IGS Operations and Thoughts on GNSS Timescales

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Overview

- IGS and Clock Products Working Group
  - Response to action requested by Working Group S in June 2019.
  - IGS Organizational Structure
  - Role of Clock Products Working Group and Coordinator
- IGS Clock Products Overview
  - Conventions
  - Role of timescales
- Traceability to UTC(k)
- Impacts of a new GNSS reference time
- Existing reference times
- Conclusions

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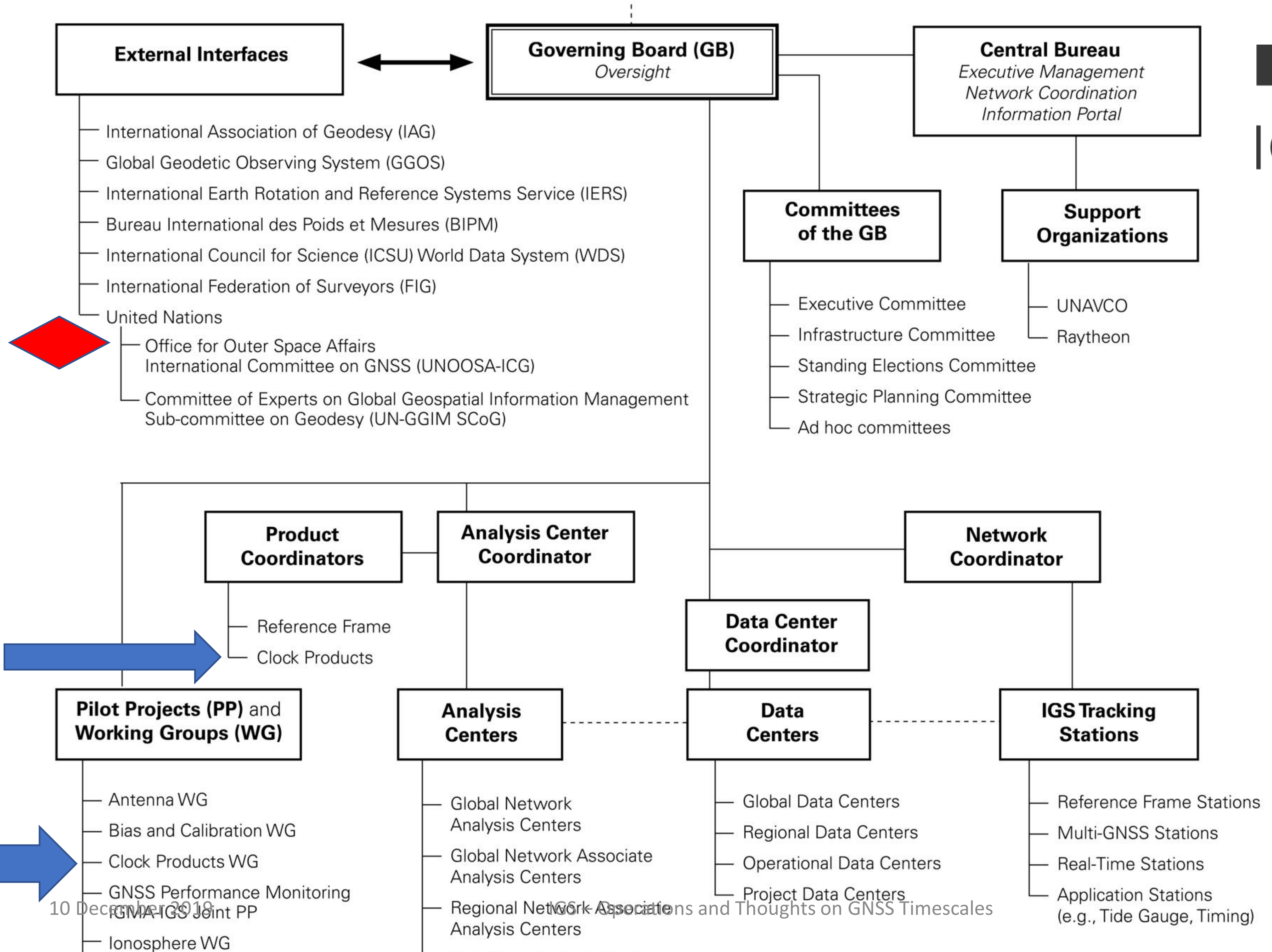
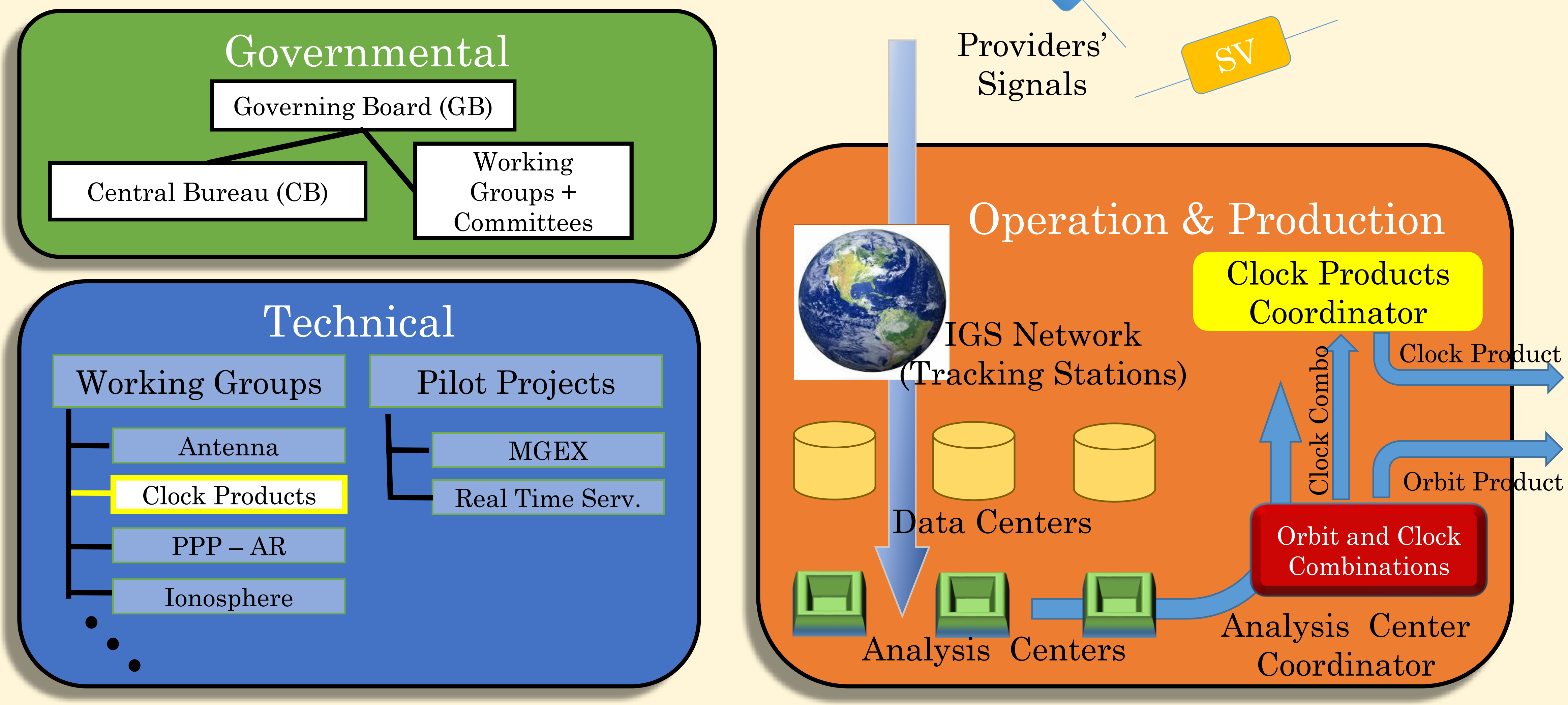


IGS Structure Overview



Clock Products Working Group

- Established 01 January 2003 to maintain products for the accurate comparison of remote clocks using GPS code and phase measurements.
- Present Functions:
  - Ensure continued production of clock products and associated IGS reference times;
  - Consult with GB and others working groups on matters concerning time.
- Members / Contributors:
  - Representatives of IGS stations that are also UTC(*k*)
  - Representatives from analysis centers that commit clock products
  - Governing members of the IGS (WG chair, Central Bureau Member)
- Several members are also IGS clock product users.

Clock Products

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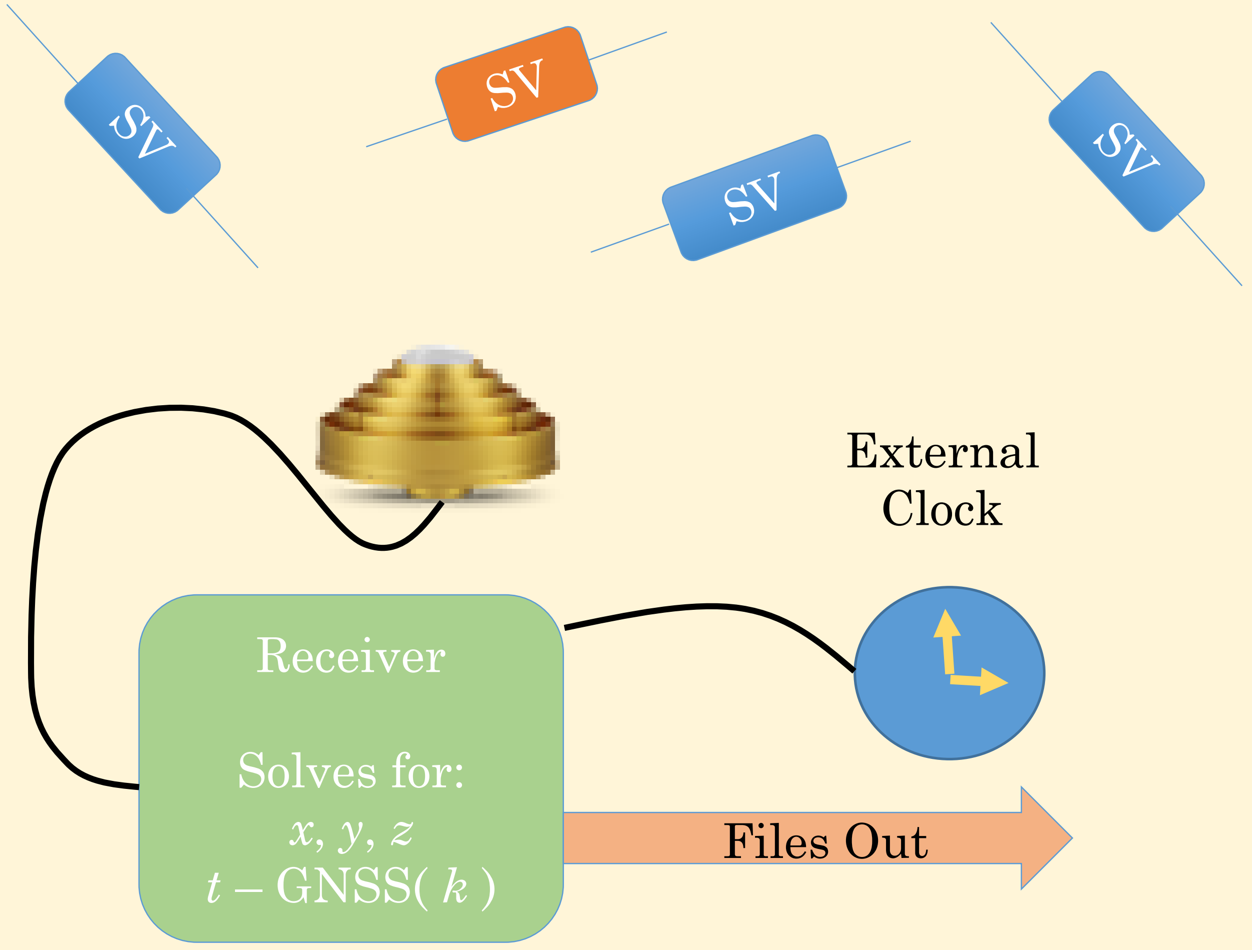
- Products consist of clock offsets for satellites and receivers in the IGS tracking network and are published at several intervals:
  - Ultra-rapid: every six hours. Satellite clocks only.
  - Rapid: daily. Station and GPS satellite clocks referenced to IGRT.
  - Final: weekly. Station and GPS satellite clocks reference to IGST.
- The timescales IGRT and IGST differ as they are generated on different solutions and from different groups of analysis centers.
- The two most common questions asked from IGS data users:
  - What is the sign convention? (For the record: x_clock – x_ref)
  - What is the reference time?

Resolving Time via GNSS Receiver



Calibration of a set-up requires measuring several delays:

- Cable delay
- Antenna delay
- Receiver delay (signal dependent)
- Tick to Phase ratio

The local clock can be resolved with respect to the GNSS(k) and thus associated UTC(k), by broadcast.

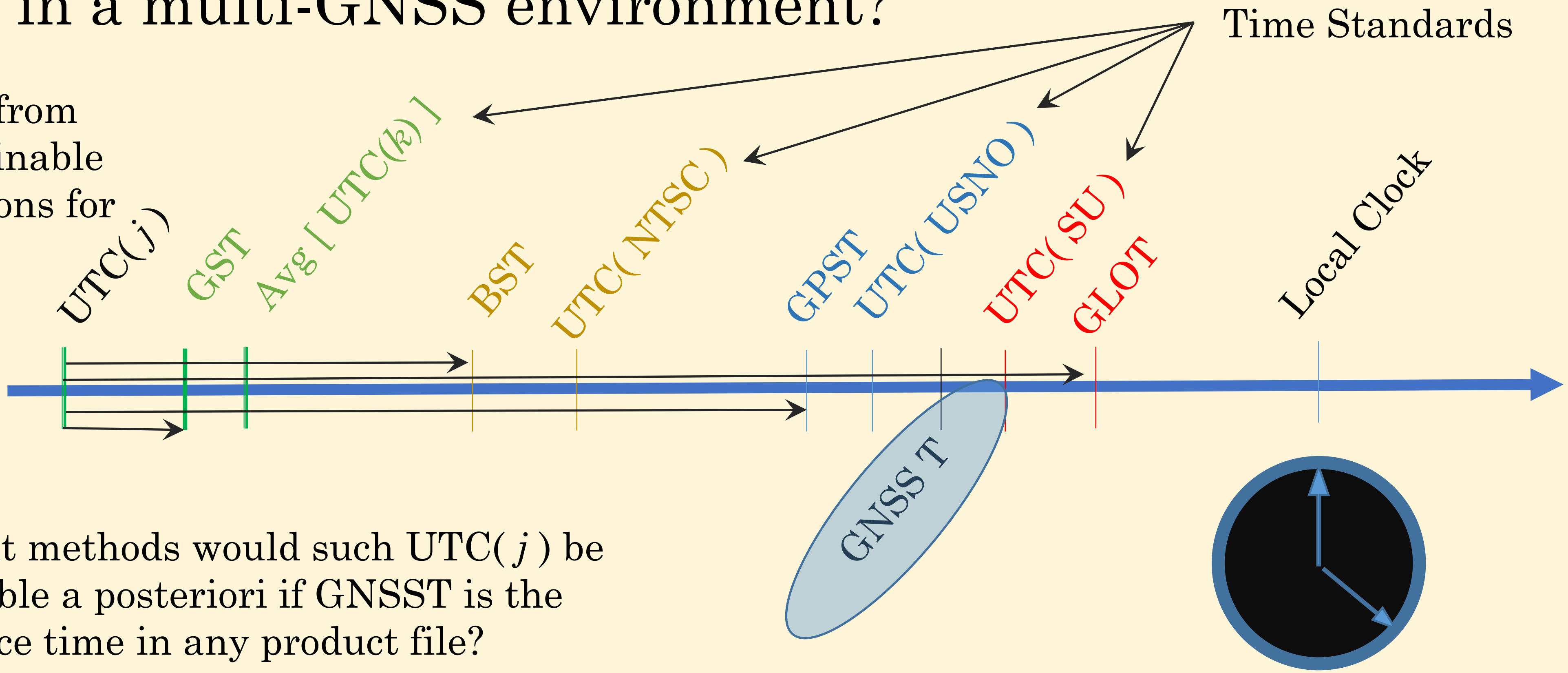
User's Perspective

- Which UTC(k) is resolved at the receiver?
  - Not clear if a common GNSS timescale is the synchronizing agent
  - Receiver manufacturer's might not have consistent results.
- The most common method of attaining UTC(k) is now GNSS and these systems therefore very influential for this purpose.
- The importance of accurate time, especially over long distances is important to many of the world's industries.
  - Financial institutions are increasingly using GNSS to timestamp major transactions. In some cases, proof of traceability to UTC is needed.
  - Electric power grids require synchronization across long distances to ensure safe and efficient operation. Many are turning to GNSS.

Reference Time

As files are logged, which reference time will be that used when in a multi-GNSS environment?

UTC(j) offset from GNSS(k) attainable with calibrations for that GNSS.



By what methods would such UTC(j) be attainable a posteriori if GNSST is the reference time in any product file?

Items for Thought

- The ability to establish "what time it is" and with respect to what reference is an important feature of GNSS. Users may expect to know *which* time standard is available to them in real time.
- Establishing a reference time with traceability to UTC(k) a posteriori is an important part of the IGS rapid and final clock product generation.
- It is not clear what consequences (perhaps remote and long term) could ensue if a new globally distributed reference time enters this arena.
- It is not clear what improvement could result from a new globally distributed reference time as long as no improvement is made on calibrations between systems, and predictions of broadcast information

Existing Timescales

- Disseminated timescales have grown in number and confuse the question of which time is reference both in real time and data.
- Can an existing one be used to reduce adding to the complexity?
  - UTC: The standard for time seems ideal but is not available in real time. Each GNSS already broadcasts a link to its own proxy of UTC. Perfomance in that case depends on the agreement between these proxies and on accuracy of broadcast messages.
  - GST, or GPST, or BDT: Simplest method that avoids a globally distributed time. But, which system would be pivot?
  - IGST: As the IGS moves towards multi-GNSS clock products, such a timescale would fit the technical needs of serving as a common reference to all satellite clocks. But, the IGS does not guarantee the same reliability of service, has limited production resources, and may not have all constellations in service at first (presently looking at GPS, GAL and GLO).

Concluding Remarks

- A prime concern for the IGS clock products is potential ambiguity in time references that might lead to errors in production and maintenance.
- The IGS as a whole has not converged on a particular stance on this issue and further discussion among working groups will take place over the next year.
- Many in the IGS are receptive to a position that recommends ensuring timing standards are carefully observed regardless of the actions taken.
- What can be done? The IGS is open to discussion on what paths can be taken that assure traceability of standards and improved interoperability.