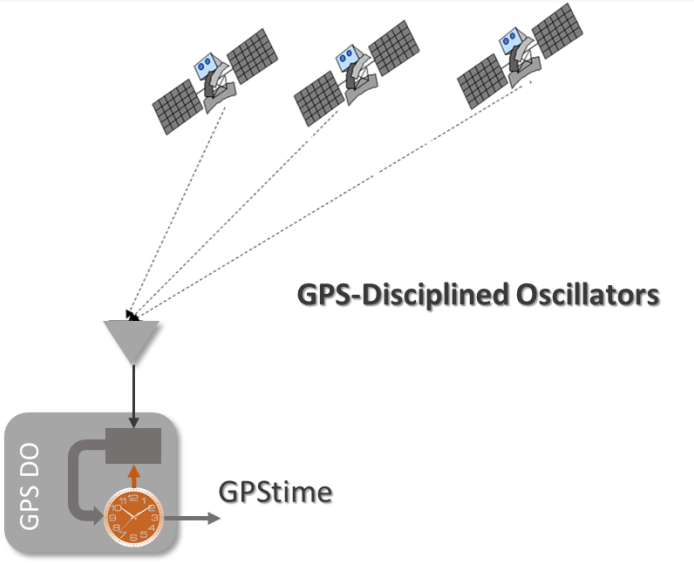
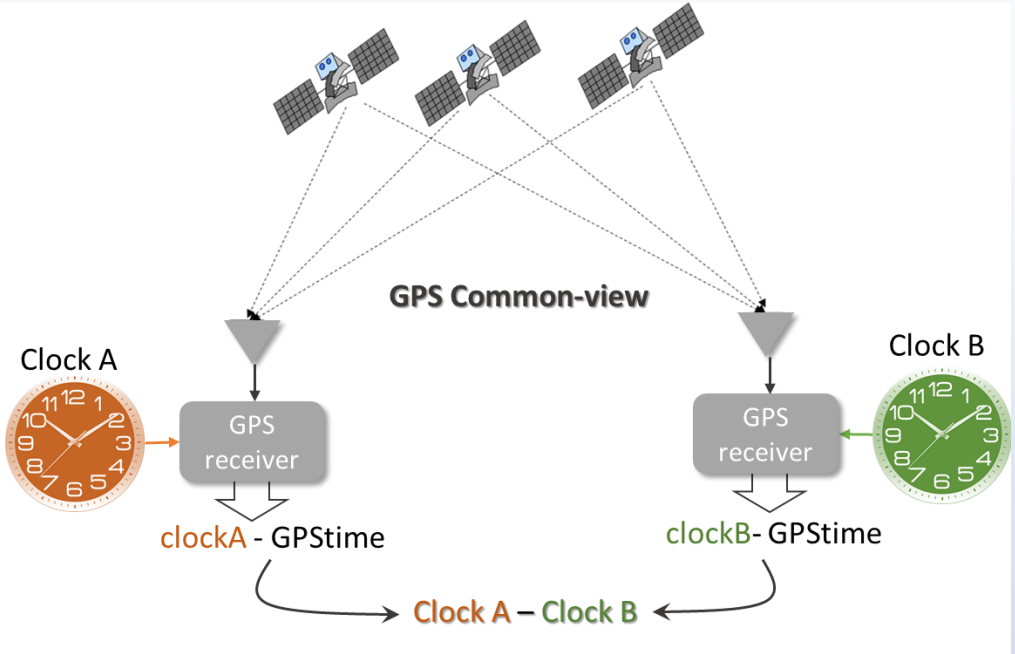
Civil GPS Service Interface Committee

Timing Subcommittee

Chair: Dr. Stefania Römisch – NIST Time and Frequency Division
Co-Chair: Dr. Lin Yi – JPL - NASA

Timing using GPS is everywhere



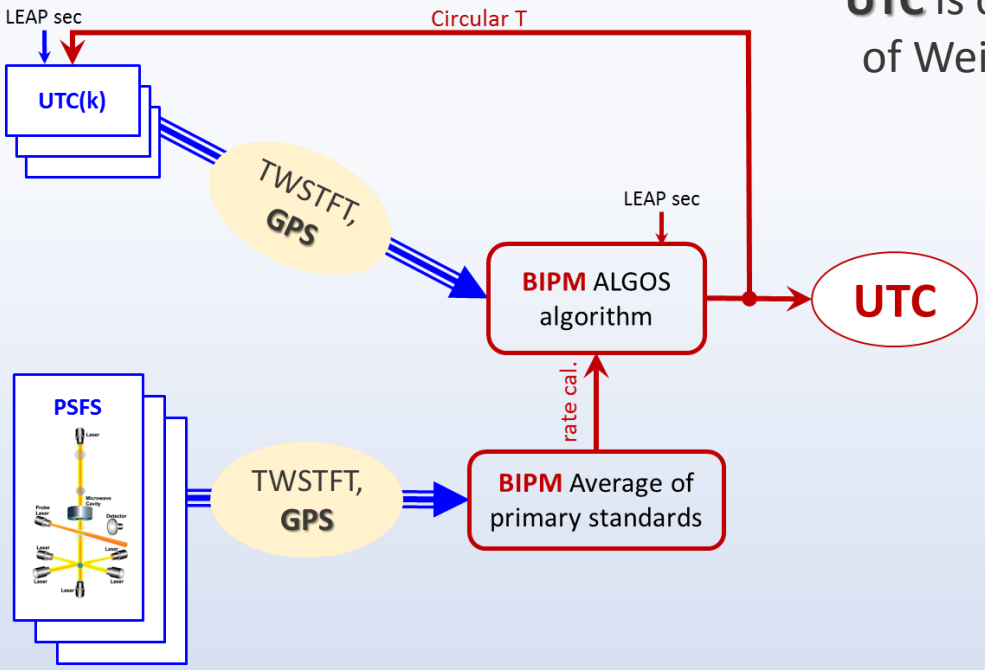


Timing using GPS is everywhere

- Time Generation: Coordinated Universal Time (Common-View)
- Time Dissemination: Telecommunications, financial markets and power grid among others (GPSDO, Common View)
- As a research and comparison tool: Earth observations, remote comparison of clocks, etc. (Common View)

Time Generation

Coordinated Universal Time (**UTC**) is the official world time scale.



UTC is computed by the International Bureau of Weights and Measures (**BIPM**) in France.

UTC(k) is each local realization of UTC. UTC(k) may consist of clock ensembles, or even single Cs clocks.

Cs Rb, Yb, Ca…

PSFS are Primary and Secondary Frequency Standards

Time Generation

Technical requirements for the time laboratories for the participation in UTC

Laboratories willing to participate in the calculation of UTC should be equipped of

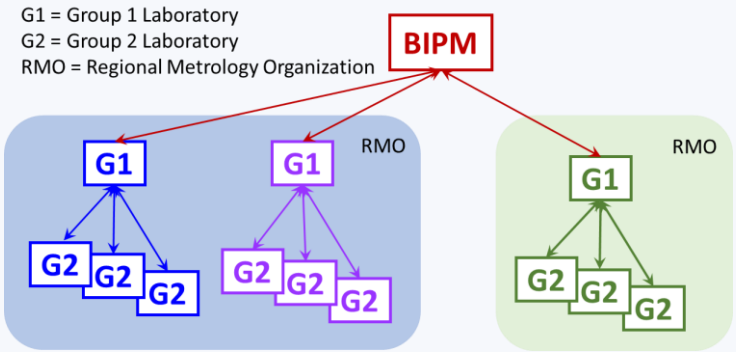
1. one or more atomic clocks;
2. instruments to allow remote clock comparisons.

Clocks participating in UTC are linked at present by time transfer with:

- **GNSS receivers (**multi-channel, single and dual frequency)
- Two-way satellite time and frequency transfer (TWSTFT) stations.

GPS receivers enabled the participation in UTC of a large number of smaller timing laboratories around the world.

Time Generation



Time Dissemination

Telecommunications

GPS-based timing **enables** precise synchronization of networks that can be operated by different providers, enabling network scalability and bandwidth increase (i.e. 5G) ⇒ Need reliability!

Financial markets

GPS-based timing **has enabled** the operation of international markets using advanced trading techniques, thereby also creating the need to use that same precise timing to enforce appropriate regulations. ⇒ Need reliability!

Power industry

Smart grids, a result of the NASPI (North American Synchro-Phasors Initiative) activities are already using measurements of operational parameters of the grid, synchronized over wide areas. GPS-based timing **enabled** the power industry to understand and monitor potentially problematic transient behaviors. ⇒ Need reliability!

Time Dissemination

If GPS is vulnerable, timing is vulnerable….

- Jamming
- Spoofing
- Unavailability (i.e. urban canyons)
- System problems (user segment, control segment)
- User problems (improper installation)

A flurry of activities:

- Receivers hardening techniques (best practices, data validation, etc)
- GPS back-up strategies (optical fibers, terrestrial beacons)
- …

⇓

The development of a robust timing infrastructure, incorporating diverse dissemination techniques, including GPS.

Research tools

IGS, NRCan
Provide products and services in support of the terrestrial reference frame, Earth observation and research. Among others, ionospheric maps and precise orbits for accurate time comparisons.

ACES (Atomic Clock Ensemble in Space) mission support
Precise determination of ISS orbits

Local Position Invariance principle of general relativity
Null test of LPI principle using long-term comparison of remote clocks, via UTC.

Timing Subcommittee

2:00 **Introduction**
Dr. Stefania Römisch, NIST

2:10 **Report from U.S. Naval Observatory (USNO)**
Mr. Arnold Colina, USNO

2:30 **Report from NASA Jet Propulsion Laboratory (JPL)**
Dr. Lin Yi, JPL/California Institute of Technology

2:50 **Report from National Institute of Standards and Technology (NIST)**
Dr. Stefania Römisch, NIST

3:20 **Break**

Timing Subcommittee

3:40 **XXX**
Mr. Kevin Skey, MITRE Corporation

4:00 **An Introduction to High-Altitude Space Use of GNSS (For Timing People)**
Mr. Joel J. K. Parker, NASA Goddard Space Flight Center

4:20 **Predicting the Rotation of the Earth**
Dr. Demetrios Matsakis, USNO

4:40 **Discussion**

5:10 **Session End**