Report From the

U.S. Naval Observatory

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Timing Session of the
Civil GPS Service Interface Committee (CGSIC)
September 19, 2011
Portland, Oregon

DoD Directive 4650.05

- Signed by Deputy SecDef 19 Feb 2008
- The Secretary of the Navy shall direct the U.S. Naval Observatory to:
  - Develop and maintain the standards for Precise Time and Time Interval (PTTI) services, earth orientation parameters, and the celestial reference frame for the DoD Components
  - Provide representation to Position, Navigation, and Timing (PNT) committees and working groups, as necessary
  - Serve as the DoD PTTI Manager

USNO Master Clocks

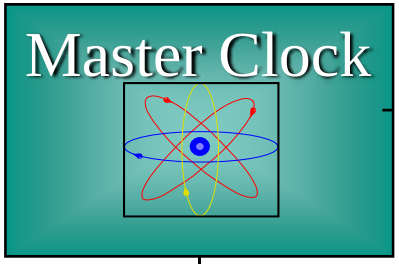
Master Clock Washington, DC

- 75 High Performance Cesiums
- 26 Cavity-Tuned Masers

Alternate Master Clock Schriever AFB

- 12 High Performance Cesiums
- 4 Cavity-Tuned Hydrogen Masers

DoD Time Dissemination



Alternate Master Clock

Voice

Computer Modem

Internet

GPS

Two-way Satellite Time Transfer

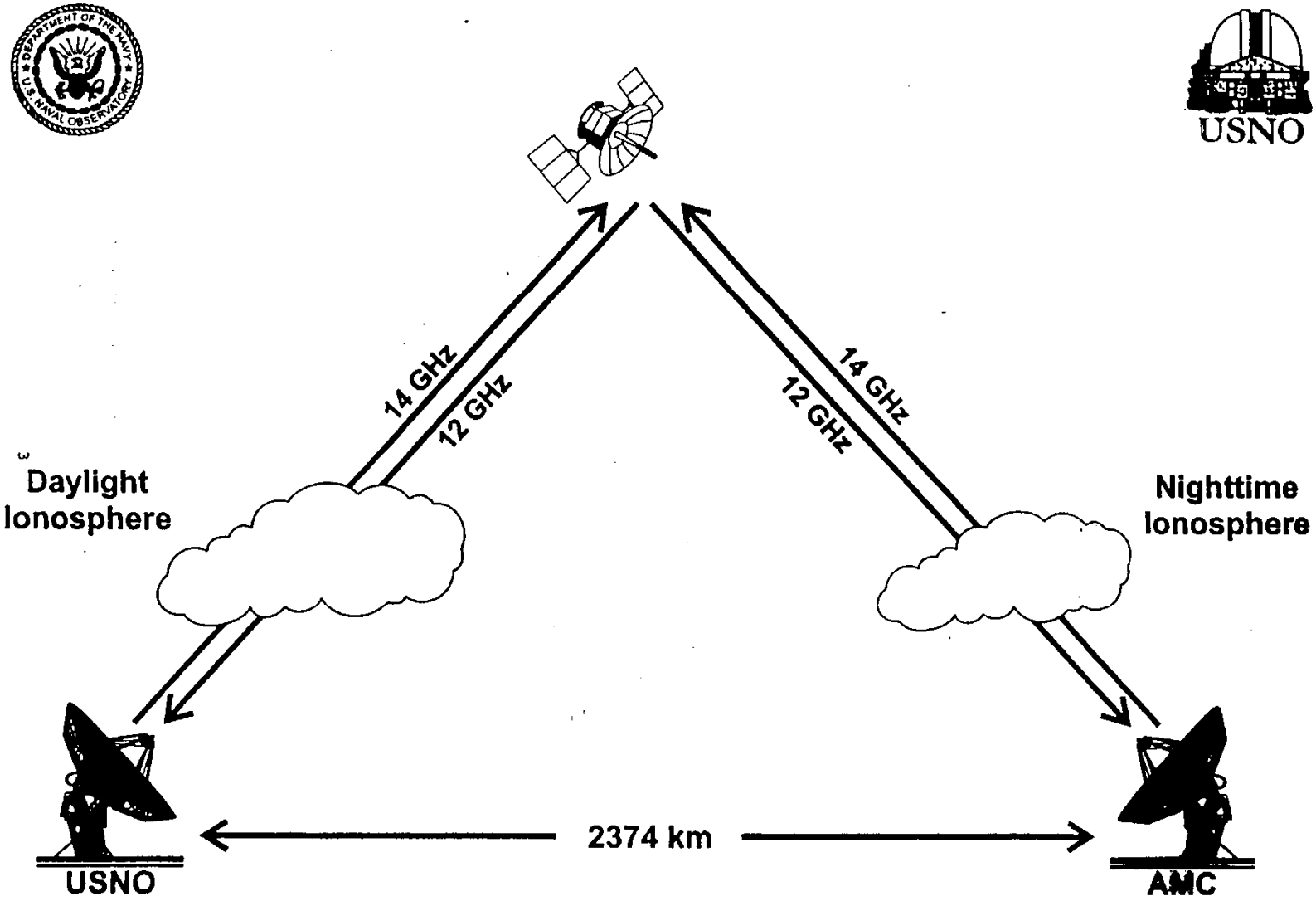
- Ships, Submarines, Aircraft
- Ground Forces
- Shore Activities
- Space Commands
- NIMA
- GPS

- Communications Centers
- Operation Centers

- GPS
- DSCS
- Classified Programs

- GPS
- DSCS
- Satellite Tracking Ranges
- Satellite Ground Control Stations

Two-Way Satellite Time Transfer



TWSTT at a Glance

- Time at 1.0 nanosecond to specific users
  - Operational with NICT (Japan)
    - Supporting QZSS
    - Uses Hawaii (Kokee Park) for a hop
  - Cape Canaveral operations over extended range
  - Extensions to Pacific
- AMC time link rebuilt
  - Engineering for better and cheaper
    - Thermal Control, Impedance Matching,
  - Calibration requires frequent and expensive travel
- GPS PPP now used for USNO's link to BIPM

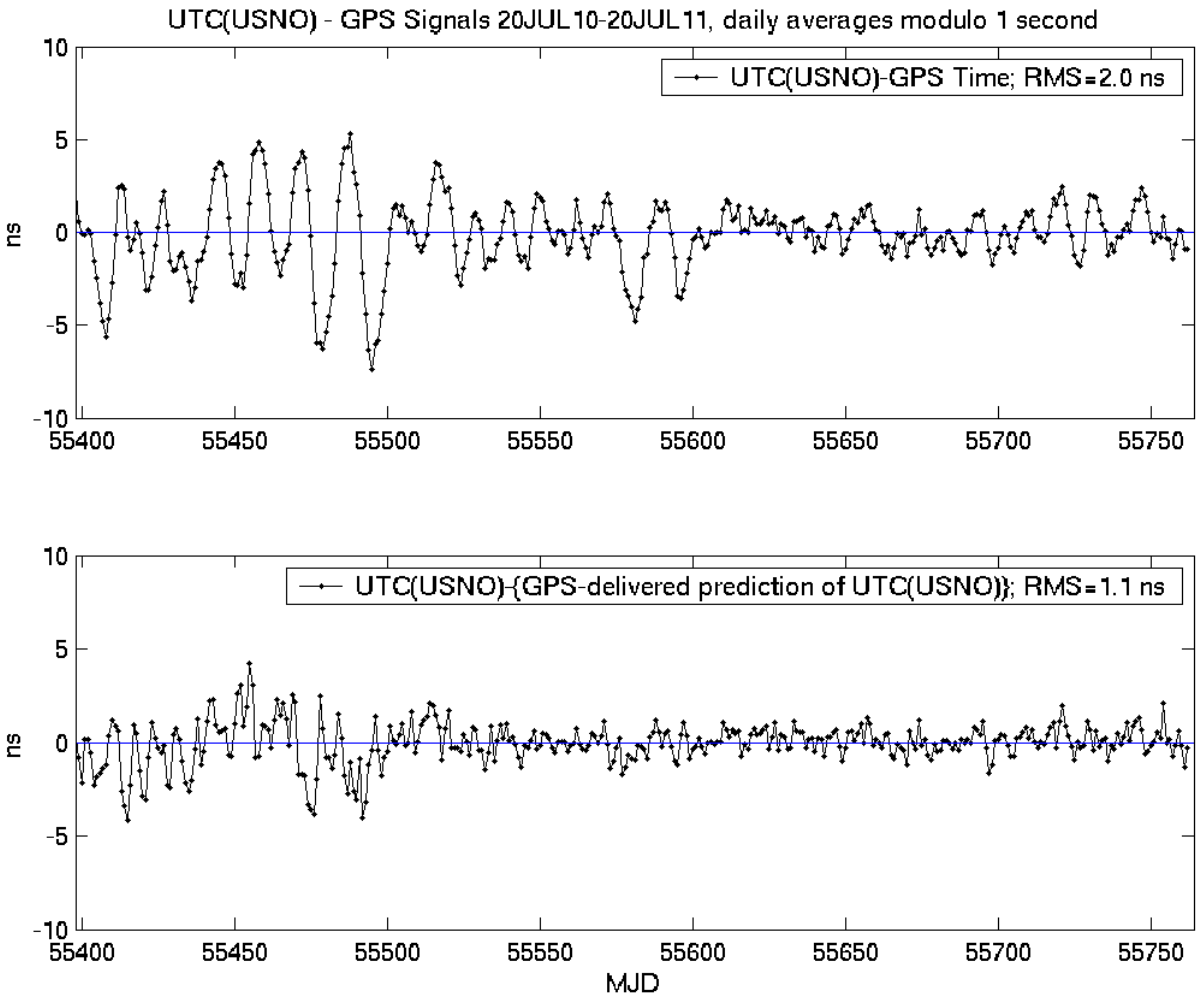
USNO Network Time Servers
Time Service Department

- **Internet** **http://tycho.usno.navy.mil/ntp.html**
  - 26 U.S. Stratum-1 Time Servers
  - USNO Master Clock & GPS SPS Time References
  - Millisecond Time Synchronization
  - >200 Billion Network Requests yearly
- **SIPRnet**
  - 2 U.S. Stratum-1 Time Servers operational
  - USNO Master Clock References
- We are working to develop authentication for DoD
  - Use of multiple servers is highly recommended
- **Contact: Richard E. Schmidt, 202-762-1578 DSN 762-1578, res@usno.navy.mil**

Internet and Other Time Products
Time Service Department

- **ftp server, ftp://tycho.usno.navy.mil**
  - 9 million connections/month
- **Time Service Web server, http://tycho.usno.navy.mil**
  - 1.6 million connections/day
  - 2.9 Gigabytes transferred/day
  - Audio Service installed
- **Telephone Voice Announcer**
  - **Traffic up to 4 million calls/year**
  - USNO DC, **202-762-1401 (DSN 762)**
  - USNO AMC, **719-567-6742 (DSN 560)**
- **Modem Time**
  - Traffic falling, but 50,000 calls/year
  - USNO DC, **202-762-1594 (DSN 762); 1200 baud 8N1**
  - USNO AMC, **719-567-6743 (DSN 560); 1200 baud 8N1**

GPS Time Transfer Performance

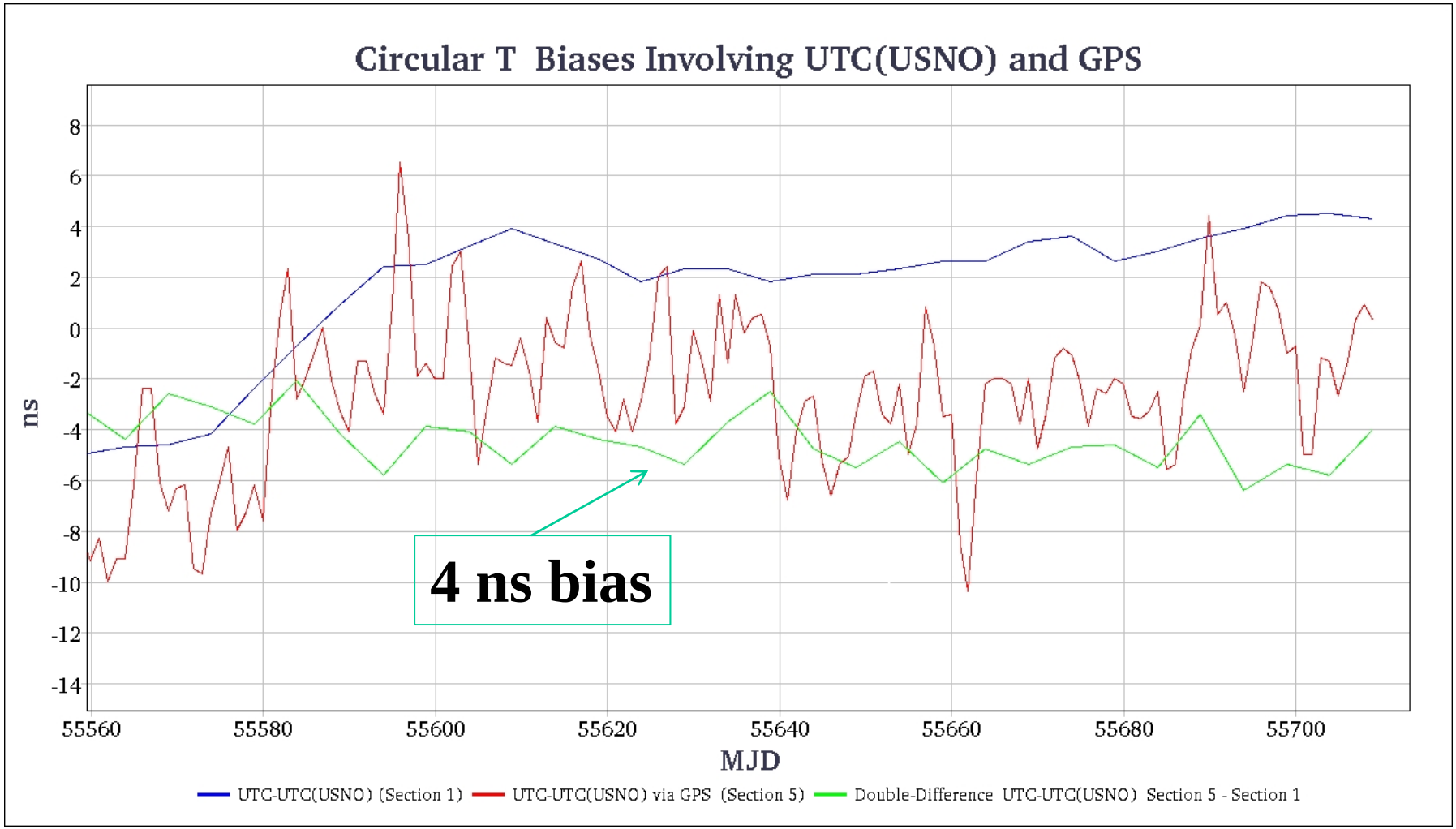


Tighter Steering Controls Initiated MJD 55573

International Cooperation

New Galileo uplink site, and masts for GNSS antennas

UTC(USNO)-GPS bias Circular T



USNO Portion of the GPS III Error Budget

All values 1 σ	Threshold	Objective
Signal in Space	0.75 ns	0.25 ns
M-Code Rcvrs	0.625 ns	0.275 ns
UTC(USNO)	0.25 ns/day	.05 ns/day
TOTAL	1.0 ns (1σ)	.375 ns (1σ)

Master Clock Improving

- For Future Requirements
  - GPS III
  - Space
- Order of Magnitude Improvement Coming
  - More robust (reliable)
  - More precise (more self-consistent)
  - More accurate (closer to target)
- We know how to do it
  - Better clocks, better care, better time transfer

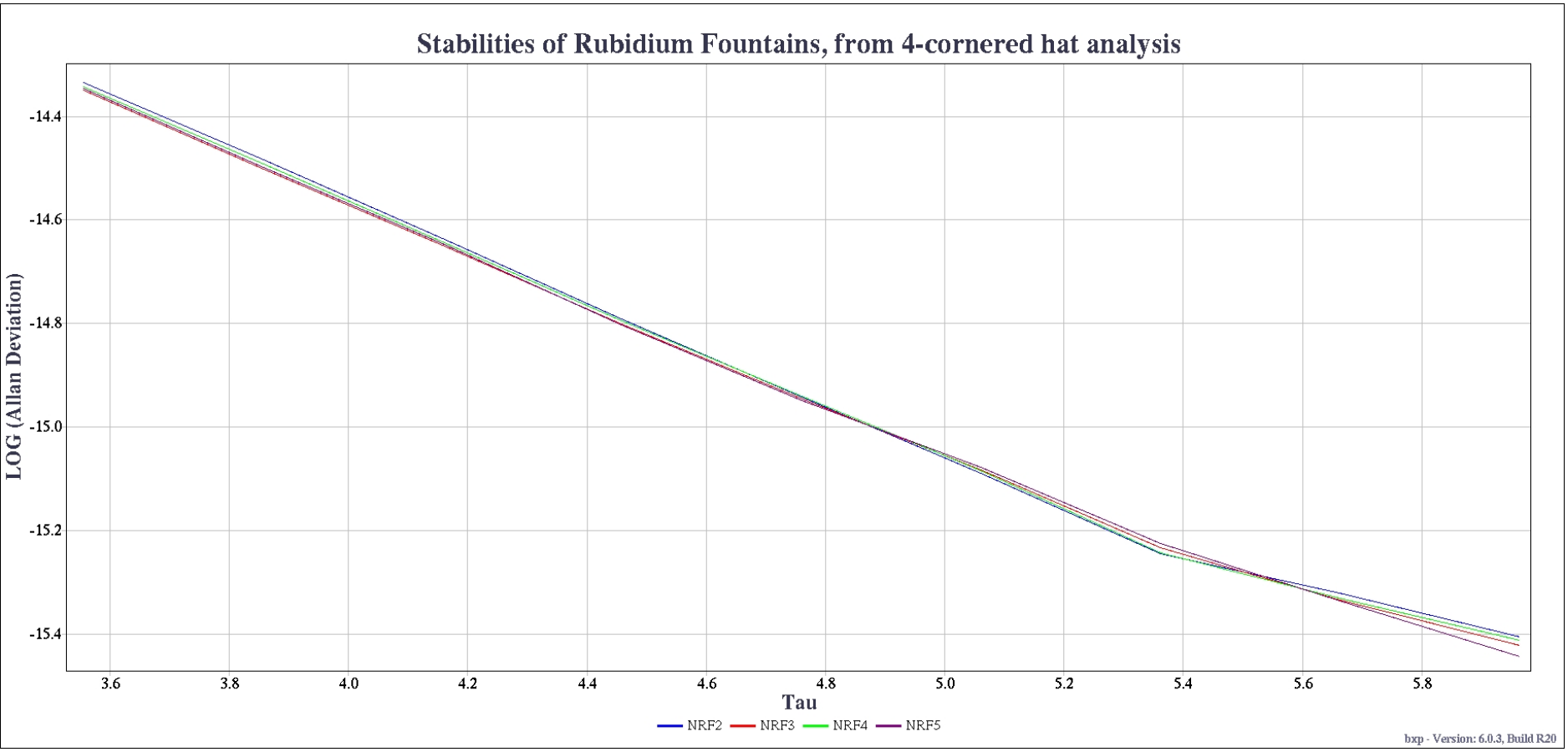
New Clock Building: testing better

Specifications: Temperature +/- 0.1 C Humidity +/- 3% RH *ALWAYS*

Fail-safe HVAC: second room ordered

Four Rb. Fountains In Use

three more under construction



USNO Operational Clock Ensemble

- Clock Chambers Being Upgraded
- Cesium Ensemble
  - Replacement beam tubes fully funded

- USNO also measures the Earth Orientation Parameters, including the Earth's rotational angle, for GPS

Roadmap to Upgraded GPS

- USNO provides GPS with one datum per day
  - The daily average of UTC(USNO)-GPS
  - Upload source could be USNO-DC or USNO-AMC

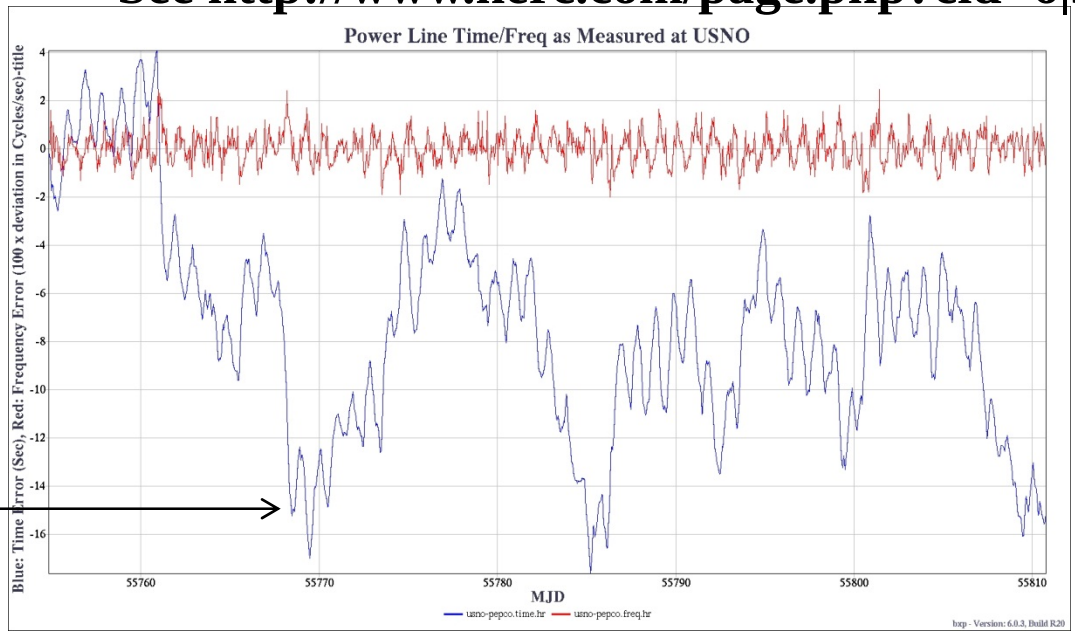
- USNO directly supports two GPS Monitor Stations
  - USNO-DC is a GPS monitor station through NGA
  - USNO-AMC provides frequency to Colorado Springs Monitor Station

- In the not-so-distant future
  - SAASM-enabled receivers, now in use, will fully handle operations
  - M-Code receivers are being ordered
  - USNO could upload satellite-specific dual-frequency data every 15 minutes
  - USNO-AMC will continue to be able to fully back up USNO-DC
    - Each will have three (3) rubidium fountains

Why Does Your Alarm Clock Stay on Time?

- Henry Warren & the Boston Edison Power Co.
  - Demonstration October 16, 1916
- NERC Test under consideration
  - Freq. kept as close to 60 Hz as possible
  - East-coast clocks could drift 20 min/year
  - Other parts of USA to drift less
- See http://www.nerc.com/page.php?cid=6|386

hottest July on record



PTTI-11

- PTTI = Precise Time and Time Interval
- PTTI Systems and Applications Meeting
  - Nov 13-18, 2011
  - Long Beach, Ca
- For meeting: http://www.pttimeeting.org
  - For past papers too

Spring 2013: Conference on History of Time and Navigation

- In support of Smithsonian's Exhibit on Time and Navigation
- 100 years since longitude between USNO and Paris Observatory, using transmissions from the Naval Radio Station in Arlington and the Eiffel Tower
- 50 years since the Harrison Chronometer came to the USNO, to dedicate Master Clock's building
- 40 years since the April 17, 1973 formation of GPS JPO.
- 30 years since President Ronald Reagan initiated the dual-use system of GPS, in response to the KAL007 disaster
- 20 years since the June 1993 launch of the 24th satellite, completing the original design for GPS
- 10 years since coalition forces initiated the liberation of Iraq, which made heavy use of GPS-guided systems.
- 240 years since King George III awarded Harrison the prize money for the Harrison Chronometer

Conference Topics

- History of GNSS
- Space Clocks and Navigation Systems
- Navigation Policy
- Historical Relation Between Government Funding and Progress
- Near-Term Future Navigation Systems
- Time Travel and Relativity
- …

Summary

- USNO specializes in real-time timekeeping
  - UTC realization
  - Dissemination
  - Monitoring
  - Device and analysis R&D
- Upgrades are continuously happening
- We work for you