

# TIME AND FREQUENCY ACTIVITIES AT THE JHU APPLIED PHYSICS LABORATORY

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## Abstract

*The Time and Frequency Laboratory (TFL) at the Johns Hopkins University Applied Physics Laboratory (JHU/APL) provides support to multiple NASA/JPL missions that span our solar system from the study of the Sun's coronal mass ejections (STEREO) to the examination of the outer planets and the Kuiper Belt objects (New Horizons). This support includes providing precise time and frequency to the integration and testing of flight hardware, frequency reference for spacecraft ranging and communications via the APL communications facility, and the time-stamping of ground receipt telemetry packets from various spacecraft. The TFL's ensemble of three high-performance cesium standards and three hydrogen masers are integrated to form the APL timescale that is the basis for estimating UTC – UTC (APL) and for evaluating the performance of the individual clocks. Traceability to the USNO, NIST, and UTC is maintained via GPS common-view and all-in-view time transfer. The TFL's clocks are also incorporated into the formulation of International Atomic Time (TAI). Recently, the TFL Master Clock was transitioned from a cesium-beam frequency standard to a hydrogen maser, and the frequency adjustments of UTC (APL) are now performed with a high-resolution offset generator. These changes have greatly improved the stability of UTC (APL) and have also improved our ability to steer to UTC.*

## APL Time and Frequency Lab



## Mission

Provide precise time and frequency in support of critical APL projects and maintain traceability to U.S. and international timing laboratories.

## APL Space Science Missions

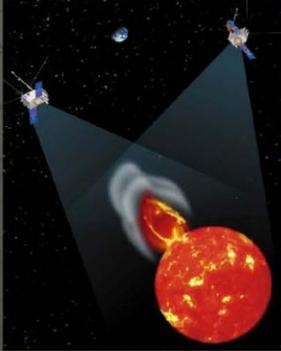


- ◆ **TIMED** – **T**hermosphere **I**onosphere **M**esosphere **E**nergetics and **D**ynamics



- ◆ **MESSENGER** – **M**ercury **S**urface, **S**pace **E**nvironment, **G**eochemistry, and **R**anging

## APL Space Science Missions (continued)



- ◆ STEREO – **S**olar **T**errestrial **R**elations **O**bservatory



- ◆ New Horizons

## Lab Facilities

- ◆ Located in standard laboratory room
- ◆ Temperature maintained at 68 degrees +/-3 degrees Fahrenheit
- ◆ Humidity maintained at 60% maximum
- ◆ AC power is on building UPS plus local UPS for critical systems

## Time and Frequency Lab Hardware

- ◆ 3 High Performance Cesium Standards
- ◆ 3 Hydrogen Masers
- ◆ 5 MHz measurement system
- ◆ 1 PPS clock monitor system
- ◆ 1 High Resolution Offset Generator
- ◆ 2 GPS Time Transfer Receivers

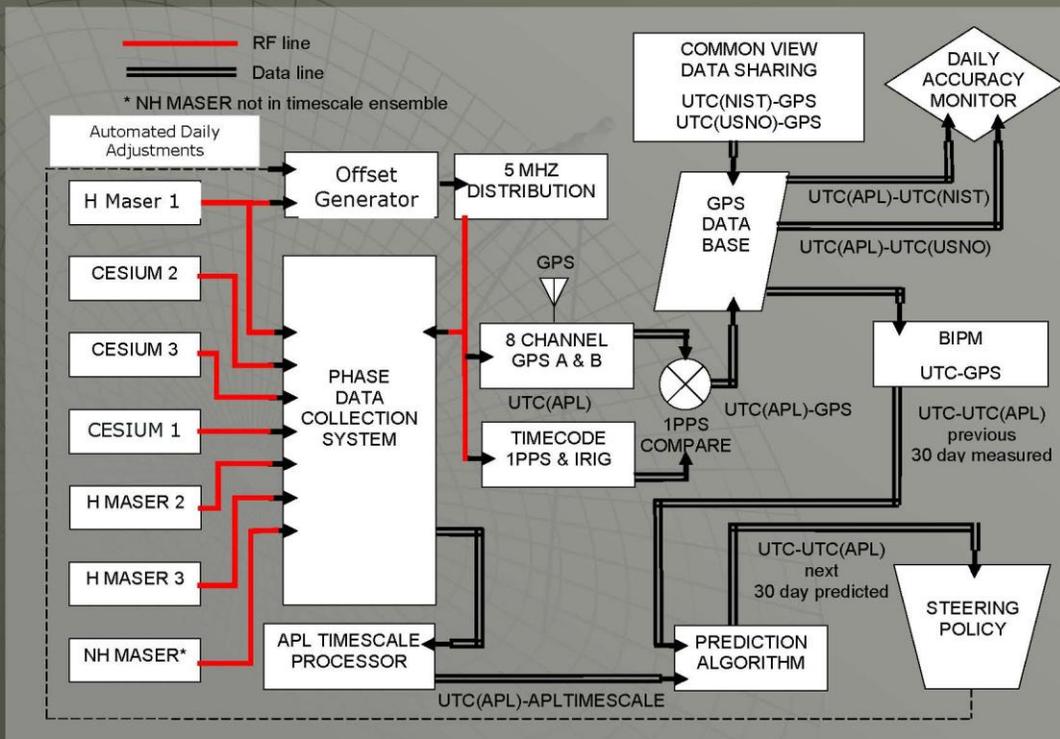
## Time and Frequency Dissemination

- ◆ 1 MHz, 5 MHz, 10 MHz, 100 MHz
- ◆ 1 PPS
- ◆ IRIG-B APL Local Time
- ◆ IRIG-B UTC
- ◆ Common View GPS Time Transfer
  - NIST, USNO, BIPM

# APL Timescale

- ◆ 3 Hydrogen Masers
- ◆ 3 High Performance Cesiums
- ◆ Clocks are selectively weighted
- ◆ Referenced to UTC(APL)

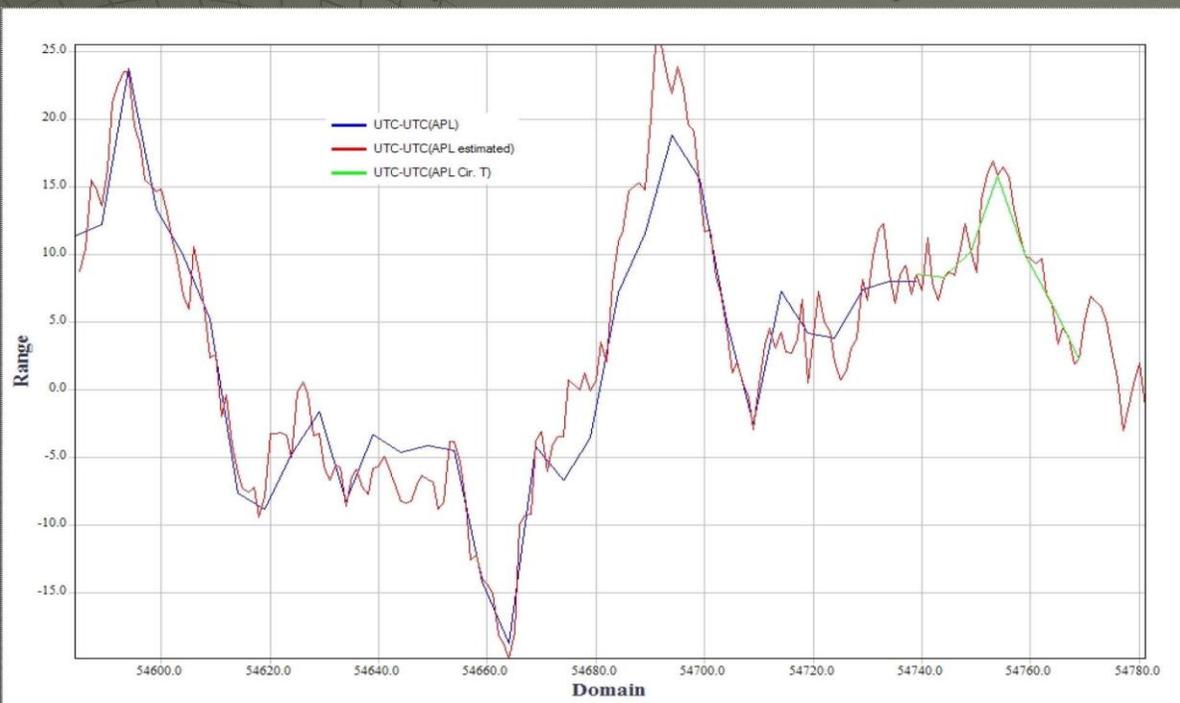
## APL Timekeeping System



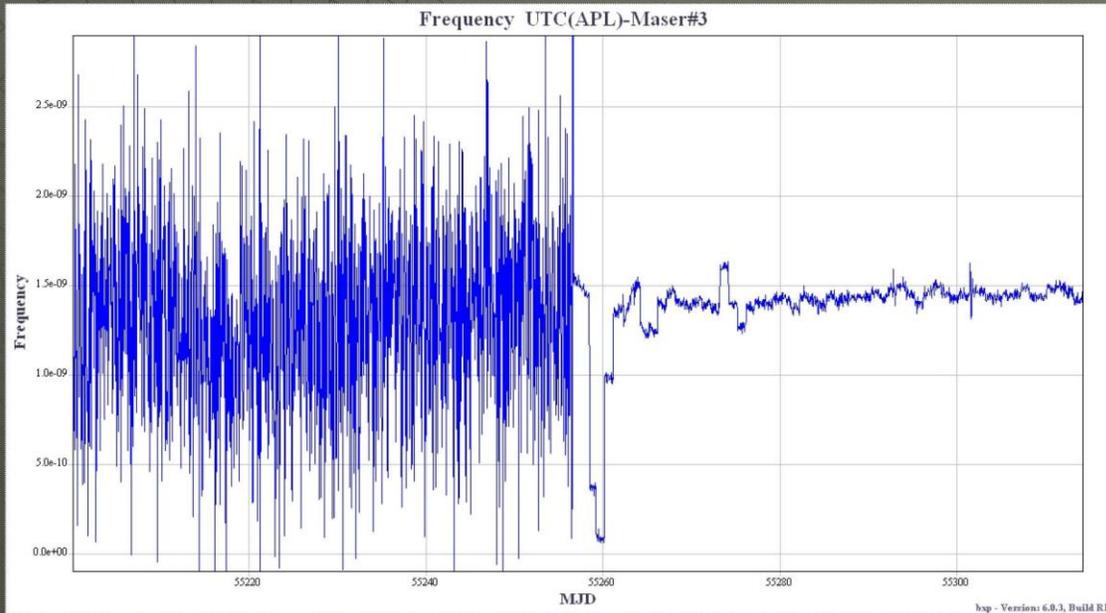
# UTC(APL)

- ◆ Output of Offset Generator
- ◆ Offset Generator driven by a Hydrogen Maser
- ◆ Offset Generator adjustments are based on estimation of UTC-UTC(APL)
- ◆ Adjustments are made daily

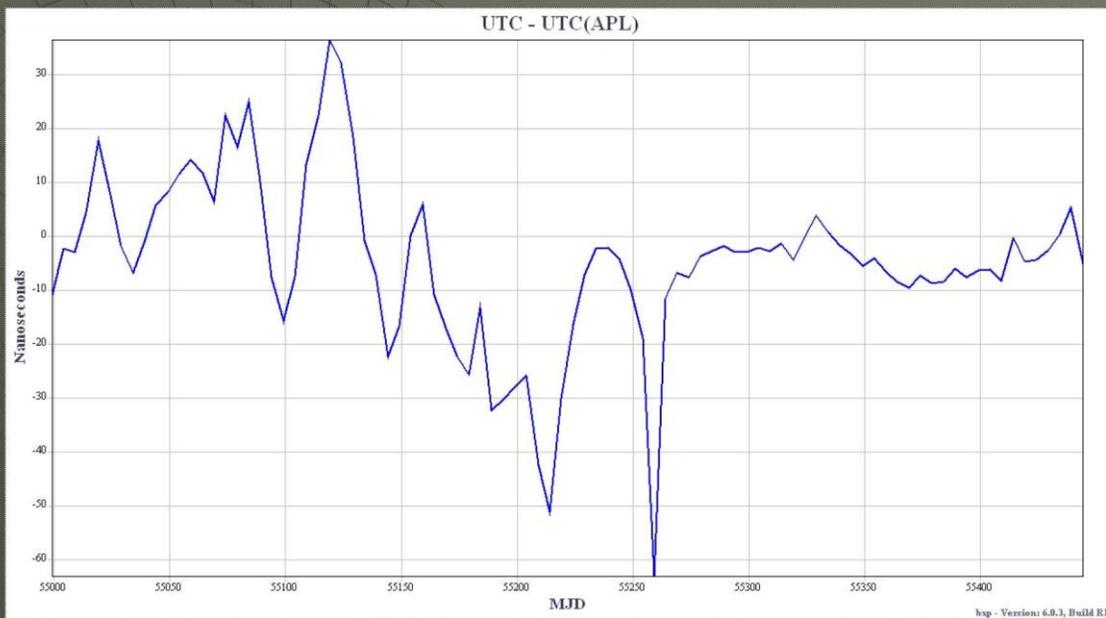
## UTC – UTC(APL) & UTC – UTC(APL estimated)



# Switch from Cesium & Microstepper to Maser & Offset Generator



# Automated Daily Adjustments Using Offset Generator Beginning MJD 55259



## Summary of Improvements 2003 - 2010

- ◆ GPS Antenna Survey
- ◆ Reporting GPS & Clock Data to the BIPM
- ◆ GPS Common-View Time Transfer with the USNO & NIST
- ◆ APL Autonomous Time Scale Algorithm
- ◆ UTC – UTC(APL) Estimation Algorithm
- ◆ Automated Daily Offset Generator Frequency Adjustments