USNO Report
to the
CGSIC Timing Subcommittee

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U.S. Naval Observatory (USNO)

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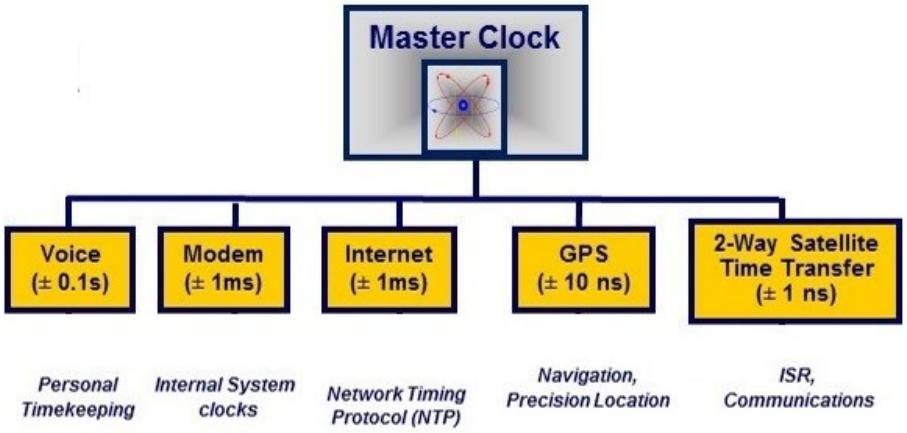
UNCLASSIFIED

USNO Mission Areas

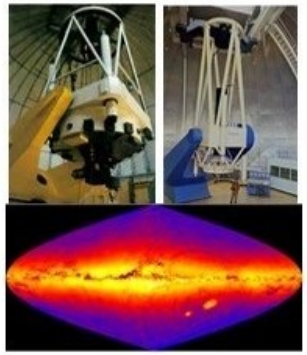
Precise Time

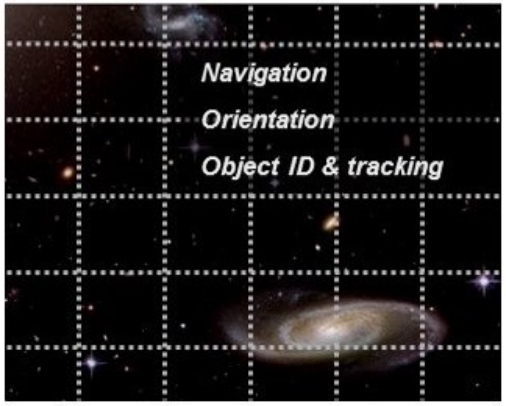


Earth Orientation Parameters

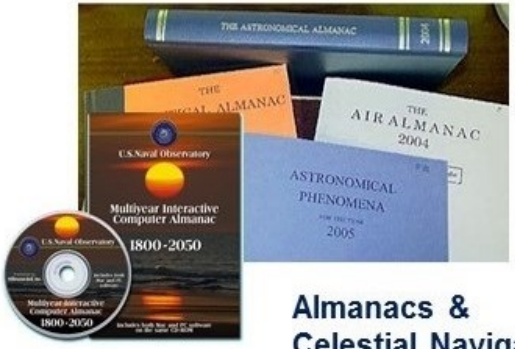
- ★ Departures from "pure" rotation
- ★ Synchs the earth and its orbiting space platforms
- ★ GPS Error = 2 meters w/in 1 week & 400 meters at 6 months w/o EOP

Astrometry – star positions & motions





Astronomical Applications



Almanacs & Celestial Navigation

Solar/Lunar Illumination

Precise Timing Applications

Communications

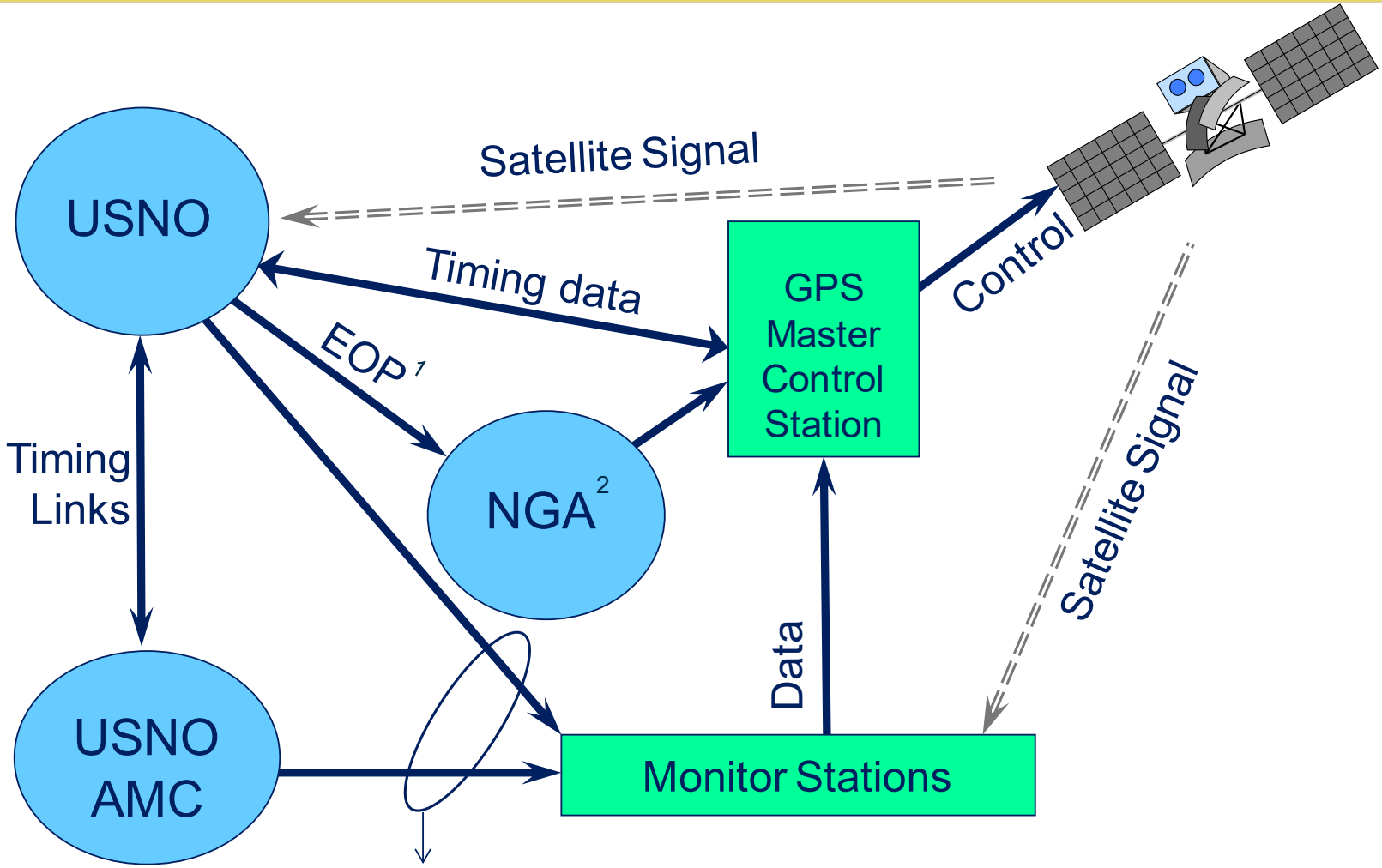
Power Grid

Financial

Scientific

Precise Timing is Critical to the Modern World's Infrastructure

GPS Operations and USNO



[1]Earth Orientation Parameters
[2]National Geospatial-Intelligence Agency

GPS Time and USNO

GPS Time

- Internal system timescale of GPS
- Continuous → No leap seconds; fixed to UTC on January 6th, 1980
- 18 seconds off from UTC now
- An intelligent average of satellite and ground monitor station clocks

USNO utilizes a specialized set of calibrated GPS timing receivers to track GPS

- We compute the offset of GPS System Time to UTC(USNO) and deliver this to the United States Space Force (USSF)

USSF 2nd Space Operations Squadron (2SOPS) use these data to steer GPS Time to match UTC(USNO) modulo 1s

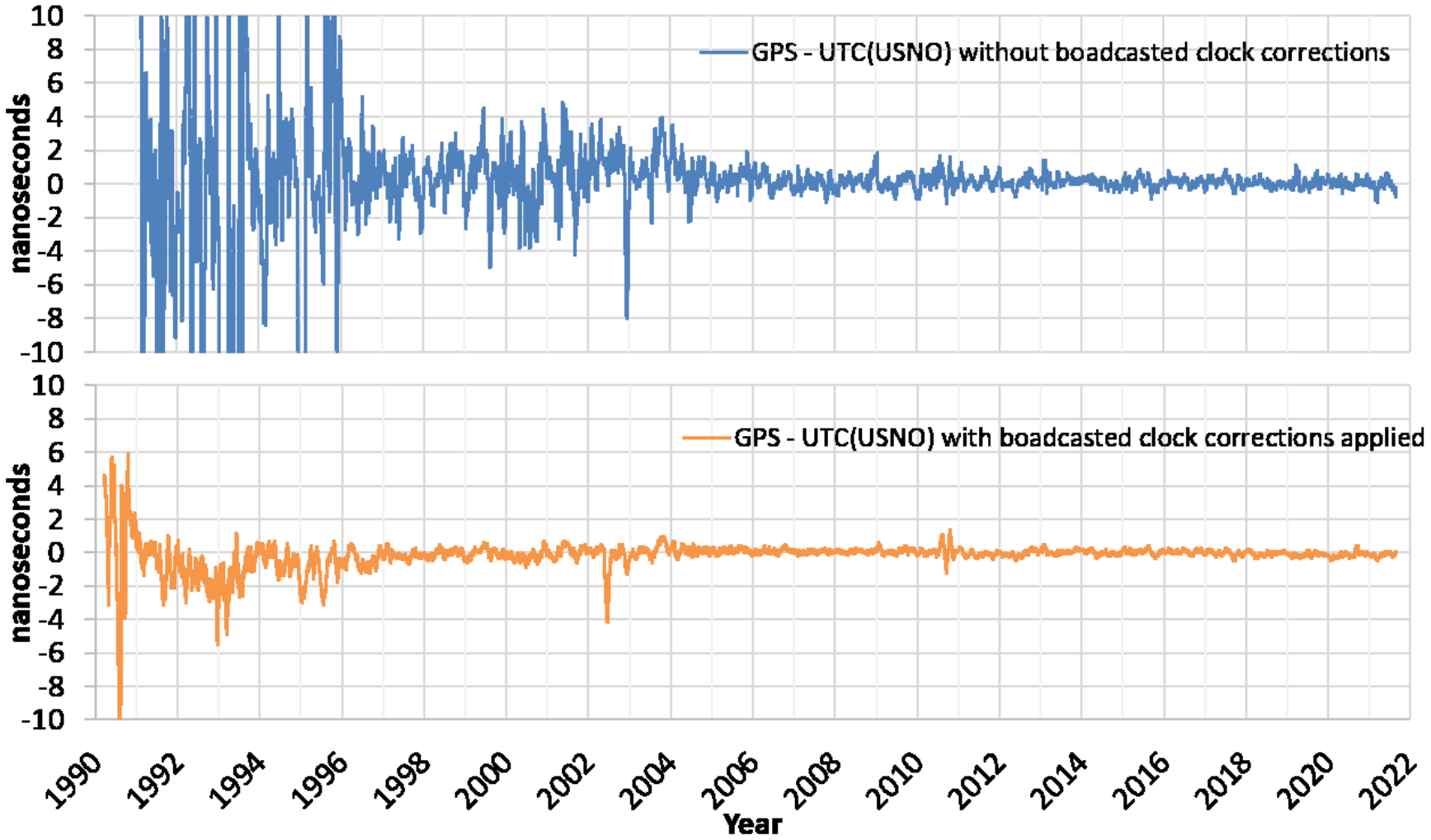
- There are no time or frequency steps in GPS Time, only steps in the frequency drift

GPS delivers timing and frequency offsets to convert from GPS Time to a prediction of UTC(USNO)

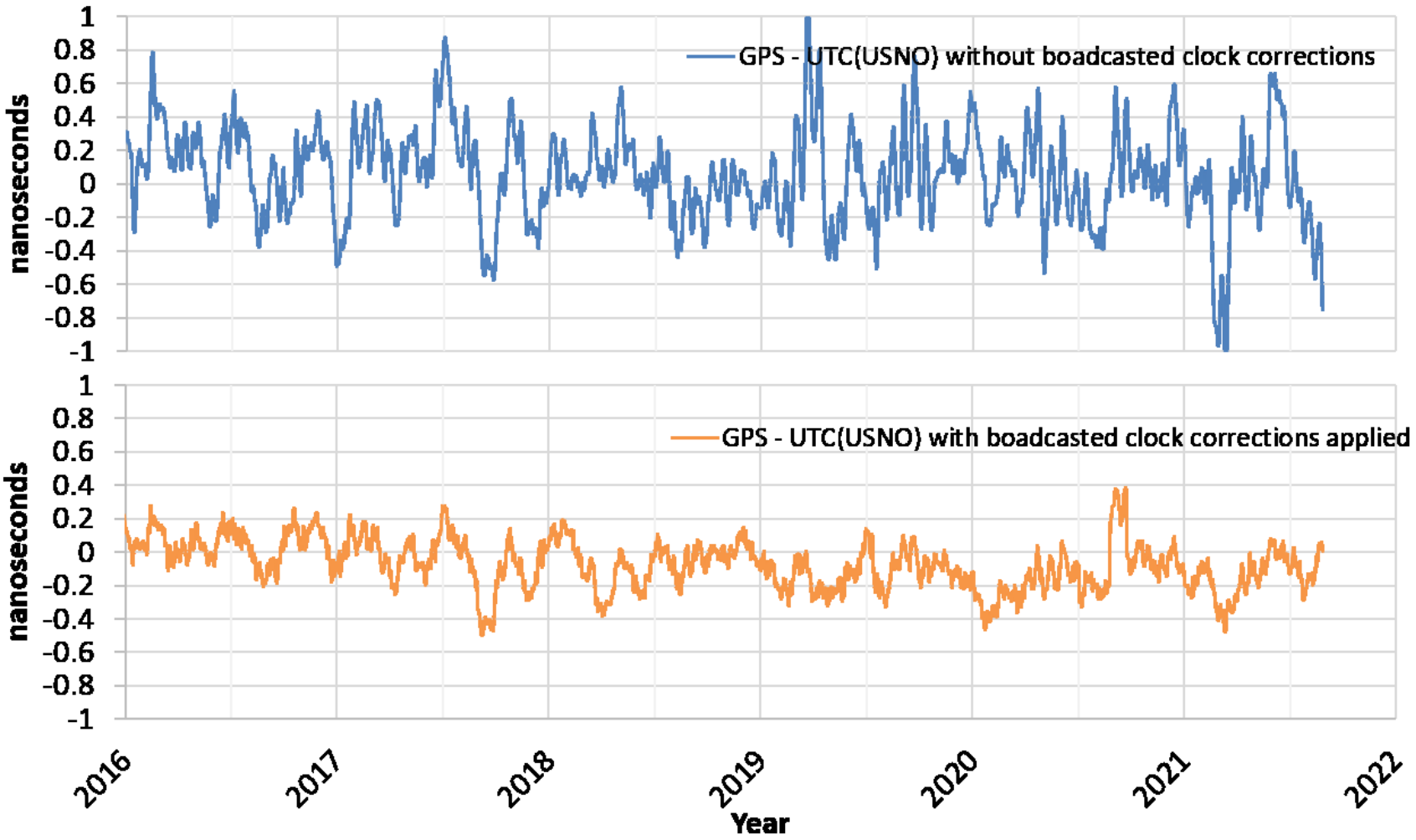
- This information is contained in the GPS Legacy Navigation (LNAV) data in Subframe 4, Page 18 (SF4P18), and in the modernized Civil Navigation (CNAV) in Message Type 33

GPS Time Delivery, 30-day Averages

- Nearly 30 years of GPS accurately delivering UTC(USNO)



GPS Timing, More Recent History



GPS + other GNSS Added Benefit

GNSS: Global Navigation Satellite System (such as GPS, GALILEO, etc.)

Increased reliability and availability of Position, Navigation, and Timing

- Especially in challenging environments such as urban canyons where users can only see 1-2 satellites from each system

Challenge: Ensure interoperability of all different GNSS

- Need to measure and report timing offset between systems
  - GPS-to-GNSS Time Offset (GGTO)
- Requires stable, repeatable GNSS receiver calibration for all GNSS signals

USNO will provide GGTOs for broadcast by GPS

- USNO is presently providing both GLONASS and Galileo time differences in support of special CNAV testing (not presently being broadcast)
- CNAV Message Type 35 contains the GPS-to-GNSS Offset (GGTO) for various systems
- Current schedule for broadcast is 2022 with the GPS Next Generation Operational Control System (OCX)

USNO Additional GPS III support

USNO will act to coordinate GGTO determination methods with other Global Navigation Satellite Systems and provide GGTO information to GPS

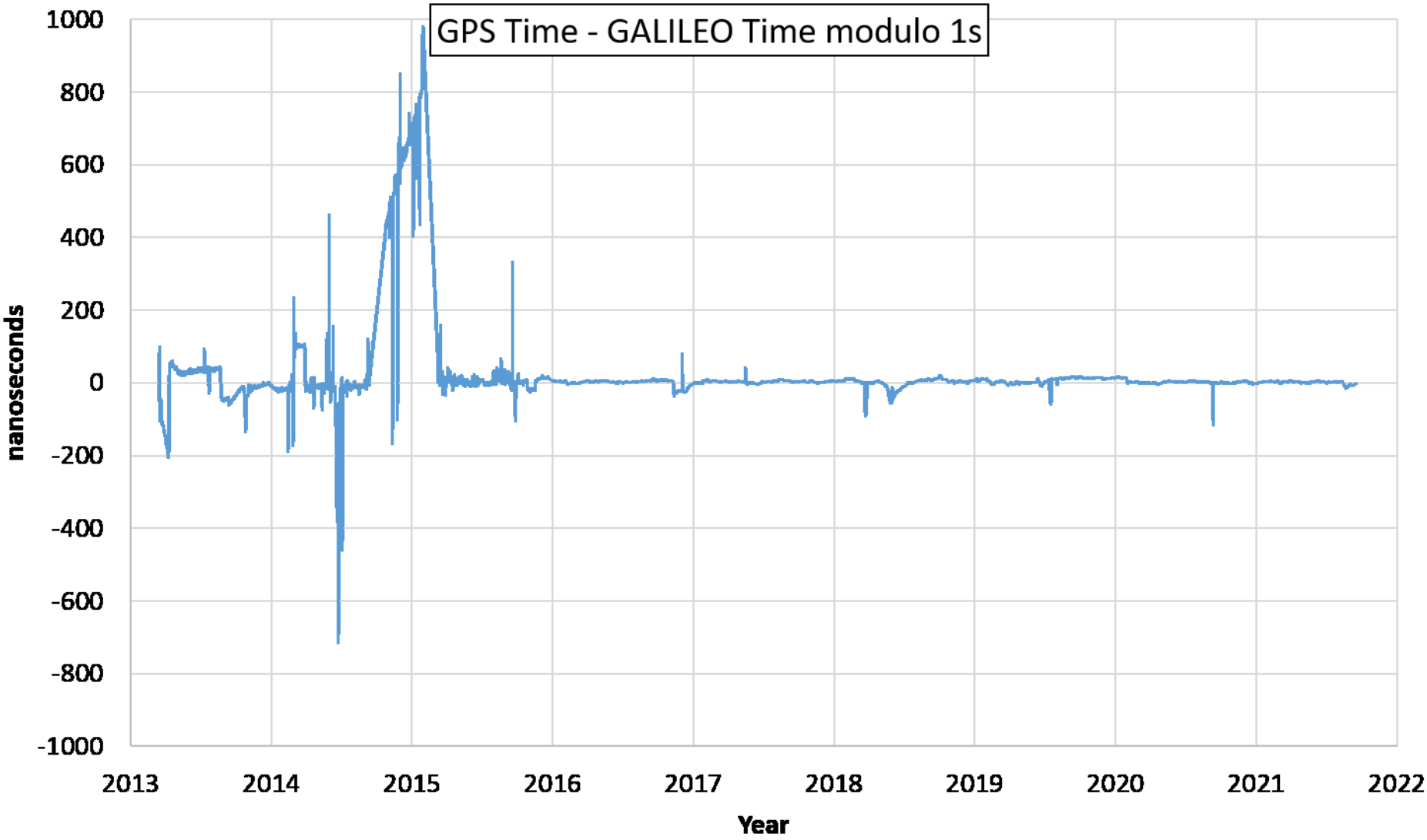
- Ensure consistent messaging from GNSS providers on using provided GGTO values

Also supporting OCX, USNO will work with USSF for the determination of the GPS satellite and reference stations inter-signal and inter-frequency biases

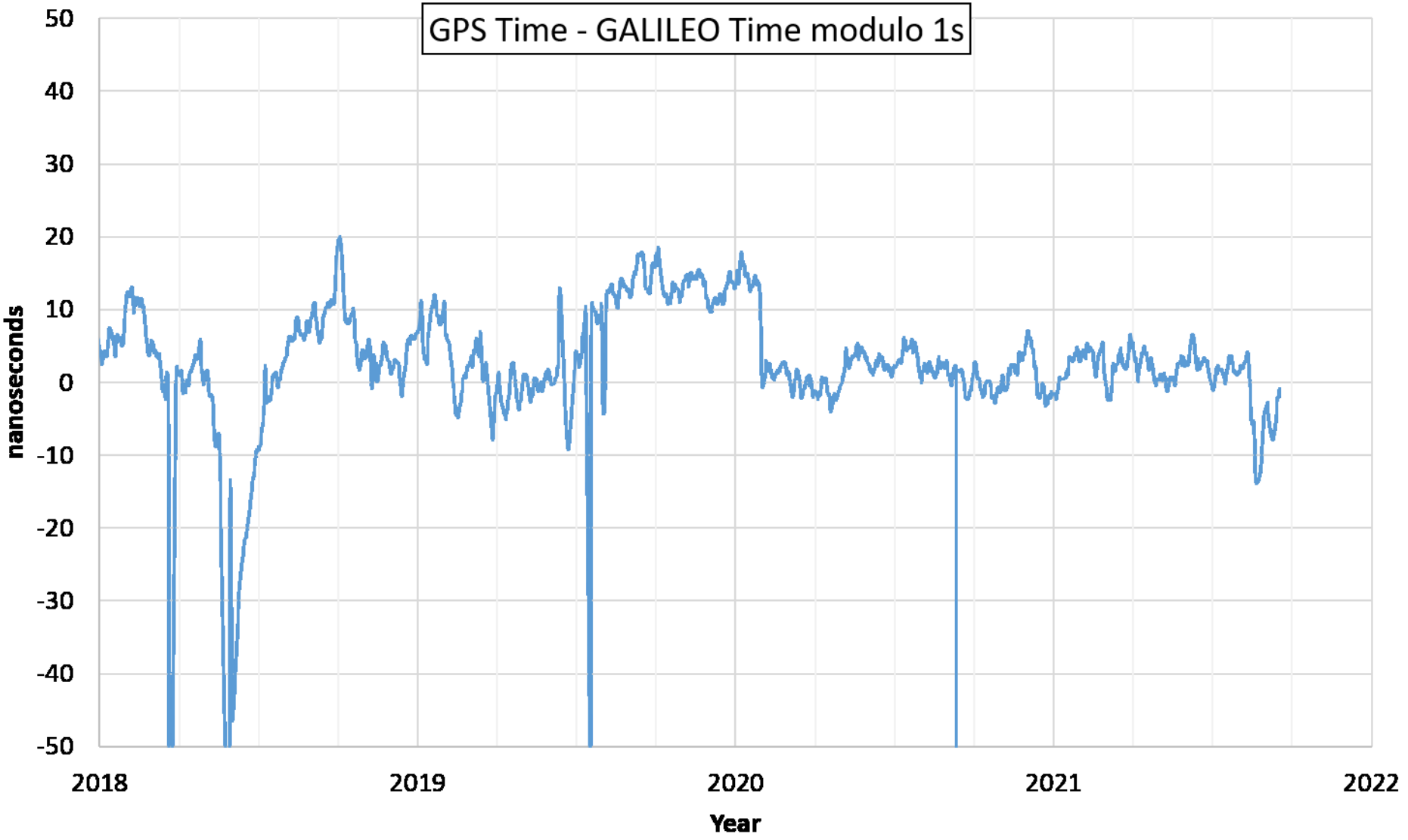
- This is needed to ensure that average constellation biases are removed in a consistent way to ensure accuracy for timing user community
- Many different signal pairs to be available with differing biases per pair (e.g.: L1 C/A + L2C, L1C + L5Q, etc.)

GNSS simulator calibration procedures are being validated and tested to ensure consistency and accuracy

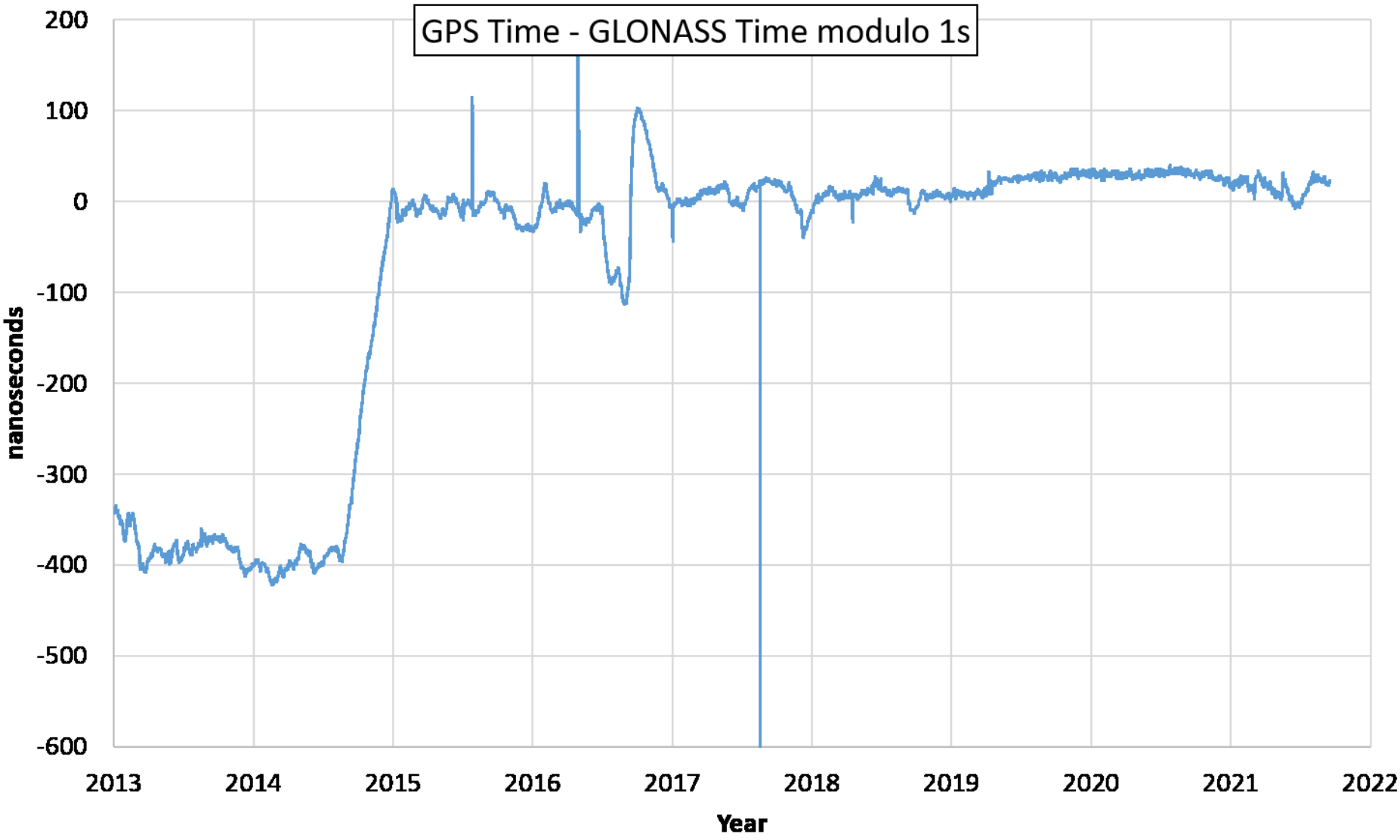
GALILEO GGTO



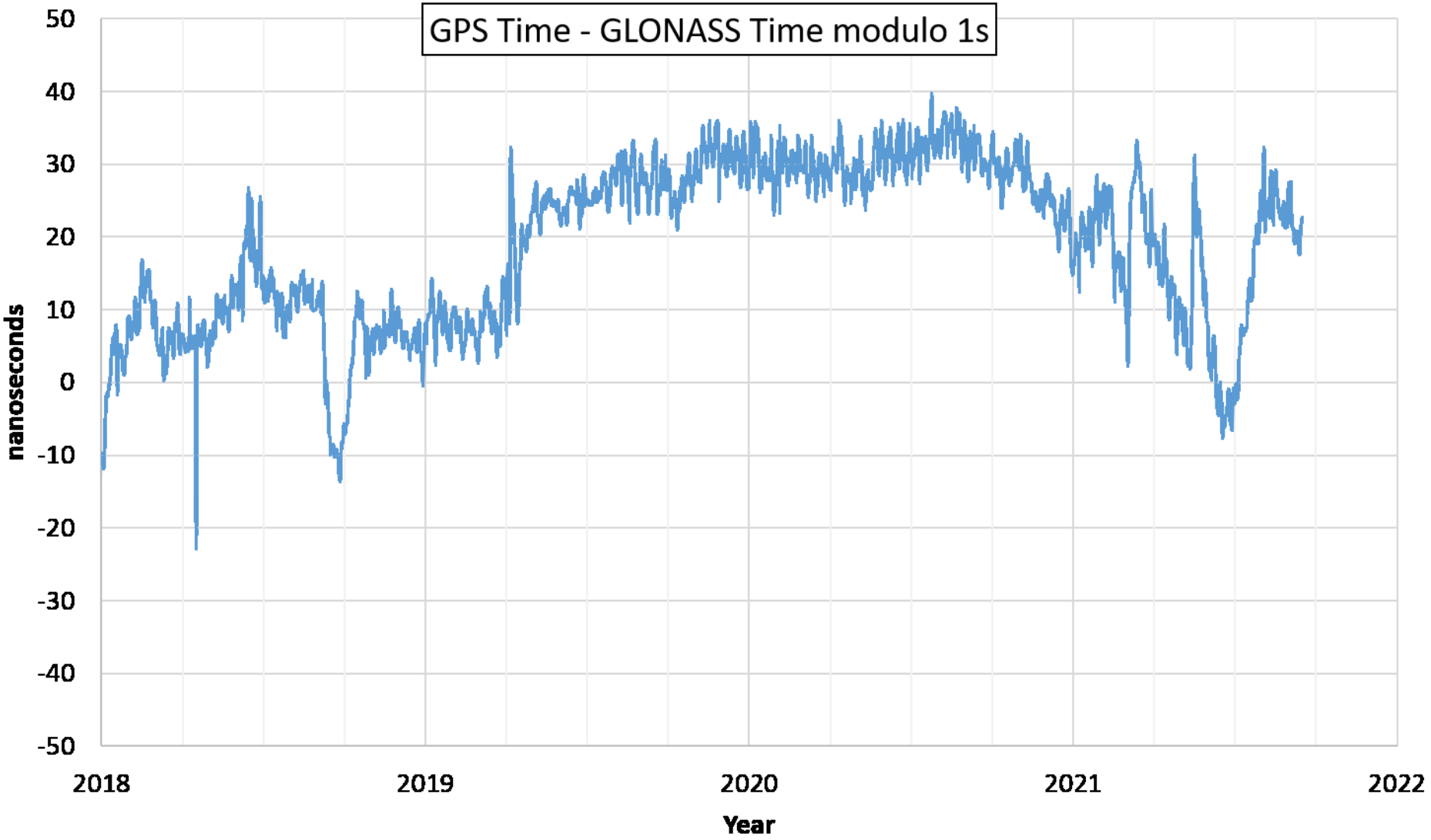
GALILEO GGTO



GLONASS GGTO



GLONASS GGTO



Summary

USNO specializes in real-time timekeeping

GPS supports many Precise Time Users

USNO provides the timing reference for GPS

- Monitor and report the offset of GPS Time from UTC(USNO)
- Ensure the validity of reported numbers through receiver calibrations

USNO monitors other GNSS Time

- Will report GGTO data to GPS with OCX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