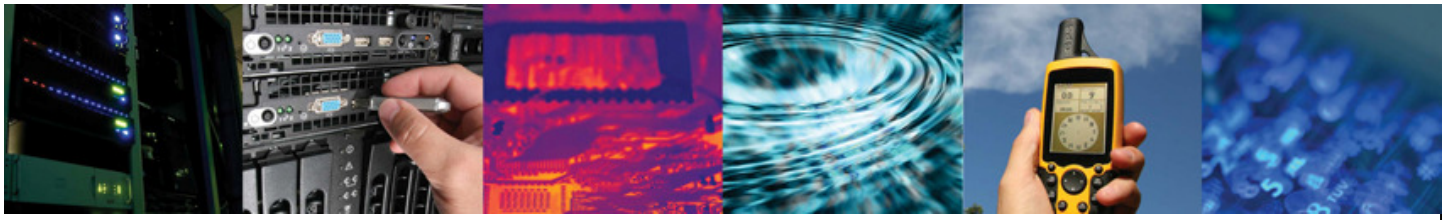

GRACE - APPLICATIONS SHOWCASE 2009

GNSS Derived Timing Solutions &
GNSS Enabled Time and Time Error Monitoring

Charles Curry B.Eng (Electronics), FIET
MD – Chronos Technology Ltd

11th November 2009

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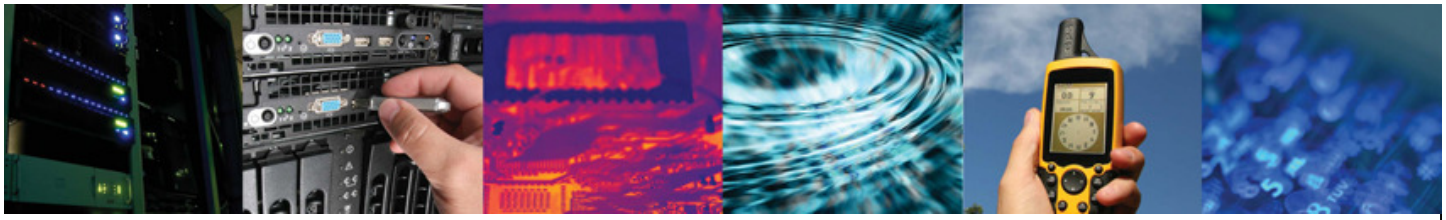

This Presentation

- Short Introduction to Chronos
- GNSS Timing Solutions for High Speed Networks
- GNSS Enabled Time Error Monitoring
- Demonstration
- GAARDIAN

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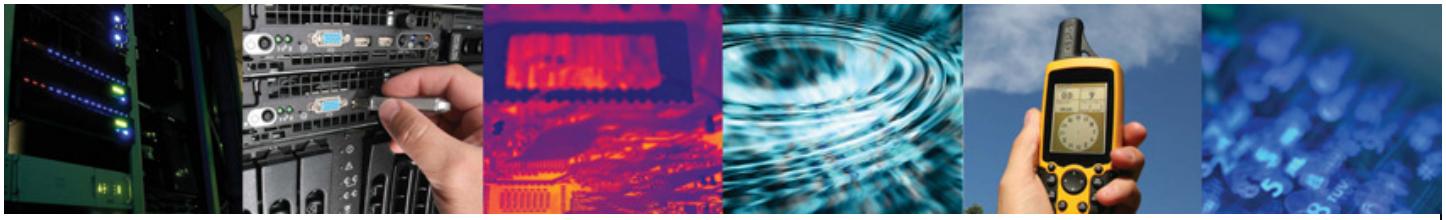

Chronos Technology Ltd

- System Integrator of Time and Timing Solutions
  - Telecoms
  - Government
  - Defence
- Services
  - Manufacturing
  - Hardware Supply
  - Installation
  - Commissioning
  - Support
  - Asset Life Extension
  - Knowledge

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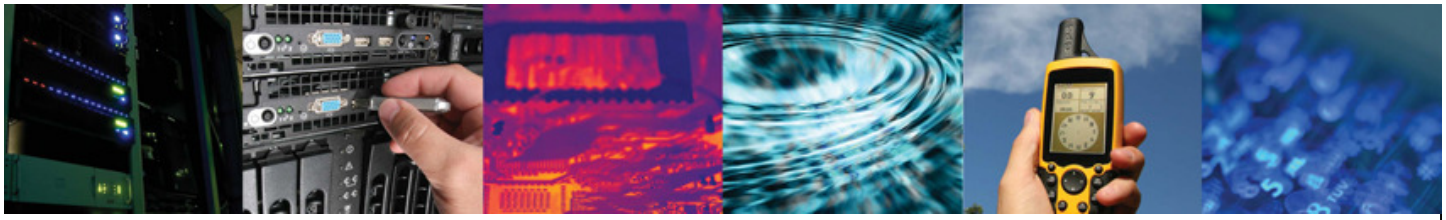

Technologies

- All Positioning Navigation & Timing (PNT) Technologies
  - GPS Receivers, Design and Interference
  - Glonass, Galileo, Compass
  - eLoran & initiative to deploy as a GNSS augmentation
- All Stable Oscillator Technologies
  - Quartz – TCXO, VCXO, OCXO
  - Atomic - Rb, Cs
- Timing, Time of Day, Time Slot Alignment
  - PDH & SDH Timing
  - GSM/CDMA Timing
  - Computer Timing
  - NGN (Ethernet) Timing
  - Cable Timing
  - TDD (LTE & WiMax) Timing
- Phase Locked Loop (PLL) Solutions
  - VCOs
- Time Testing
  - TIE, MTIE, TDEV, minTDEV
  - <100 psec granularity, lab, field and 24x7

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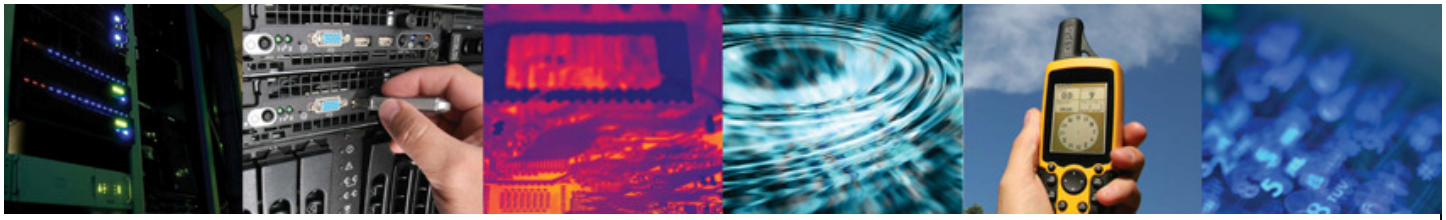
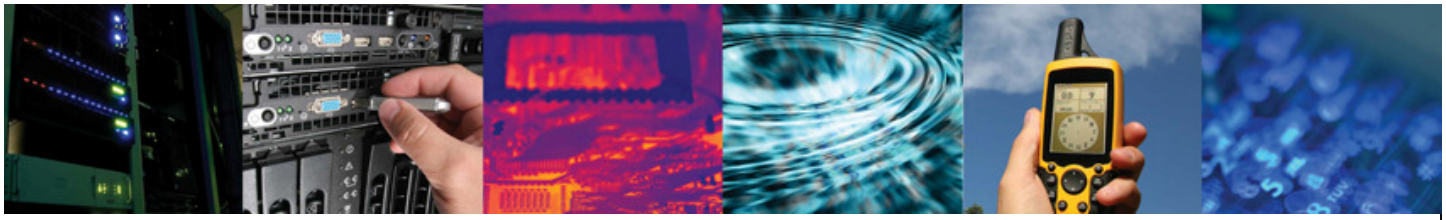


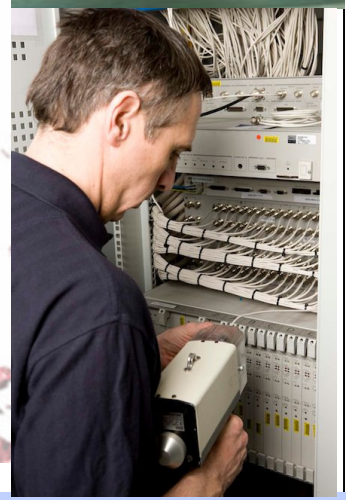
Customers



Global Installations (1000's)

- Site Surveys
- Installation
- Commissioning
- Cut-Over

- Security Clearance
- Climbing Certification
- Electrical Certification
- Health & Safety Awareness



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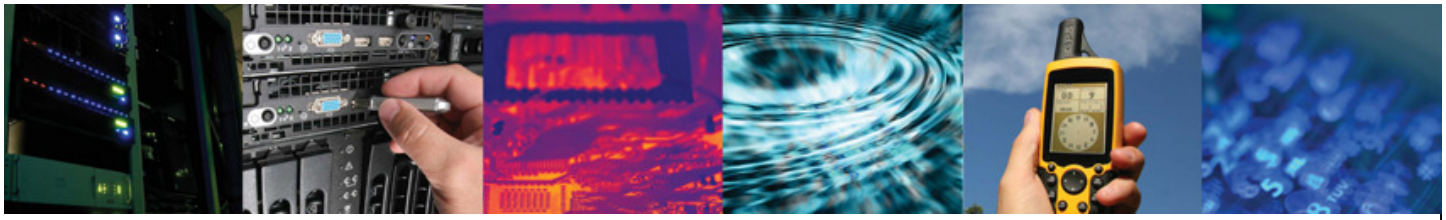
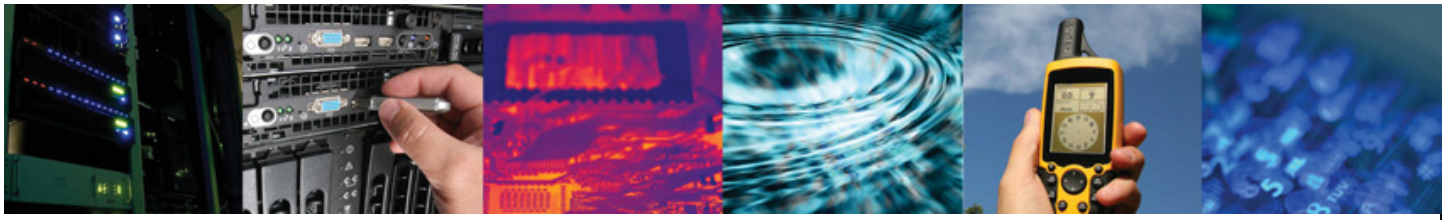


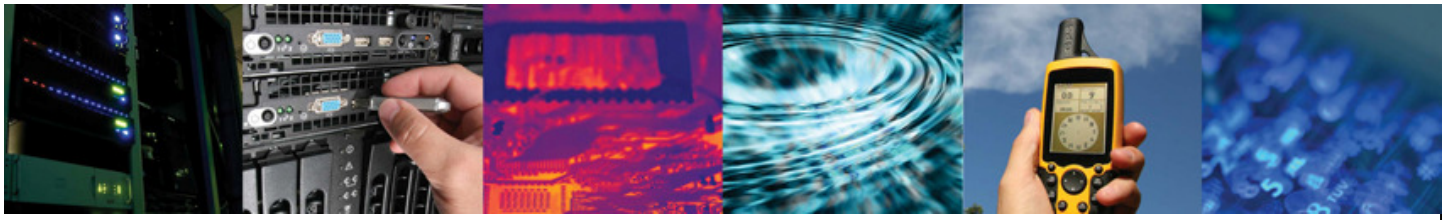
Knowledge

- Sync knowledge consultancy & product training with over **1000** engineers trained on time & timing
- Founder & Chairman of International Telecom Sync Forum – (**ITSF**) **3-5 Nov Rome**
- Member of Steering Group of Workshop on Synchronization in Telecommunication Systems (**WSTS**) **10-12 March 2010**
- Member of **IET** Professional Network – Communications and **FIET**
- Member of **ITU-T** Study Group 15 Question 13 – Synchronisation
- Member of **KTN** – Digital Systems (was Location & Timing) Steering Group
- Member **IAB** for Bath and Liverpool Universities

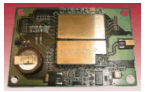


GNSS in High Speed Telecom Networks

- Wireline Carriers (BT)
  - Traffic Timing at Major Switches (City Locations)
  - NTP Time of Day – Billing, Time Stamping, VoIP Phones
  - PTPv2 Ethernet Timing
  - TIE Monitoring
- Wireless Carriers (Orange, T-Mobile, Vodafone, Three UK, O2)
  - Traffic Timing at Major Switches (MSC)
  - NTP Time of Day - Billing
  - Radio Stability for Base Stations – MacroCells, MicroCells, PicoCells & (future) Femtocells
  - Phase/Frequency Alignment – Future LTE Systems
  - TIE Monitoring
- PMR/Emergency Services (TETRA)
  - Radio Frequency Stability - Base Stations



Typical GNSS Traffic Timing Solutions



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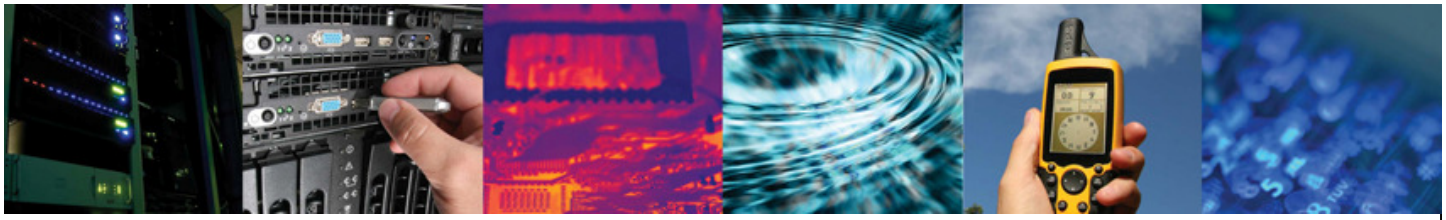
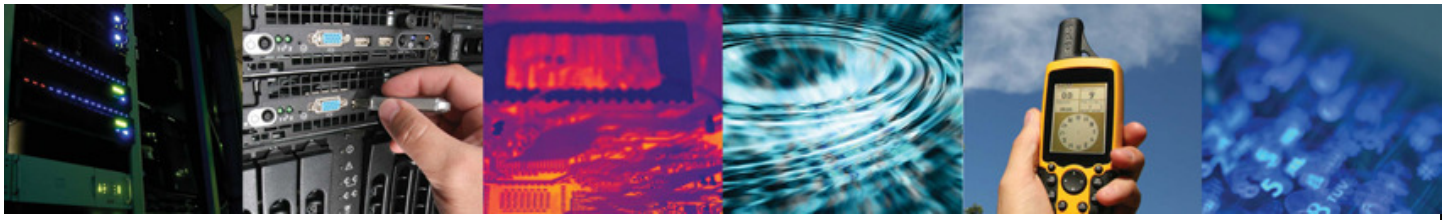


GNSS Enabled NTP & PTP Solutions

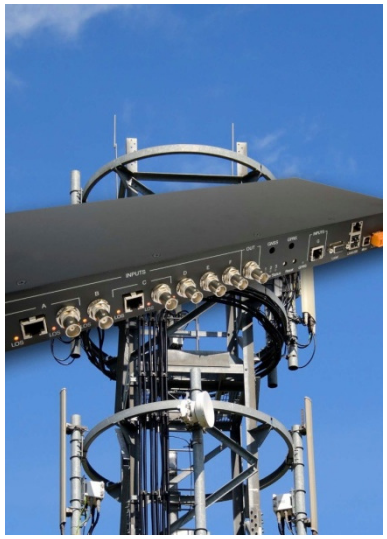
NTP for Billing and Event Time Stamping ~ ms

NTP for Base Station Sync <1ms

PTPv2 for Time and Timing through Ethernet ~ 10/100 µs



GNSS Timing & Time Error Monitoring



- SyncWatch (TimeWatch)
  - 24x7 Web enabled timing test system. 1nsec resolution.
  - Remote Probe – with dedicated Server
  - Standalone – with Symm TimeMonitor
  - Solo – USB access
- SyncWatch Internal Reference Options
  - GPS, GPS/OCXO, GPS/Rb
- OEM Timing Solutions
  - GPS, with Quartz, Rb & CSAC

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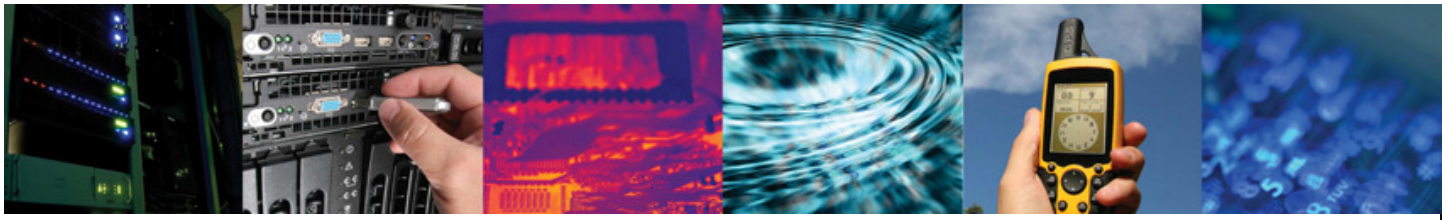

UTC Traceability for Time and Timing uses GNSS

Mobile Base Station

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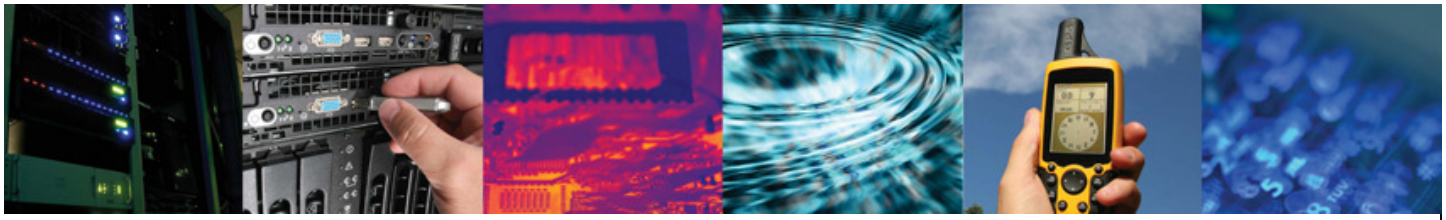

Time Error Monitoring

- Quality Metrics are well documented in ITU Standards
- Telecom Industry using TIE and MTIE since 1996
  - TIE – Time Interval Error
  - MTIE – Maximum Time Interval Error
  - TIE can be used to compute Allan Variance
- Standards
  - ITU G.810 "Definitions and terminology for synchronisation networks" 1996
  - www.chronos.co.uk/pages/knowledge/standards.php
- All Standards Organisations now reference this technique

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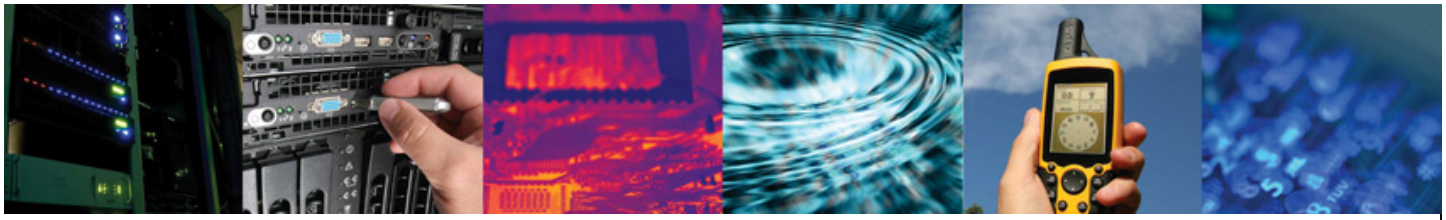
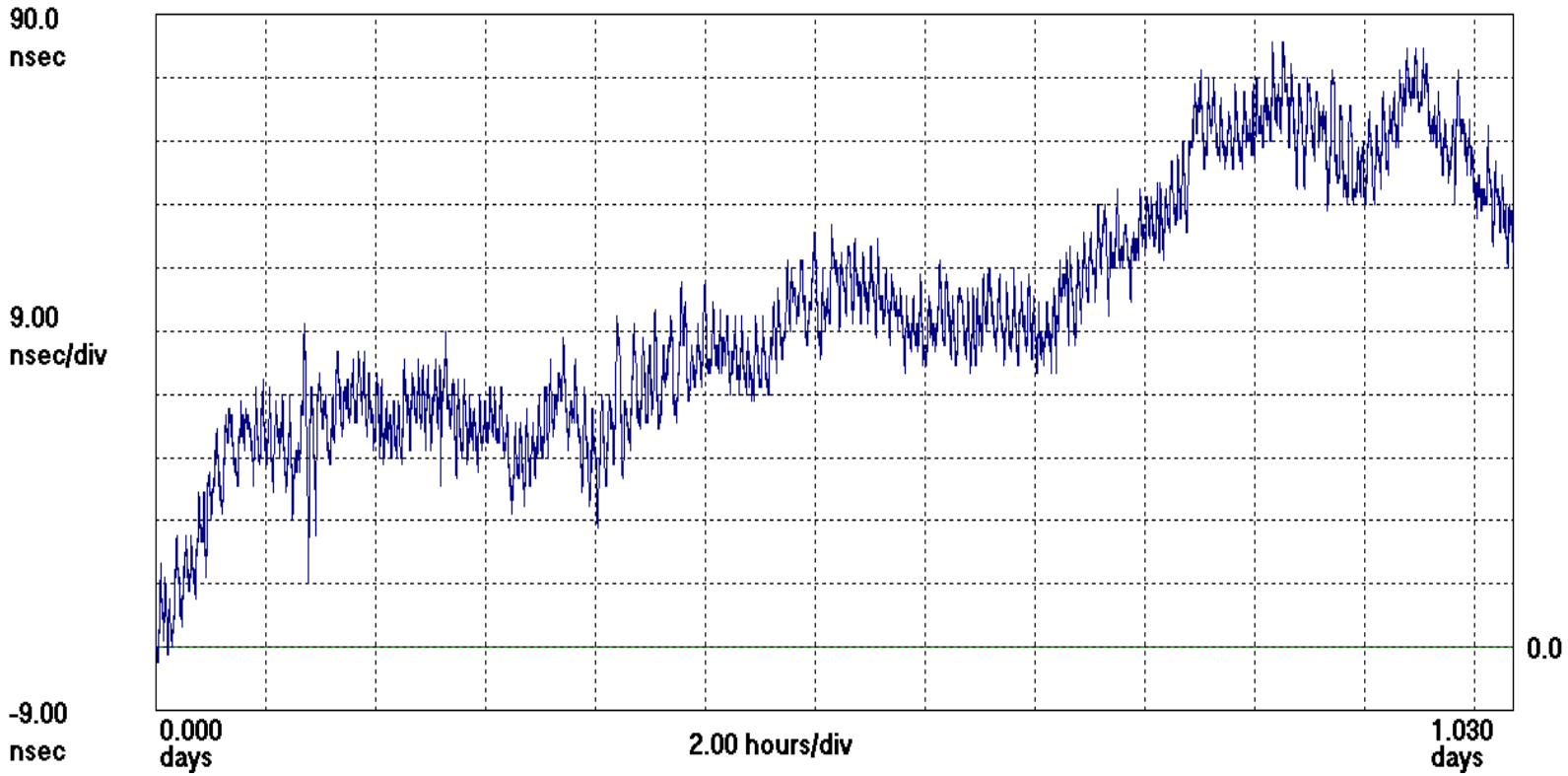


Look at Raw Data

SyncWatch Phase; Samples: 88986; DataSource=Chronos Technology SyncWatch Probe
Measured Signal - 2.048 MHz Output from Loran Rx; Reference=2.048 MHz from Local Cs; SampleSpacing=1/sec



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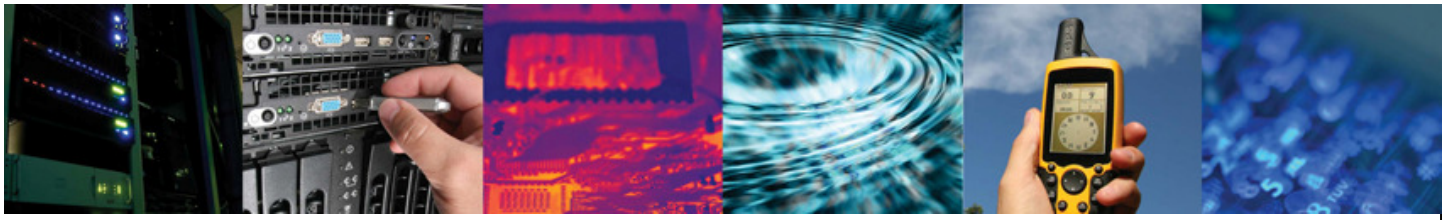

Analyse Data Using Window

SyncWatch Phase; Samples: 88986; DataSource=Chronos Technology SyncWatch Probe
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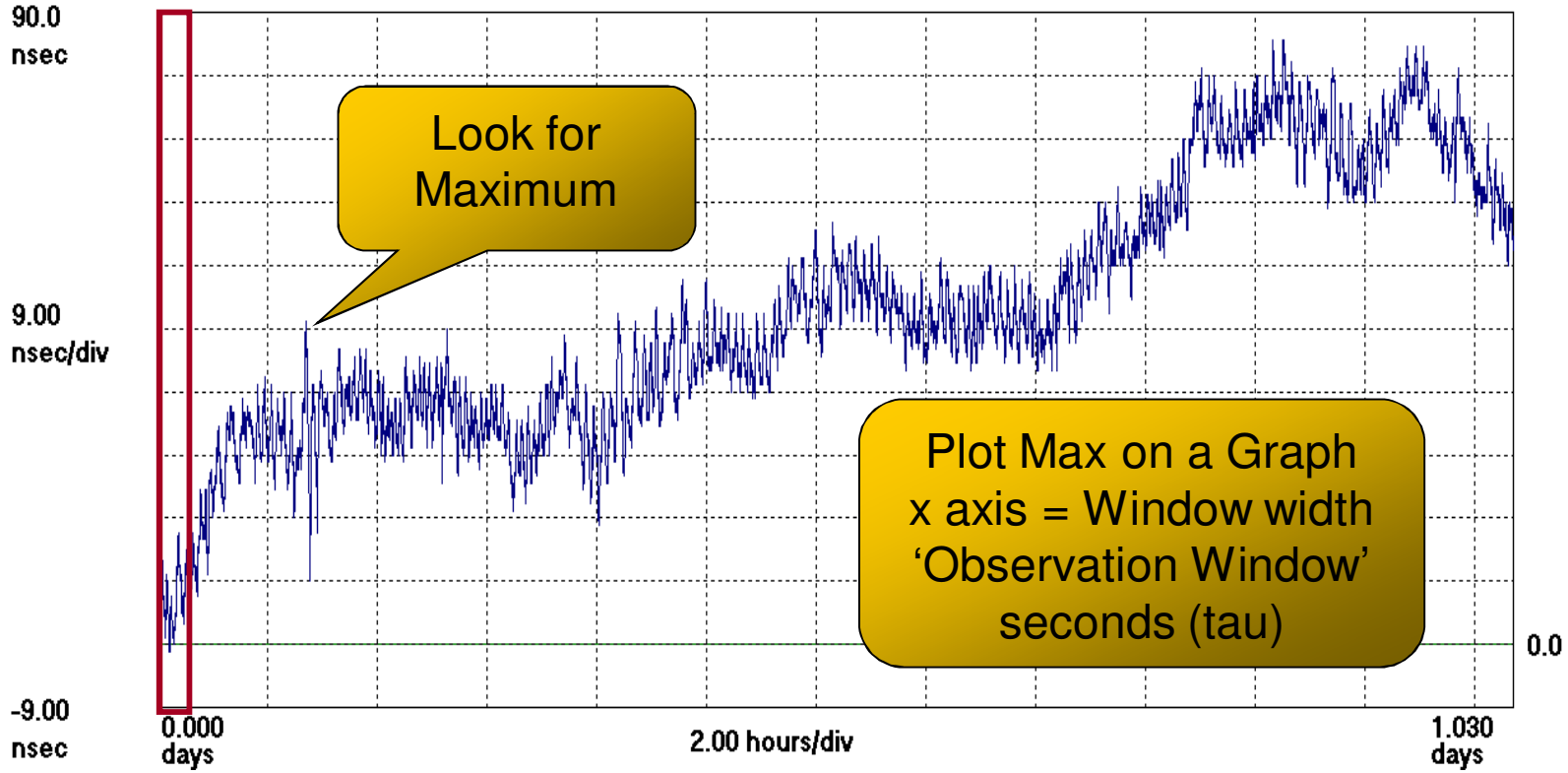

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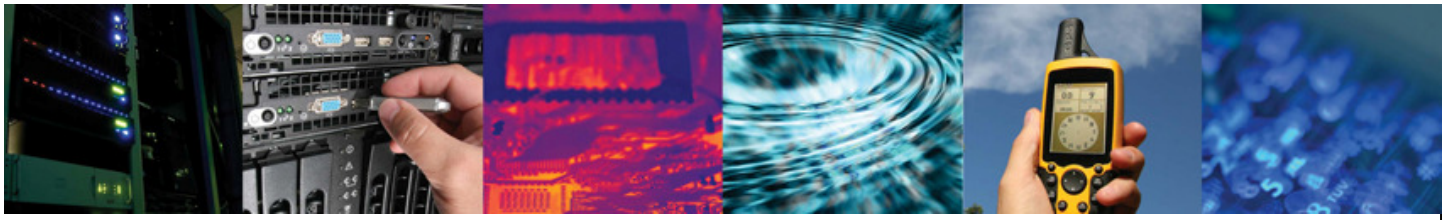

Plot Maximum Points

SyncWatch Phase; Samples: 88986; DataSource=Chronos Technology SyncWatch Probe
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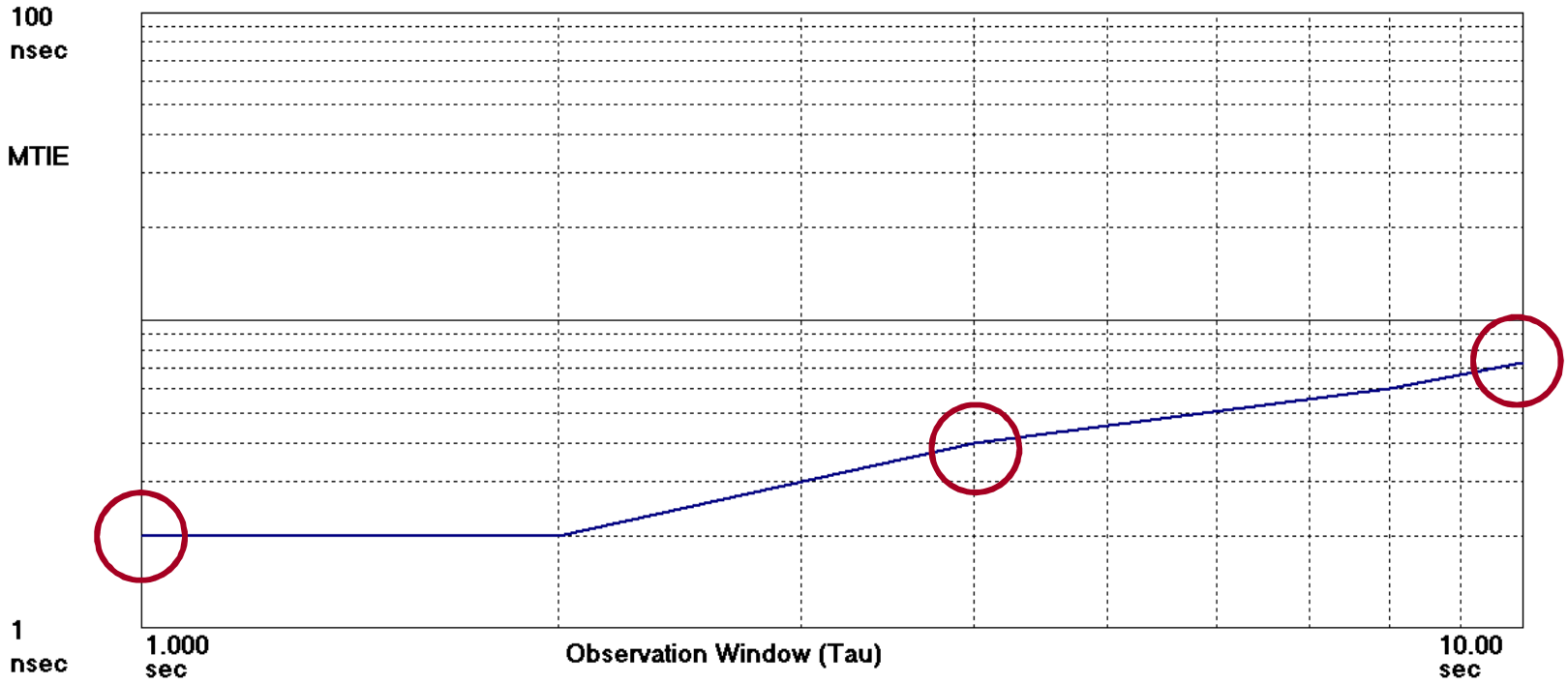

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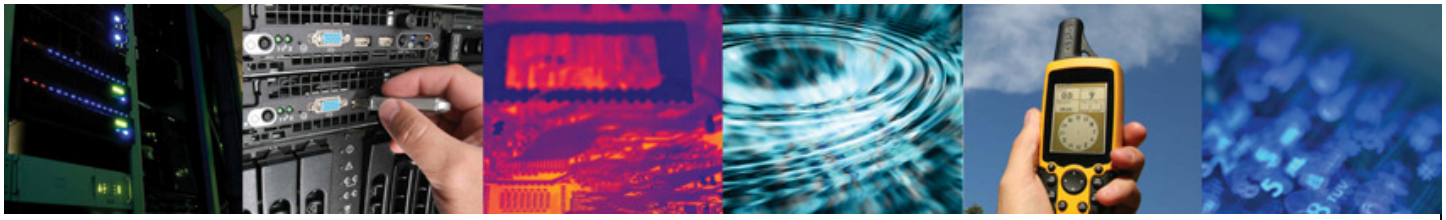
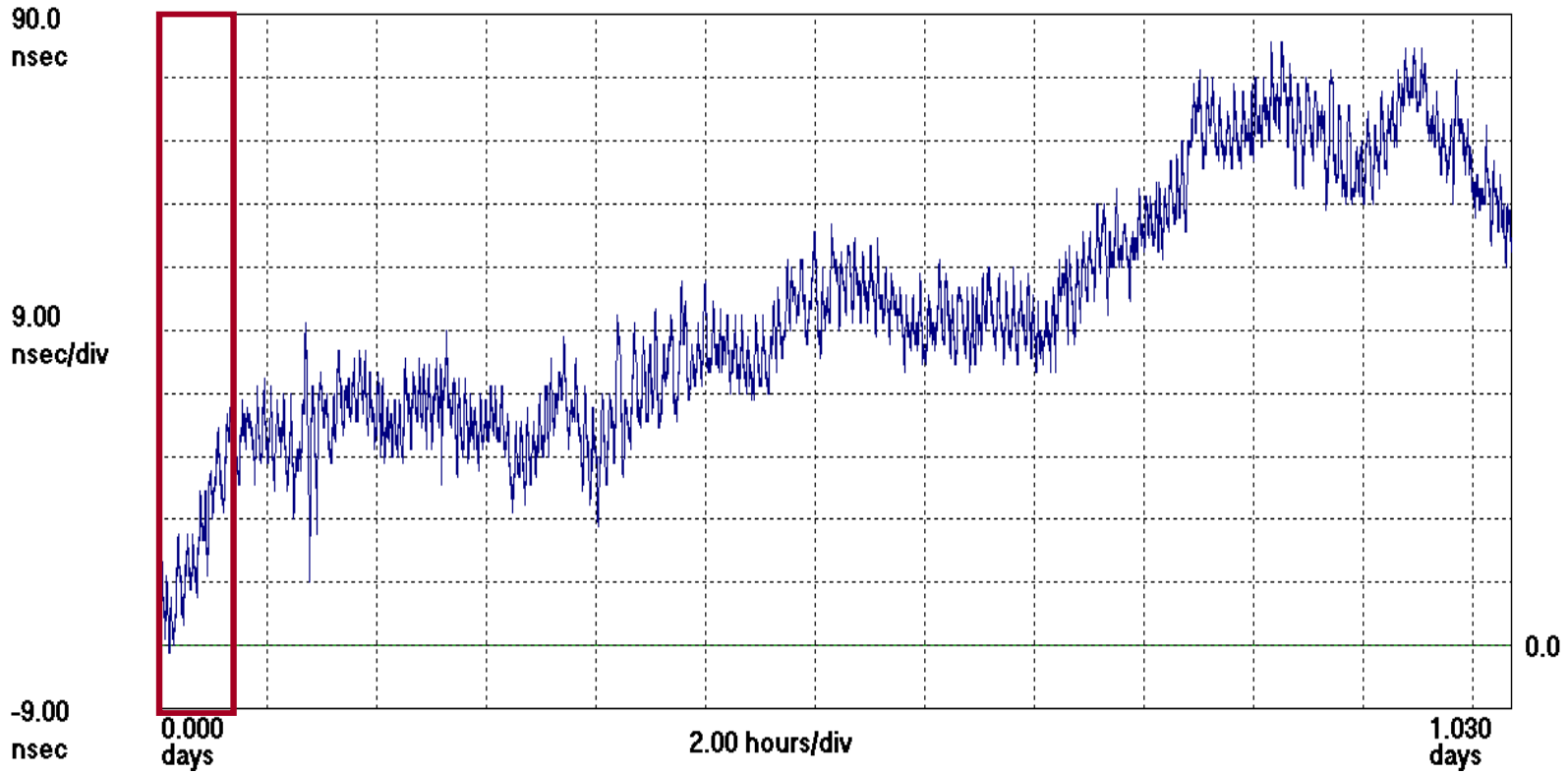


Use Bigger Window

SyncWatch Phase; Samples: 88986; DataSource=Chronos Technology SyncWatch Probe
Measured Signal - 2.048 MHz Output from Loran Rx; Reference=2.048 MHz from Local Cs; SampleSpacing=1/sec



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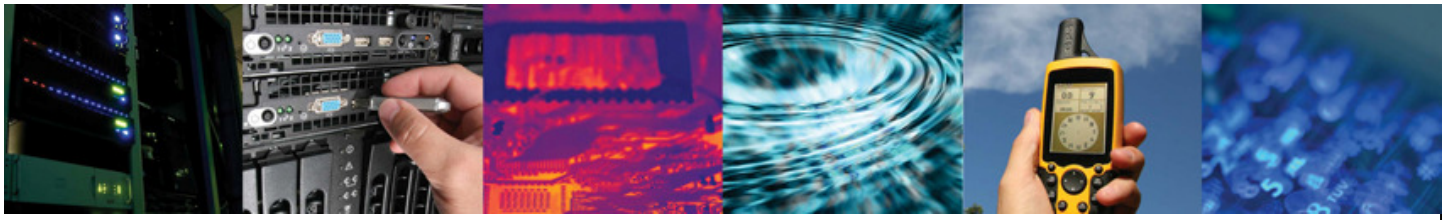
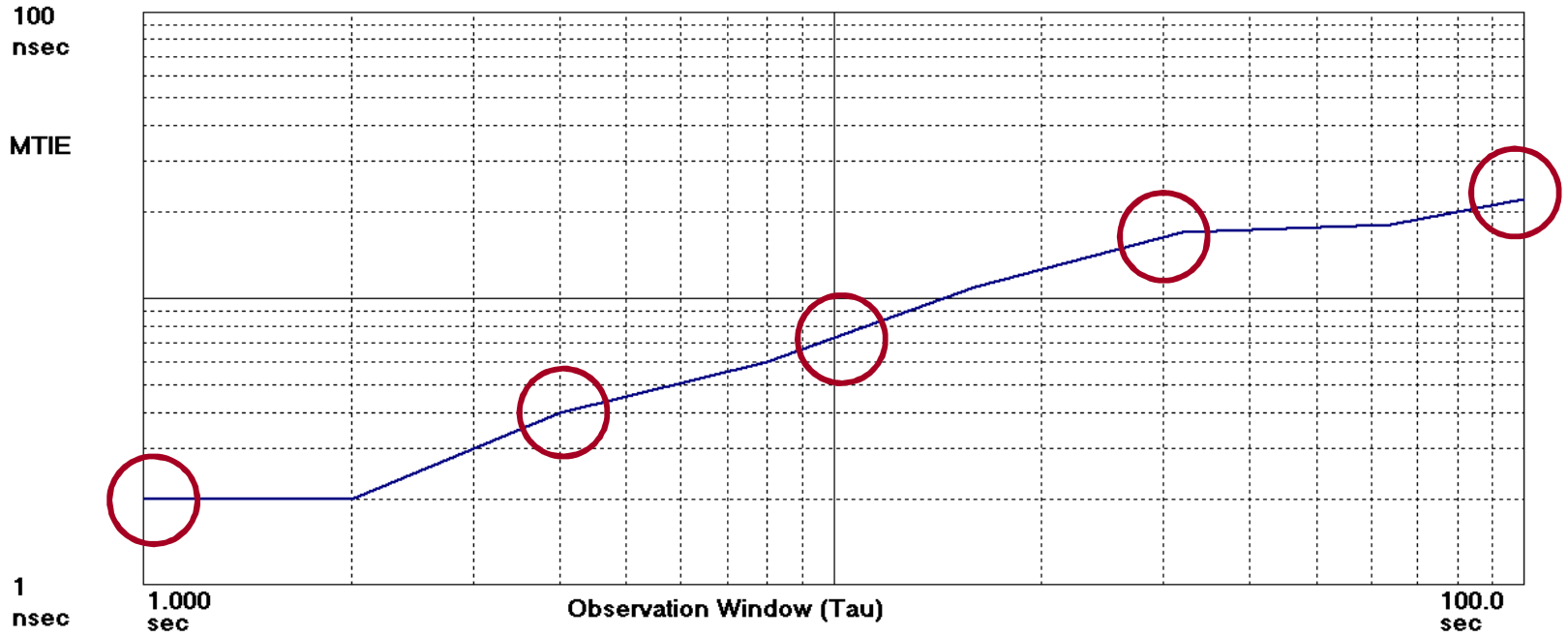


Add the new ‘Max’ points

SyncWatch Phase; Samples: 88986; DataSource=Chronos Technology SyncWatch Probe
Measured Signal - 2.048 MHz Output from Loran Rx; Reference=2.048 MHz from Local Cs; SampleSpacing=1/sec



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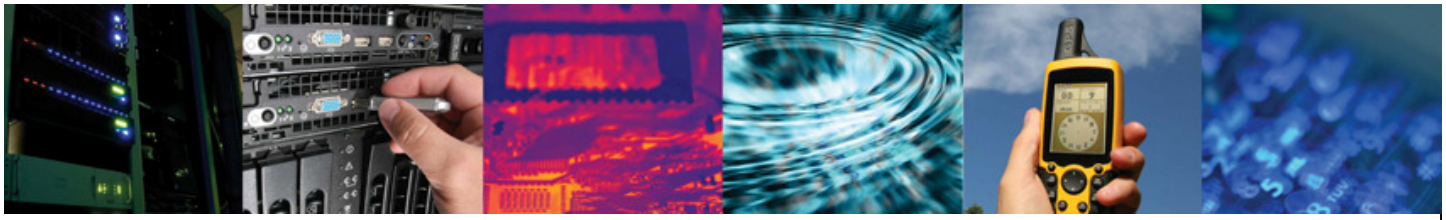
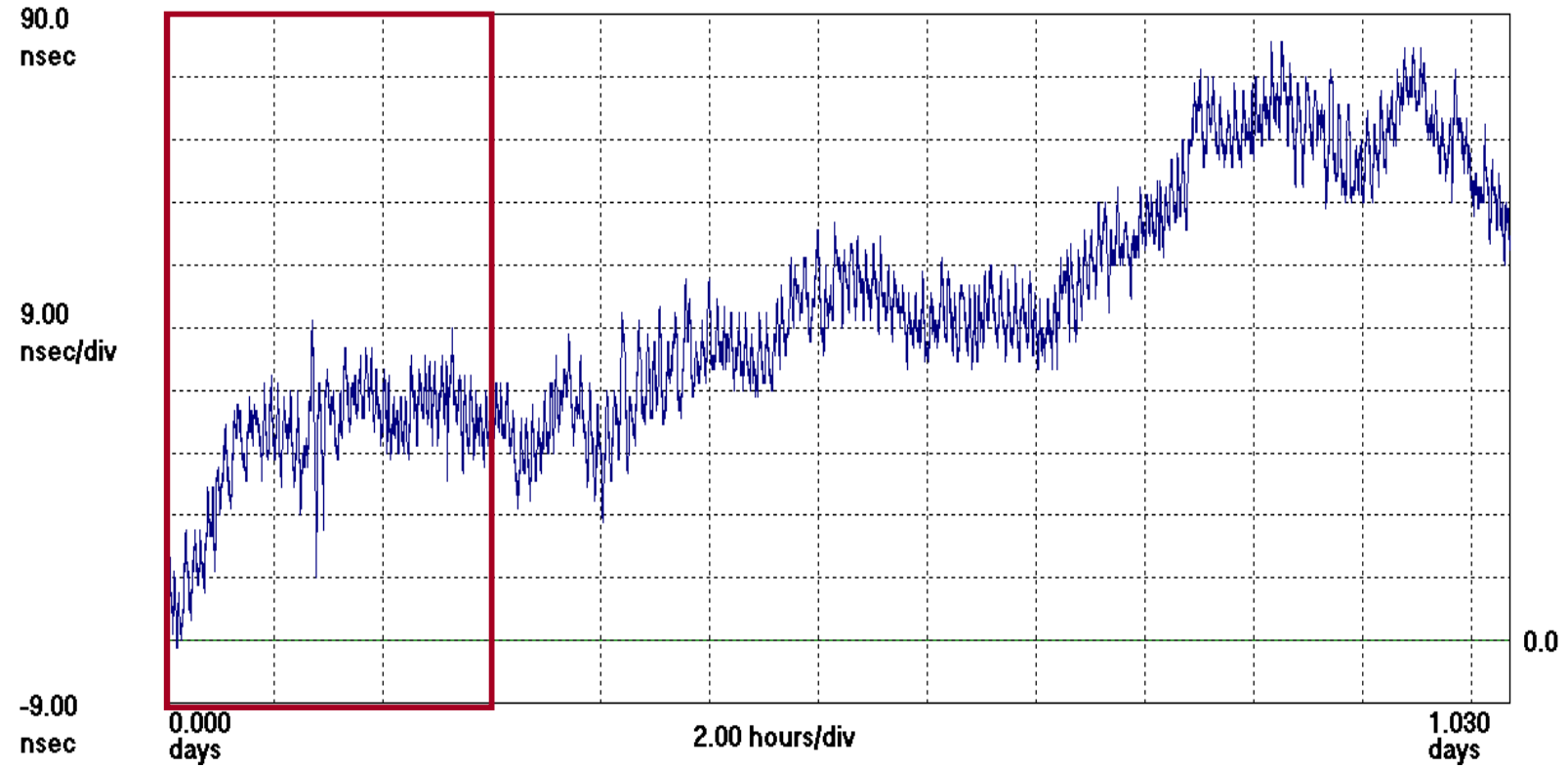


Use Even Bigger Window

SyncWatch Phase; Samples: 88986; DataSource=Chronos Technology SyncWatch Probe
Measured Signal - 2.048 MHz Output from Loran Rx; Reference=2.048 MHz from Local Cs; SampleSpacing=1/sec



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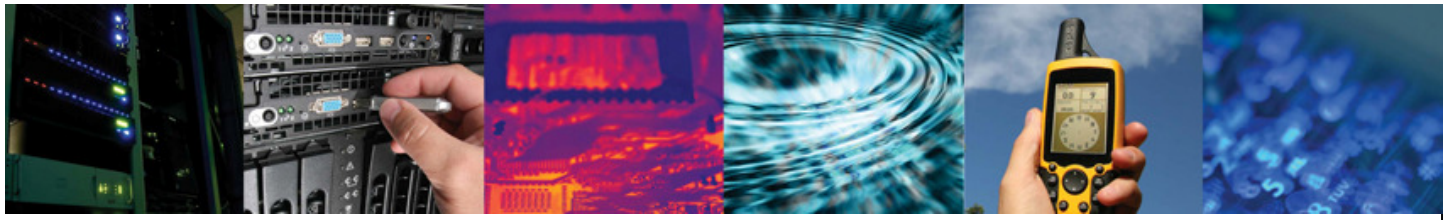
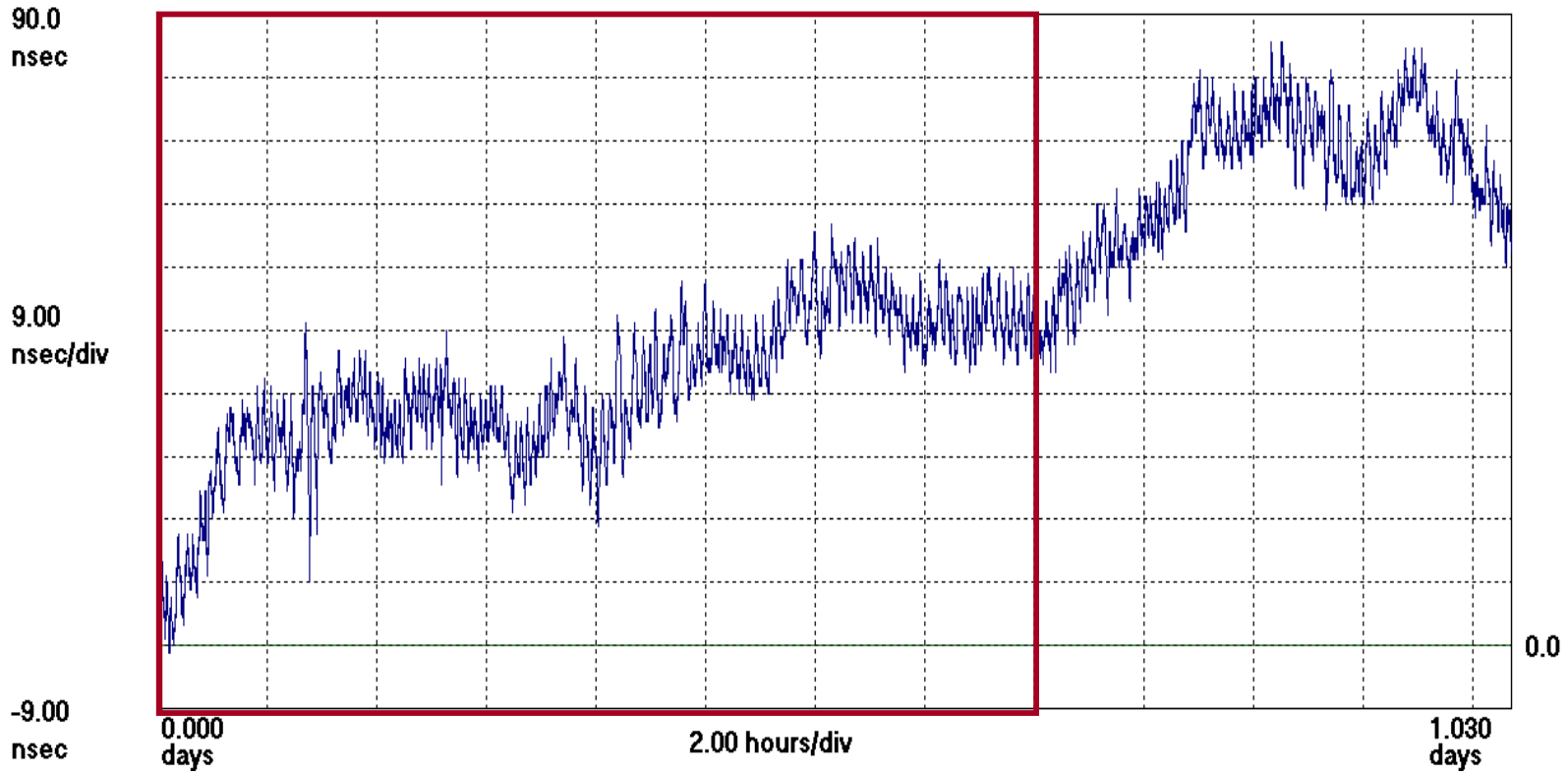


Use even BIGGER Window!

SyncWatch Phase; Samples: 88986; DataSource=Chronos Technology SyncWatch Probe
Measured Signal - 2.048 MHz Output from Loran Rx; Reference=2.048 MHz from Local Cs; SampleSpacing=1/sec



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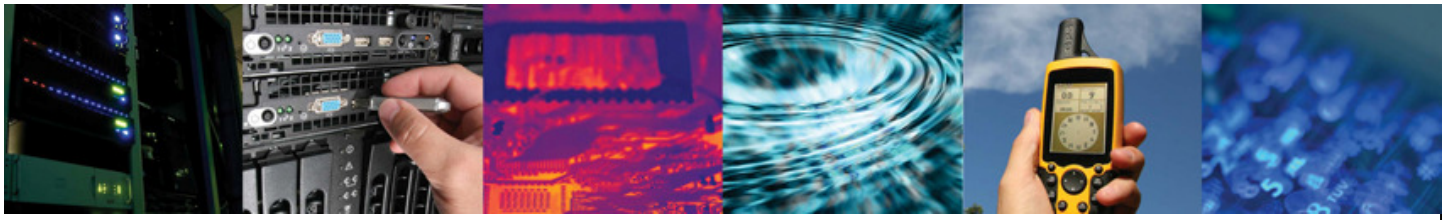
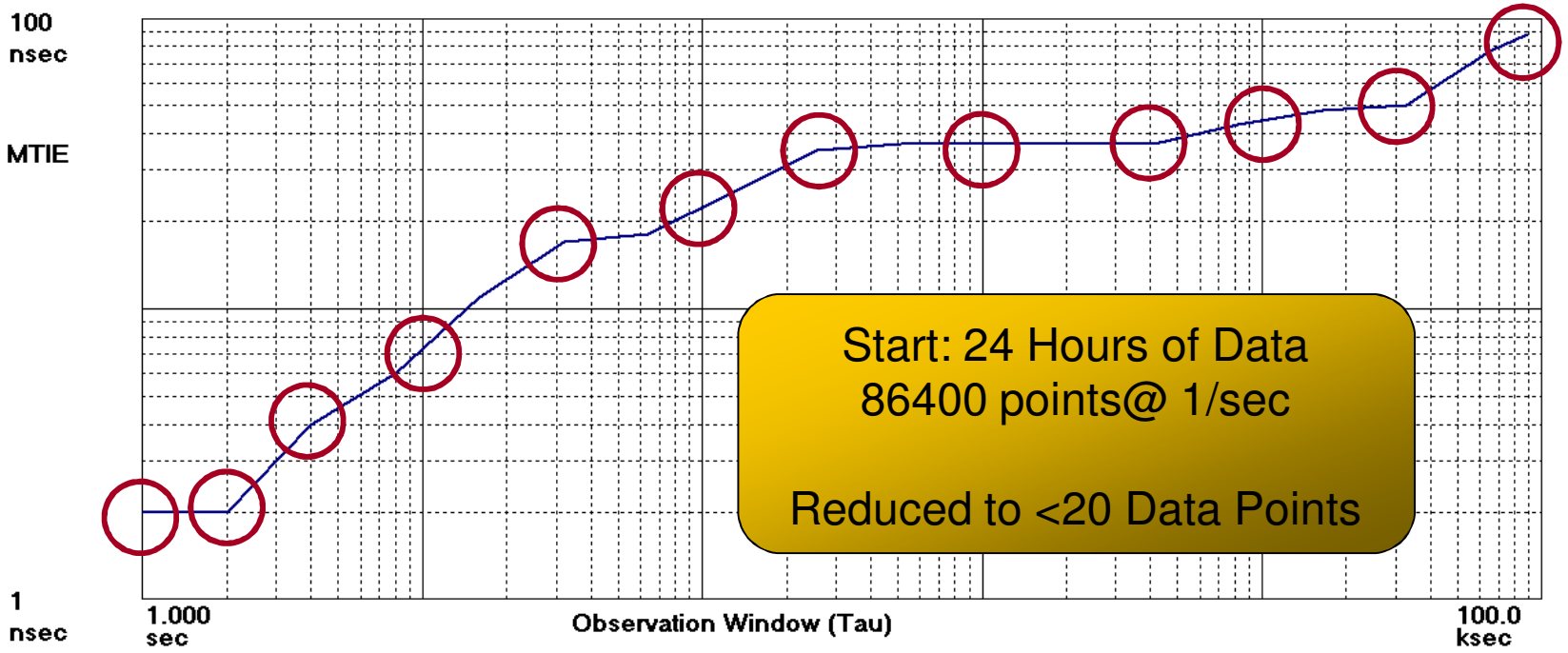


Eventually we get the whole set

SyncWatch Phase; Samples: 88986; DataSource=Chronos Technology SyncWatch Probe
Measured Signal - 2.048 MHz Output from Loran Rx; Reference=2.048 MHz from Local Cs; SampleSpacing=1/sec



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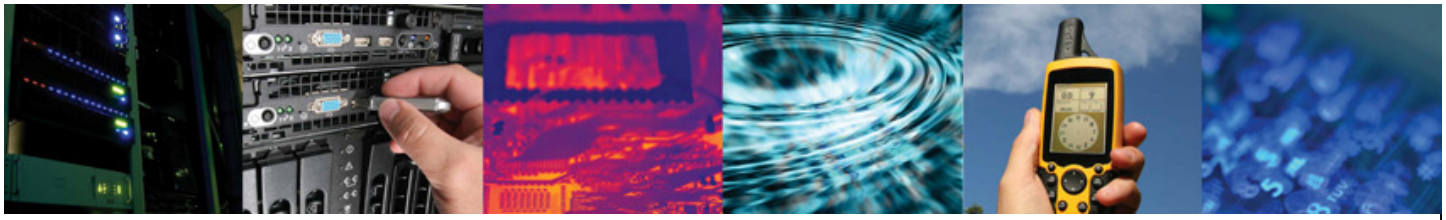
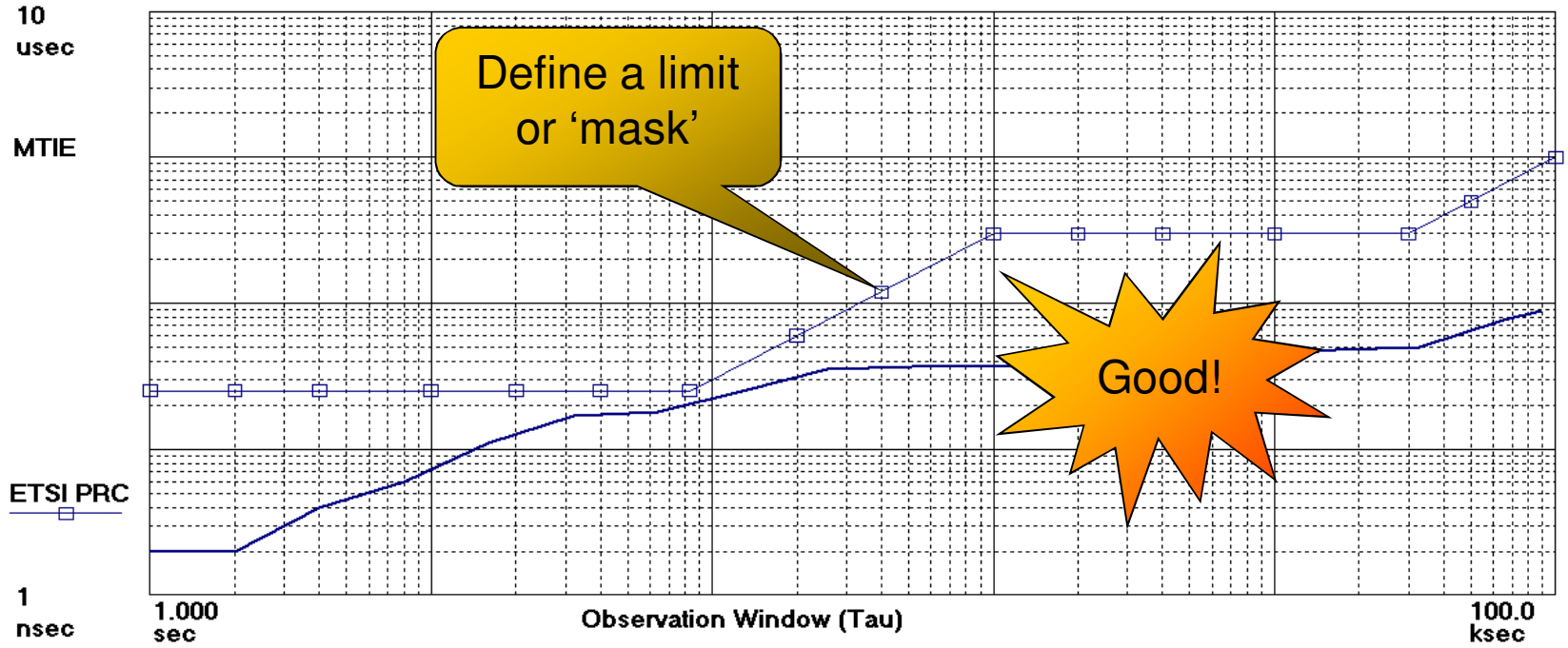


Compare to a Limit

SyncWatch Phase; Samples: 88986; DataSource=Chronos Technology SyncWatch Probe
Measured Signal - 2.048 MHz Output from Loran Rx; Reference=2.048 MHz from Local Cs; SampleSpacing=1/sec



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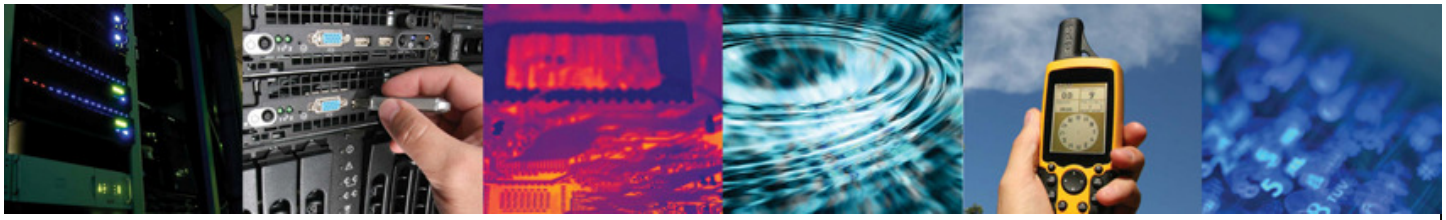
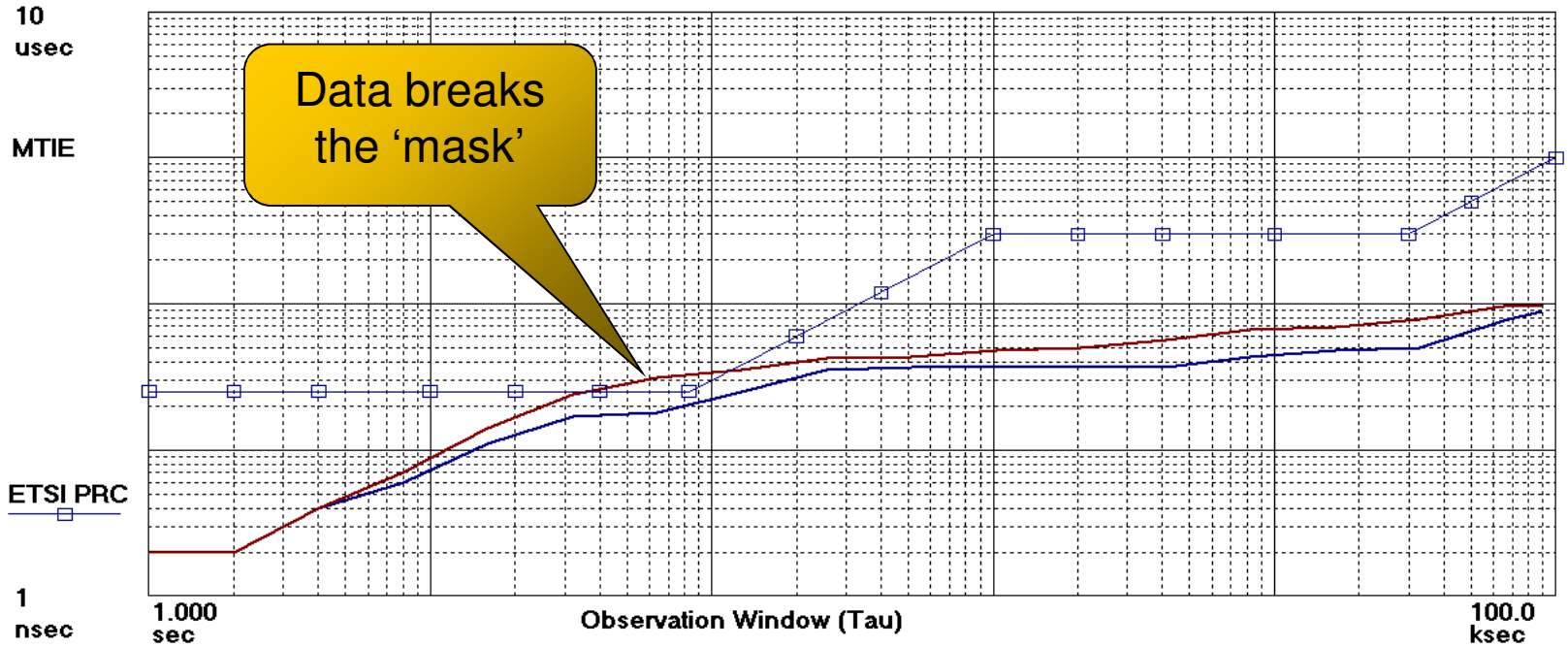


Compare MTIEs v Mask

1 (blue): SyncWatch Phase; Samples: 88986; DataSource=Chronos Technology SyncWatch Probe; Measured Signal - 2.048 MHz Output fror
2 (red): SyncWatch Phase; Samples: 88826; DataSource=Chronos Technology SyncWatch Probe; Edition=Standard; MeasurementType=2M



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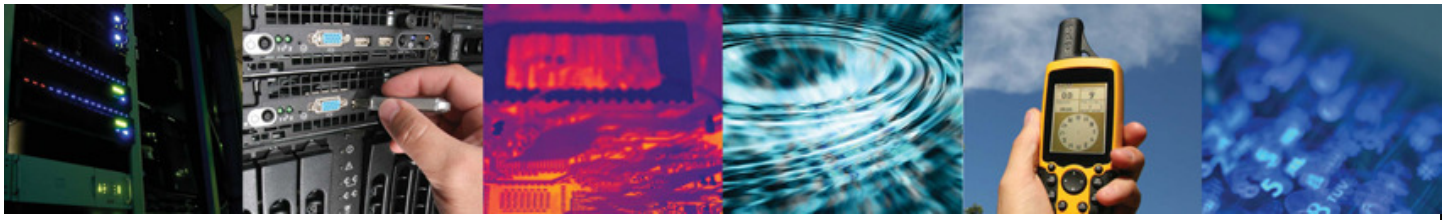

MTIE Conclusion

- A method to reduce data
- Summarise/Reduce N points to n points
  - e.g. N = 86400, n = 15
  - Without losing knowledge of content
- Do this 24x7
- Compare to MTIE ‘Mask’ defined by Standards

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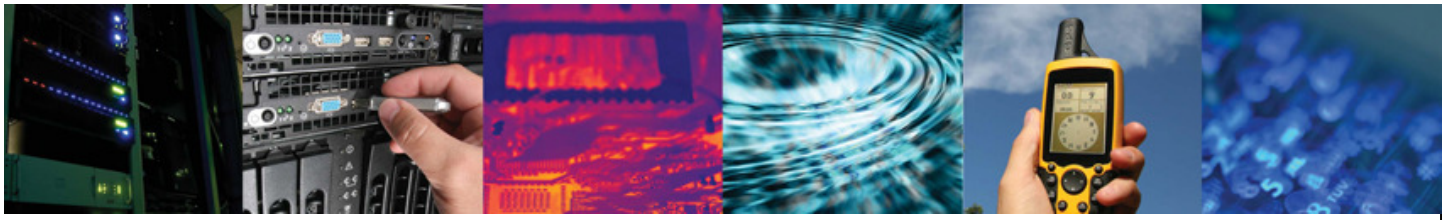
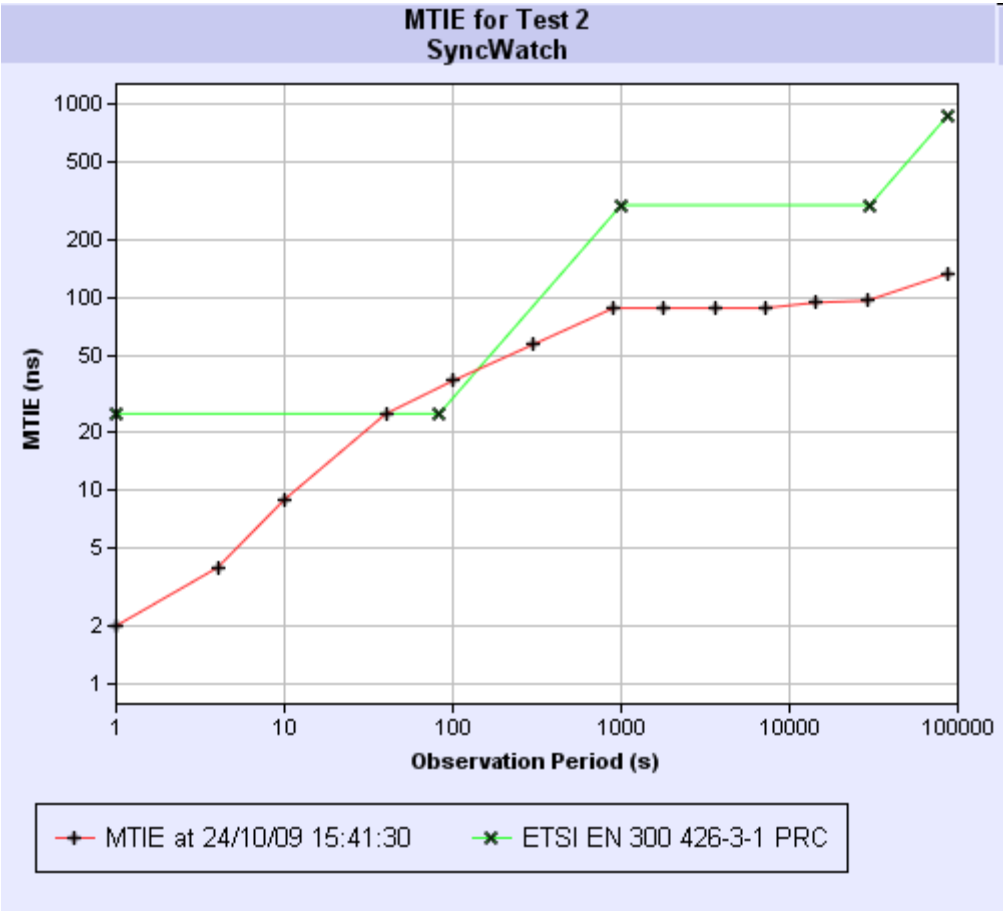
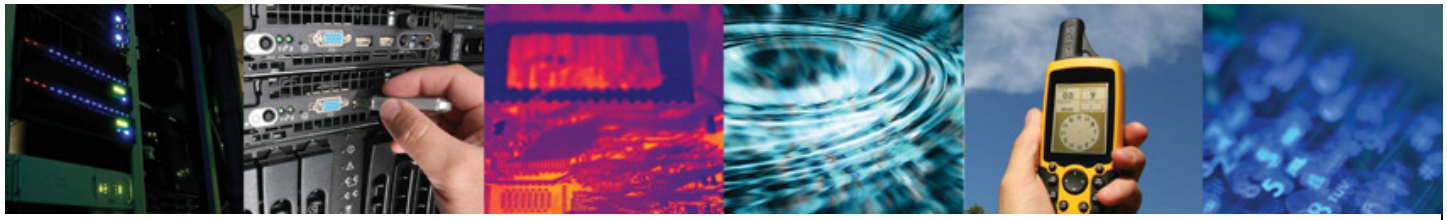


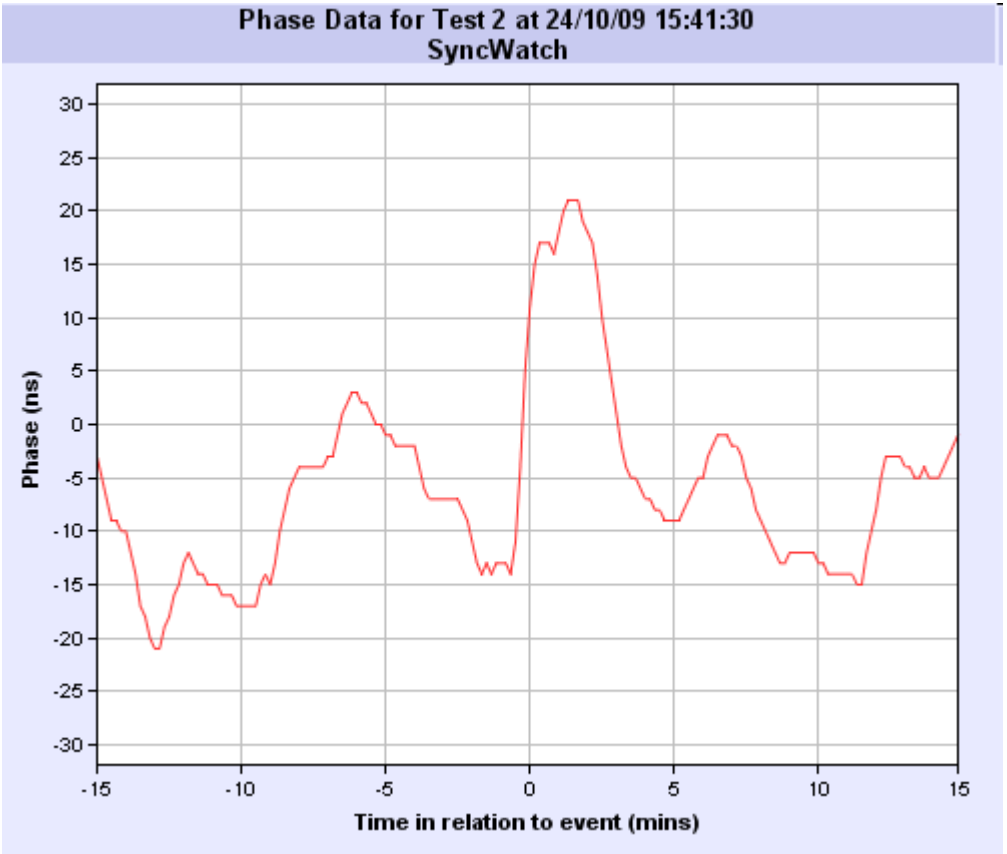
Same Data from Automatic System - SyncWatch



- Automatic MTIE
- Compare to location signature
- Alarms when mask broken
- SMS on alarm
- View over internet



Capture the Data around Event



- Capture event that caused the alarm
- +/- 15 Minutes either side
- “Straw that broke the camel’s back”

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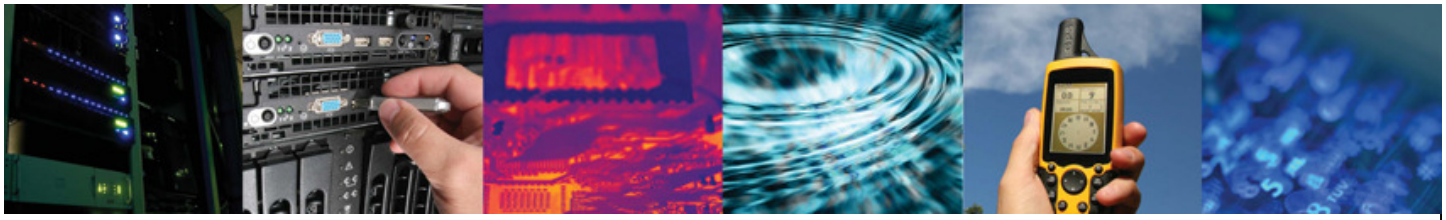
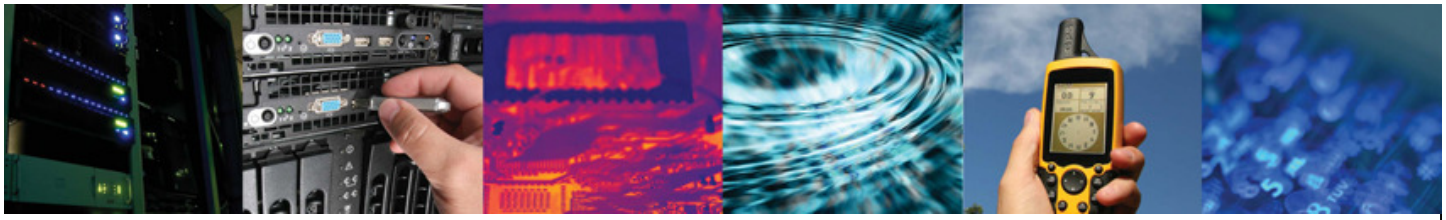


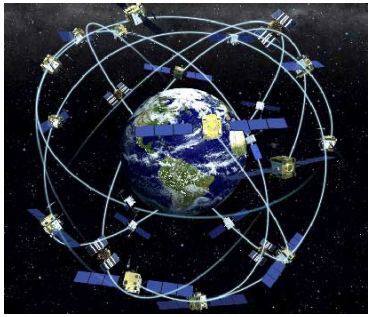
Demonstration - Autonomous Time Error Monitoring

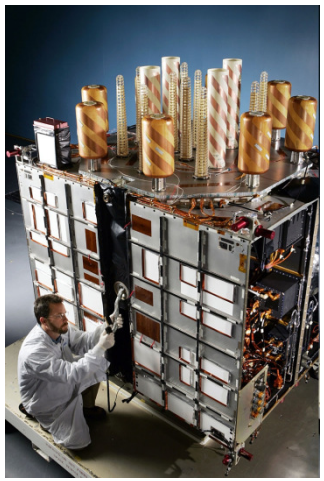
- SyncWatch
  - Web Enabled,
  - 24x7 TIE Monitoring System
  - Heartbeats
  - Alarms if MTIE threshold exceeded
  - Server alerts users
  - Users view events over the internet

- www.syncwatch.com



The GAARDIAN Project - *GPS Interference Detection & Mitigation*





- **G**NSS **A**vailability, **A**ccuracy, **R**eliability an**D** **I**ntegrity **A**ssessment for Timing and **N**avigation
- Research Data Gathering necessary to create a GPS Interference Detection & Mitigation (IDM) network
  - At point of use, 24x7x365
  - for mission & safety critical applications
  - Which use GPS (or GNSS) signals
  - **Leveraging eLoran signals for QoS determination**
- UK Government Funded R&D Project (>£2m)
  - through Technology Strategy Board

GNSS – Global Navigation Satellite Systems – e.g. GPS, Glonass, Galileo, Compass, QZSS

QoS – Quality of Service

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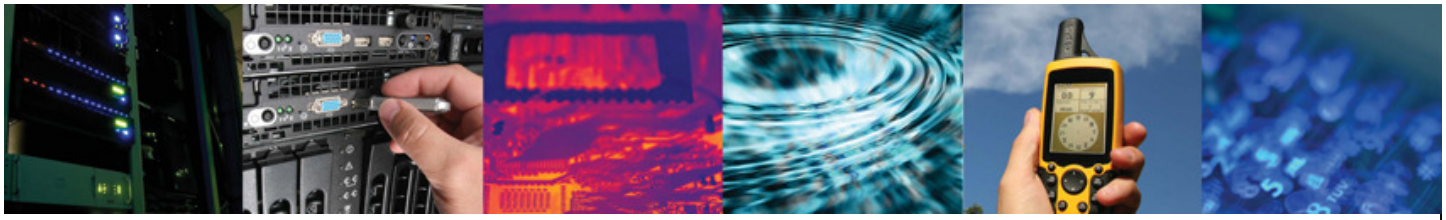

The GAARDIAN - Partners

- GLA – General Lighthouse Authorities
  - User Community - Maritime
  - eLoran
- Imperial College London - Dept of Civil Eng
  - User Community - Transport
  - Integrity Monitoring Algorithms
- University of Bath - Dept of Electrical & Electronics
  - GPS & Space Weather
- BT – Adastral Research Laboratories
  - User Community – Telecoms
- Ordnance Survey
  - User Community – Land Geolocation
- NPL – National Physical Laboratory
  - Time, UTC Traceability
- Chronos Technology Ltd
  - Real time Timing measurement to ns granularity
  - GPS products, components & system integration
  - GAARDIAN Project Leader

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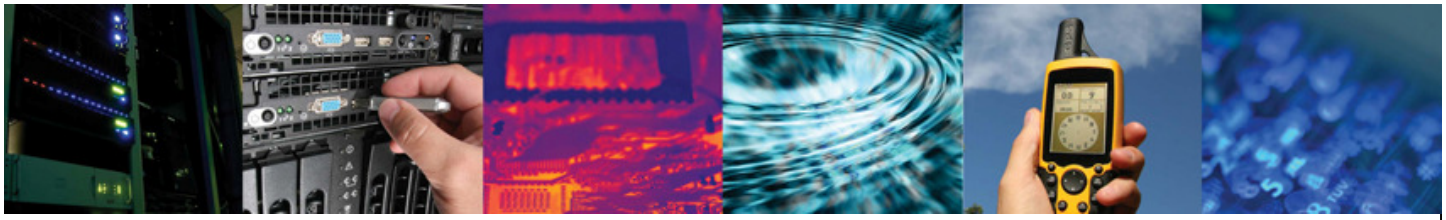
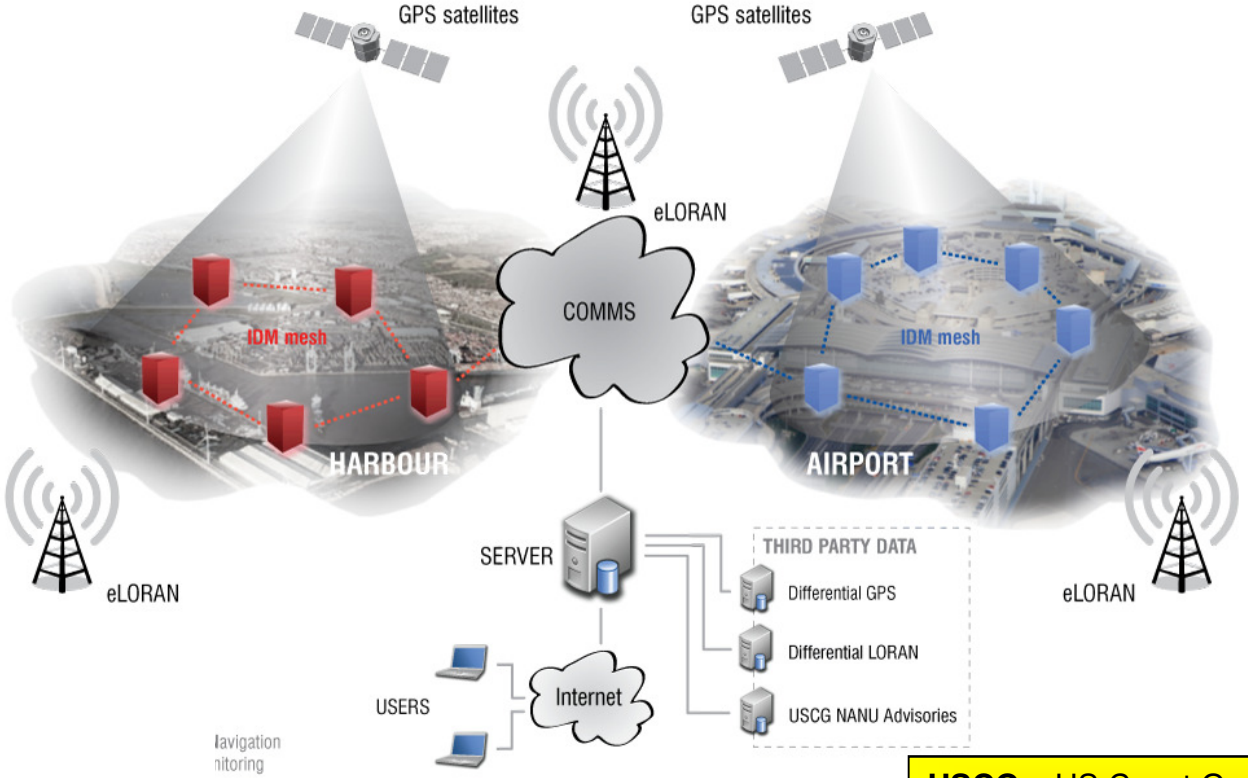


GUARDIAN



USCG – US Coast Guard

NANU – Notice Advisory to Navstar Users

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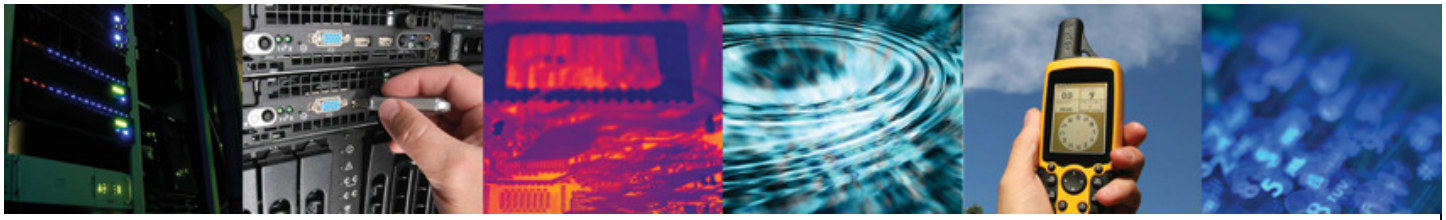
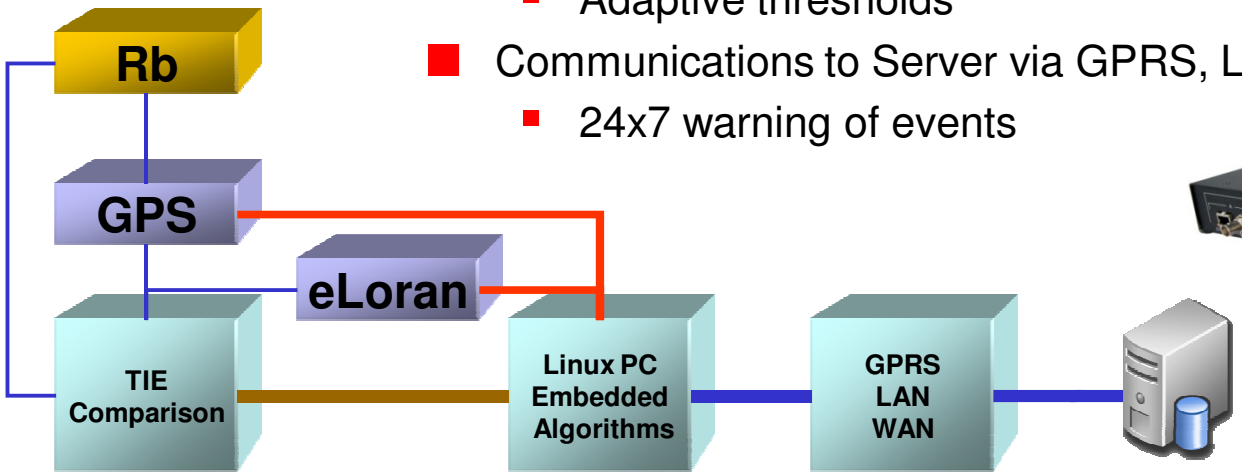


GAARDIAN – IDM Sensor

- IDM Sensors based on Chronos SyncWatch probes
  - Watching GPS & eLoran Signals
- Time Interval Error (TIE) Monitoring between PNT signals from BT
- Embedded Linux to process TIE and PNT data
  - Algorithms from CTL, GLA, ICL and UoB
  - Event severity and manageability discrimination
  - Adaptive thresholds
- Communications to Server via GPRS, LAN or WAN
  - 24x7 warning of events



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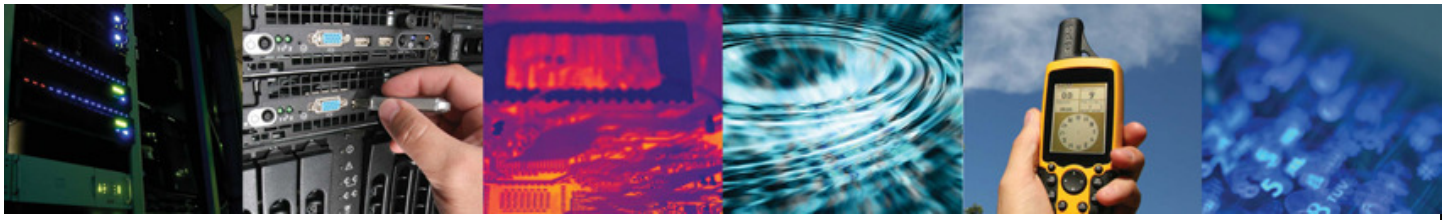
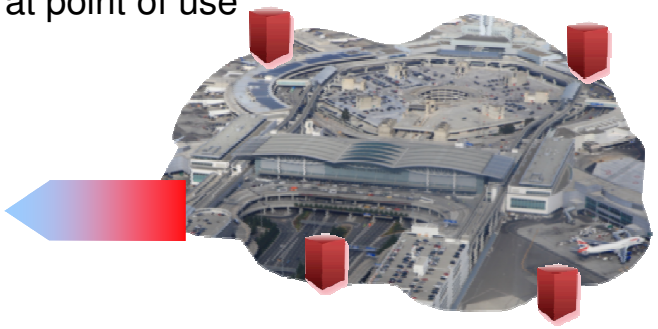


GAARDIAN – Deliverables

- Develop 24x7 web enabled IDM sensors
  - IDM – Interference, Detection & Mitigation
  - Which can be deployed as networks
- Locally deployed networks of IDM sensors in the vicinity of the user
  - GAARDIAN will deploy trial sensors to analyse data
  - Reduce data at source without losing "content"
  - Heartbeats and "Event" communication back to Server
  - Store for user viewing over internet
- Enable Real-Time GPS, Galileo, Glonass or eLoran (PNT) monitoring
  - For Mission/Safety critical users at point of use



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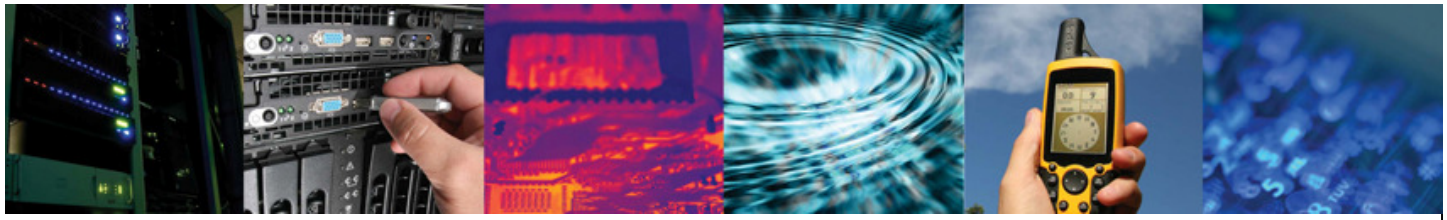

Chronos Technology Ltd

Making Technology Work For You

Thank You

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