

DSN Frequency and Timing

Foundational for Space Exploration, Tracking & Navigation, and Science

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Frequency and Timing Advanced Development Group (335E)

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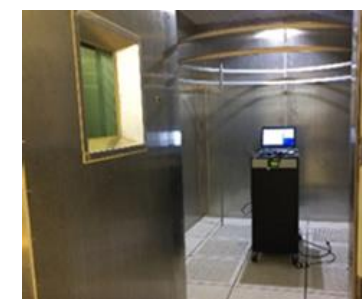
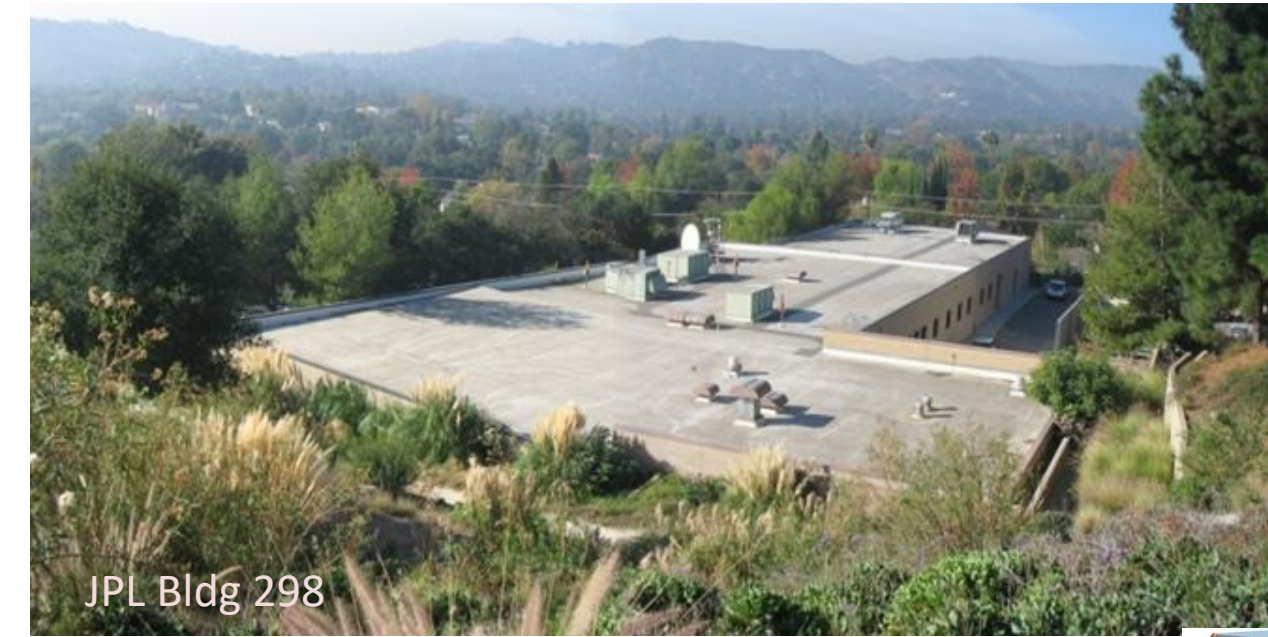
JPL Frequency and Timing (335E)

Technology Development, Engineering, Instruments, and Science

- Space exploration relies on *state-of-art frequency and time metrology* to determine spacecraft position and motion within the solar system and beyond.
 - Includes low noise oscillators, atomic frequency standards, atomic timekeeping (clocks), degradation free reference signal distribution, frequency syntonization and time synchronization between users and sites, and absolute calibrations to Coordinated Universal Time (UTC-atomic) and Universal Time (UT1-Earth rotation).
 - Exceptionally high reference stability and reliability needs typically require solutions beyond what is commercially available.
- JPL is one of the nation's premier *frequency and timing centers*, each with specialized focus:
 - Dept. of Commerce - NIST: Accuracy, Definition of the SI second
 - Dept. of Defense - USNO: UTC Timescale and "GPS Time" reference
 - NASA - JPL: Ultra-stable and reliable frequency and time metrology and references enabling deep space exploration
- NASA/JPL *DSN Frequency and Timing Subsystem (FTS)*
 - Calibrated atomic standards/clocks reside in each DSN SPC, operate 24/7, and support scores of missions.
 - Serves as the *DSN heartbeat and calibrated ruler* to track and navigate spacecraft via two-way radiometric tracking.
 - Enables Range (position), Doppler (velocity), and Delta DOR (angular) measurements.
 - Provides low phase noise sources for reference frame determination (VLBI).
 - JPL's *Frequency Standards Test Laboratory (FSTL)* provides state of art references and characterization capability.

JPL Frequency Standards and Test Laboratory (FSTL)

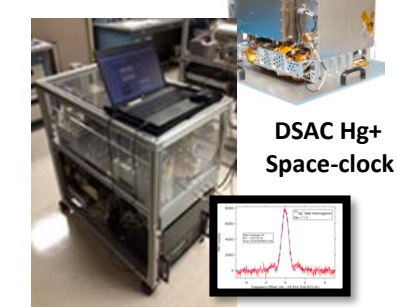
Mission Critical Frequency and Timing Capability and Expertise
Specialized and reliable frequency and timing sources, distribution, measurement and test capabilities



Stability Measurements.
UTC calibrations via GPS time transfer.



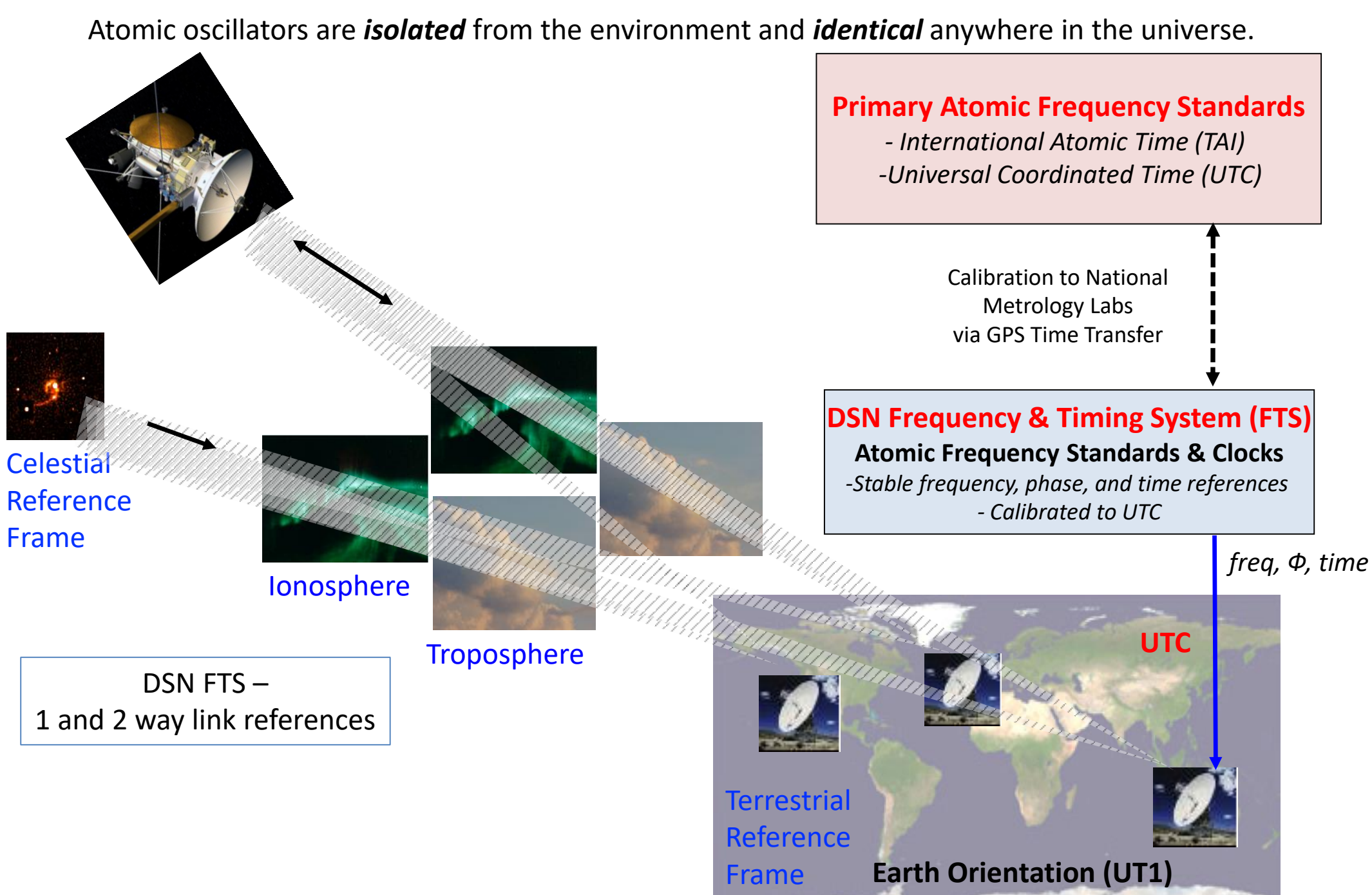
Environmental Tests



FSTL Ultra-stable Reference Clocks

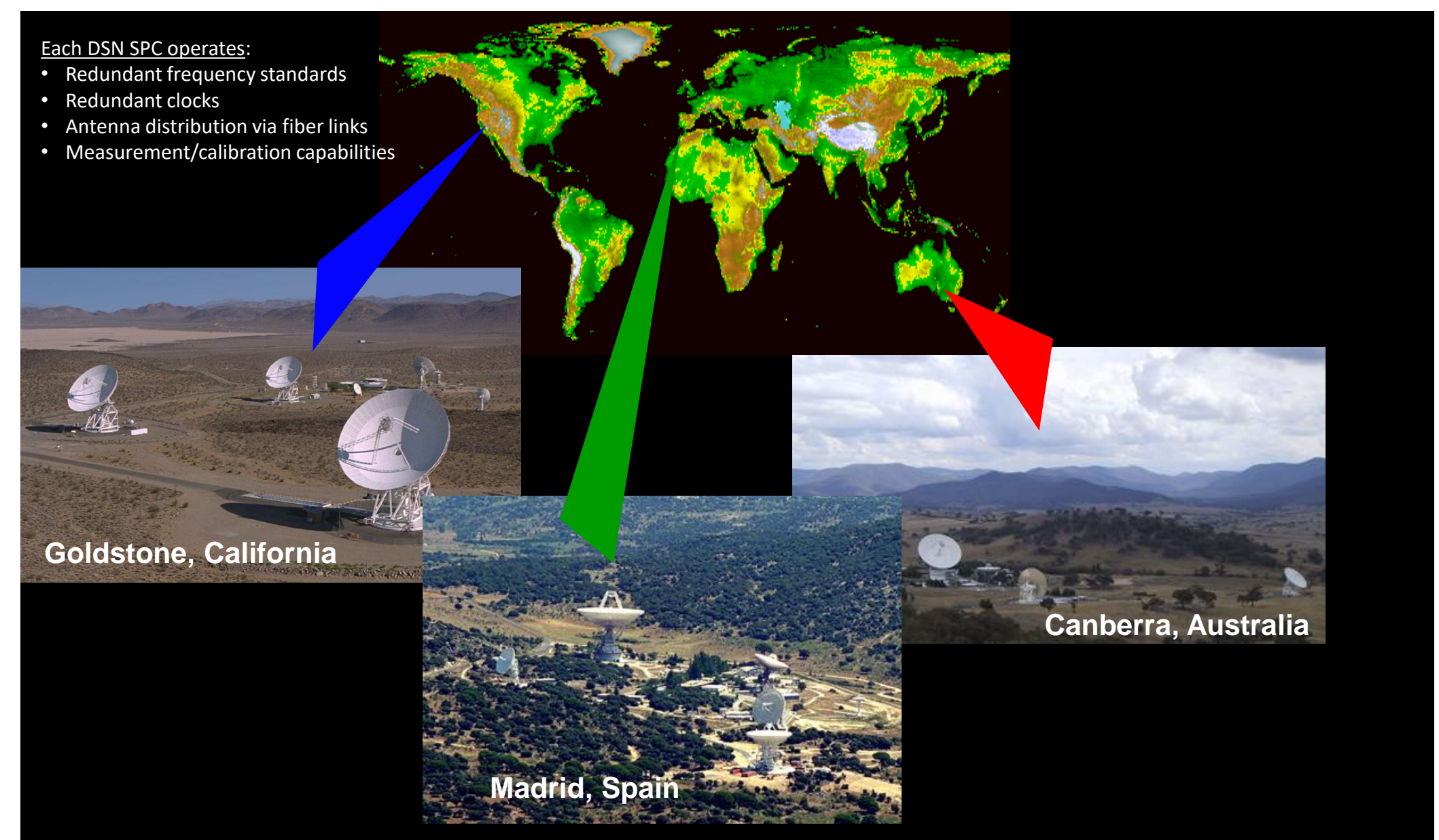
DSN Frequency & Timing System (FTS) Role in Spacecraft Tracking

Enabling NASA mission communications, navigation, and radio science



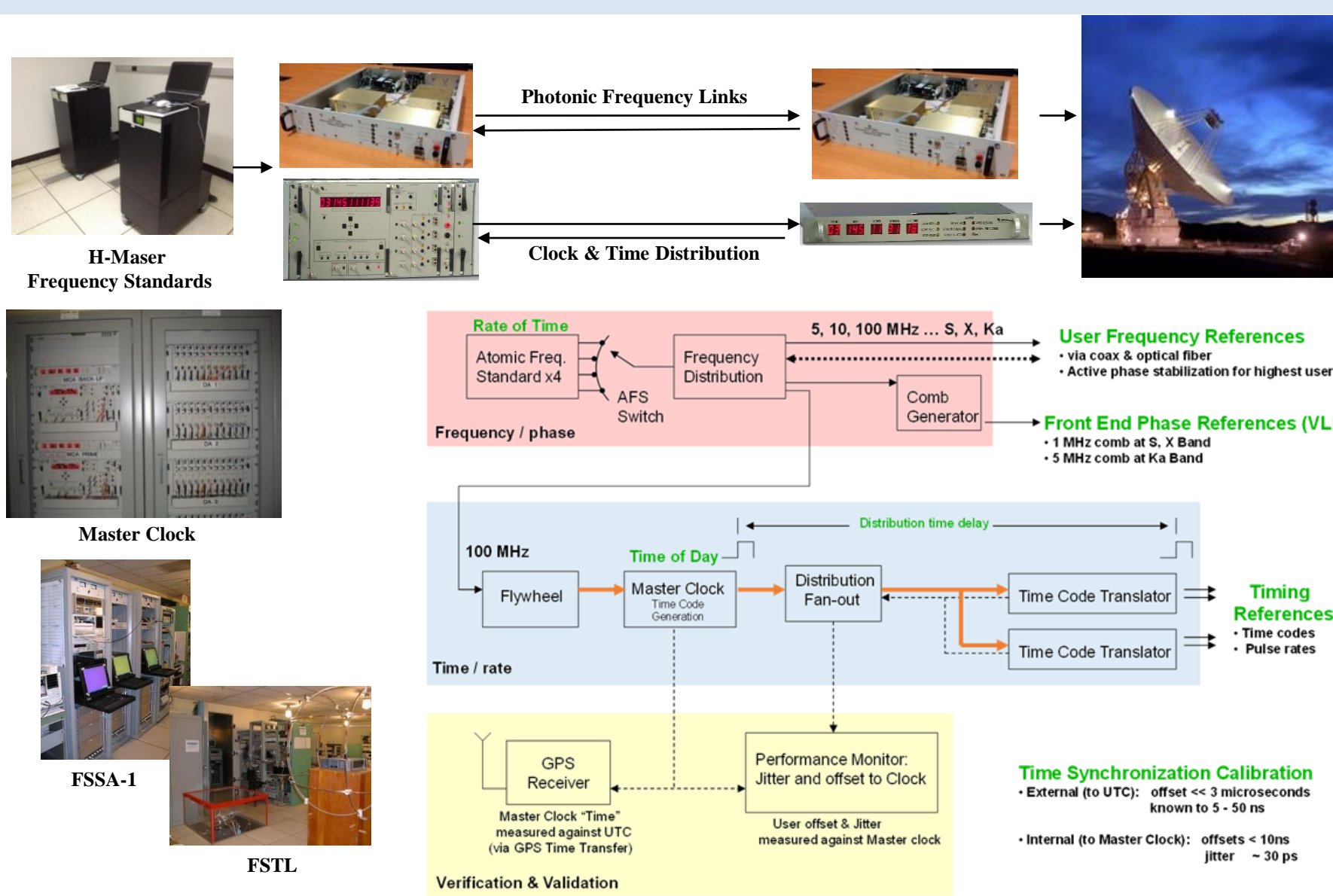
NASA's Deep Space Network (DSN)

Local Frequency and Time References
Time and Frequency Calibrations to UTC and between each DSSC



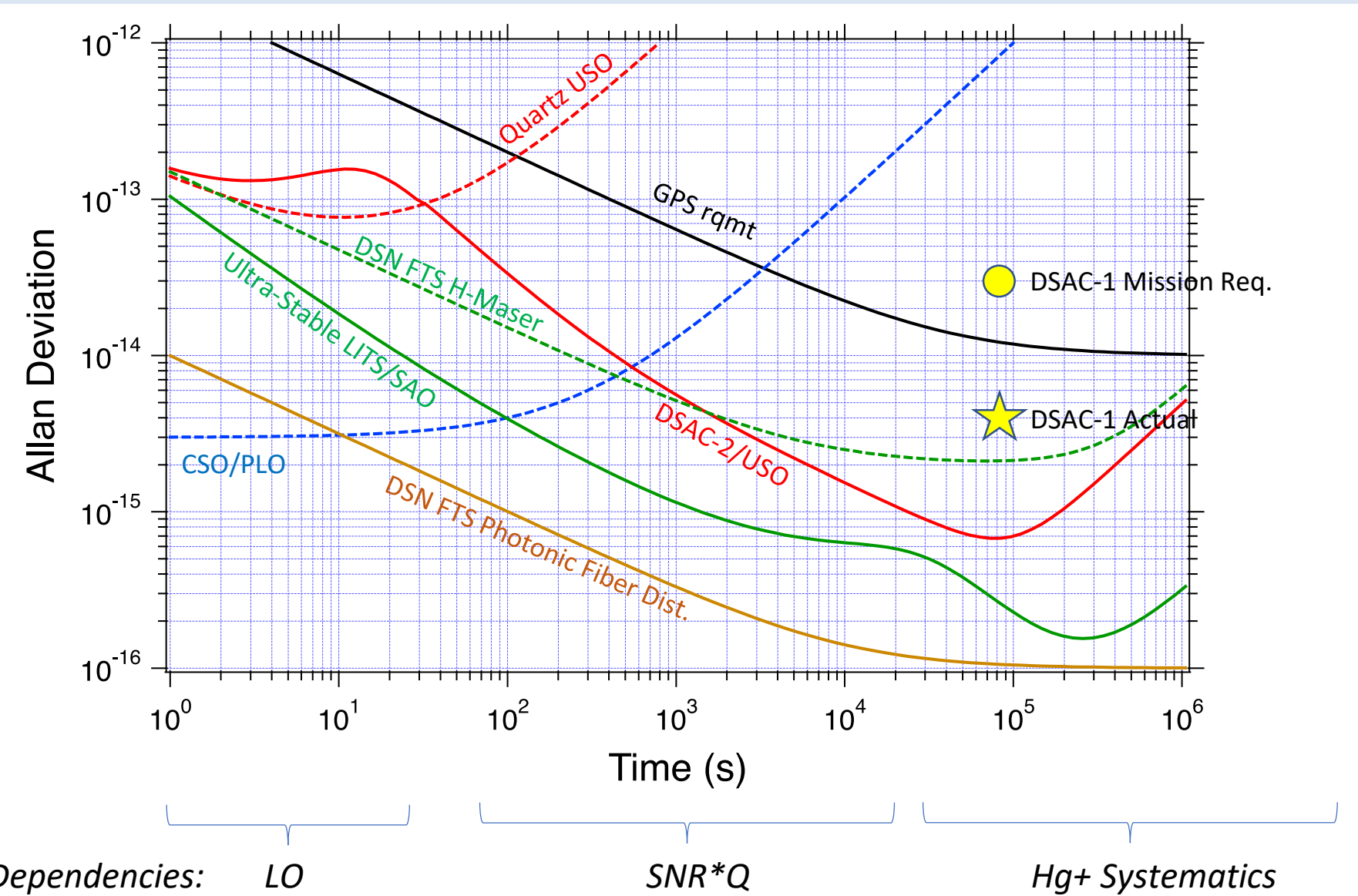
DSN FTS: Frequency Standards, Clocks, Distribution, and Metrology

Enabling NASA mission communications, navigation, and radio science



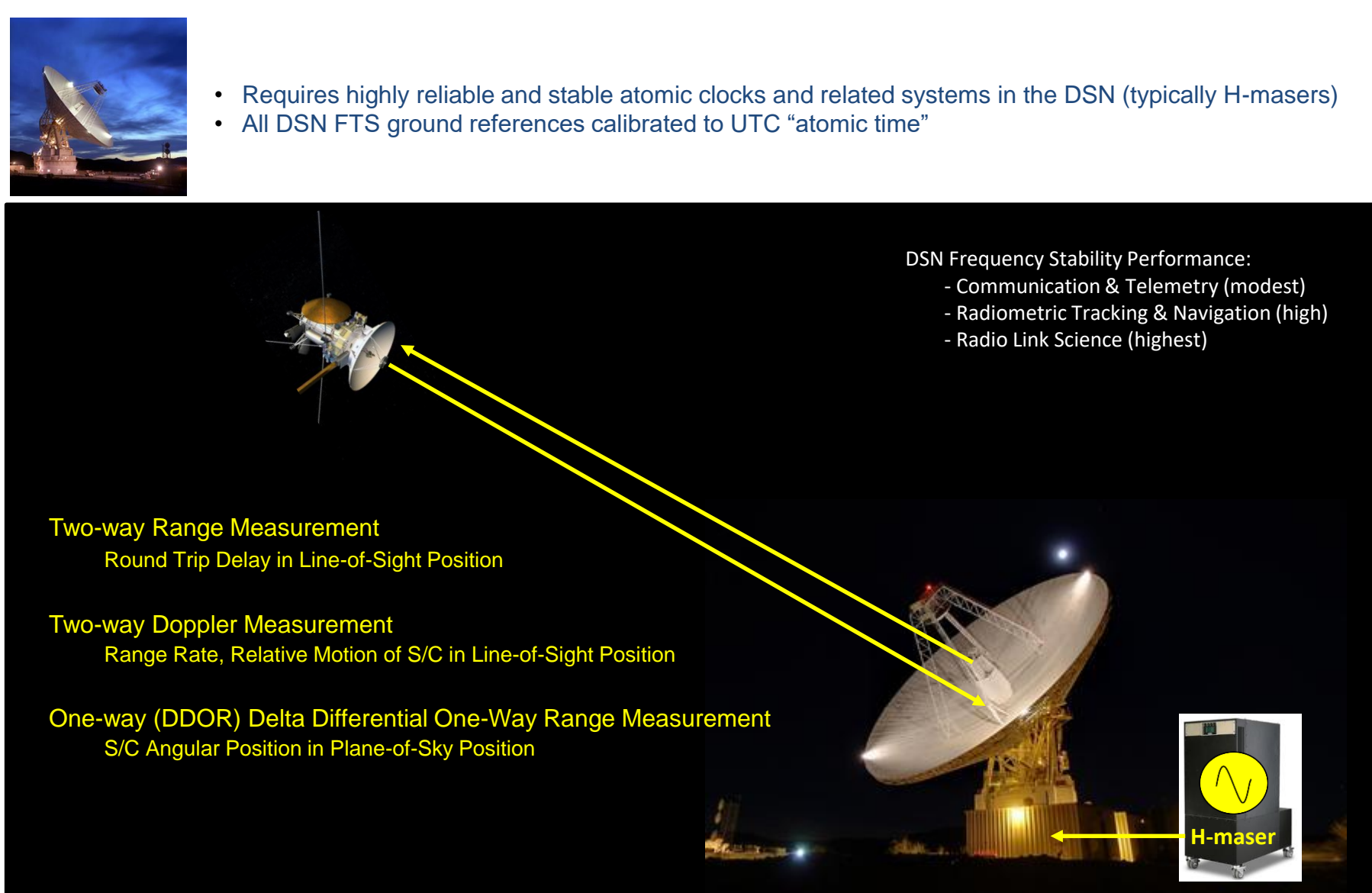
DSN FTS Frequency Reference Stability

USO's, H-masers, Hg ion Clocks, link noise floors



Current Frequency and Timing

Traditional Two-Way Radiometric Tracking Links between the DSN FTS and the Spacecraft



Future Frequency and Timing: Extended FTS, Clocks in Space

Reliable, high stability space clocks will be essential for establishing permanent space-based infrastructure

