CISA
CYBER+INFRASTRUCTURE

DEFEND TODAY. SECURE TOMORROW.

TIME – THE INVISIBLE UTILITY

WHY IS TIME IMPORTANT?

Time is critical to certain services used within most organizations, yet many organizations are unaware of their dependence on time, the source of their time, or the existence of a world time standard.[1] As systems grow in complexity, becoming global and mobile, access to resilient, accurate, and precise time is a necessity in both the private and public sectors worldwide. Without accurate and resilient time, critical functions and services can become unreliable, inaccurate, or unavailable.

SECTORS AND INDUSTRIES DEPENDENT ON TIME

Communications	Transportation	Power Grid	Finance	Security	IT
Telecommunication Cloud Operations Internet of Things (IoT)	Aviation Maritime Pipelines Rail	Frequency Monitoring Multi-rate Billing Fault Detection	Regulatory Requirements ATM Networks	Cryptography Access Control Forensics Surveillance	Smart Devices Incident Investigations

WHY SHOULD YOU BE CONCERNED ABOUT TIME NOW?

GPS has become the *de facto* time standard for many commercial users because of its relatively low cost and ubiquitous availability. In 1997, the President's Commission on Critical Infrastructure Protection (PCCIP) identified overdependence on the Global Positioning System (GPS) as a growing vulnerability within the United States Critical Infrastructure. In 2017, 5.8 billion Global Navigation Satellite Systems (GNSS) devices, such as those using GPS, were in use. By 2020, this number is forecasted to increase to almost 8 billion—an estimate of more than one device per person on the planet[2].

Until recently, GPS devices were viewed simply as radio receivers. However, they are actually computers, with similar security risks. Threats include denial-of-service attacks (jamming) and the introduction of bad data into the system (spoofing). The advent of software-defined radios has increased the ease and lowered the cost with which these types of attacks can be launched. Efforts should be made to ensure accurate and resilient timing for your GPS devices.

WHAT CAN YOU DO TO UNDERSTAND AND IMPROVE YOUR "TIME HYGIENE"?

Know your systems' timing requirements:

- Identify what services / missions require time for operation within your organization.
- Identify the primary source of time for your organization, for example:

- From where does your web server or firewall obtain time?
- How does your organization rely on time?
- Are the products and services provided to internal and external customers reliant on time?

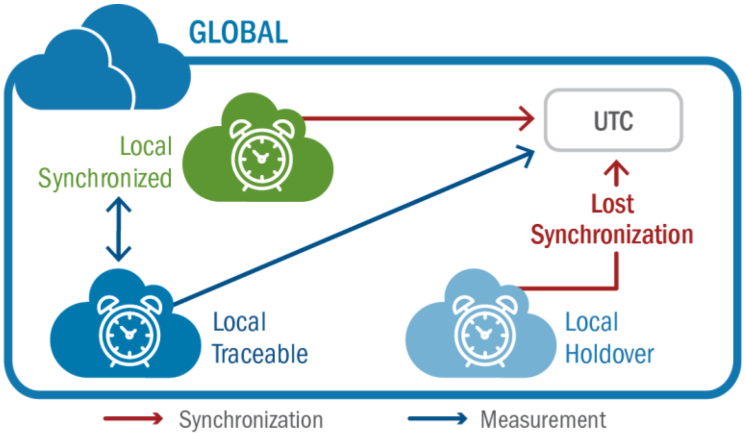
Principal sources of time for the United States*:

- National Institute of Standards and Technology (NIST)
- U.S. Naval Observatory (USNO)

- Determine the level of time performance (accuracy and resilience) needed for your systems or applications.
- Is your organization's time traceable[3] to the principal source(s) of time?
- Does your organization need global synchronization (i.e., to UTC) or local synchronization (Figure 1)?
  - Can your globally synchronized systems be replaced by locally synchronized systems?
- Identify, verify, and document timing dependencies in your organization's systems or applications.

Figure 1. Relative vs. Absolute Time

- **Absolute**: Do you need global synchronization (**traceability** to UTC)?
- **Relative**: Do you only need to synchronize within your own organization?
- Can your systems tolerate time source outages, providing internal **holdover** if synchronization is lost (*Refer to Figure 3*)?



Assess your timing system:

- Assess the ____________ of your time source:
  - Availability
  - Reliability
  - Resilience
  - Integrity
- Assess what happens when your primary source of time goes away:
  - Do your internal systems alarm?
  - Do your systems continue to operate in a predictable manner?
  - Are your systems able to holdover for X hours/days until external time returns?
- Assess the time **accuracy** needed for your organization and select an appropriate method

Figure 2. Common Methods for Distributing Time

Method	Path	Accuracy	Cost
Dial-up[4]	Telephone Lines	<1s	$
Network Time Protocol (NTP)[5]	Network	1ms	$
WWVB[6]	RF	<1ms	$
Precision Time Protocol (PTP)[7]	Network	50ns	$$
GPS[8]/GPS Carrier Phase Time Transfer[9]	RF	<10ns	$-$$$
Two-Way Satellite Time Transfer (TWSTT)[10]	RF/SatCom	~1ns	$$$
Two-Way Fiber Time Transfer (TWTToF)	RF->Optical	<1ns	$$$
Alternate / Evolving Commercial Methods	Varies	Varies	Varies

Best Practices:

- Include time as part of your cyber hygiene and risk management process.
- Follow best practices for:
    - GPS Systems[11]
    - NTP servers and clients[12]
- Create and maintain documentation to prepare for unforeseen events (internal or external threats, failures, and power outages) and scheduled anomalies (UTC Leap Second adjustments, GPS Week Number rollover)
    - In the case of unforeseen events, simple redundancy may be the answer. In the case of scheduled anomalies, software patches / system updates may be required.
- Consider local synchronization, which may be more secure and less expensive.
- Employ redundant and independent timing sources with sufficient holdover to meet system requirements.
    - See Figure 3 for example oscillator specifications (typical values are provided for each oscillator type but oscillator performance will vary).

Figure 3. Common Oscillators Holdover Performance

Oscillator Type*	Estimated Elapsed Time to 100 ns error**	Cost
Temperature Compensated Crystal Oscillator (TCXO)	2 minutes	$
Oven Control Crystal Oscillator (OCXO)	16 minutes	$$
High Performance OCXO	1 hour	$$$
Chip Scale Atomic Clock	2 hours	$$$
Rack Mount Rb Cell	6 hours	$$$$
Cesium Beam	11 days	$$$$$
High Performance Cesium Beam	72 days	$$$$$
Maser	405 days	$$$$$$

*Assuming 0 initial time error. Frequency synchronization error at the oscillator’s flicker [noise] floor.
**Additional factors affect oscillator stability such as aging and environmental changes due to temperature, humidity, pressure, and vibration.

FURTHER READING

[1] Memorandum for U.S. Owners and Operators Using GPS to Obtain UTC Time (with 2019 GPS week rollover)

- https://ics-cert.us-cert.gov/Memorandum-US-Owners-and-Operators-Using-GPS-Obtain-UTC-Time
    - Timing Criticality & GPS 1024 Week Rollover: https://www.gps.gov/governance/advisory/meetings/2017-11/powers.pdf

[2] The GPS 2019 Week Rollover - What You Need to Know

- https://spectracom.com/resources/blog/lisa-perdue/2018/gps-2019-week-rollover-what-you-need-know

[3] Responsible Use of GPS for Critical Infrastructure (Dec 2017)

- https://www.gps.gov/multimedia/presentations/2017/12/CIPRNA/skey.pdf

[4] Federal Radionavigation Plan: Sections: 3.1.1 (Timing Policy), 5.7 (Timing Plan), A.2.6 (Timing Systems)

- https://www.navcen.uscg.gov/pdf/FederalRadioNavigationPlan2017.pdf

[5] Leap Seconds FAQs
- https://www.nist.gov/pml/time-and-frequency-division/leap-seconds-faqs

[6] Best Practices for Improved Time and Frequency Sources for Fixed Locations (Jan 2015)
- https://www.dhs.gov/sites/default/files/publications/GPS-PNT-Best-Practices-Time-Frequency-Sources-Fixed-Locations-508.pdf

References:

* Federal Radionavigation Plan. Section 1.6 Authority: https://www.navcen.uscg.gov/pdf/FederalRadioNavigationPlan2017.pdf

[1] Coordinated Universal Time. Retrieved from https://www.nist.gov/pml/time-and-frequency-division/nist-time-frequently-asked-questions-faq#tai

[2] GNSS Market Report, Issue 5, copyright © European GNSS Agency, 2017, pg 10. Retrieved from https://www.gsa.europa.ea/system/files/reports/gnss_mr_2017.pdf

[3] Metrological and legal traceability of time signals (2018); https://tf.nist.gov/general/pdf/2941.pdf

[4] Dial Up: https://www.nist.gov/pml/time-and-frequency-division/services/automated-computer-time-service-acts

[5] NTP: https://www.nist.gov/pml/time-and-frequency-division/services/internet-time-service-its

[6] WWVB: https://www.nist.gov/pml/time-and-frequency-division/radio-stations/wwvb

[7] PTP: definition is embodied in IEEE Std. 1588-2008: https://ieeexplore.ieee.org/document/7949184/

[8] GPS: https://www.gps.gov/

[9] For example: Time Measurement and Analysis Service: https://www.nist.gov/programs-projects/time-measurement-and-analysis-service-tmas

[10] Two way Satellite Time Transfer: https://www.usno.navy.mil/USNO/time/twstt/what-is-twstt

[11] Improving the Operation and Development of Global Positioning System (GPS) Equipment Used by Critical Infrastructure - Jan 2017 (PDF): https://ics-cert.us-cert.gov/sites/default/files/documents/Improving_the_Operation_and_Development_of_Global_Positioning_System_%28GPS%29_Equipment_Used_by_Critical_Infrastructure_S508C.pdf

[12] Best Practices for NTP Services: https://insights.sei.cmu.edu/sei_blog/2017/04/best-practices-for-ntp-services.html