

Time and Frequency Activities at the JHU Applied Physics Laboratory

M. Miranian, E. Sanchez

September 25, 2017

ION GNSS+ 2017 Conference



JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

The Johns Hopkins University Applied Physics Laboratory



The largest University Affiliated Research Center in the United States

Located between Baltimore, MD and Washington, DC in Laurel MD on 400 acres with 20 major buildings + satellite campuses

Staff of about 6000 employees (68% are engineers & scientists)

Major sponsors are the DoD, NASA, DHS, IC

Time & Frequency Lab Mission

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

Time & Frequency Laboratory



Clock Vault



Time and Frequency Lab Hardware

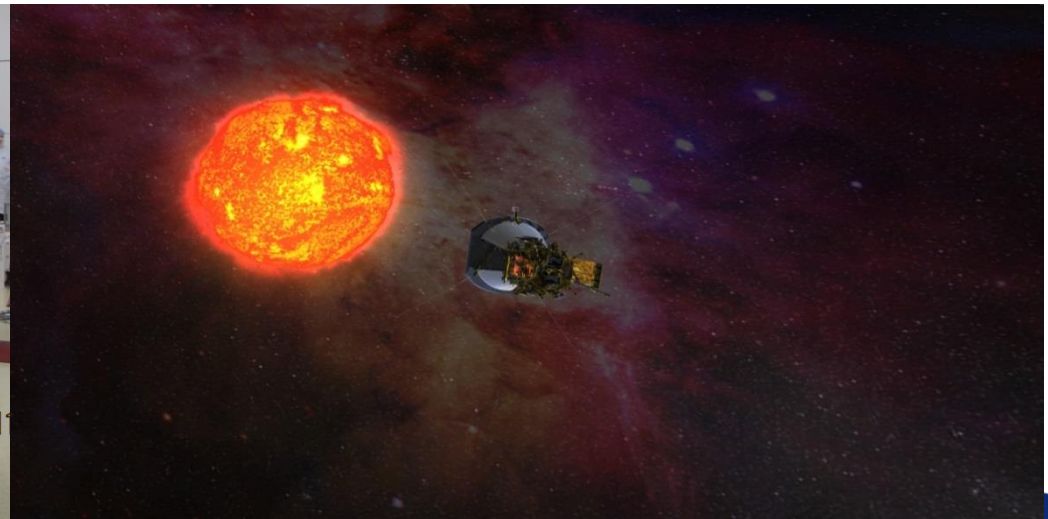
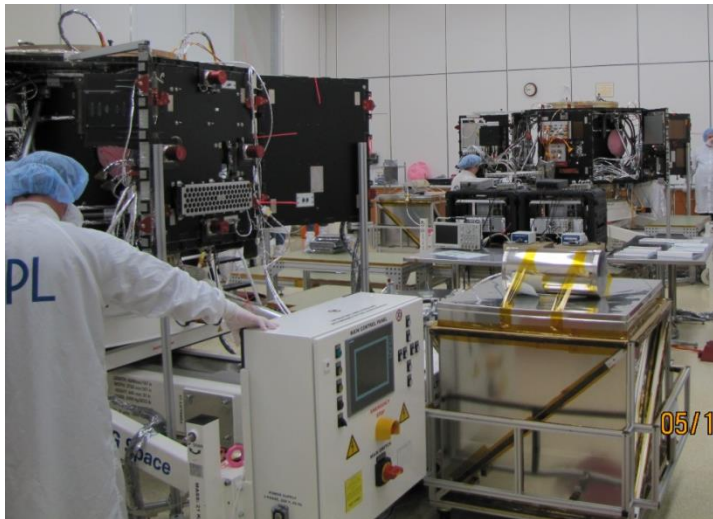
- **4 High Performance Cesiums & 1 Standard Performance Cesium**
- **3 Hydrogen Masers**
- **2 5MHz clock measurement systems**
- **1 1pps clock monitor system**
- **2 High Resolution Offset Generators**
- **3 GPS Time Transfer Receivers**

Mission Support

- **Integration and testing of flight hardware**
- **Frequency reference for spacecraft ranging and communications**
- **Time-stamping of ground receipt telemetry packets**
- **R & D of time and frequency devices and distribution systems**

Support of APL Space Science Missions

- **Continued mission operations support for:**
 - TIMED – Thermosphere Ionosphere Mesosphere Energetics and Dynamics
 - STEREO – Solar TERrestrial Relations Observatory
 - New Horizons - mission to Pluto and Kuiper Belt Objects
 - Van Allen Probes - (formally Radiation Belt Storm Probes), launched Aug 2012
- **Integration support for Solar Probe Plus and Europa**

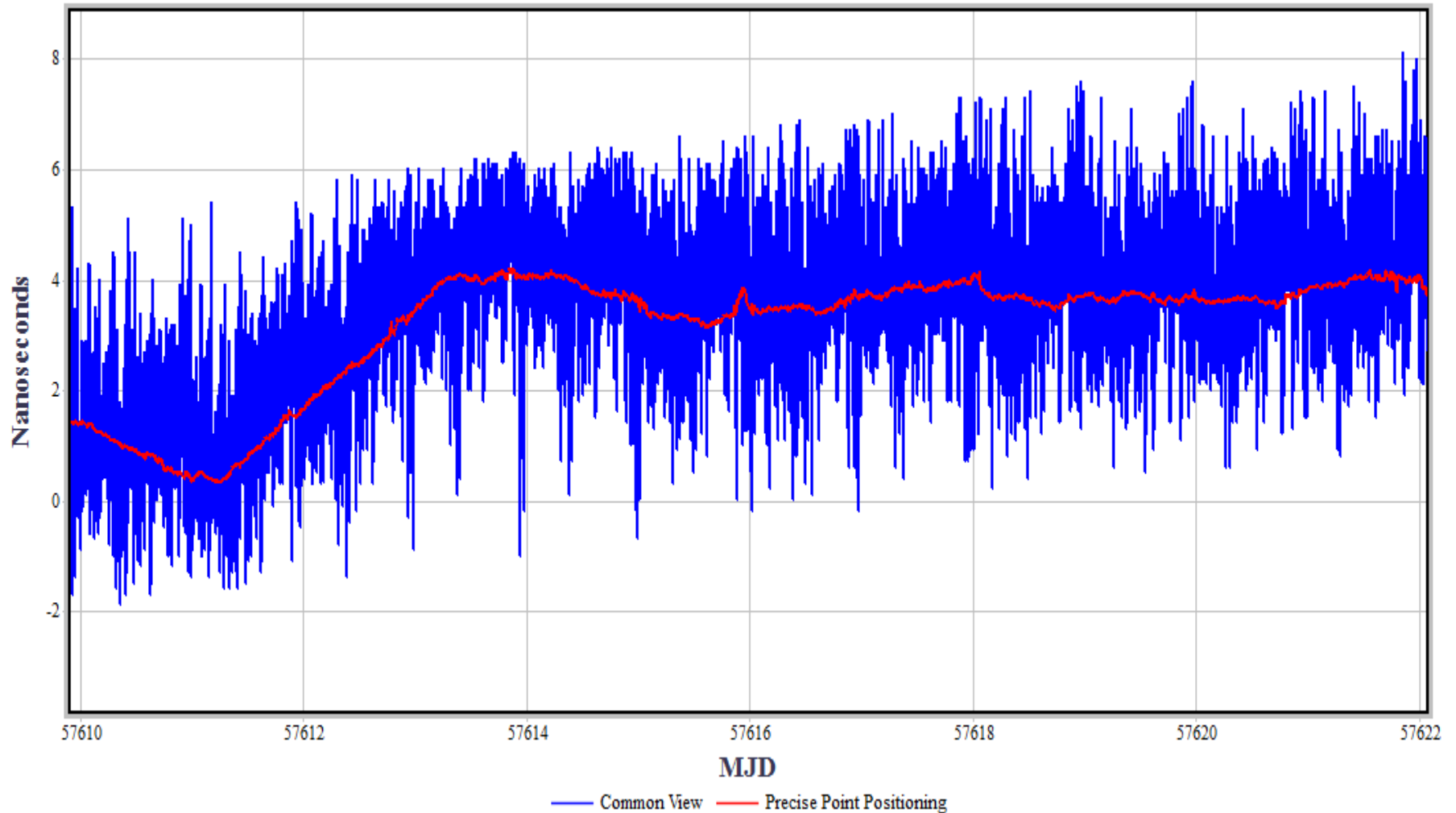


GPSPPP Time Transfer with the USNO

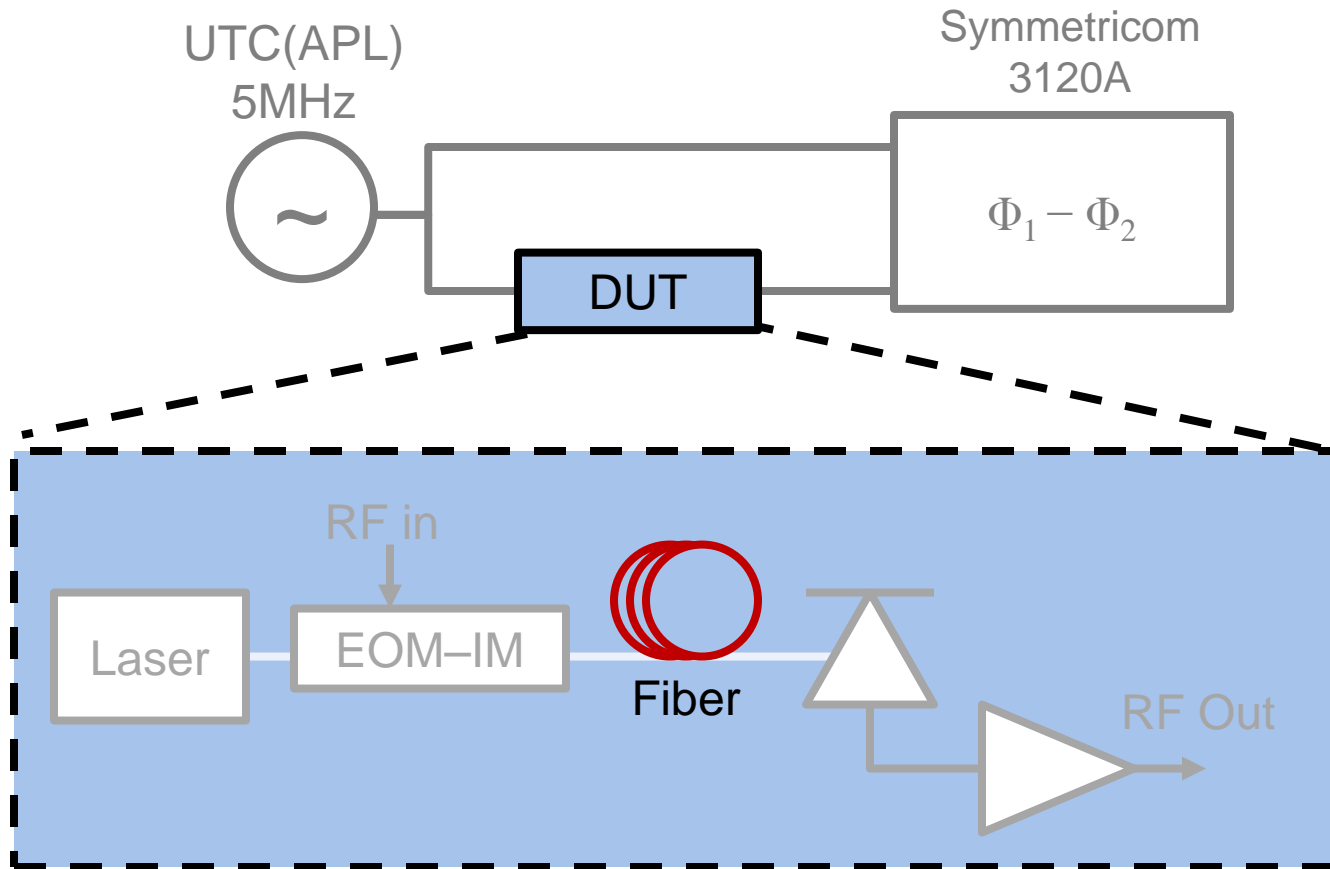
- **PPP software and license acquired from NRC**
- **APL RINEX files generated by a NovAtel Propac6 GPS receiver**
- **UTC(Lab) RINEX files downloaded from the BIPM**
- **Overlapping three-day solutions computed daily**
- **Only the Backward Solution is retained**
- **APL developed software corrects day cross-over ambiguities**

Common View vs PPP

UTC(APL) - UTC(USNO)

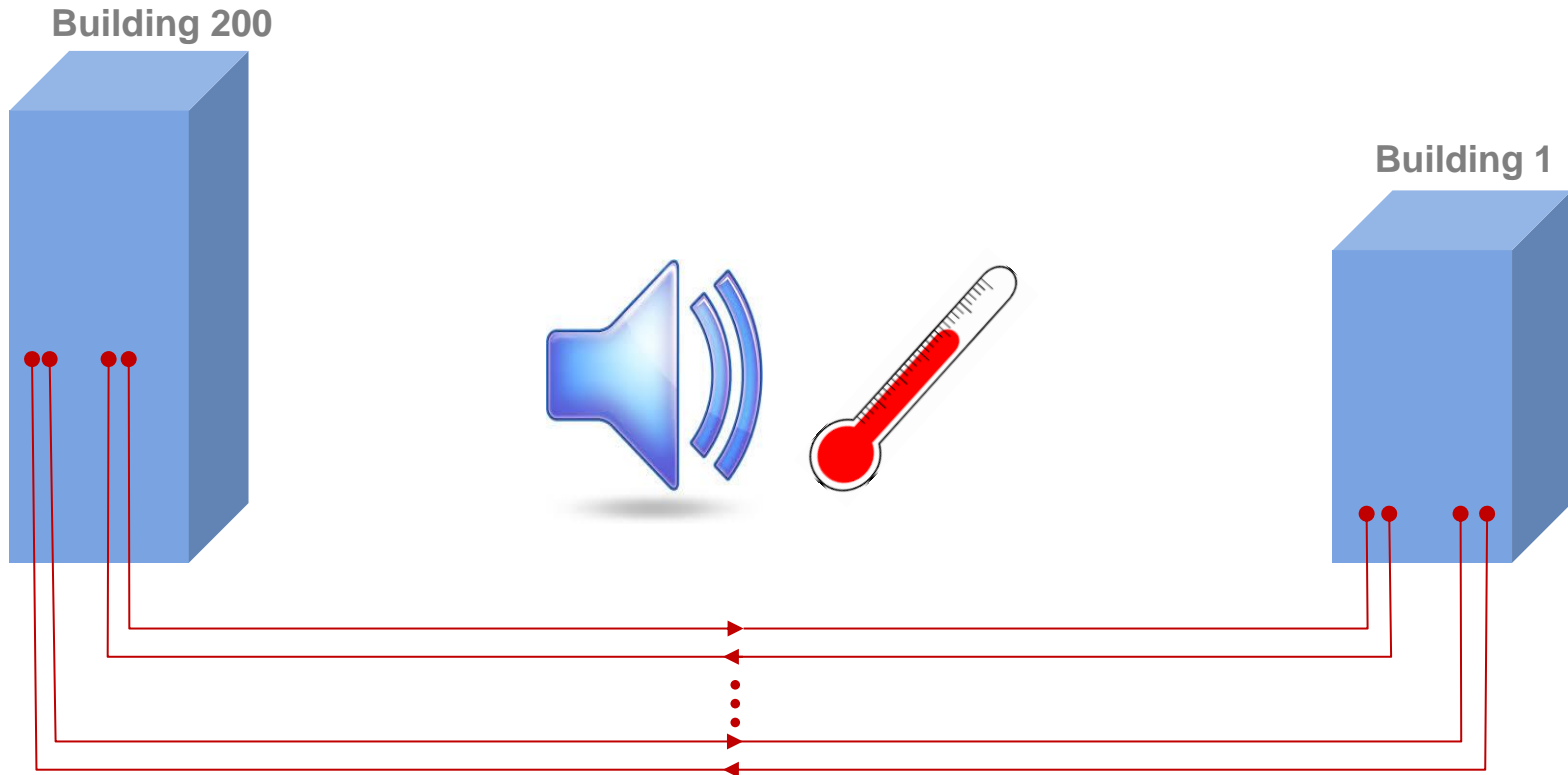


TFL Project Collaboration - Fiber-Induced Noise



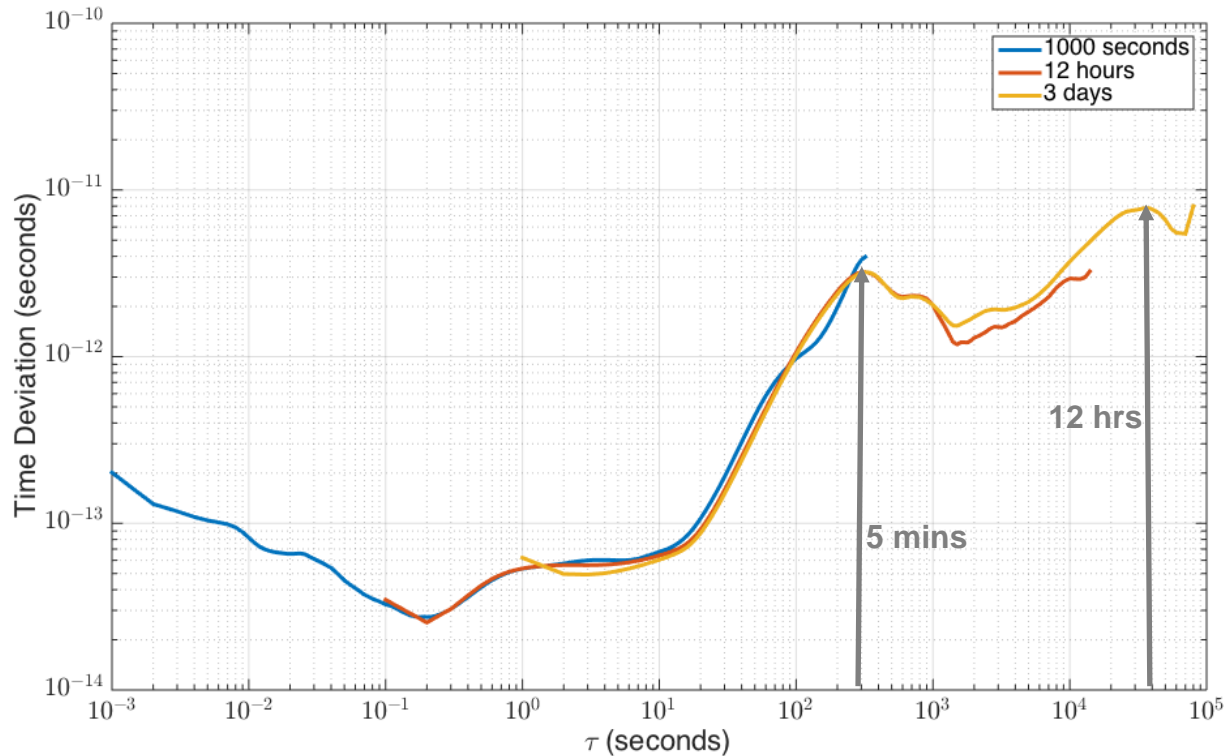
Find the noise of the fiber.

Outdoor Setup



- Each fiber is 1.05 km long
- Ten fibers were connected to reach ~10 km.
- Environmental effects dominated by:
 - Traffic on Johns Hopkins Road (hypothesis)
 - Daily thermal fluctuations (sunrise to sunset).

Accomplishments: Time Deviation with Dither



- Time deviation was <10 picoseconds for 24 hours

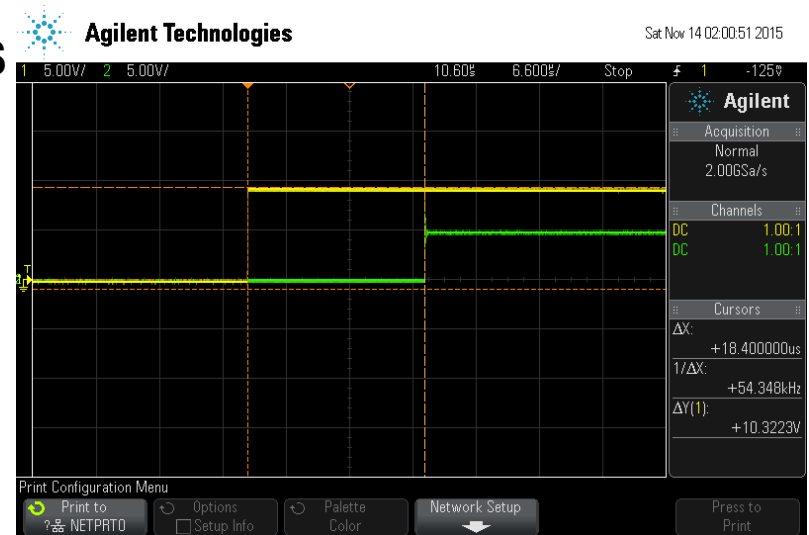
Precise Time Transfer via Fiber Optic Distribution

■ Requirements

- Provide local on-time 10MHz and 1PPS distribution in in lab across campus using TFL fiber optic distribution
- Use existing lab hardware

■ Verification Methods

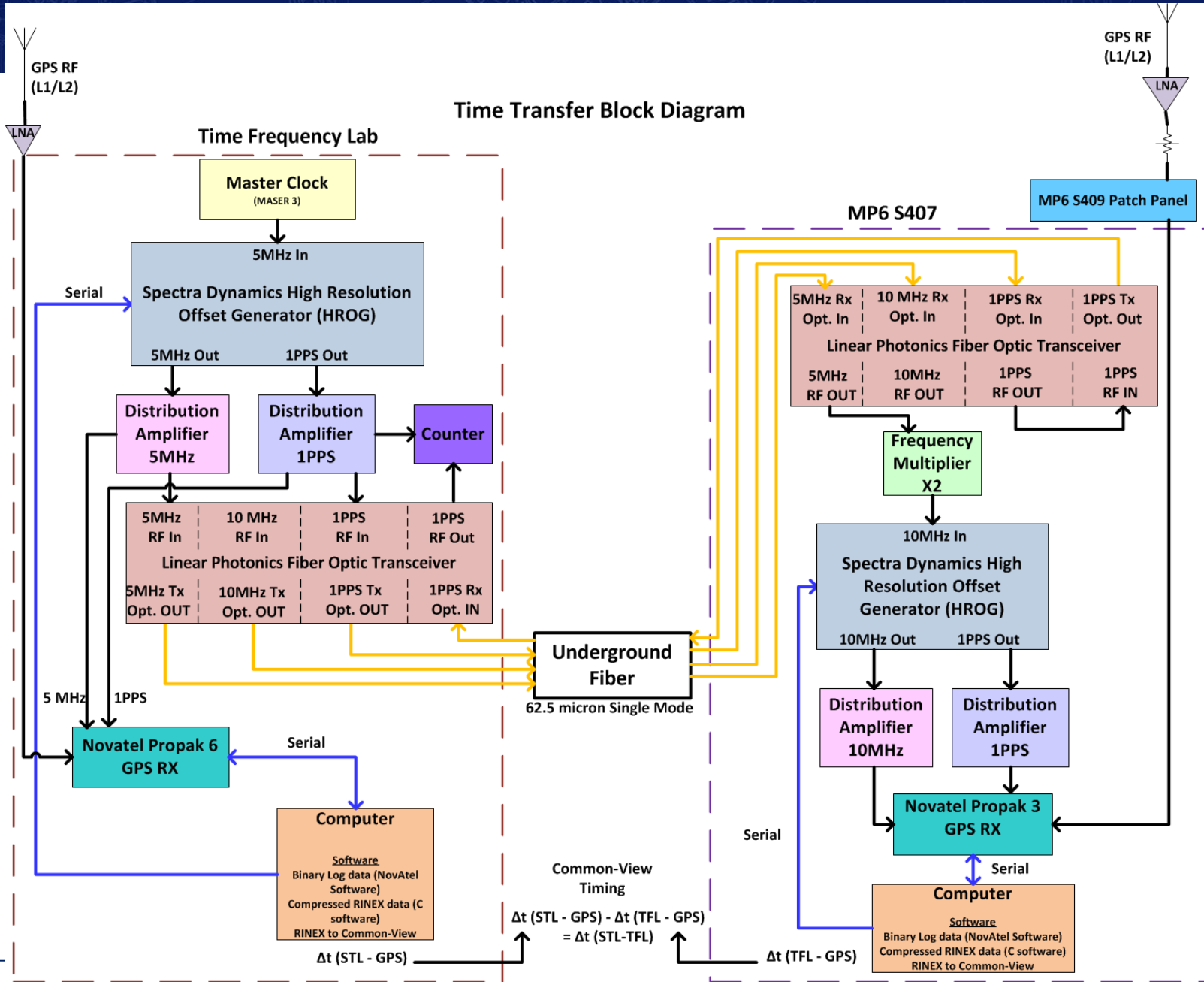
- USNO Portable Atomic Clock Trip
- 1PPS Fiber Feedback Measurement
- Precise Point Positioning using IGS



Method	Measured One-Way Delay through Fiber (μ seconds)
USNO Portable Atomic Clock	9.214030
1PPS Feedback Signal	9.217528
PPP Carrier Phase (Natural Resources Canada)	9.197902 (approx.)

Block Diagram

Time Transfer Block Diagram



Thank you!



JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

