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**Report From the  
U.S. Naval Observatory**

**Dr. Demetrios Matsakis  
CGSIC Timing Session  
September 16, 2008**



# USNO as seen by Google-Earth





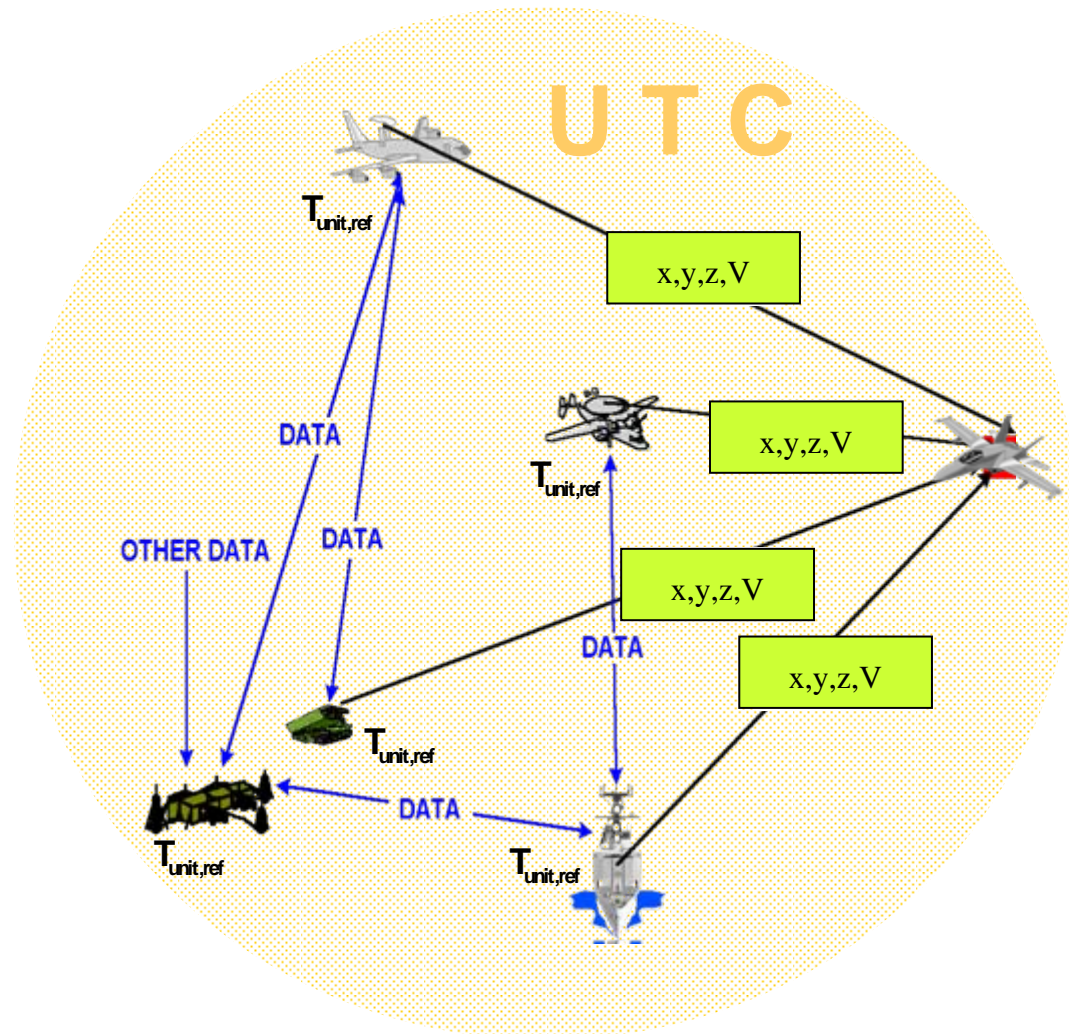
# DoD Directive 4650.05

- 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



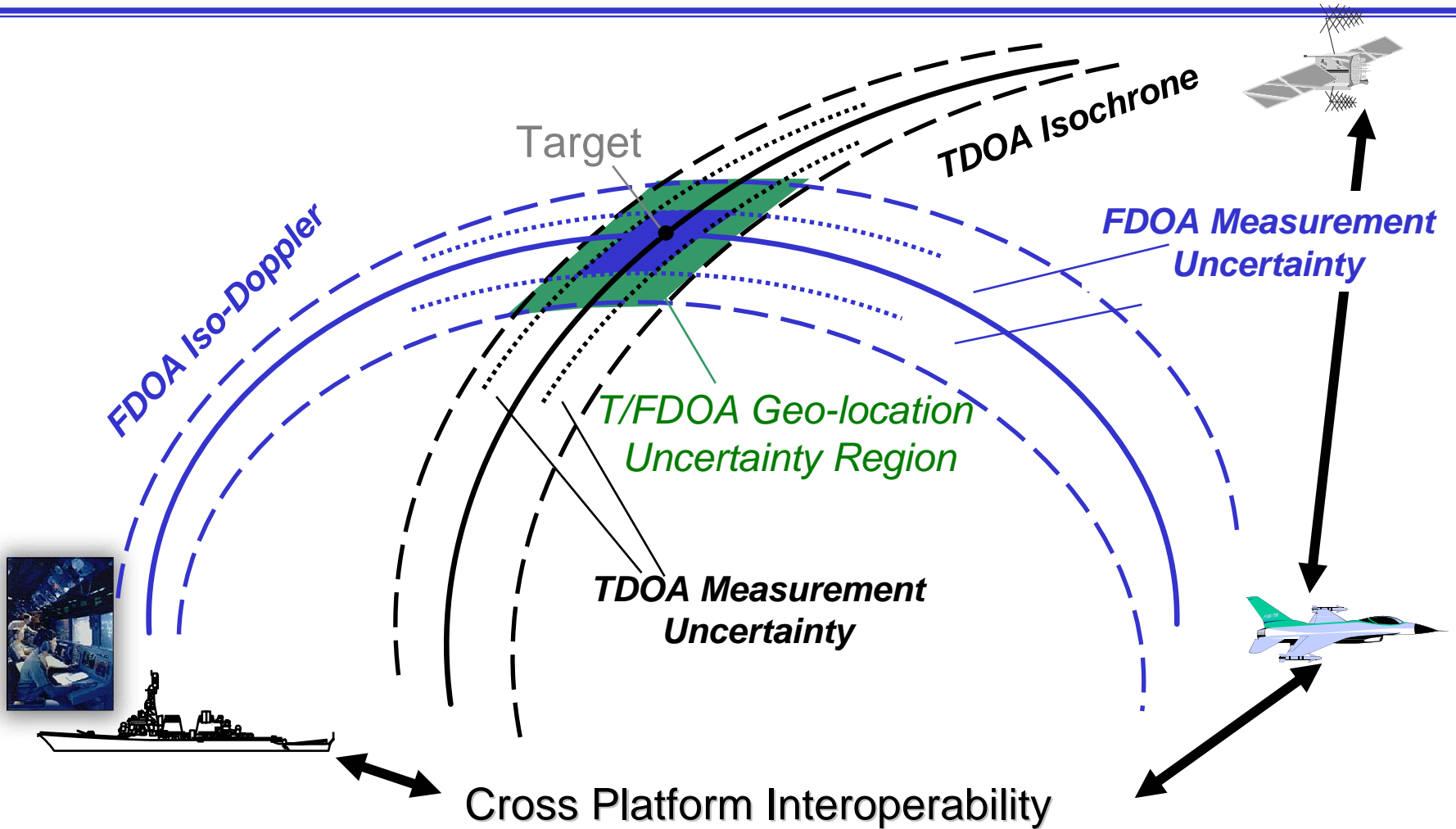
# Absolute Time is Required

- Facilitates cross-system synchronization
  - Communications
  - Detection
  - Targeting
- Each node must time tag using absolute time
- Coordinated Universal Time (UTC) is the standard
  - Provided by USNO (via GPS, or other means)





# How Time Affects TDOA & FDOA Geo-location



**TDOA: Time Difference of Arrival**

**FDOA: Frequency Difference of Arrival**



# Timing Requirements

## Current

1 ns: NRL, NSA, NRO, CIA

10 ns: Master Navigation Plan (ECCM comms, radar & surveillance), DOT

12 ns: GPS

20 ns: Master Navigation Plan (Space Tracking)

30 ns: Hostile Intercept Tactical System (HITS)

50 ns: Joint Tactical Info. Distribution System

Seconds to microseconds:

Communications

## Future

<1ns: Advanced communication systems

<1 ns: DoD space operations

<0.01 ns: Space applications

**1 nanosecond = 1 foot (TDOA)**



# USNO Master Clocks

## Master Clock Washington, DC

- 57 High Performance Cesiums
- 24 Cavity-Tuned Masers

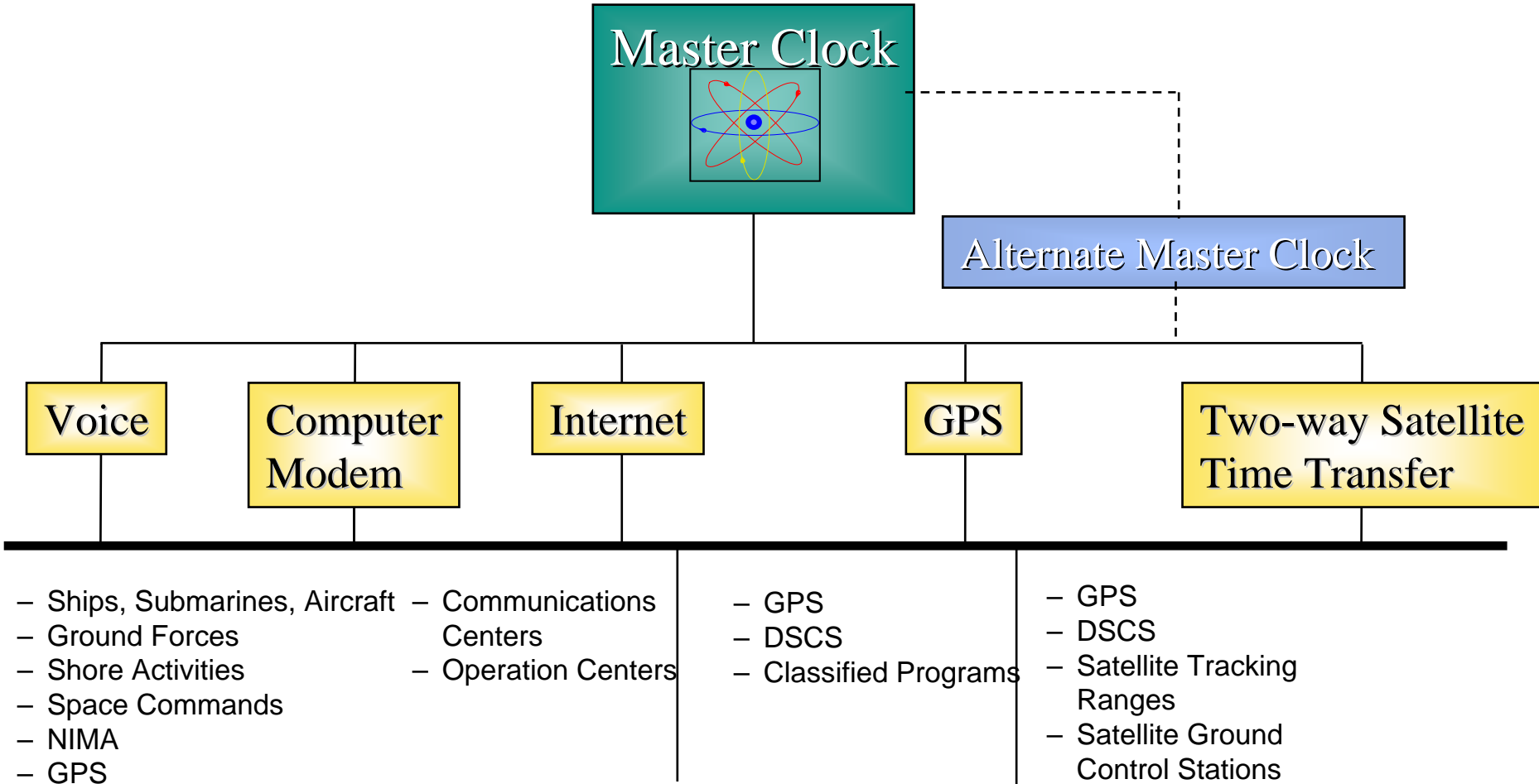


## Alternate Master Clock Schriever AFB

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



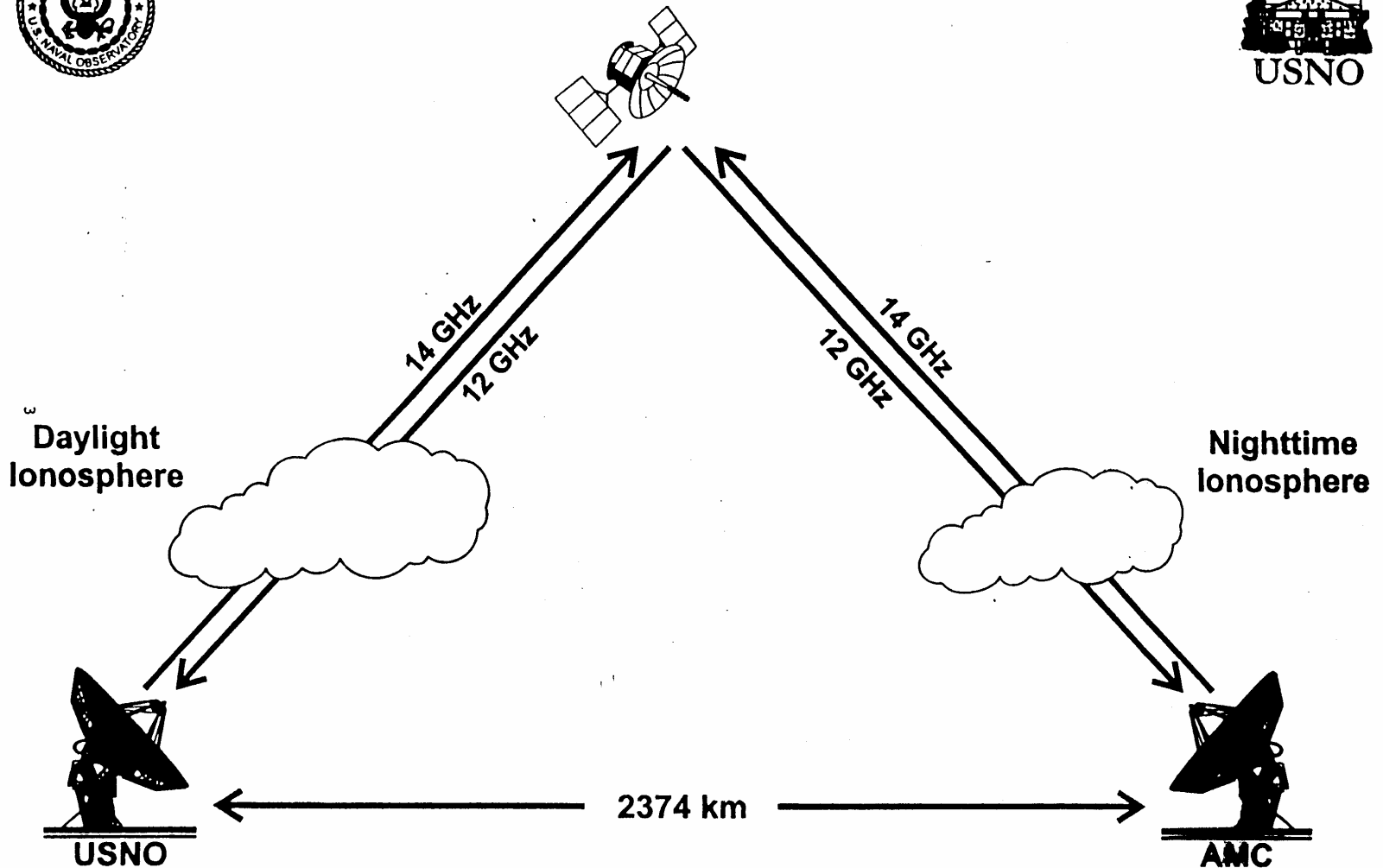
# DoD Time Dissemination







# Two-Way Satellite Time Transfer





# TWSTT at a Glance

- Time at 1.0 nanosecond to specific users
  - Expanding to Hawaii (Kokee Park)
    - Link with NICT (Japan)
  - Cape Canaveral operations also expanding
    - Adding 3 Caribbean and Atlantic sites
- International Timekeeping (BIPM)
- AMC time link
- Improvements Required for Operations
  - Engineering for better and cheaper
    - Satellite Simulators
    - Thermal Control
  - Calibration requires frequent and expensive travel



# 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
  - 2 OCONUS awaiting deployment
  - USNO Master Clock References
- This year we replaced and upgraded entire ensemble
- **Contact: Richard E. Schmidt, 202-762-1578 DSN 762-1578, [res@usno.navy.mil](mailto:res@usno.navy.mil)**



# Internet and Other Time Products

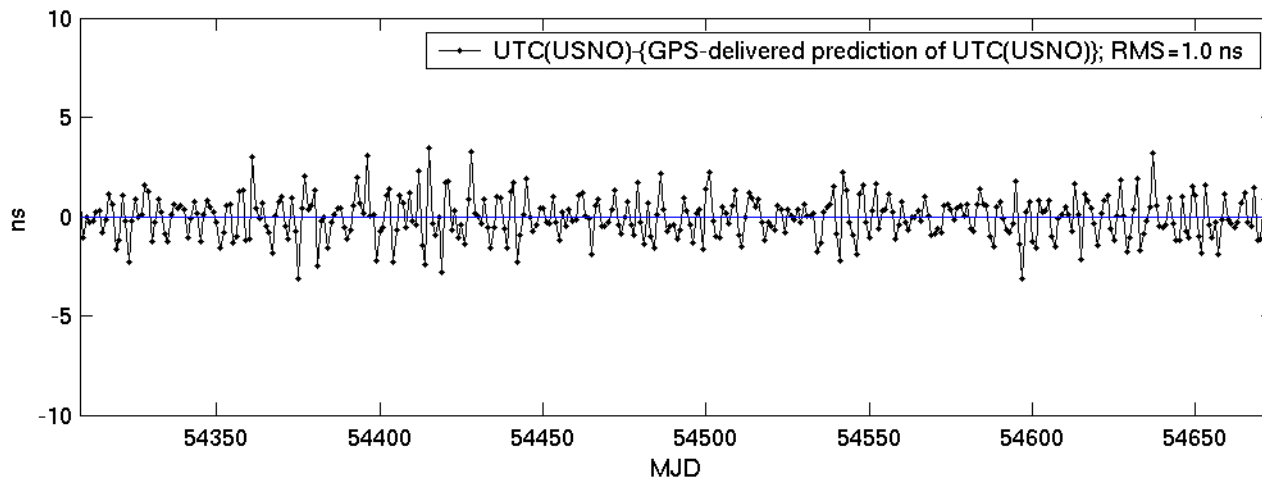
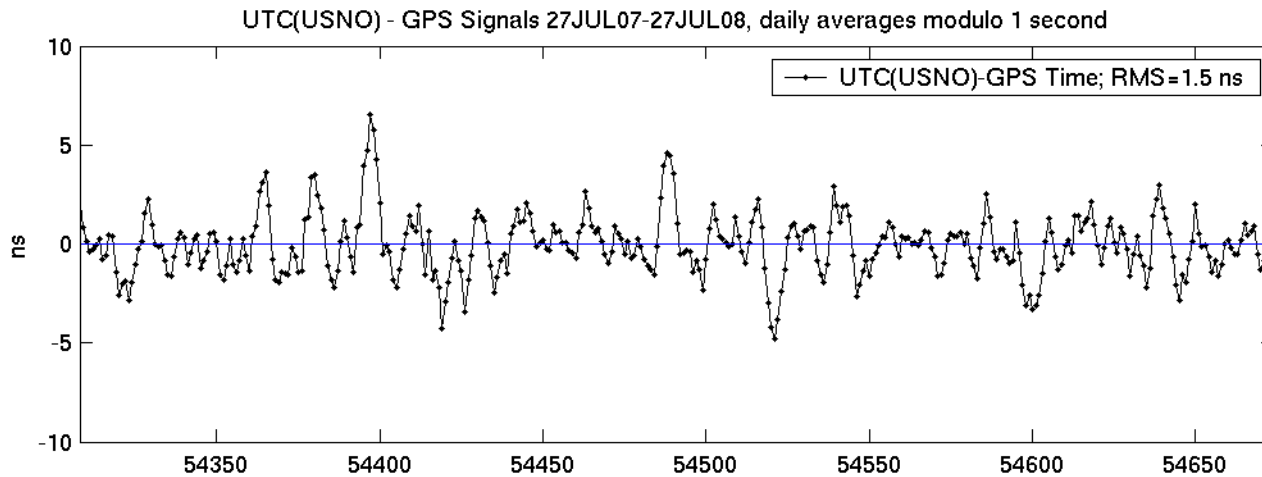
## Time Service Department

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- **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**
  - USNO DC, [202-762-1401](tel:202-762-1401) (DSN 762)
  - USNO AMC, [719-567-6742](tel:719-567-6742) (DSN 560)
- **Modem Time**
  - USNO DC, [202-762-1594](tel:202-762-1594) (DSN 762); 1200 baud 8N1
  - USNO AMC, [719-567-6743](tel:719-567-6743) (DSN 560); 1200 baud 8N1



# UTC(USNO) and GPS





# USNO Portion of the GPS III Error Budget

All values $1 \sigma$	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
<b>TOTAL</b>	<b>1.0 ns (<math>1\sigma</math>)</b>	<b>.375 ns (<math>1\sigma</math>)</b>



# Master Clock Must Improve

- For Future Requirements
  - GPS III
  - Space
- Order of Magnitude Needed
  - 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



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





# Fail-safe HVAC





# Clock Rooms in New Building



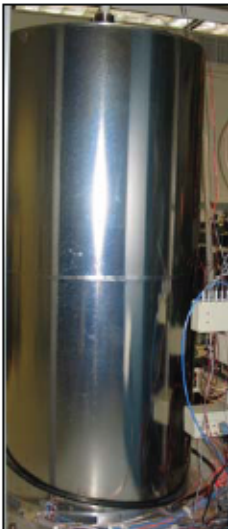
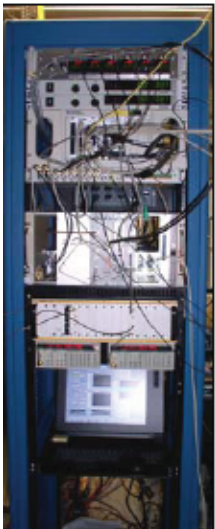
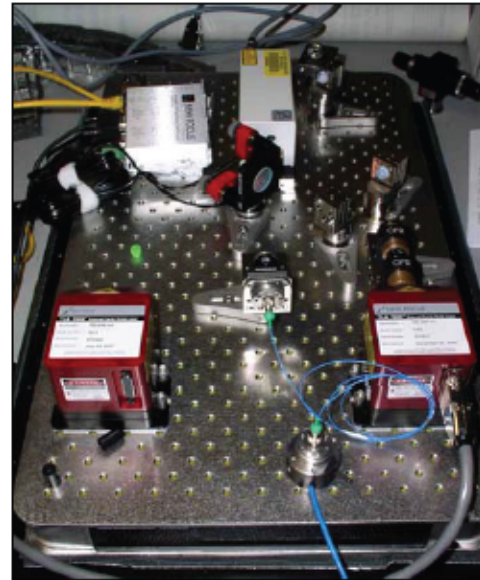
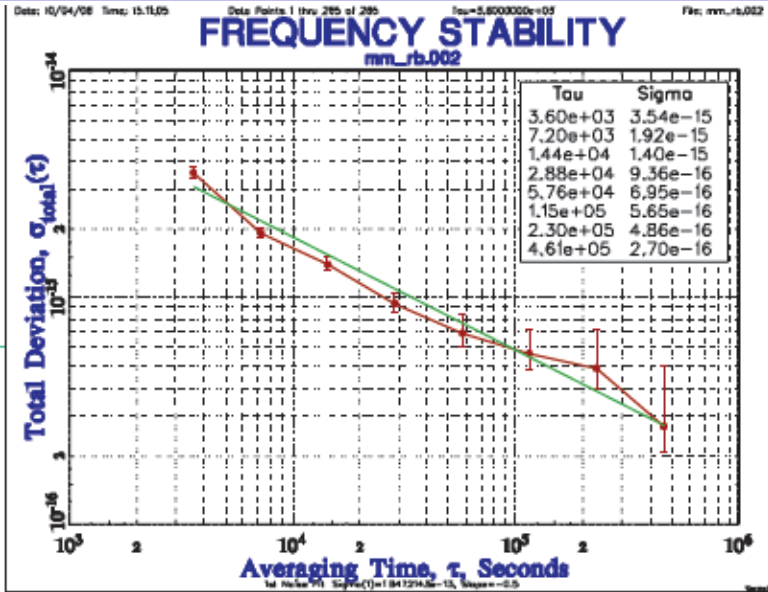


# Secure Computing

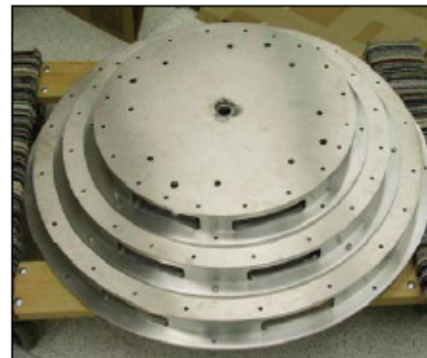




# Two Rubidium Fountains Ready



Laser table



Magnetic Shields



Vacuum Chamber



# 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, now under development, will be made operational
  - 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



# PTTI-08

- PTTI = Precise Time and Time Interval
- PTTI Systems and Applications Meeting
  - Dec 1-4, 2008
  - Reston, Va
  - Tour of USNO
- For meeting: <http://www.pttimeeting.org>
- For papers and a few other things,  
<http://tycho.usno.navy.mil/ptti.html>



# http://tycho.usno.navy.mil


UTC Leap Second Survey Form - Internet Explorer provided by Dell

http://tycho.usno.navy.mil/leap\_second\_poll.html

Google

Search Web

Microsoft Outlook Web Ac... Inbox (10) - Yahoo! Mail Microsoft Outlook Web Ac... UTC Leap Second Surv...

 U.S. Naval Observatory  
UTC Leap Second Survey Form

### UTC LEAP SECOND SURVEY

The International Telecommunications Union Radiocommunications Sector will soon be considering a proposal to discontinue the periodic addition of [leap seconds](#) to Coordinated Universal Time. This [Memorandum and white paper](#) from Assistant Secretary of Defense John G. Grimes dated Sep 03, 2008 provides background information.

[Privacy and Security Notice](#)

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**Contact Information** *This information is confidential and will not be made public.*  
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\* Address 1:

Address 2:

\* City:

\* State/Province/Country:

\* Postal Code:

Internet | Protected Mode: On 100%

UTC Leap Second S... rom.usno.navy.mil -...

8:50 AM



# Summary

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