 645; A: QuTC eLoran; B: 5071A-2; Cs 10 MHz; Samples: 1134893; Gate: 1 s; Start: 1000000; Total Points: 2134892; Ref ch2: 10.00 MHz; T1/Time Data Only; T1 1->2; 172.31.2.61; A-53230A-02821 - 3; 2015/09/22; 04:38:11
2 (red): Agilent 53220A; Test: 644; A: QuTC GPS; B: 5071A-2; Cs 10 MHz; Samples: 1134893; Gate: 1 s; Start: 1000000; Total Points: 2134892; Ref ch2: 10.00 MHz; T1/Time Data Only; T1 1->2; 172.31.2.55; A-53230A-02820 - 2; 2015/09/22; 04:38:11
3 (magenta): Agilent 53220A; Test: 643; A: 5071A-3; B: 5071A-2; Cs 10 MHz; Samples: 1134893; Gate: 1 s; Start: 1000000; Total Points: 2134892; Ref ch2: 10.00 MHz; T1/Time Data Only; T1 1->2; 172.31.2.38; A-53230A-02819 - 1; 2015/09/22; 04:38:11

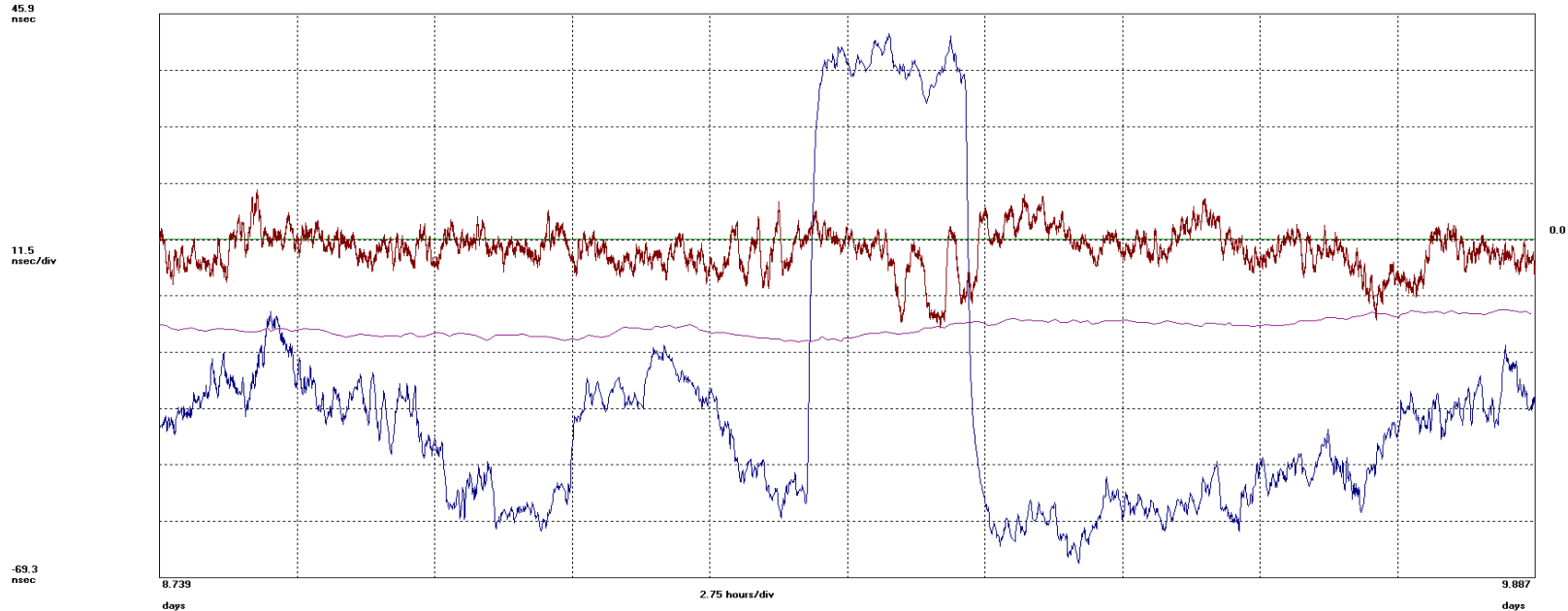


Red = GPS Caesium v GPS
Blue = eLoran Caesium v eLoran
Magenta = Caesium synchronised to eLoran v Caesium synchronised to GPS

First Thursday



Symmetricom TimeMonitor Analyzer
Phase deviation in units of time: Fs=999.3 MHz; Fo=1.0000000 Hz; 2015/09/22; 04:38:11
1 (blue): Agilent 53220A; Test: 645; A: QuTC eLoran; B: 5071A-2; Cs 10 MHz; Samples: 1134893; Gate: 1 s; Start: 1000000; Total Points: 2134892; Ref ch2: 10.00 MHz; TI/Time Data Only: TI 1->2; 172.31.2.61; A-53230A-02821 - 3; 2015/09/22; 04:38:11
2 (red): Agilent 53220A; Test: 644; A: QuTC GPS; B: 5071A-2; Cs 10 MHz; Samples: 1134893; Gate: 1 s; Start: 1000000; Total Points: 2134892; Ref ch2: 10.00 MHz; TI/Time Data Only: TI 1->2; 172.31.2.55; A-53230A-02820 - 2; 2015/09/22; 04:38:11
3 (magenta): Agilent 53220A; Test: 643; A: 5071A-3; B: 5071A-2; Cs 10 MHz; Samples: 1134893; Gate: 1 s; Start: 1000000; Total Points: 2134892; Ref ch2: 10.00 MHz; TI/Time Data Only: TI 1->2; 172.31.2.38; A-53230A-02819 - 1; 2015/09/22; 04:38:11



**Red = GPS, Blue = eLoran, Magenta = Cs synchronised to eLoran
Phase jump on eLoran due to adjacent transmitter maintenance
causing ground plane change.**

Note minimal impact on Magenta Cs performance

International Situation - USA



- Strong movement to bring back eLoran- Initially for Timing
- **"You Placed this Country at Risk"** Highlights of 7/28 Congressional Hearing - A shortened summary is available here..
 - https://www.youtube.com/watch?v=MrZg8QdHvQQ&utm_source=Annual+Mtg+FINAL+evite+LIST&utm_campaign=81e150a82a-ummer_eNews&utm_medium=email&utm_term=0_147758946a-81e150a82a-165977625
- The full hearing is here (~1 Hour)
 - <https://www.youtube.com/watch?v=8Tb6xW4XkYk>
- Report by Dee Ann Divis - Washington Correspondent for Inside GNSS
 - <http://rntfnd.org/2015/08/01/key-lawmakers-move-to-make-dod-responsible-for-eloran-gps-backup/>

International Situation - USA



“GPS use by
Military... a
Vulnerability” 2014

- US administration (Army acting as the agent for Defense) has asked industry for quotes on 50,000 eLoran sets
- Department of Transportation went out for public comment and got overwhelmingly positive response on proposal to establish eLoran
- Because of the above plus rumors heard, expect USA to announce in the next couple weeks it's going to look for a commercial partner to build an eLoran timing system

UK Situation



- Anthorn & Sylt
 - Operated by the General Lighthouse Authorities of United Kingdom and Ireland
- Public/Private Partnership Discussions Underway
- Innovate UK - GAUL
- Defence Select Committee – SDSR Submission
 - Chronos

Europe Situation

- France will switch off Dec 31st 2015
 - Control Centre Brest (CCB)
 - Transmitter @ Lessay
 - Transmitter @ Soustons
- Norway
 - Norway likely to follow France
- Denmark
 - Ejde – Will lose French finance support



UK Government - SDSR

Strategic Defence and Security Review Public Engagement

From: Ministry of Defence, Foreign & Commonwealth Office, Home Office,
Department for International Development and Cabinet Office

First published: 5 August 2015

Work on the 2015 National Security Strategy (NSS) and Strategic Defence and Security Review (SDSR) is now under way.



Whitehall

The Cabinet Office, Department for International Development, Foreign and Commonwealth Office, Home Office, Ministry of Defence as well as other departments are working together on the NSS and SDSR. This review will look at the full range of threats that we face; it will examine the capabilities we need to counter them; and help us judge how to resource those capabilities.

As part of this work, we are engaging with a range of audiences, including Parliament, academics, industry, think tanks, Allies and partners, non-governmental organisations and the public. This is why we

<http://www.parliament.uk/business/committees/committees-a-z/commons-select/defence-committee/inquiries/parliament-2015/an-sdsr-checklist-of-potential-threats/>

SDSR - Submission



- Committees
- All committees A-Z
- Commons Select
- Defence Committee
- Inquiries
- Parliament 2015
- An SDSR checklist of potential threats**
- Publications

Defence Committee

Flexible Response? An SDSR checklist of potential threats

Background to the inquiry

The Committee will seek to examine the credible threats currently facing the UK and its interests, and assess the Government's ability to evaluate these threats.

■ Full terms of reference



Latest evidence

Flexible response? An SDSR checklist of potential threats | PDF version (286 KB)
HC 493 | Published 21 Oct 2015
Evidence given by Professor Malcolm Chalmers, Royal United Services Institute, Nigel Inkster, The International Institute for Strategic Studies, Professor Andrew Dorman, King's College London

Watch this evidence session

Strategy and Security Institute - written evidence | PDF version (720 KB)
CPT0017 | Ordered to be published 20 Oct 2015

Chronos Technology Ltd - written evidence | PDF version (129 KB)
CPT0020 | Ordered to be published 20 Oct 2015

The Royal Aeronautical Society - written evidence | PDF version (90 KB)
CPT0016 | Ordered to be published 20 Oct 2015

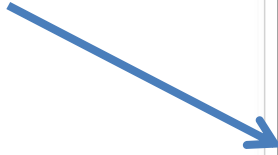
Meeting(s)

27 October 2015 | 11:30 AM
An SDSR checklist of potential threats

View details

Witness(es):
General Sir Nicholas Houghton, Chief of the Defence Staff
General Sir Richard Barrons, Commander of Joint Forces Command
Command Campbell McCafferty, Director of the Civil Contingencies Secretariat, Cabinet Office

Location
Room 8, Palace of Westminster



SDSR – Credible Threats

- A surge in serious, organised crime such as to have direct economic/social consequences
- Hostile attacks upon UK cyber space
- Severe disruption to information received, transmitted or collected by satellites, possibly as the result of a deliberate attack by another state
- A large scale conventional military attack on the UK
- International terrorism

- What are the credible threats to the UK and its interests posed in maritime, land and air domains

SDSR - Threat Evaluation

- What is the government's ability to evaluate credible threats to the UK and its interests?
- What is the government's ability to 'think the unthinkable' and how flexible are the UK's thought process and planning process to meet the wide range of credible potential dangers?
- Does the government have the ability for generic capability and capacity building in the event of an unforeseen threat?

Chronos Recommendations

- Acknowledge threat from GPS (GNSS) Jamming and Spoofing
- Vulnerability to precise time used to support Critical National Infrastructure Operations
 - Applications < 1 Microsecond
- Urgently review Mitigation Solutions that can deliver sovereign time and position
 - eLoran
- Acknowledge that the existing NW Europe infrastructure could serve in excess of 350 million people

Further Reading



DELIVERING A NATIONAL TIMESCALE USING eLORAN

ABSTRACT

A Positioning, Navigation and Timing (PNT) service using Enhanced Loran (eLoran) has been transmitted experimentally in the United Kingdom for more than 3 years. The eLoran transmitter employed, at Anthon in North-West England, is operated by a commercial company on behalf of the General Lighthouse Authorities of the United Kingdom and Ireland. It is funded in part by the Department for Transport and other UK government agencies. Chronos Technology has used these and other eLoran transmissions to conduct research into the viability of employing eLoran as a means of distributing time traceable to UTC, including for indoor applications. There is growing concern internationally regarding the vulnerability of GPS and other global navigation satellite systems (GNSS) to natural and man-made interference, plus the jamming and spoofing of their transmissions. These vulnerabilities have led to a demand for sources of resilient PNT, including a robust means of distributing precise time nationally and internationally.

This paper explores the ability of eLoran to disseminate UTC-traceable time to applications in GNSS-denied environments. It proposes the creation of a National Timescale with UTC distributed via eLoran signals. Practical results from a test programme are very encouraging: UTC-traceable time signals with an accuracy of better than 100ns and with a quality comparable to that provided by GPS are received even indoors. This new source of precise time meets the latest ITU standards for primary reference timing clocks in Internet Protocol networks.

PROPRIETARY INFORMATION

THE INFORMATION CONTAINED IN THIS DOCUMENT IS THE PROPERTY OF CHRONOS TECHNOLOGY LIMITED.
© COPYRIGHT CHRONOS TECHNOLOGY LIMITED 2014.

Registered in England No. 2056049. Registered Office: Stowfield House, Upper Stowfield, Lydbrook, GL17 9PD.
VAT No: G.B. 791 3120 44

This Issue Originated by: Charles Curry Managing Director, Chronos Technology Ltd

Document Status: **For Publication**

- **Chronos White Paper**

- **“Delivering a National Timescale using eLoran”**

- <http://www.chronos.co.uk/index.php/en/product-groups/time-and-timing/eloran-timing>

Find Out More?



<http://www.rntfnd.org>

- Improve anti-jamming and spoofing deterrence and enforcement
- Promote establishment of resilient terrestrial navigation and timing systems
- Looking at setting up an EU/UK Chapter

Dana Goward - dgoward@rntfnd.org



www.chronos.co.uk
www.gpsworld.biz
charles.curry@chronos.co.uk