

eLoran “PRTC Ready” Off-Air Signals In-Doors



Charles Curry BEng, CEng, FIET

Managing Director
Chronos Technology Ltd

ITSF 2014

4-6th Nov 2014

Budapest, Hungary

PNT – First Experiences



My First GPS Receiver - 1984

Photo, Gary Pierce, Texas. www.gcpierce.com/



My First VLF Timing - 1974



My First Loran-C Receiver - 1974

UK Research on eLoran



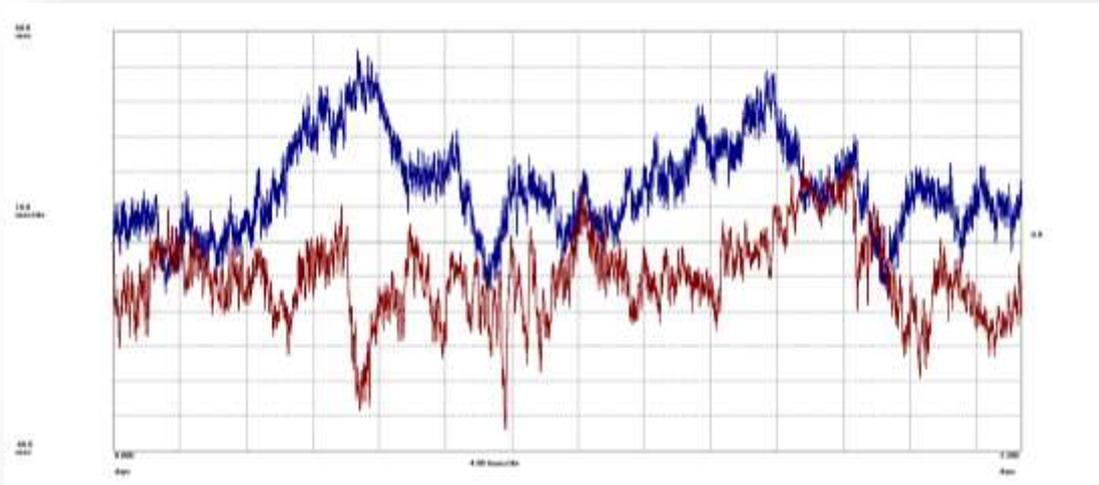
Research Tools



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

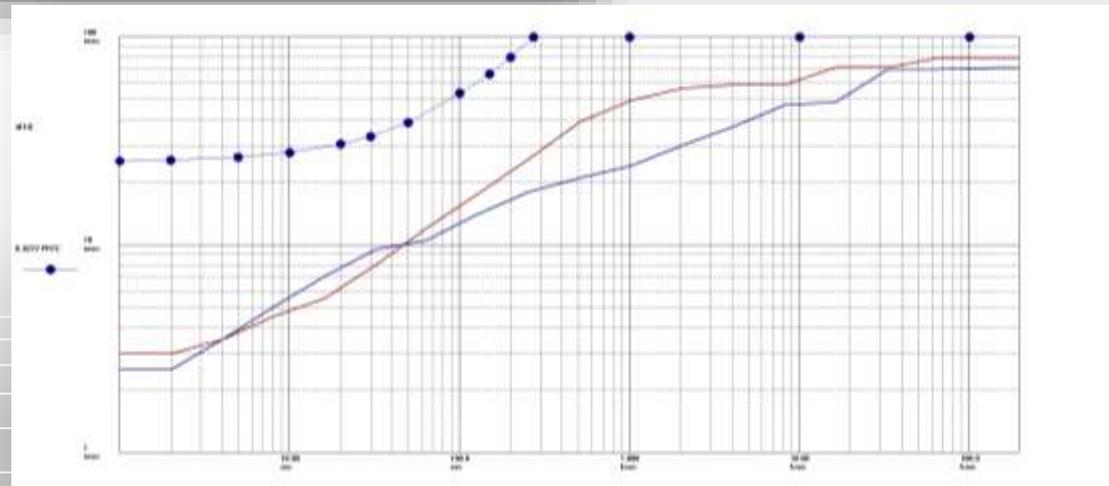


Some Results – TIE and MTIE

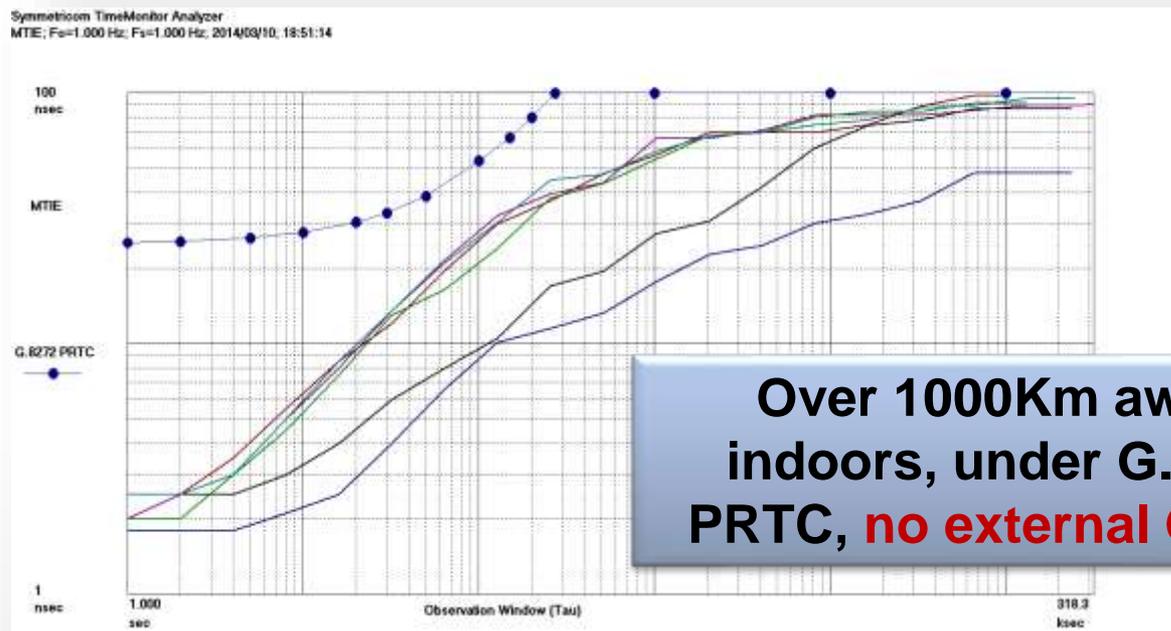


TIE Graphs
Blue: GPS
Red: Indoor eLoran
3 days, 10ns/div

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



Distant Station Testing



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

How do we get UTC?

- Loran Data Channel (LDC) transmits a UTC message
- Aligns the 1pps close to UTC
 - Error due to Additional Secondary Factor (ASF)
 - Dependent on land path and seasonal conditions
 - A few microseconds
 - Fixed with low seasonal variations (100ns)
- Can be calibrated out
- Either at installation or automatically

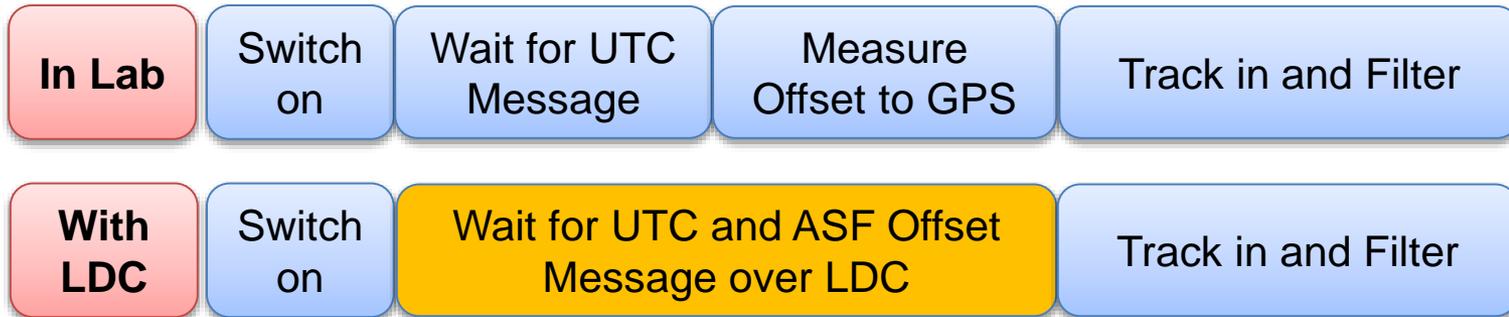
eLoran Differential Timing Rx

- eLoran Differential Timing Receiver – EDTR
- Measures ASF and establishes....
 - ASF Differential Timing Correction (ADTC)
- Enables UTC alignment to a few 10s of ns
- Sends ADTC to eLoran Transmitter to broadcast on the LDC
- UTC corrections can now be received indoors
- Local eLoran Rx with **no sky view** are now UTC aligned to G.8272 PRTC

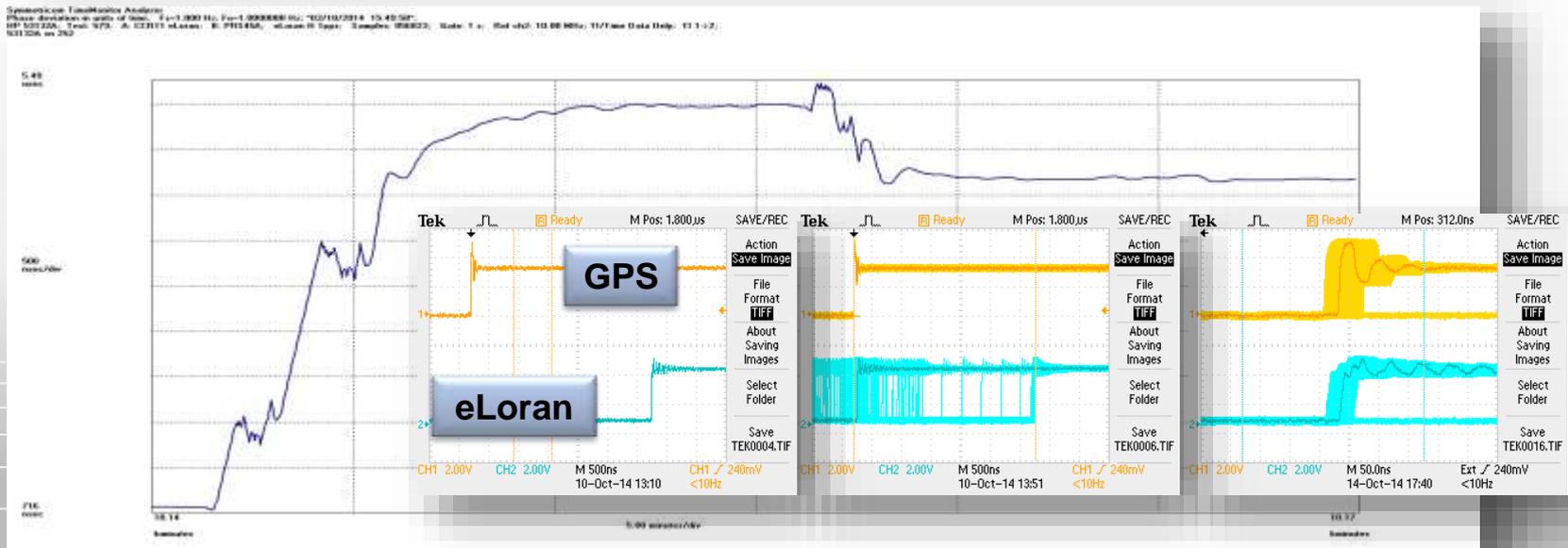
Loran Data Channel

- Eurofix Message Format ver 2.15
 - Radio Technical Committee for Maritime Services (RTCM) Special Committee-104, Eurofix working group, and the International Telecommunication Union (ITU) Recommendation M.589-3
- 16 “Message Types” can be broadcast
- Message Type 6 is the Eurofix Message
 - Rough correction to UTC
- Message Type 13 is now allocated for “ADTC”
- Experimental Transmissions from Anthorn

UTC Alignment Process

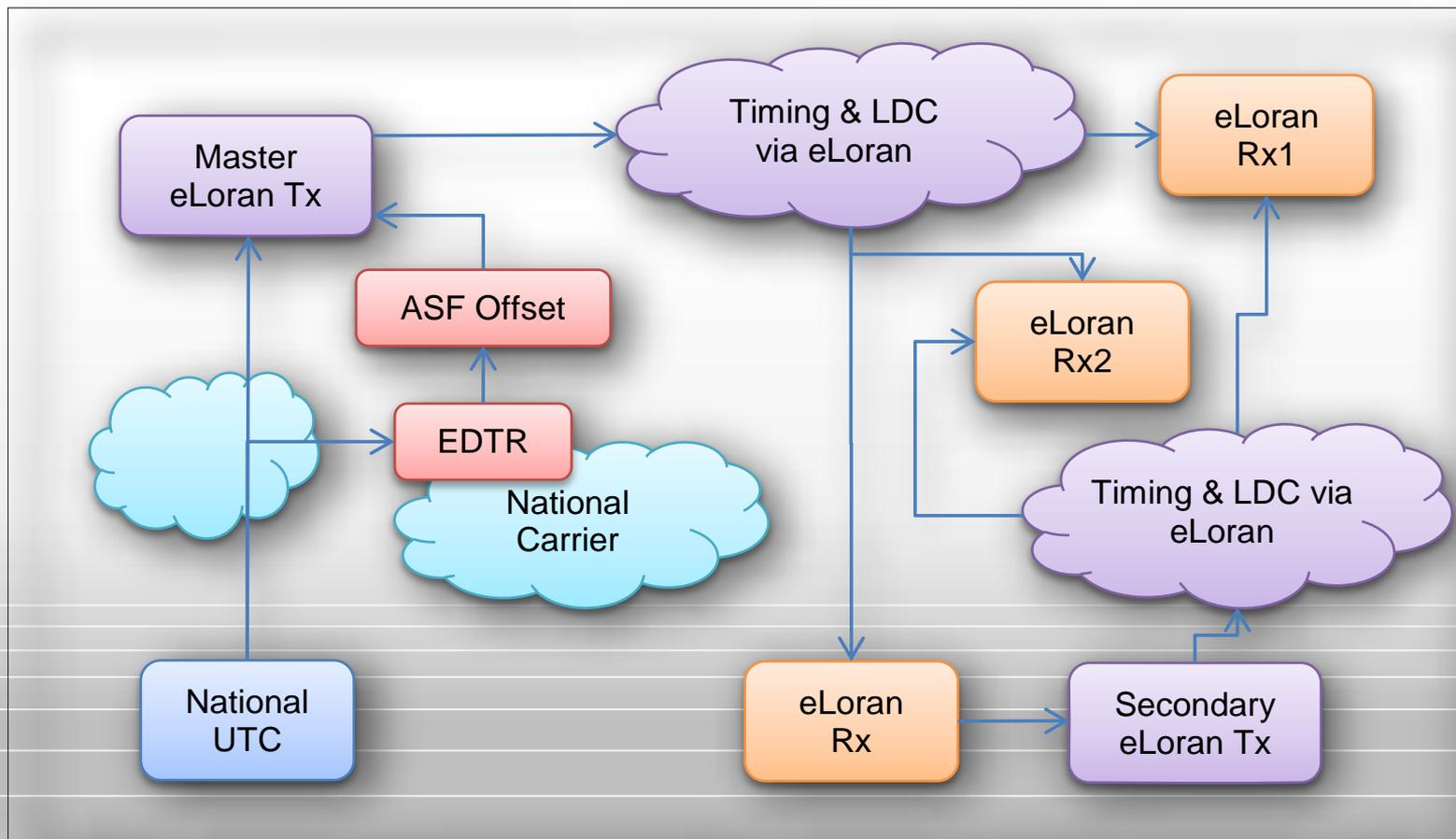


No sky view required with LDC!



Loran Data Channel (LDC)

LDC can broadcast a local regional differential UTC corrections

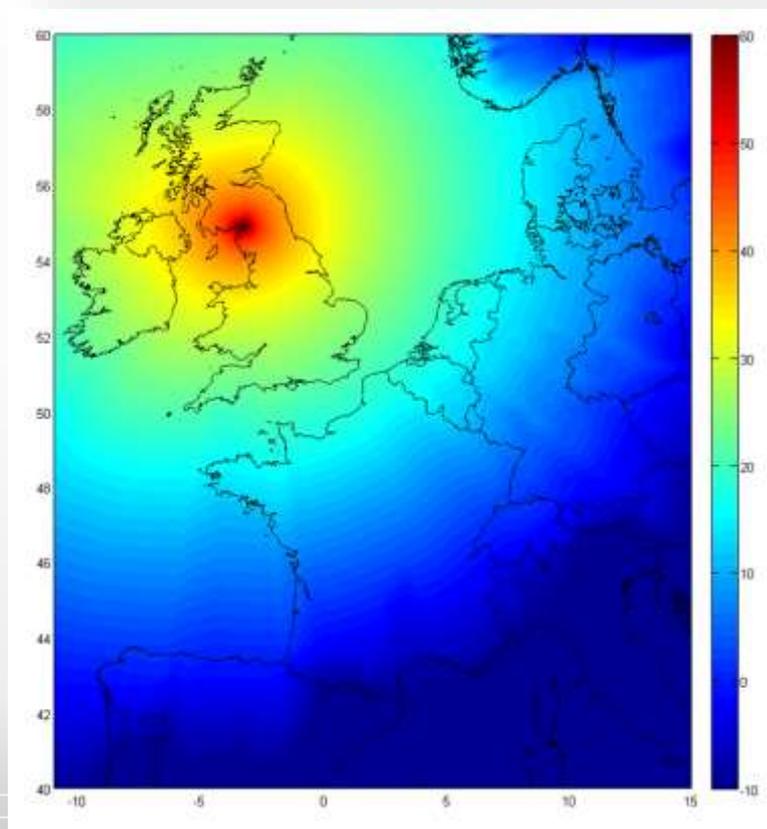


eLoran – for UTC “Time”



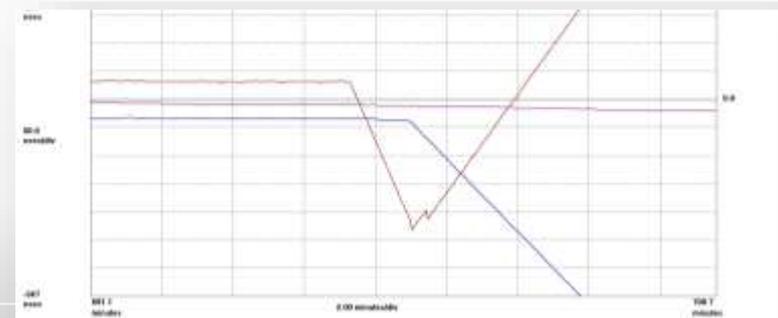
- Independent source of UTC
- Works in-doors, no expensive antenna roofwork
- Seamless cutover to back-up stations
- Meets ITU telecom PRC masks. (G.8272)
- LDC Broadcast Messaging enables continuous fine tuning of UTC
- Enabler for new LTE features - CoMP, eICIC indoors in GNSS denied locations
- Complements PTP, GNSS

Coverage & Resilience



***SNR Calculations and Image:
Chris Hargreaves (GLA)***

- Receivers monitor multiple stations
- Seamless Transition to backup



ITSF 2011, Edinburgh

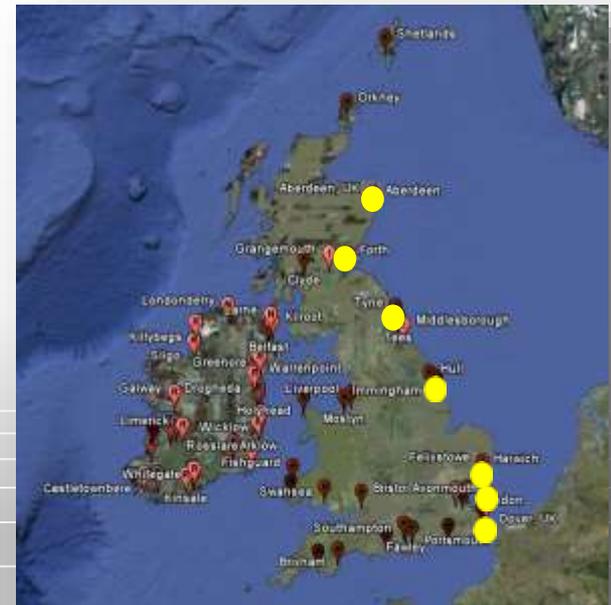
eLoran Status

- Operational in UK and Europe
 - GLA Announced IOC for maritime users *last week*.
- International Upgrade projects
 - **South Korea**, Saudi Arabia, India
- Chronos – Ongoing Timing Research
 - Use of LDC for Differential Timing Corrections
 - Seasonal variations
 - Indoor H-Field antenna deployments
 - Combined PTP/eLoran
 - Combined GNSS/eLoran

eLoran in UK – Run by GLA



- Prototype operational > 4 years
– high reliability
- Precise timing throughout UK
- Robust data channel
- Maritime resilient PNT:
- Initial Operational Capability
 - 7 major east coast ports
 - announced last week!
 - £1m investment by DfT
- Full Operational Capability
 - all major ports UK/Ireland
 - planned by 2019



Research Topics – (100ns limits)



- Spatial and Temporal ASF variations
 - <100ns?
- EDTR regional grid size
 - >500 miles/100ns?
- H-Field performance in indoor environments
 - <100ns Deep inside, under ground/water
- Long term LDC operations for remote UTC sync
 - <100ns/12 months/GNSS denied
- Studies with complementary technologies
 - PTP, SyncE, A-GPS, Low cost XO

Phase 1 Research Collaborators include EE, H3G & SFR
Deploy H-Field Systems at various locations

eLoran and “Standards”- UTC

- *“Eurofix Message Format”, Ver 2.15 (Offermans. 2014)*
- *RTCM* Recommended Standards for Differential GNSS (Global Navigation Satellite Systems) Service*
 - Ver 2.2, RTCM Special Committee 104, January 15, 1998.
- *Recommendation ITU-R M.589-3, Technical Characteristics of Methods of Data Transmission and Interference Protection for Radionavigation Services in the Frequency Bands between 70 and 130 kHz*

* RTCM – Radio Technical Commission for Maritime Services

eLoran and “Standards” - Transmission



- ITU-R SG7 WP4A
 - *Time signals and frequency standard emissions*
 - *Terrestrial and Satellite*

- Q249
 - *What is the geographical coverage for time and frequency use of eLoran?*
 - *Can eLoran provide similar backup to users of other Global Navigational Satellite System (GNSS) services?*
 - *What is the time and frequency performance of eLoran?*
 - *Will time and frequency information from eLoran be traceable to National Metrology Institutes and to Coordinated Universal Time (UTC)?*
 - *that the results of the above studies should be included in one or more Recommendations and/or Reports;*
 - *that the above studies should be completed by 2015*

- UK response via Ofcom (National Coordinating Office)
 - Information Note delivered to WP4A Meeting Sept 2014
 - Contribution planned in the May 2015 Meeting

LDC 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

Find Out More?



<http://www.rntfnd.org>

- Improve anti-jamming and spoofing deterrence and enforcement
- Promote establishment of resilient terrestrial navigation and timing systems

Dana Goward - dgoward@rntfnd.org

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 transmitters 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

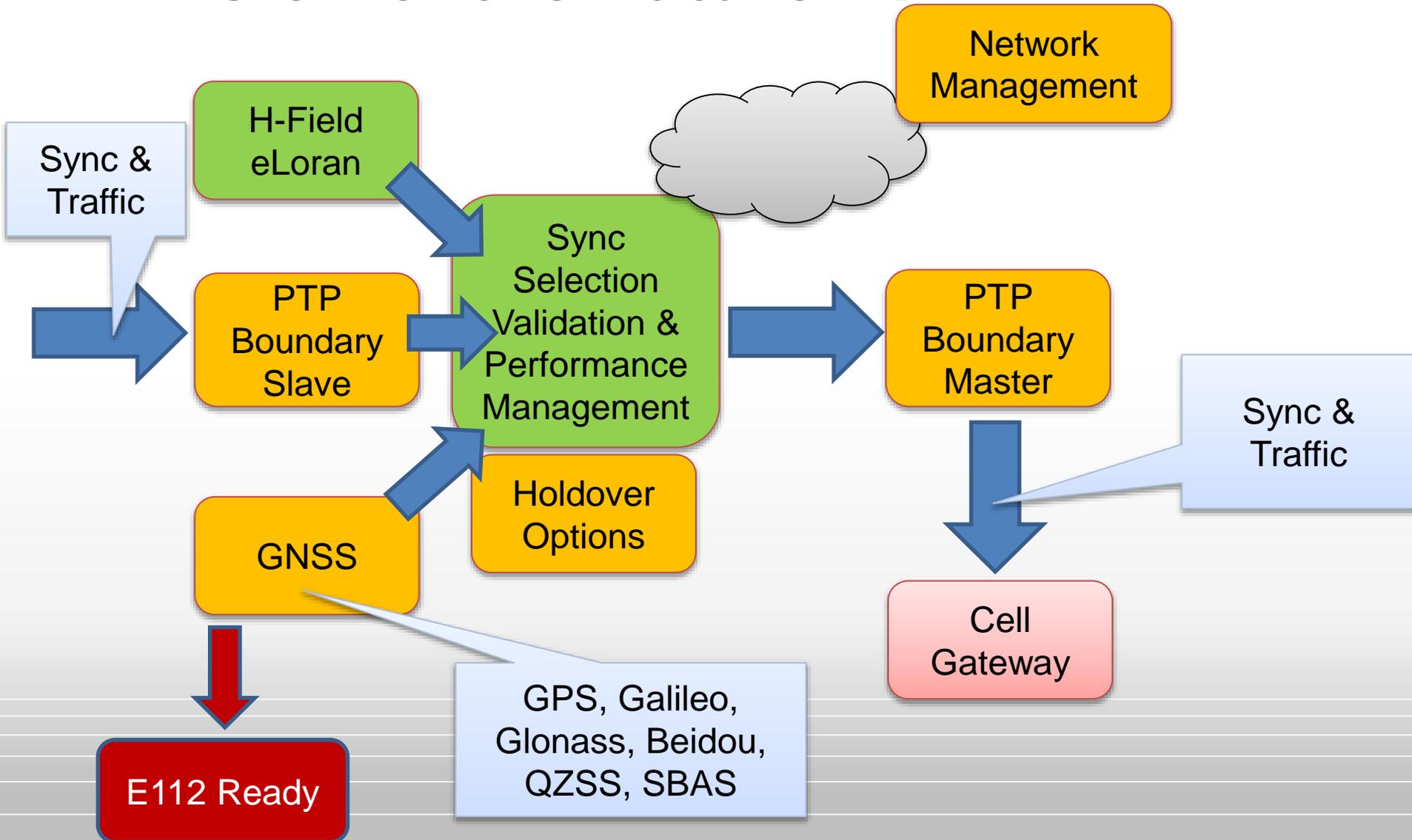
THE INFORMATION CONTAINED IN THIS DOCUMENT IS THE PROPERTY OF CHRONOS TECHNOLOGY LIMITED.
© COPYRIGHT CHRONOS TECHNOLOGY LIMITED 2014.

Registered in England No. 2056449 Registered Office: Stonefield House, Upper Stonefield, Lydbrook, GL17 9PL.
UK Tel: 018 791 3126-44

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/products-groups/time-and-timing/eloran-timing>

A Vision of the Future....



Conclusions

- eLoran is in the “Standards” – Active Questions
- LDC enables in-door operations
- eLoran delivers PRTC performance in-doors
- First phase of operational eLoran complete
- Plans brewing to run eLoran transmissions independently of Governments
- Cross border research projects underway

Thank You for Listening

A horizontal collage of six images: a blue and white abstract pattern, a server room with blue lights, a purple and red abstract pattern, a sunset over a landscape, a blue and white abstract pattern, and a man working on a server rack.

Chronos Technology Ltd

www.chronos.co.uk

charles.curry@chronos.co.uk

© Chronos Technology Ltd - 2014