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Leading the world in precise time solutions.

How NTP Servers with Atomic Clocks Protect Against GPS Jamming/Denial to Maintain Accurate Network Time

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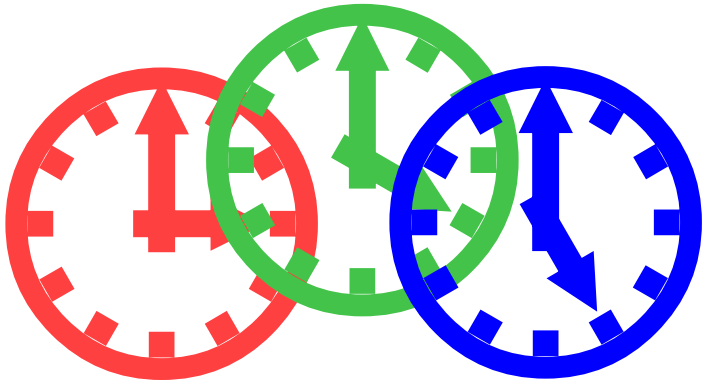
Product Marketing Manager
Enterprise Solutions

Program

- Enterprise Network Timing
- GPS Generalities
- GPS Clock Steering
- GPS Jammers / GPS Signal Loss
- Types of Clocks (oscillators) and Why it's Important
- Server Behaviors During Jamming /Loss of GPS (data!)
- Symmetricom® Time Servers for Your Enterprise
- Key Takeaways
- Q&A

Why Network Clocks are a Problem in Enterprise Applications



- Every network element has a clock
- Clocks drift due to:
  - Oscillator quality
  - Temperature changes
  - Intentional oscillator frequency dithering to lower overall frequency emissions (reduce harmonics)
  - Power save modes
  - Oscillator aging
- Distributed computing exposes new challenges with clock drifts:
  - Lack of initial time of day synchronization
  - Different clock drift rates between servers, switches, routers lead to performance degradation

Enterprise Application/Operation Areas that Require Accurate Time

- **Log file accuracy, auditing & monitoring**
  - Faster systems require better granularity and accuracy in the log time stamps
  - NMS report integrity
  - Network fault diagnosis and recovery
- **Access security and authentication**
  - Issues with security, access rights, non-repudiation
  - Login errors when time drift beyond predefined skews (PDC)
- **Transaction processing**
  - Time stamping in a fast disparate networks with heavy traffic
- **Scheduled operations**
  - Backup, archive, retrieval
- **Real-world time values**
  - Email
  - Phone systems
  - Workstations
- **Legal & regulatory requirements**
- **Directory services**
- **Other applications**
  - Password & digital ID
  - Software development
  - QoS Metrics

Essential Elements of Network Time Synchronization

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Accuracy

Reliability

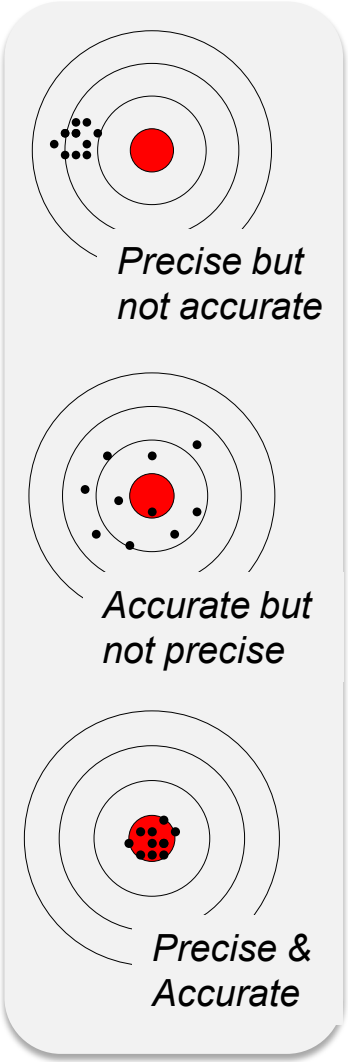
Security

Accuracy (and Precision)

- Accuracy is a function of “correctness” relative to an agreed to standard, (UTC for example)

- Hardware clock characteristics for accuracy:
  - 50 ns rms, 150 ns peak to UTC while tracking GPS
  - Single satellite operation to 1 μs to UTC

- As network & CPU speeds improve, so does precision, but not necessarily accuracy



Reliability

- Time Reliability means:
  - Providing time from a reliable source
  - Notification when time synchronization is in question
- Time Reliability should include:
  - Solutions with oscillator upgrades for holdover
  - Time sanity cross-checking to other clocks (Peers in NTP)

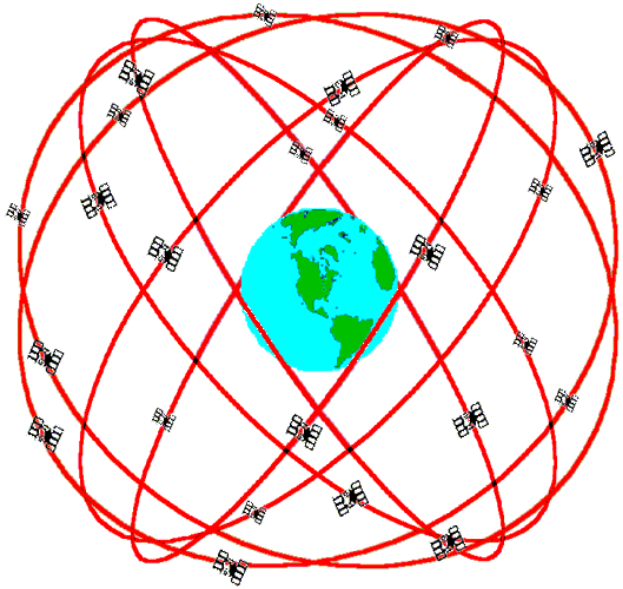
atomic clock

- Management architecture for reporting reliability
  - SNMP, Customizable alarms, Email alerts

GPS, Clock Steering, and Jamming

GPS Space Segment

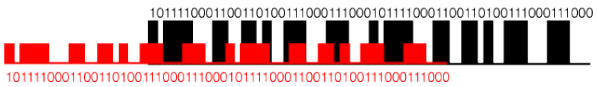
- 31 satellites (32 maximum)
- Equally spaced in 6 orbital planes
- 55 degree inclinations
- 11 hr, 58 minute orbits
- 12,500 miles/20,200 km (MEO)

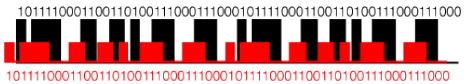


12,500 miles

-155dBW

PRN Codes
From satellite■
Inside GPS receiver ■



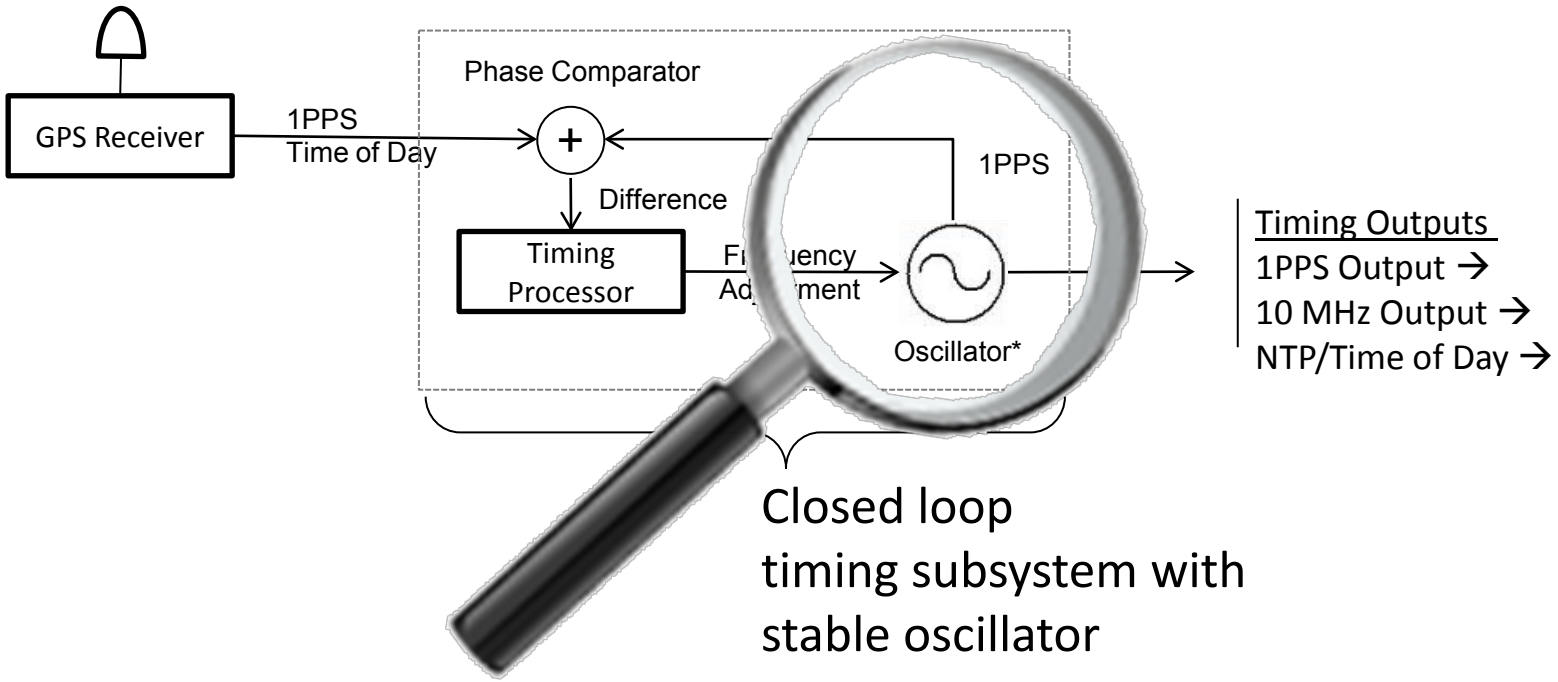


“locked” →

500 watts
(27 dBW)

GPS Clock Steering (Disciplining)

- 1 pulse per second (1PPS) signal from GPS receiver used to check/adjust timing
- Time of Day from GPS

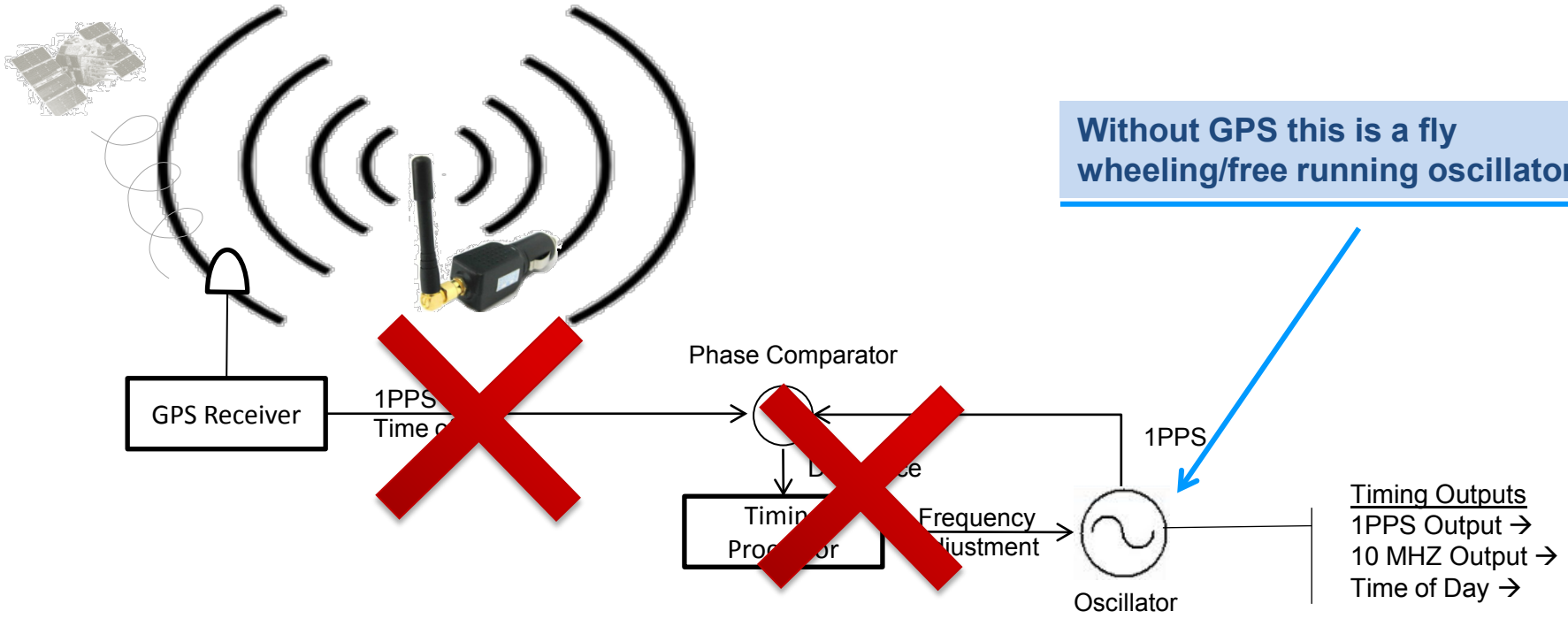


* TCXO or Atomic

GPS Jammers

- Per GPS.GOV…
  - Jamming devices are radio frequency transmitters that intentionally block, jam, or interfere with lawful communications, such as cell phone calls, text messages, GPS systems, and Wi-Fi networks.
- What often happens in GPS jamming…
  - A jammer outputs high powered noise at the L1 frequency (1575.42 MHz) that overpowers the GPS receivers analog to digital circuits.
  - The low powered GPS signals cannot be tracked; the receiver “unlocks” to the PRN signals.
- **Same effect as unplugging the GPS antenna**
- The GPS receiver stops outputting the 1PPS and time of day signals

GPS Clock Steering with GPS Jamming

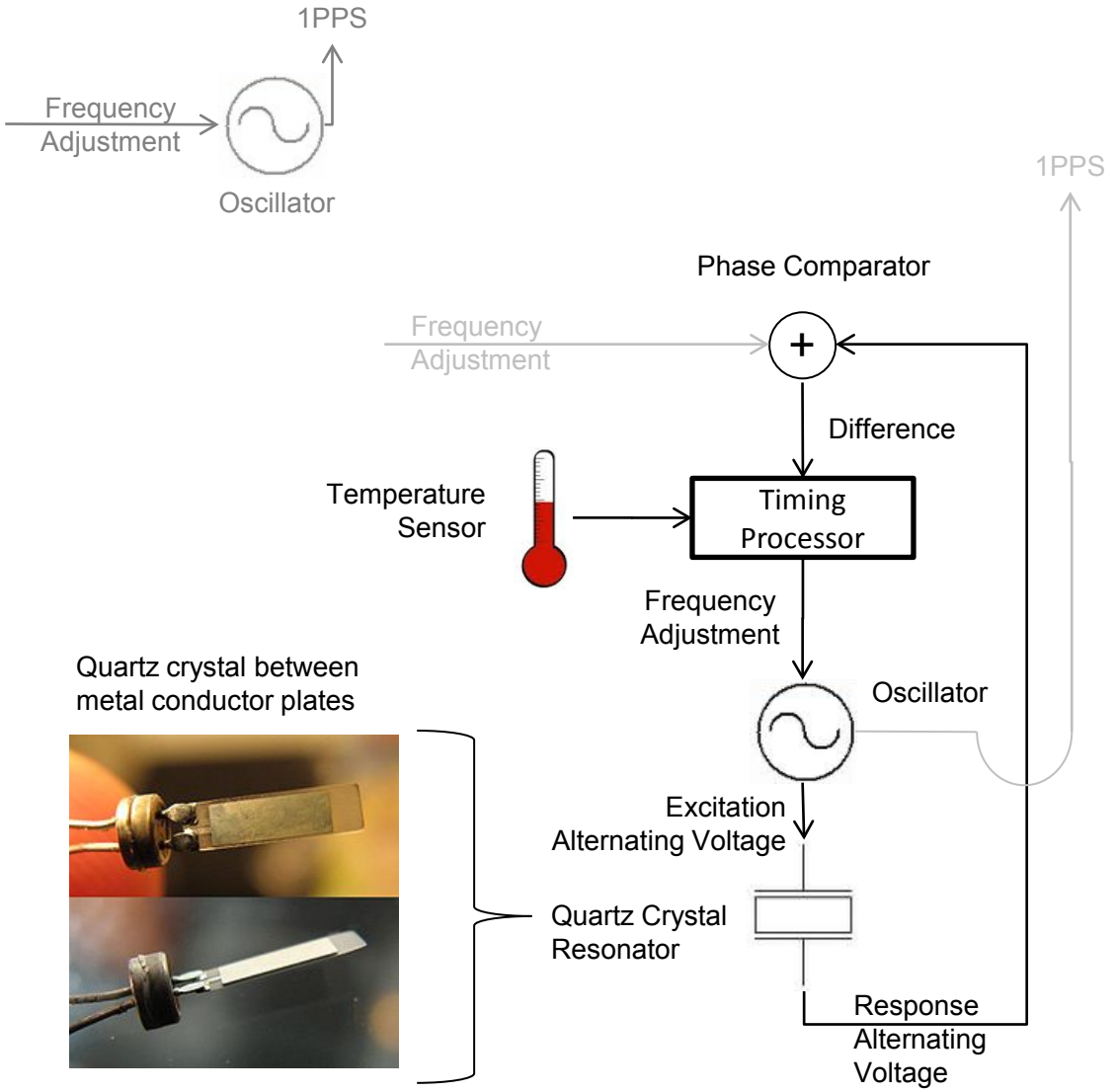


- GPS Jamming unlocks GPS signal/satellite tracking (can't track PRN codes)… (*just like an antenna disconnect or antenna lightning strike*)
- If GPS is unlocked, timing system does not use the GPS 1PPS signal
- Timing subsystem goes into "holdover" or "fly wheeling" on the installed oscillator.

Time Server Oscillators…

Standard Oscillator (TCXO) vs. Atomic Oscillator

Temperature Compensated Crystal Oscillator (TCXO) - Overview



TCXO

- Electro-mechanical resonator
- Tuned alternating voltage signal excites piezoelectric quartz at it's natural resonant frequency.
- Adjust alternating voltage frequency input to maximize piezoelectric alternating voltage output
- Temperature sensitive

TCXO - Pros and Cons

- Pros
  - Relatively low price
  - Good performance for the price
  - Can compensate for some environmental temperature changes
  - Microsecond stability

- Cons
  - Very temperature sensitive quartz crystal
    - Change in temperature causes a change in frequency output
    - Change in frequency output “speeds up” or “slows down” the clock
  - Only as good as the resonant frequency “Q” of specially cut quartz crystal – electro mechanical resonator

Atomic Clocks – What are they?

- Devices that use the frequency of excited electron states of specific atoms such as Rubidium, Cesium, Hydrogen, etc. as a resonator
- Very stable frequency output possible
- Not very temperature sensitive over good operating range of temperatures
- Getting smaller in size…..

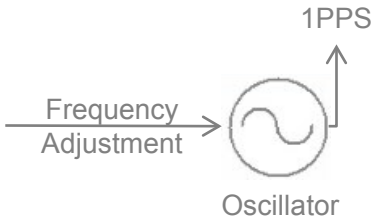
Hydrogen Maser

Cesium Standard

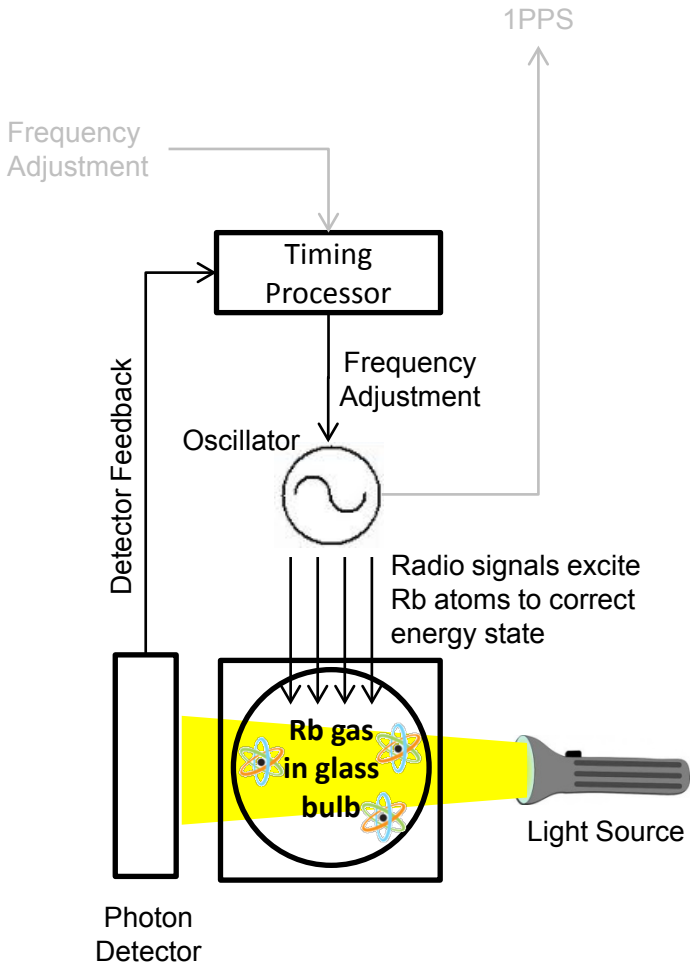
Rubidium Module

Chip Scale Atomic Clock (CSAC)

Rubidium (Rb) Atomic Clock Operation



- When Rb atoms are in the "correct" energy state (at a very precise frequency) the photons are absorbed by the Rb atoms
- Precisely adjust Rb excitation frequency to maximize photon absorption (minimize photon detection)



Symmetricom Miniature Atomic Clock

Rubidium Atomic Clocks (Oscillators)

- Pros
  - Very stable oscillator – (atomic resonator)
    - Sub microsecond stability
    - Microseconds per day drift (or less)
  - Excellent stability for the price
  - Small size
  - Stays accurate and a precise for a long time to allow GPS problems to be fixed.

Symmetricom Miniature Atomic Clock

- Cons
  - Needs to warm up at power on
  - Typically 50°C upper operating temperature for the time server it's installed in.
  - More expensive than a TCXO

Effects of GPS Jamming and Temperature Change on Time Server Clocks

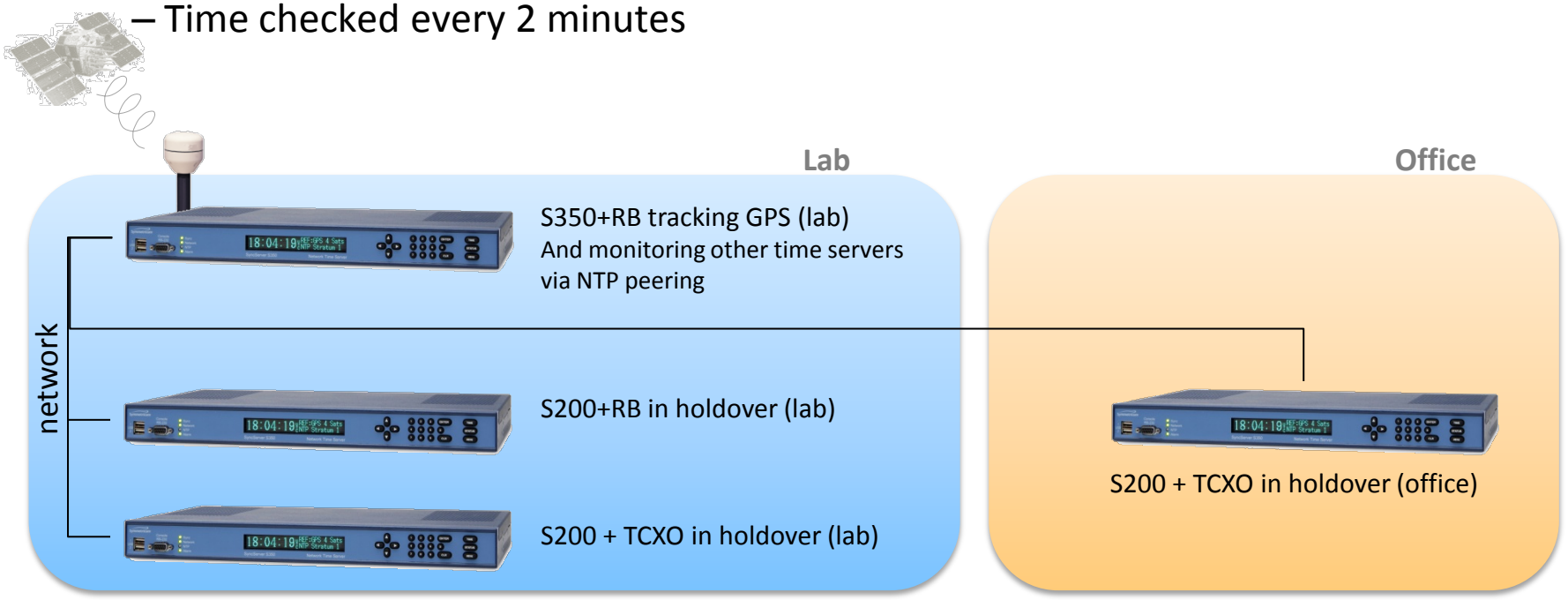
Test Setup – Combined Lab and Office

Lab Environment

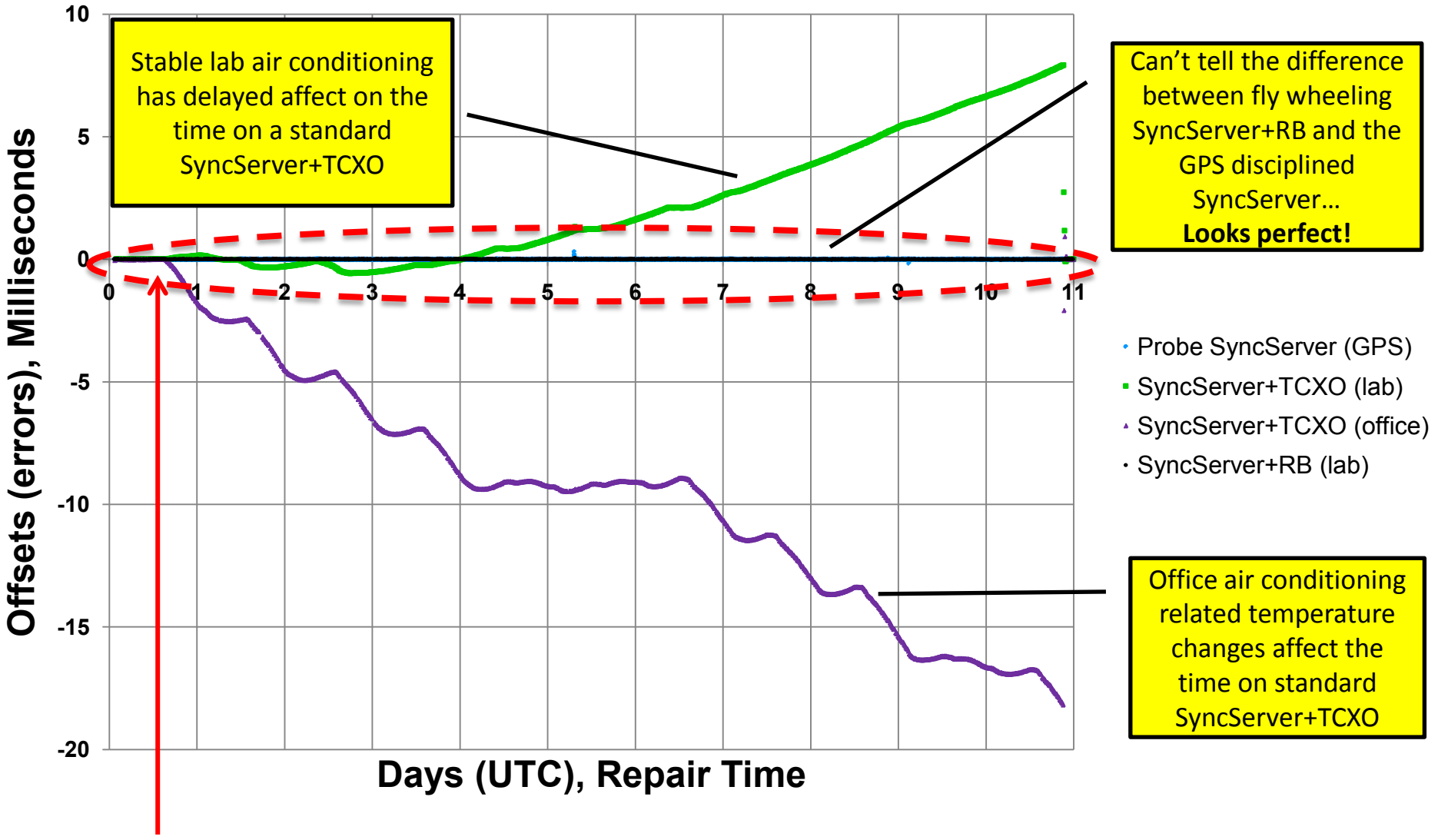
- Even temperature 24 hours a day
- Procedure
  - SyncServer S350+RB tracking GPS monitors SyncServers in holdover via NTP peering.
  - Time checked every 2 minutes

Office Environment

- Variable temperature over 24 hours



Drift Data Using NTP to Measure Offsets



Time Server Time Compare: GPS Steered vs. Atomic Clock in Holdover

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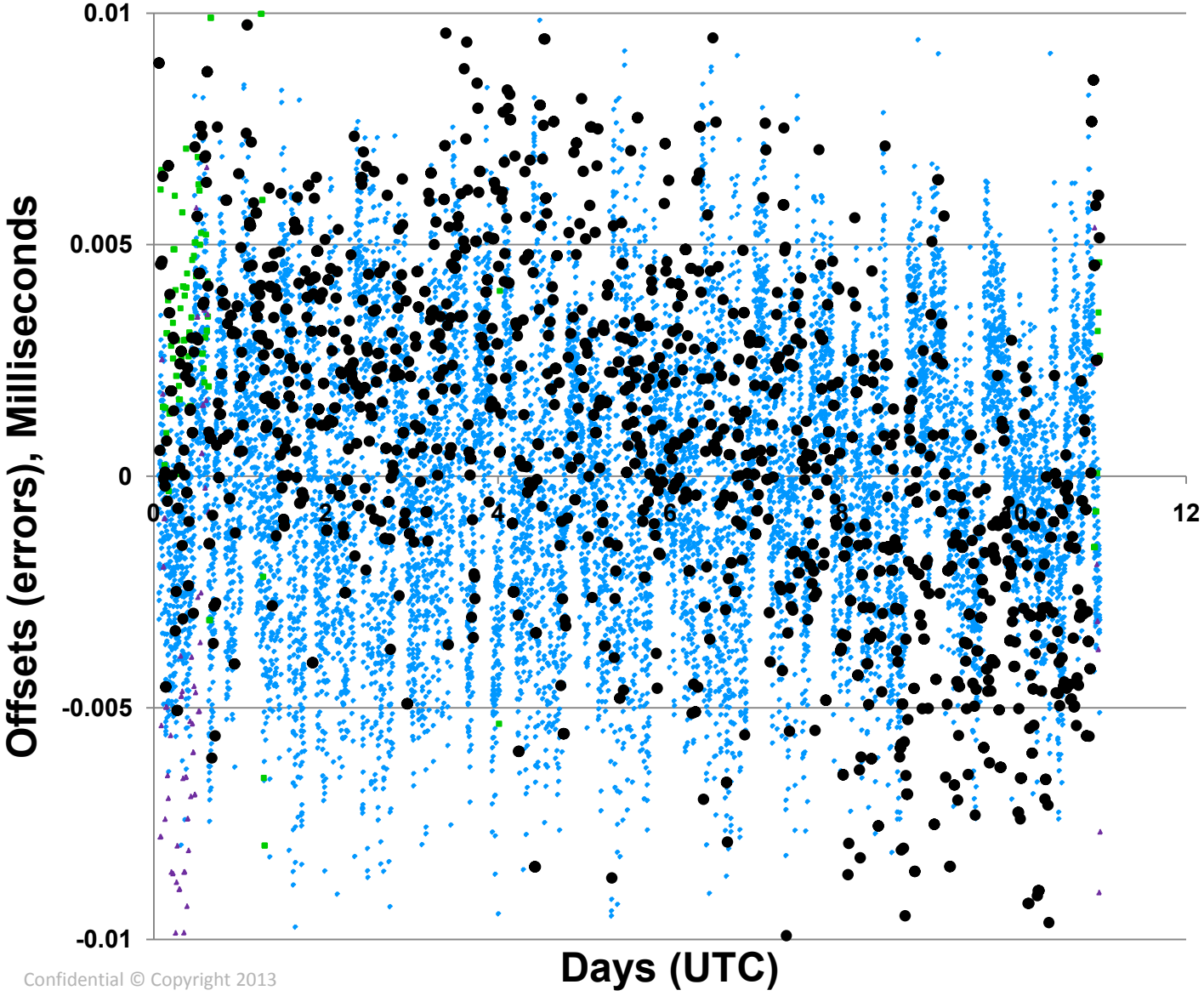

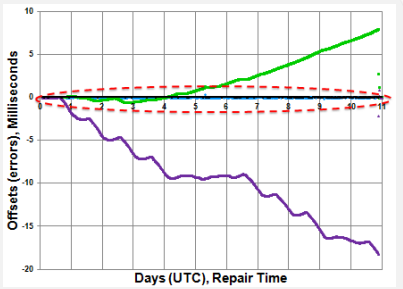

←Zoom-in of circled area above. RB in holdover virtually the same as GPS over test period (+/- 10 microseconds).

- Probe SyncServer (GPS)
- SyncServer+TCXO (lab)
- SyncServer+TCXO (office)
- SyncServer+RB (lab)

Precise Measurement of Rb Atomic Clock Drift

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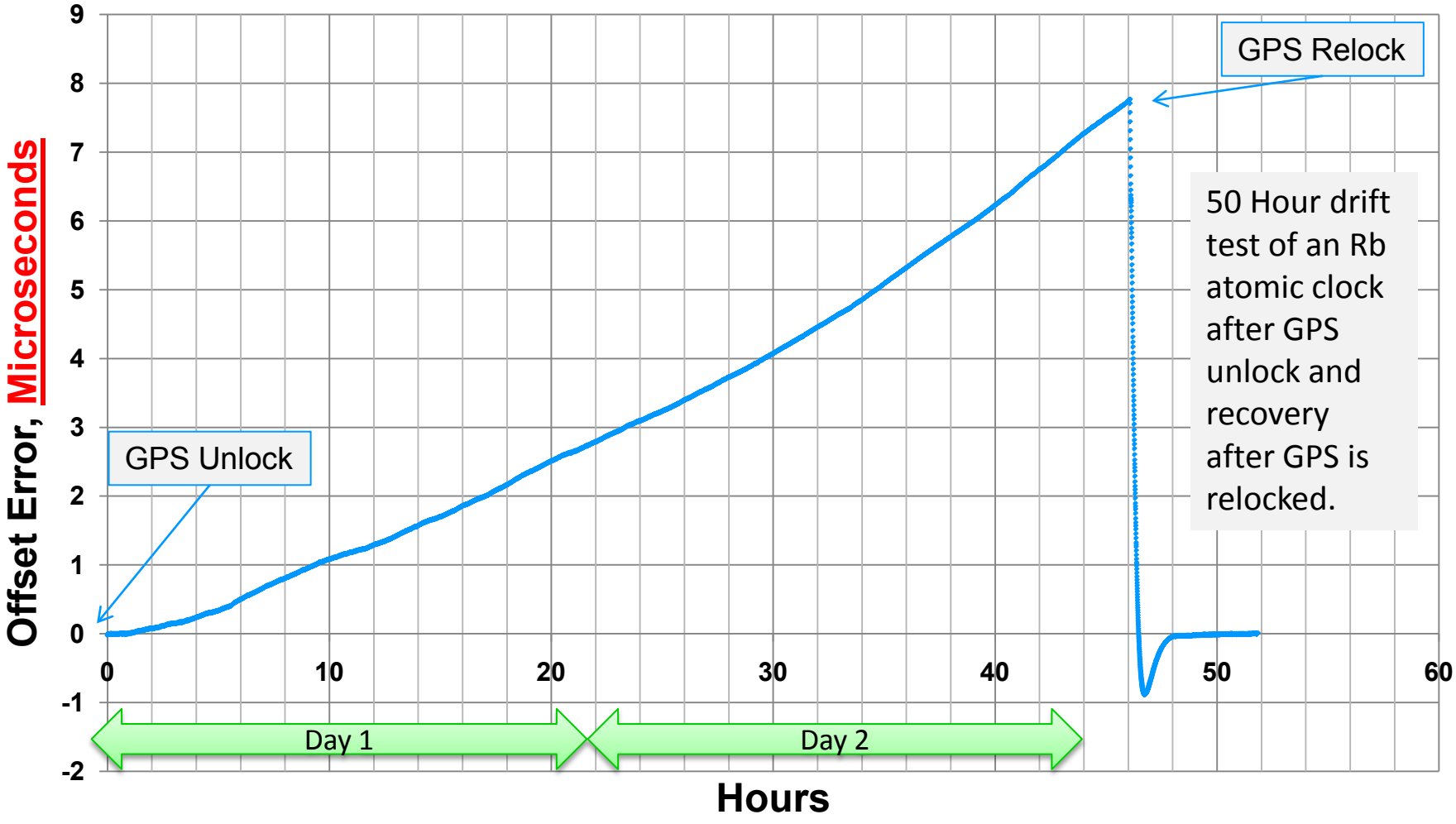
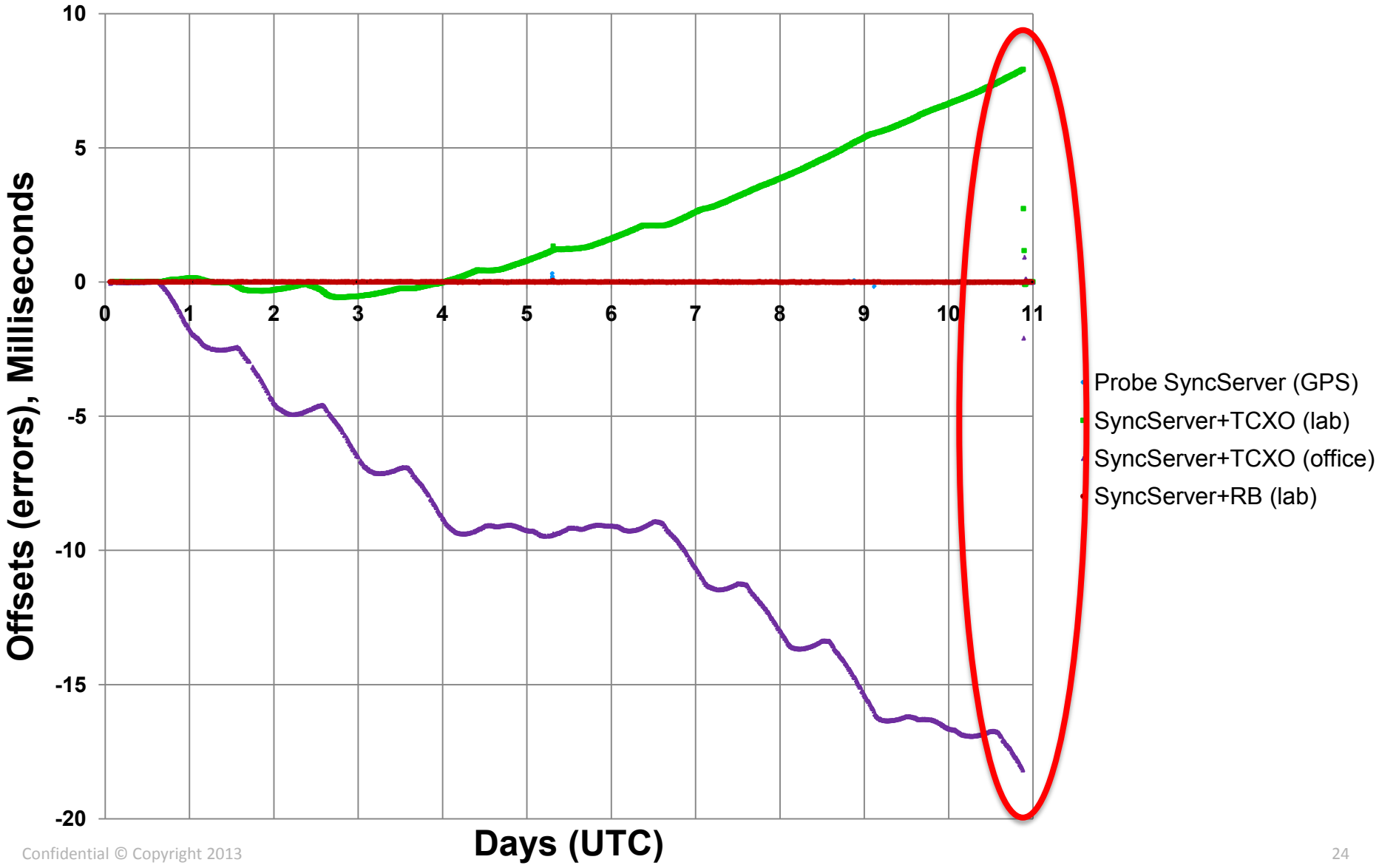
GPS Unlock, Rubidium Oscillator Drift and Recovery



What happens when GPS is reconnected…



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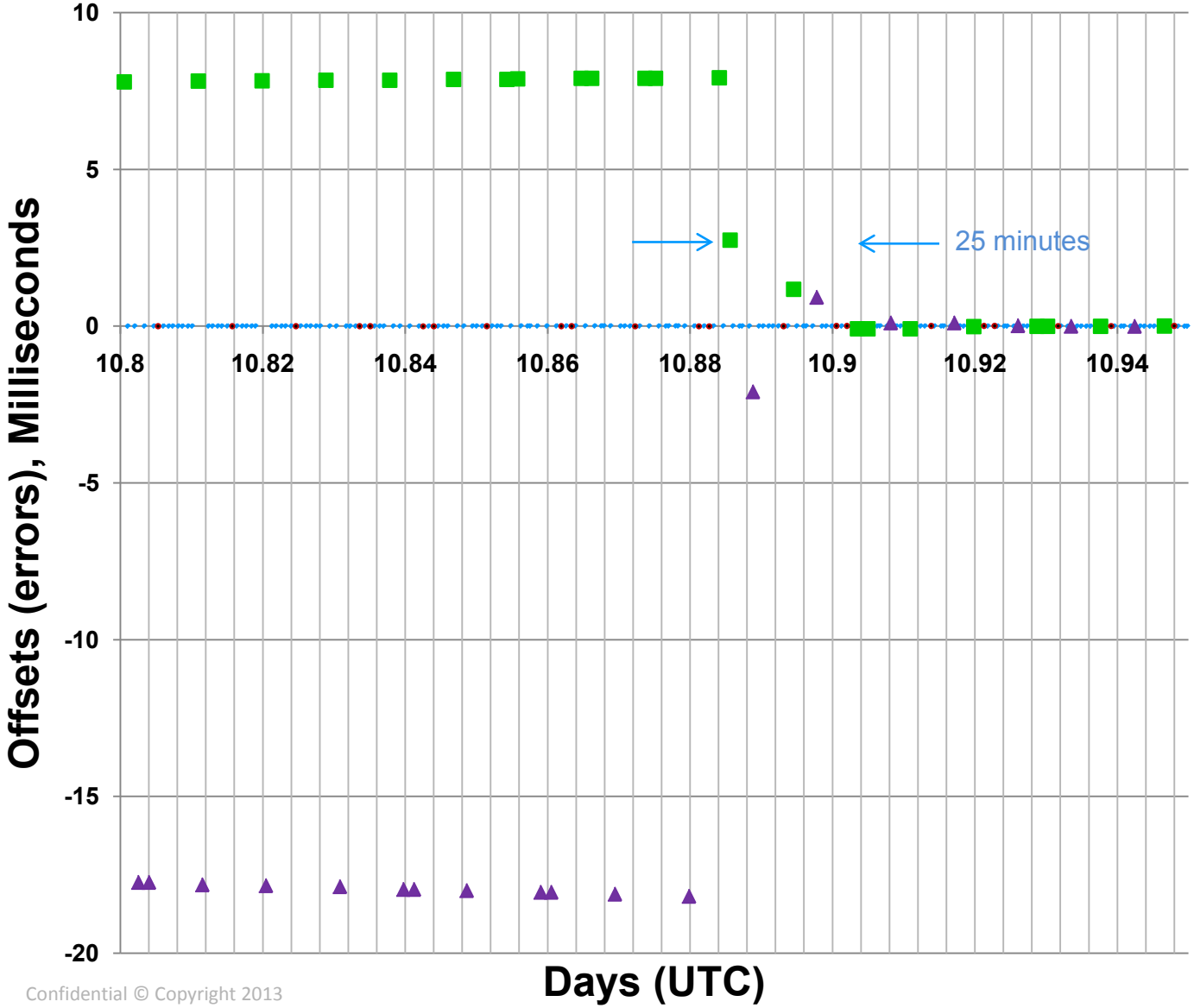

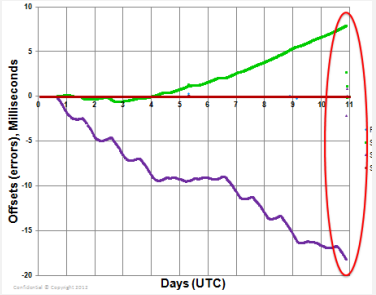

←Zoom-in of circled area above. Shows accuracy recovery after GPS reconnected.

- Probe SyncServer (GPS)
- SyncServer+TCXO (lab)
- SyncServer+TCXO (office)
- SyncServer+RB (lab)

Symmetricom Time Servers for Enterprise Networks

Symmetricom NTP/PTP Time Servers

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NTP Time Servers
(Optional PTP Grandmasters)

SyncServer S350

SyncServer S300

NTP Time Servers

SyncServer S250

SyncServer S200

SyncServer S100

Price

Functionality

Enterprise Time Server: SyncServer S300

Target Enterprise Network: 10 or more servers

Key Benefits

- Synchronize thousands of client, server & workstation clocks
- Very reliable & secure source of time for your network
- Extremely accurate time source for network sync
- Very easy to install and maintain
- Multiple NTP ports for easy network configuration and adaptation
- Intuitive web interface for easy control & maintenance

Key Features

- **Accuracy**
  - Stratum 1 operation via GPS satellites
  - Nanosecond time accuracy to UTC
  - IEEE 1588 / PTP Grandmaster option
- **Reliability**
  - **Rubidium oscillator upgrades**
  - Stratum 2 operation via NTP servers
- **Security**
  - TACACS+, RADIUS, NTPv4 autokey, MD5 authentication
  - Secure web-based management
  - SSH, SSL, HTTPS, Telnet
- **Ease of Use**
  - Web Interface
  - SNMP
  - IPv6 and IPv4 compatible
  - Lots more!

Key Takeaways

- GPS Jamming no different than antenna disconnect/failure
- Standard oscillators
  - Poor holdover accuracy and are temperature sensitive
- Rubidium Atomic Oscillators
  - Provide excellent holdover accuracy
  - Allow plenty of time to fix a GPS antenna problem with no network time accuracy degradation

- ***Request a quote today on an S200 or S300 SyncServer with an Atomic Clock inside!***

Summary

Paul Skoog is a product marketing manager at Symmetricom responsible for enterprise-class GPS referenced network time servers and clock card bus level timing products. Paul has diverse experience in precise time technology, enterprise network timing, GPS positioning and dynamic signal analysis software. He holds a BSME degree from California Polytechnic State University and an MBA from Santa Clara University Graduate School of Business.

- Symmetricom has decades of experience in delivering timing solutions to the Enterprise
- Symmetricom has a full featured portfolio of NTP network time servers
- Contact Symmetricom for more information and to discuss your Enterprise network timing requirements…

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Thank You!