GPS & other Radio Time sources

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Wireless Heritage SIG
'Time for Telecoms'

British Science Museum
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Is time the same everywhere?

- Equation of Time and Longitude
  - London to Bristol 10 minutes 21 seconds (2.6^{o} west of Greenwich)

- This results in Time-zones
  - Unless you believe that the Earth is flat!

Increasing precision

Harrison’s H1

Harrison’s H5

Caesium Fountain

Courtesy of NPL

Time Definitions

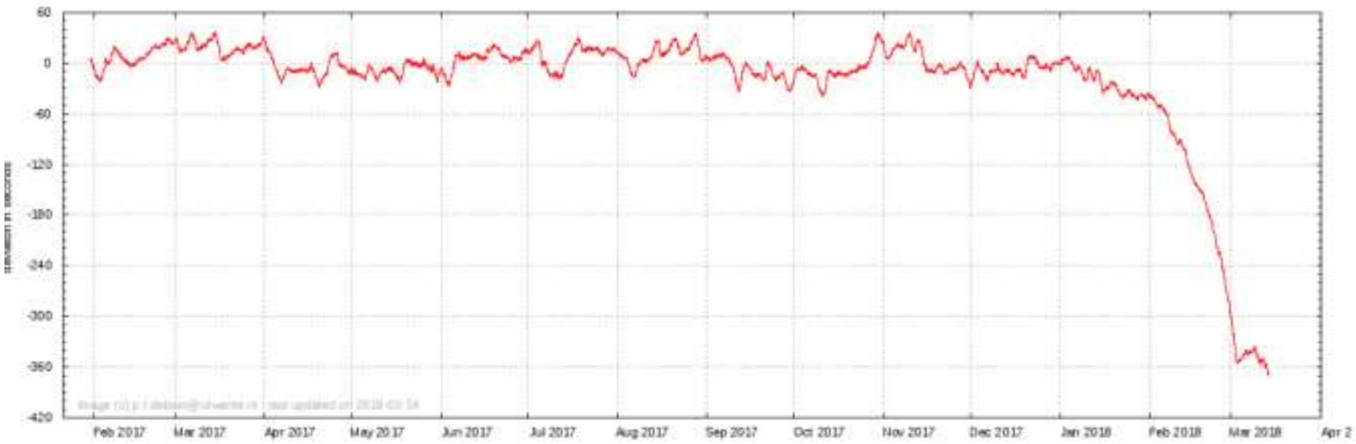
- Apparent solar time – Day approximately 24 hours
- Sidereal time – Star observation – Day approx. 23:56:04 (from Latin Sidus – Star)
- Mean Solar time – Solar time corrected for seasons
- Greenwich Meantime (GMT - 1884)
  - Observation of stars crossing meridian
  - Renamed Universal Time (UT – 1928) multiple versions
    - UT0 – Observation of diurnal movement of stars
    - UT1 - Observation of Quasars and Moon laser ranging. UT1 is the same everywhere on Earth
    - UT1R – As UT1 filters out permutations due to e.g. tides
    - UT2 – Another smoothed UT1 rarely used now

- Coordinated Universal Time (UTC – 1960)
  - Atomic timescale. Based on SI seconds 86399 – 86401 seconds per day (usually 86400). Leap seconds keep UTC within 0.9 seconds of UT1
  - Maintained by the International Bureau of Weights and Measures (Bureau international des poids et mesures) – BIPM
  - defined by ITU-R TF.460-6

How’s the time on your MicroWave (not UK)

An Energy War in the Balkans Has Slowed Europe’s Electric Clocks by 5 Minutes

Serbia and Kosovo can't decide who will pay their energy bills, and it's disrupting Europe's power grid.



Fortunately we have Radio systems to tie all of this together

- MSF from ~~Rugby~~ – Anthorn
- eLoran
- DCF
- GPS
- Other GNSS
- Etc.

Most give UTC or a known conversion to UTC

(UTC has awkward unpredictable things called leap seconds. That makes it unsuitable for arranging precise time points in the future.)

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- MSF 2 parts in 10^{-12}
- eLoran 3 parts in 10^{-14}
- DCF 2 parts in 10^{-13}
- GPS – Part of UTC
- Other GNSS – Part of UTC
- Etc.

The trouble with GNSS

- It's too damn good!
  - Very few applications require an alternative to cover short term failures/interference
- Modern Car Sat-Navs already have backup
  - Wheel rotation + Accurate cartography
- Telecoms networks (for timing) have backups
  - Centrally distributed atomic clocks
  - Mobile networks may have issues

It all depend on Availability

- That's the required availability of the application/service.
  - Five 9's is a common requirement- That's available for 99.999% of the time
  - Equivalent to 2 hours/year out of service.
- At this level you question everything and have a lot of redundancy
  - And also deep pockets!

Typical Telecoms Clocks

Typical Telecoms Clocks

1980's version

- Typically Quartz and Rubidium standby oscillators
- GPS Receiver at top
- Multiple redundant outputs
- Terrestrial sync inputs from adjacent sites
- For 2Mbit/s based networks (and SDH)

1990's version

- Typically Quartz and Rubidium standby oscillators
- GPS Integrated
- Multiple redundant outputs
- Terrestrial sync inputs from adjacent sites
- NTP and PTP card options

Telecoms grade NTP servers

Today's version

- Typically Quartz and Rubidium standby oscillators
- GPS Integrated
- Ethernet for PTP and NTP
- Limited frequency outputs

And how not to install them!

Applications depending on GNSS

- Will have redundant systems
  - It takes more that the 2 hour target to fix a faulty GNSS antenna
- Constellation outages to date make the target difficult to achieve
  - Multi constellation helps, but are mainly use the same spectrum and are hence all prone to jamming

Jamming Drive-past

Jamming/Spoofing

- Jamming Easy and commonplace
  - Usually short term and not really a big service issue
  - But could be long term
- Spoofing more complex and has been demonstrated
  - A-GPS helps mitigate but still leaves no service
- Mitigation via Satellite/Radio needs to be on a Clearly separate frequency band and preferably much higher power than GNSS
- How long do we need to mitigate for?

The Telegraph

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By James Titcomb

11 MARCH 2018 • 7:04PM

Last June, more than 20 ships on the Black Sea noticed something unusual about their satellite-based navigation systems. Instead of their true positions well away from Russia's south-west border, each ship's GPS placed it inland at Gelendzhik Airport, a small terminal that serves the picturesque coastal town.

It made no sense. The Global Positioning System (GPS), the network of satellites that we rely on every day, is rarely wrong. When it is, the margin of error is only a few metres. The ships on the Black Sea were 20 miles from Gelendzhik.

Jammers

Anthorn – UK Transmitter site for eLoran

<£££<

Short History

- Loran – **Lo**ng **Ra**nge **N**avigation. Roots,WW2
- Loran-C 1960's
- Russia - CHAYKA
- eLoran – Enhanced, more accurate
  - Loran Data Channel (LDC), UTC alignment of pps.
- US Switched off Loran-C
- USA, Saudi, ROK, India - Loran upgrades
- eLoran Managed in UK by GLAs

What does an LF solution such as eLoran give

- Difficult to Jam
  - Much higher power (250Kw for a few hundred miles compared to GPS ~20W at >= 12000 miles
- In building penetration
- Limited underground/water penetration
- Frequency available from a single station
- Time available from a single station
  - If location of transmitter and receiver are known
- Navigation needs 2 to 3 stations
  - (2 if tracking from a known location)
- Relatively simple receiver electronics – can be very low power.

European eLoran

Stations

Name	ECD	SNR	SA / SC	TOA
6731Y Anthorn	-2.96	9.31	100.00 / 100.00	28526.80
6731Z Sylt	-3.53	0.10	97.55 / 98.77	44834.40
6731M Lessay	-2.49	16.22	99.97 / 99.99	1116.55
7499Y Vaerlandet	-3.37	-4.27	92.93 / 97.20	33390.50
6731X Soustons	-2.63	-0.62	99.85 / 100.00	16106.70
9007X Boe	-9.83	-6.94	10.51 / 88.78	35076.90
9007W JanMayen			- / -	
7001Y Berlevag			- / -	
9007M Ejde	-7.47	-11.88	0.25 / 7.84	4068.00
7499M Sylt	-3.78	0.60	97.22 / 98.64	2734.58
7499X Lessay	-2.39	16.21	99.98 / 99.99	15216.60
9007Y Vaerlandet	-5.85	-4.89	86.08 / 94.42	44990.60
7001M Boe			10.64 / 88.02	
7001X JanMayen			- / -	

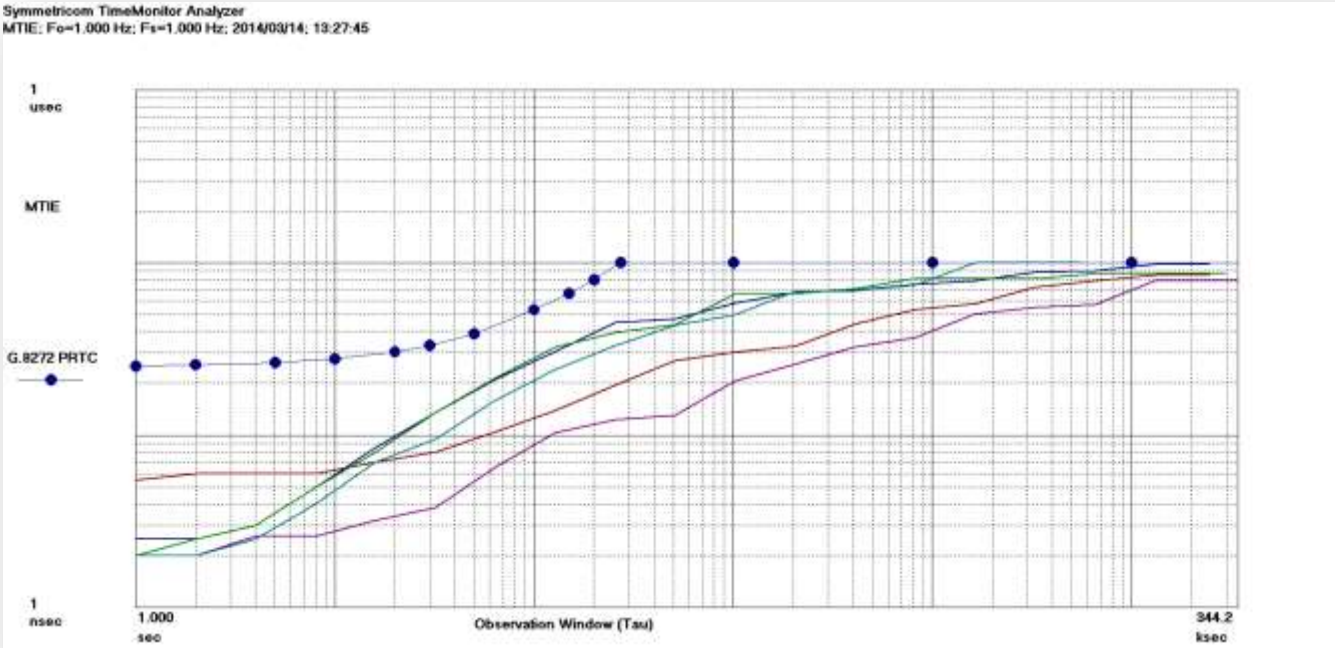
Coverage

- eLoran transmissions are at 100 KHz 250 kW
  - Radio 4 AM Droitwich at 198 KHz 500kW
- Ground Wave – Not Sky Wave
- Delays due to ground conductivity and terrain
- Delays calibrated out - differential corrections
- UTC (50ns) alignment via LDC
- Coverage in-doors via H-Field antenna

eLoran - Key Features

- Works in-doors
- In-Built resiliency using other transmitters
- Stability and Accuracy – Comparable to GPS
  - Monitored by NPL
- Immune to GPS Jamming
- Frequency – Free to Air
- Phase - LDC – Guaranteed Subscription Service
- Standardised – RTCM
  - Radio Technical Commission for Maritime Services

G.8272 PRTC



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Thankyou

http://www.chronos.co.uk/

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