

#### eLoran as a Complementary Source of PNT

Tony Flavin – Chronos Technology 14<sup>th</sup> March 2023 (V1.0)



## eLORAN as a Complementary Source of PNT

- eLORAN will soon be a viable source of timing across both the UK and North America. Wider deployments would not be difficult. It promises to deliver GPS equivalent performance for most timing applications and is a superior technology against jamming etc.
- This talk will show how this can achieved and gives an update on work in the UK towards a viable service.

## A short introduction to eLoran

- A non-sky based radio source of timing
  - And navigation
- Similar performance to GPS/GNSS
  - Fully meeting requirements for most applications sub 100ns
- Much harder to jam
  - Orders of magnitude higher power level
  - Ground based signals
- Penetrates inside buildings, below ground and also penetrates water
- Has a low bitrate FEC corrected data channel



#### Attenuation of RF Passing Through Conductive Media

## The eLoran LF Pulse

Α

A/2

(Master Shown = Secondaries do not have the 9<sup>th</sup> pulse)

Not to scale. For explanation purposes only



## The enemy ---- Skywave

- Reflections from the lonosphere creates a delayed signal at the receiver.
- This is why CW systems such as MSF DCF etc are poor candidates for synchronisation due to signal cancelation
- Unlike GPS with urban canyon reflections, this is easily defeated by eLoran





## GPS has atmospheric enemies too!





The timekeeping abilities at the Neolithic site of Stonehenge built around 3000BC in Wiltshire, England, was completely unaffected.

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### ASF

#### **Additional Secondary Factor**

Distance from Anthorn to the Chronos is 210 miles (338km) which is 1.127ms at the speed of light

Total ascent and descent from Anthorn to Chronos is around 23,000 feet (7km) Which equates to a hill climb time error of approx. 23 micro-seconds without correcting for terrain

This is the Primary factor and is effectively a known static figure. The ASF is additional variation due to ground conditions (moisture, temperature) affecting the effective air dielectric value and needs active tracking and compensation



## ASF mapping receivers



- First Development units from Microchip
- Developed for this project which is ESA funded.
- 5 sites being deployed imminently
- 20 sites will be deployed



## ASF Mapping Architecture

- Multiple stations across the UK plus 1 at ESA in the Netherlands
- Monitor ASF Variation
- Transmit correction data over Data channel 13 from Anthorn
- A second project is providing UTC(NPL) traceability at Anthorn
- New Caesiums already installed and tracking UTC.



#### ASF

#### Weather a prime influencer

Distance from Anthorn to our head office is 210 miles (338km) which is 1.127ms at the speed of light

A weather front cutting across the RF path could affect the ASF value relatively quickly



## ASF Visualisation Pre and post processing Error largely constrained to < 100ns





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## FFT of three days of ASF noise

asf Frequency distributiuon - Four days Nov 5th to Nov 9th

- Vertical scale completely arbitrary
- 338473 point FFT
  - Yes the fftw library can do that!
  - No prefiltering of data
- Nothing unexpected
- Not enough data yet to see any Day/Night effects



# 1PPS output -v- GNSS Steered 5071A Caesium 12 hours of Data from last Thursday night. No ASF Correction



Microchip TimeMonitor Analyzer

#### NPL Time over eLoran

- In April 2023 we will "Upgrade" Anthorn to provide UTC(NPL)
- This will transmit the UK National timescale from NPL
- Connecting Anthorn to the new Strathclyde NPL RETSI node
  - (Resilient Enhanced Time Scale Infrastructure)
- Initially using two way GNSS transfer between Strathclyde and Anthorn
  - Any available time transfer method/protocol could be used.
  - Currently no fibre into Anthorn
- On site Caesiums at Anthorn will be trained to UTC(NPL)
  - On site Caesiums once tuned giving Parts in 10-14 performance
  - Holdover in case of GNSS issues assured
- Fallback to UTC(USNO) if required

### Outcome

- A service proposition for a UK wide Timing service
- Comparable timing performance to GNSS
- Able to operate in GNSS blackspots
- Able to penetrate inside buildings and other GNSS blackspots



## Summary

- eLoran IS coming back for timing and ultimately navigation
- It will be available across the whole of the UK
- It will reach places that GNSS cannot
- It IS a complementary technology that can be used in conjunction with GNSS for resilience
- Combined eLoran/GNSS can reduce the cost of holdover oscillators due to the overall increased system availability
- Start putting it into future system designs now



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