Long Term Time & Timing Trials with eLoran

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Presentation Content

- Motivation – Chronos R&D Projects
- Re-Examine viable alternatives to GNSS
- Identification & Mitigation of Issues
- Latest eLoran Timing Trials
- Conclusion

Chronos R&D Projects

- UK Technology Strategy Board
  - http://www.innovateuk.org/
- Collaborative R&D Calls
- 2008 – “Gathering Data in Complex Environments”
  - “GAARDIAN” - £2.2m
- 2010 – “Trusted Services”
  - “SENTINEL” - £1.8m

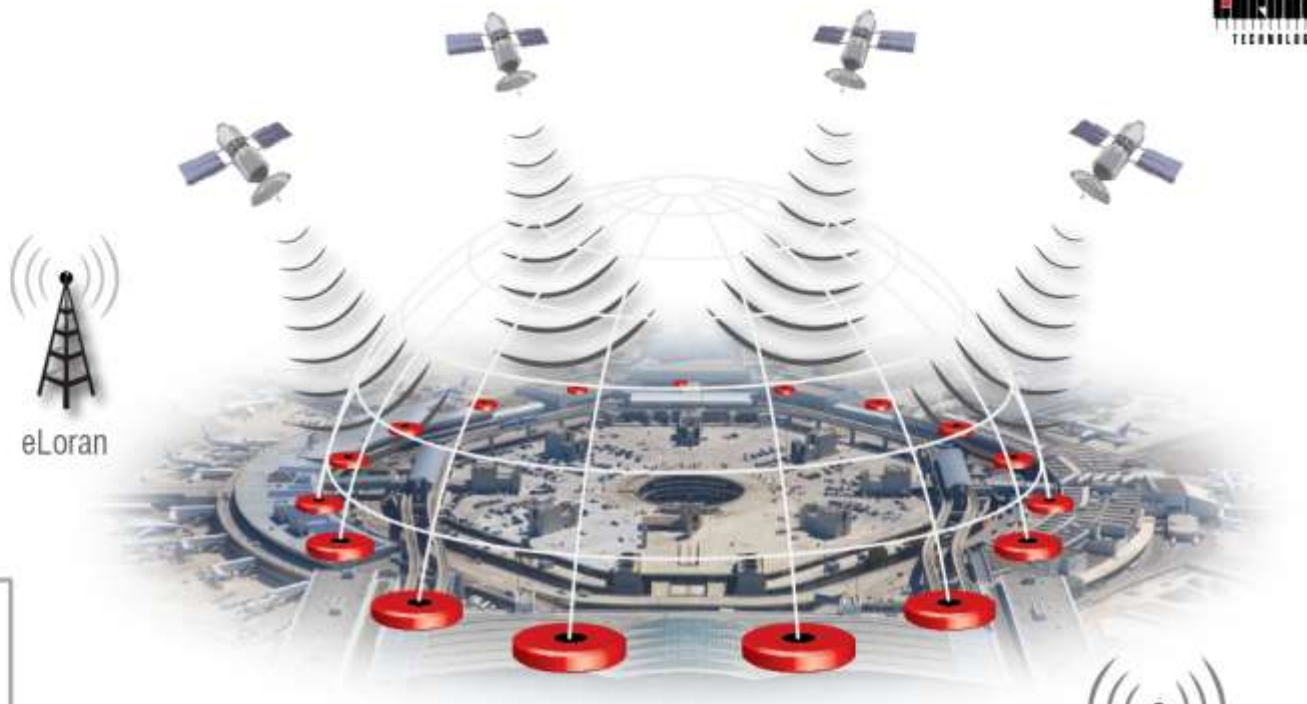
The GAARDIAN Project –
GPS Interference Detection and Mitigation

- GNSS Availability, Accuracy, Reliability anD Integrity Assessment for timing & Navigation
- Research data gathering necessary to create a GPS Interference Detection and Mitigation (IDM) network
  - At point of use, 24 x 7 x 365
  - For mission and safety critical applications
  - Which use GPS (or GNSS) signals
  - **Leveraging eLoran signals for QoS determination**
- UK Government funded R&D project (~£2.2m)
  - through Technology Strategy Board & EPSRC
  - “Gathering data in Complex Environments” Call

The SENTINEL Project –
GPS Interference Location and Mitigation

- GNSS SErvices Needing Trust In Navigation, Electronics, Location & timing
- Research the detection, quantification and location of interference to GNSS and **eLoran** signals at point of use by deploying Interference Detection & Mitigation (IDM) probes in the vicinity of critical infrastructure
- UK Government funded R&D project (~£1.8m)
  - through Technology Strategy Board and EPSRC
  - “Trusted Services” Call

sentinel



Real time detection of GNSS interference for critical infrastructure

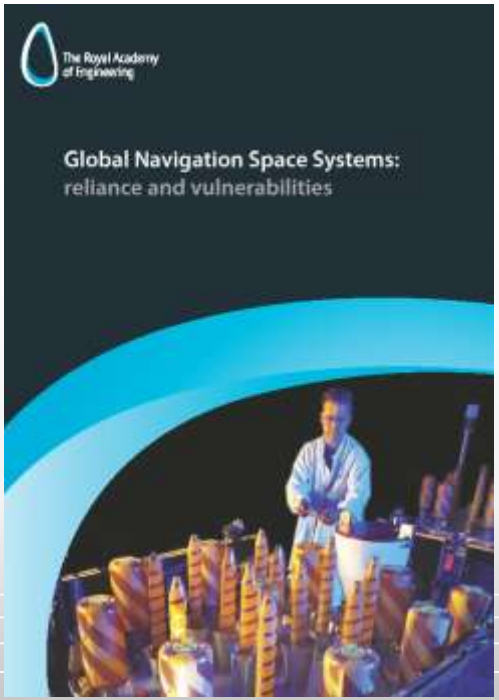
- Protection of critical infrastructure: harbours, airports, road, rail and more
- Protection of safety, mission-critical, security or revenue generating services
- Real-time alerts to locate deliberate and accidental GPS/GNSS interference, inc Jamming
- Assistance for appropriate agencies for mitigation of interference events
- Monitoring of GNSS frequency bands to provide indications of integrity and trust
- System to prove the use of eLoran as a viable alternative PNT system (where GNSS is denied)

SENTINEL - Partners

- Chronos – Lead Partner
- GLA – General Lighthouse Authorities
- ACPO - Association of Chief Police Officers
- University of Bath - Department of Electrical & Electronics
- Thatcham Vehicle Security
- OS - Ordnance Survey
- NPL – National Physical Laboratory

GPS Vulnerabilities

- Emerging GNSS Vulnerabilities
  - Royal Academy of Engineering Report – March 2011
    - http://www.raeng.org.uk/news/publications/list/reports/RAoE_Global_Navigation_Systems_Report.pdf
  - GPS Jammers
    - Criminal, PPD, Service Denial, Other
  - RF Interference
    - Key Fobs, “LightSquared”
  - Space Weather
    - 11 Year Solar Cycle starting
  - System Failure
    - PRN #24 - Jan 1st 2004
    - GAO report 2009 GAO-09-670T



GPS Jammers!

- Why?
  - Steal a vehicle, something
  - Avoid
    - Road User Charges
    - Pay as you Drive Insurance
    - Tachogragh systems
  - Use company vehicle …..
    - Skive off early, the School Run
  - Avoid being tracked
    - Drug Dealers, Celebrities, Tagged Criminals
  - Service Denial
    - Unfriendly: North Korea, Friendly: Force Protection

Alternatives?

- Timing Stability – meet ITU MTIE masks ~100ns
- UTC Traceability (Future LTE-A) ~ < 1µsec
- Other GNSS?
  - Same Vulnerability as GNSS
- LF Transmissions?
  - Parochial, Not Global, UTC, Maintenance Downtime
- NTP?
  - Not good enough, PDV, ~ms
- PTP?
  - Getting there, Hardware upgrade, Local GM, Architecture, PDV, ~µsec
- SyncE?
  - Standards not ready for UTC, Network Upgrade
- Anything Else???

eLoran?

- Pros
  - Different Frequency – 100 KHz
  - High Power (35 kV Pulses), Cs Controlled
  - International Infrastructure
  - UTC Traceability (not via GPS) - The “e”
  - Works indoors H-Field Antenna
  - Complementary technology, symbiotic not competitive
- Cons
  - Receiver Designs
  - Additional Secondary Factors (ASF)
  - Politicians!

Loran Timing Receivers ~ 2008

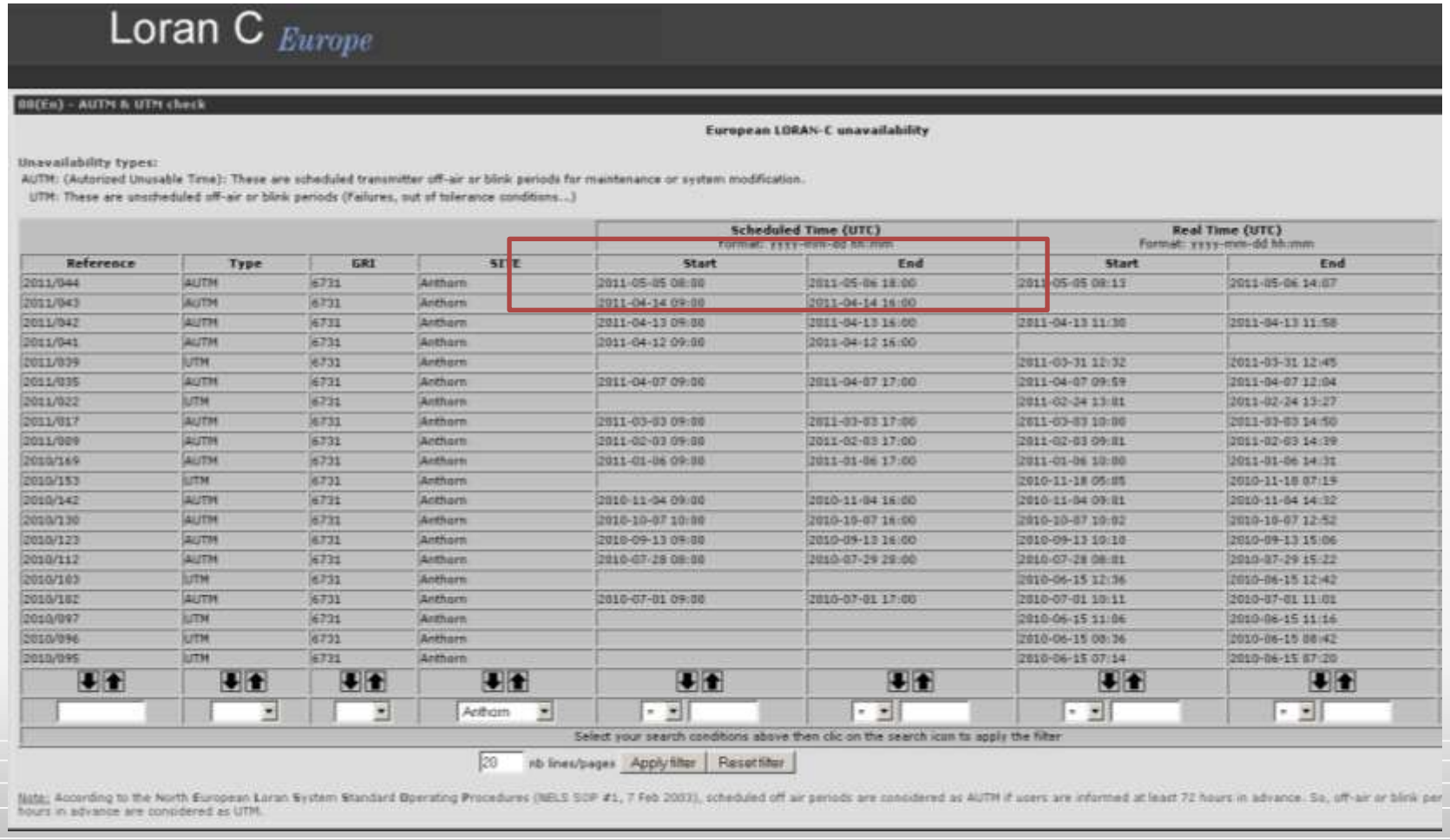
- Frequency Stability met ITU PRC MTIE mask
- Could be suitable for telecom timing – but…
- Occasional instabilities
  - Cause unknown – Weather? Station maintenance?
- Major phase hits due to Tx maintenance
- Not possible to align 1pps to UTC
- Not fit for Purpose!!

Station Outage Mitigation

- eLoran Transmitters - off air for maintenance
- Causes significant phase hits to timing outputs
- Chronos tested Loran Timing Receivers from Reelektronika (NL) and CrossRate (USA)

- Worked with UrsaNav in GAARDIAN to perfect solution - URS 150 – Beta Units Q4 2010

Outage Mitigation Results #1



Loran C *Europe*

88(En) - AUTM & UTM check

European LORAN-C unavailability

Unavailability types:
AUTM: (Autorized Unusable Time): These are scheduled transmitter off-air or blink periods for maintenance or system modification.
UTM: These are unscheduled off-air or blink periods (Failures, out of tolerance conditions...)

				Scheduled Time (UTC) Format: yyyy-mm-dd hh:mm		Real Time (UTC) Format: yyyy-mm-dd hh:mm	
Refereace	Type	GRI	SITE	Start	End	Start	End
2011/044	AUTM	6731	Anthorn	2011-05-05 08:00	2011-05-06 18:00	2011-05-05 08:13	2011-05-06 14:07
2011/043	AUTM	6731	Anthorn	2011-04-14 09:00	2011-04-14 16:00		
2011/042	AUTM	6731	Anthorn	2011-04-13 09:00	2011-04-13 16:00	2011-04-13 11:30	2011-04-13 11:58
2011/041	AUTM	6731	Anthorn	2011-04-12 09:00	2011-04-12 16:00		
2011/039	UTM	6731	Anthorn			2011-03-31 12:32	2011-03-31 12:45
2011/035	AUTM	6731	Anthorn	2011-04-07 09:00	2011-04-07 17:00	2011-04-07 09:59	2011-04-07 12:04
2011/022	UTM	6731	Anthorn			2011-02-24 13:01	2011-02-24 13:27
2011/017	AUTM	6731	Anthorn	2011-03-03 09:00	2011-03-03 17:00	2011-03-03 10:00	2011-03-03 14:50
2011/009	AUTM	6731	Anthorn	2011-02-03 09:00	2011-02-03 17:00	2011-02-03 09:01	2011-02-03 14:39
2010/169	AUTM	6731	Anthorn	2011-01-06 09:00	2011-01-06 17:00	2011-01-06 10:00	2011-01-06 14:31
2010/153	UTM	6731	Anthorn			2010-11-18 05:05	2010-11-18 07:19
2010/142	AUTM	6731	Anthorn	2010-11-04 09:00	2010-11-04 16:00	2010-11-04 09:01	2010-11-04 14:32
2010/130	AUTM	6731	Anthorn	2010-10-07 10:00	2010-10-07 16:00	2010-10-07 10:02	2010-10-07 12:52
2010/123	AUTM	6731	Anthorn	2010-09-13 09:00	2010-09-13 16:00	2010-09-13 10:10	2010-09-13 15:06
2010/112	AUTM	6731	Anthorn	2010-07-28 08:00	2010-07-29 20:00	2010-07-28 08:01	2010-07-29 15:22
2010/103	UTM	6731	Anthorn			2010-06-15 12:36	2010-06-15 12:42
2010/102	AUTM	6731	Anthorn	2010-07-01 09:00	2010-07-01 17:00	2010-07-01 10:11	2010-07-01 11:01
2010/097	UTM	6731	Anthorn			2010-06-15 11:06	2010-06-15 11:16
2010/096	UTM	6731	Anthorn			2010-06-15 08:36	2010-06-15 08:42
2010/095	UTM	6731	Anthorn			2010-06-15 07:14	2010-06-15 07:20

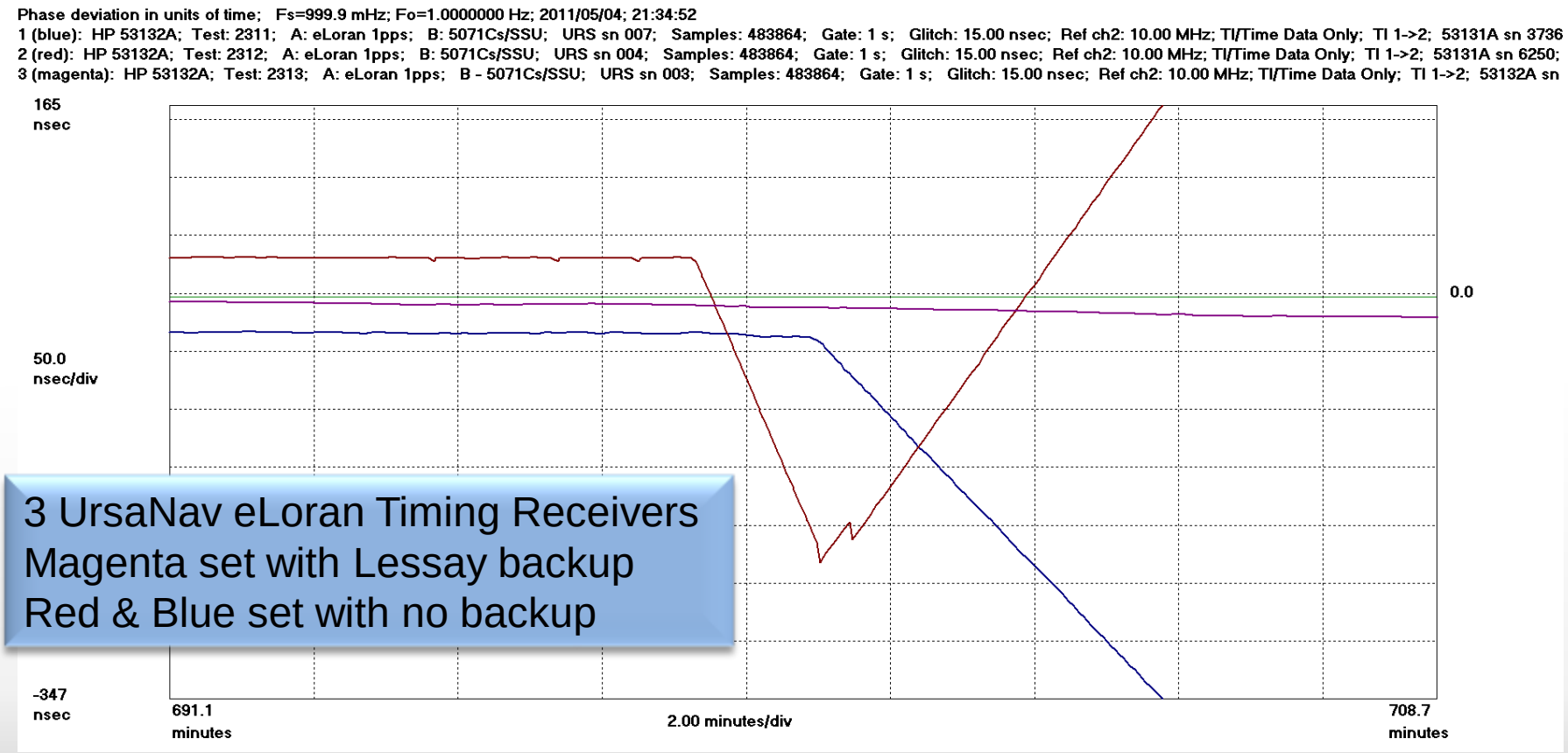
Anthorn

Select your search conditions above then clic on the search icon to apply the filter

20 nb lines/pages | Apply filter | Reset filter

Note: According to the North European Loran System Standard Operating Procedures (NELS SOP #1, 7 Feb 2003), scheduled off air periods are considered as AUTM if users are informed at least 72 hours in advance. So, off-air or blink per hours in advance are considered as UTM.

Outage Mitigation Results #2



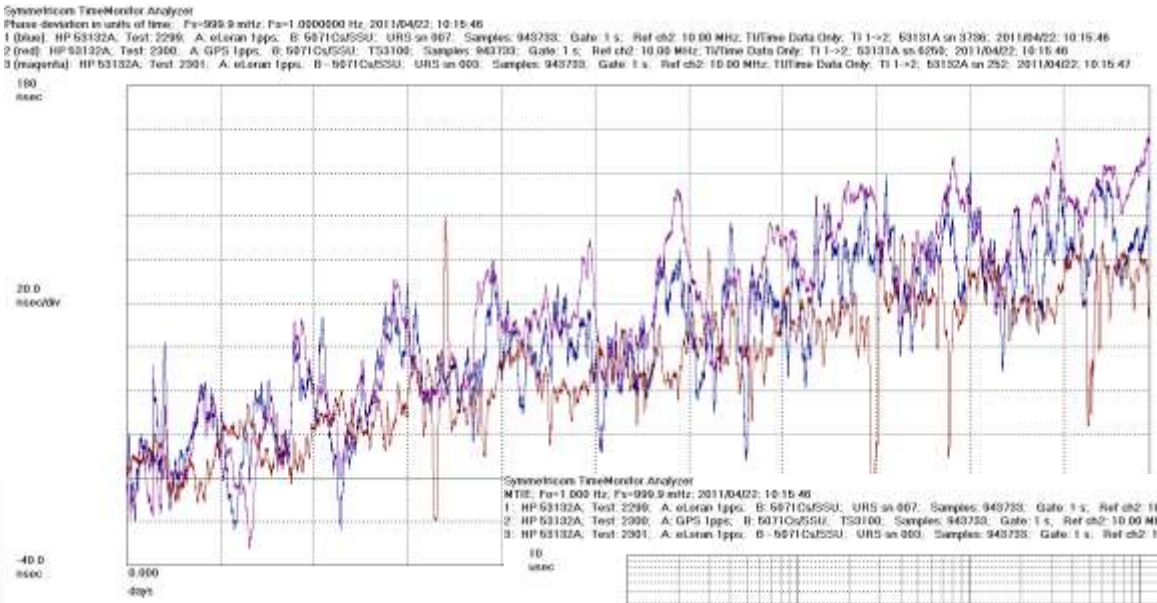
3 UrsaNav eLoran Timing Receivers
Magenta set with Lessay backup
Red & Blue set with no backup

Also proves eLoran in inherently self-resilient to Tx failure.

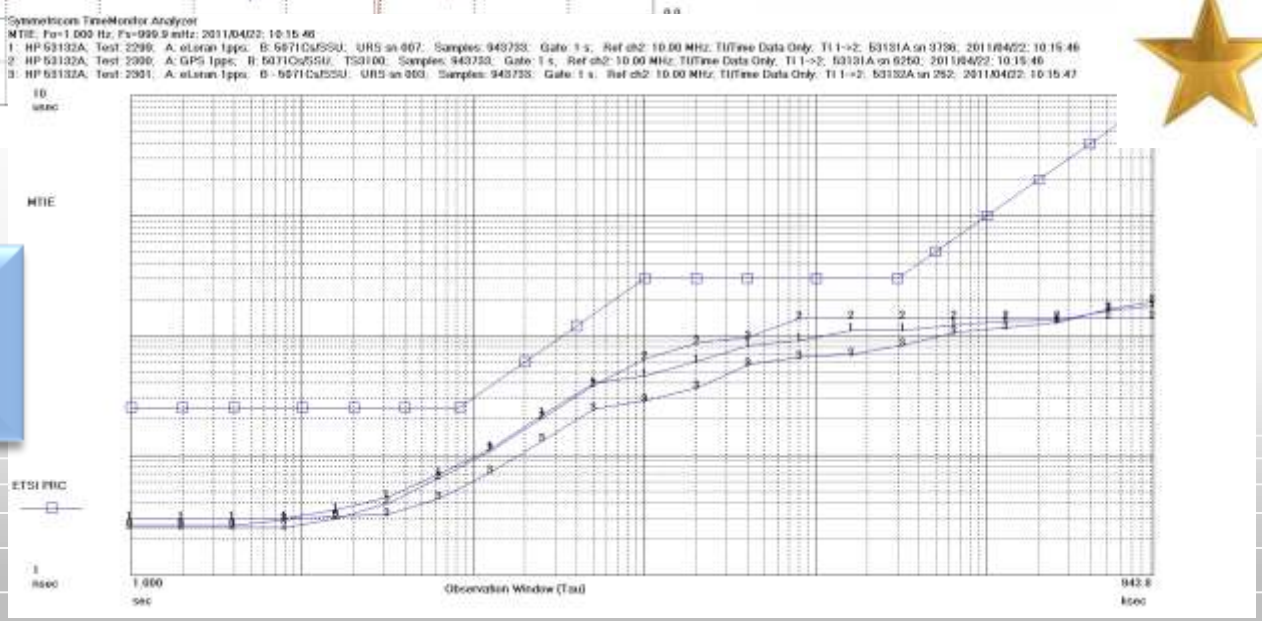
Automatic UTC Alignment

- Given location, eLoran Timing Receiver will automatically adjust 1pps to <2µsec of UTC
  - UTC “Eurofix” message from Anthorn
- Final adjustment – ASF Calibration
  - <50ns by comparison with local GPS UTC
- “GAARDIAN” proved this feature

eLoran Fit for Purpose (Update)

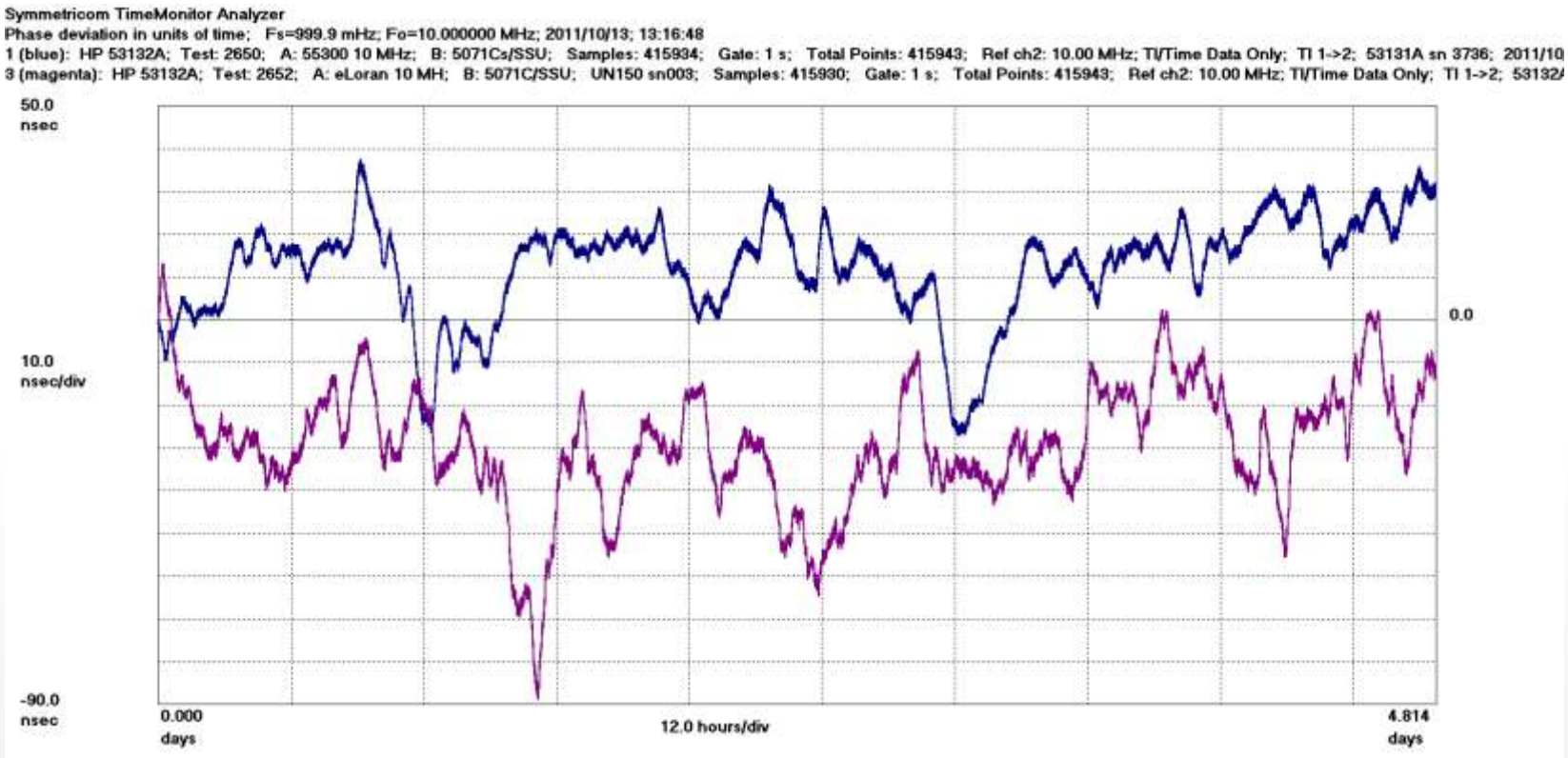


Approx 11 Days
Easter 2011
Ref= 5071 Cs



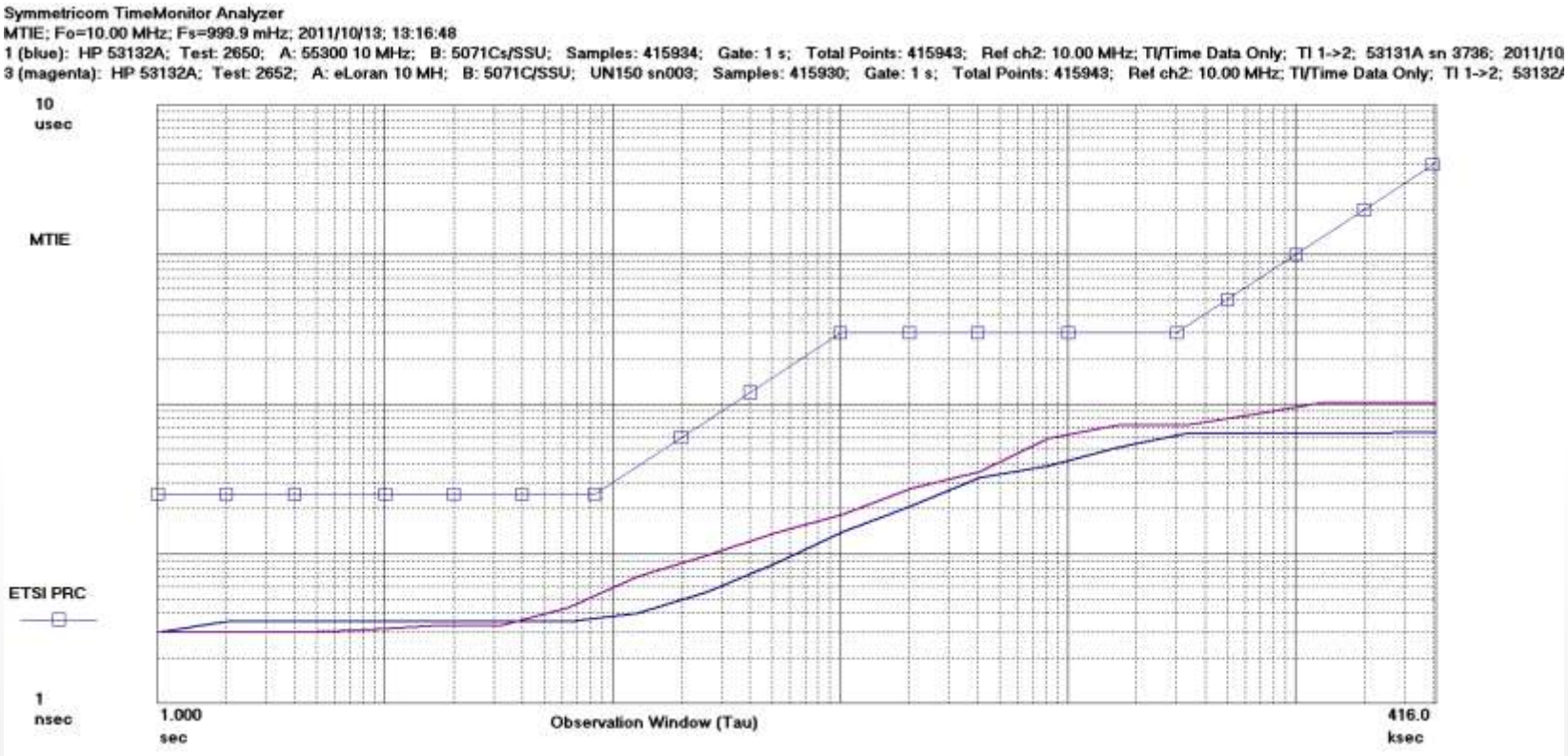
eLoran better than
Gold Std GPS
Timing Rx!

Most Recent TIE



Blue: Symmetricom 55300 GPS Rx (HP/Agilent)
Magenta : UrsaNav 150 eLoran Rx
Ref: 5071 Cs

Most Recent MTIE



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Most Recent TDEV

Blue: Symmetricom 55300 GPS Rx (HP/Agilent)
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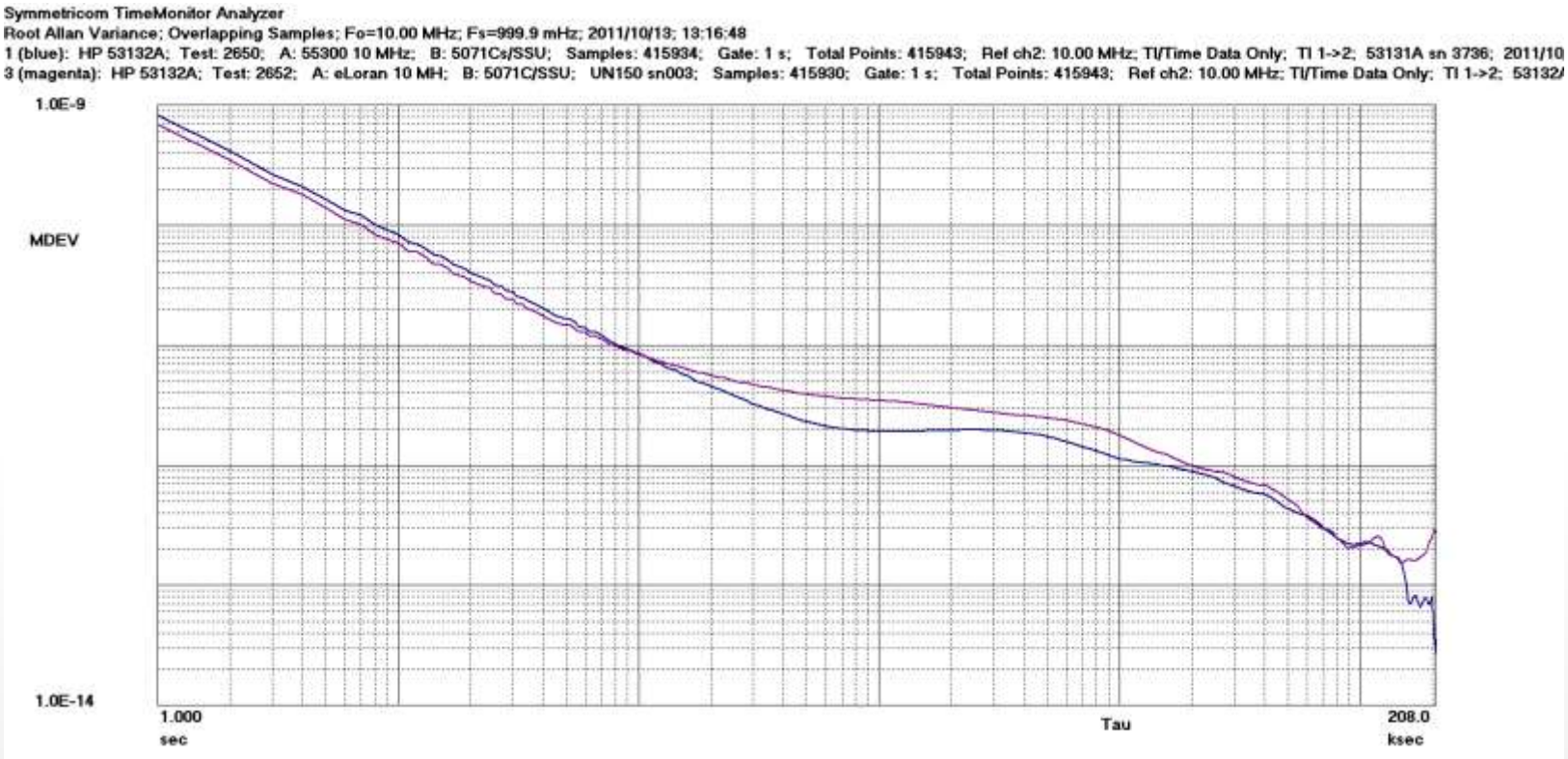
Ref: 5071 Cs

Most Recent Allan Deviation!



Blue: Symmetricom 55300 GPS Rx (HP/Agilent)
Magenta : UrsaNav 150 eLoran Rx
Ref: 5071 Cs

Conclusions

- eLoran could complement GPS or PTP timing
- Work to do…..
  - Cost reduction
  - H Field Antenna trials
  - Automatic ASF calibration for UTC alignment
  - Needs USA to re-launch LF Transmissions
  - Needs long term UK Government support

Thank you for listening

25 Years & Still in Sync!

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www.gps-world.biz