SEA Time Management Working Group
Minutes of the Meeting

This was the inaugural meeting of the Time Management Working Group. The new Working Group was approved in the Summer of 2019. J. Hamkins is the chair, and S. Mejri is the deputy chair. J. Hamkins welcomed all participants and reviewed the WG charter.

1 CWE FOLDER ORGANIZATION

The Working Group discussed the folder organization it would like to maintain in the CCSDS Collaborative Work Environment (CWE). CWE is set up with private folders viewable only by those with CWE logins, and public pages that can be viewed by anyone and may be findable with google searches. Each CCSDS Working Group is apparently free to do something slightly different. In the SLS area, for example, the MHDC, C&S, RFM, and OPT WGs only use the private folders for their discussion inputs, while SLP puts its inputs in the public folder. P. Shames suggested the Time Management WG use the public folders for storing documents. This was agreed to.

2 GREEN BOOK

The first project for the WG will be the development of a Green Book describing suitable operational domains, applications, and methods used for time correlation and synchronization. The Green Book will identify requirements for interoperable time correlation and time synchronization services.

The WG discussed an outline for the Green Book, and assign lead authors for each section. J. Hamkins agreed to construct an initial template (White Book) document and coordinate the inputs to the book. The WG agreed to the following organization and lead authors, as follows:

- Definitions – L. Pitts
- Background –
  - Frequency standards, x-ray pulsars, clocks, etc. (general knowledge about time/time management)
    - NTP – P. Shames
    - Terrestrial timing standards / atomic clocks across world – S. Mejri
    - Leap seconds, epochs, time scales, etc. – S. Mejri
    - Network considerations – Earth receive time, network delay, DTN, etc. – V. Sank
  - GNSS systems
    - GPS (V. Sank)
    - Galileo (M. Rovatti)
    - BEIDOU (Z. Yuxia)
    - GLONASS (S. Mejri (TBR))

    - References to time code formats, coding, ranging, etc.
- Time distribution and correlation for space applications
    - Concept
        - Architectural considerations
        - Spacecraft design (time calibration system design)
        - Ground design
    - How it is done
        - Method 1 a, b, c (NASA – DSN, SN, NEN) – J. Hamkins
        - Method 2 (ESA) – S. Mejri/M. Rovatti
        - Method 3 (CAST) – Z. Cuitao
        - Method 4 (DLR) – C. Stangl
        - Method 5 (JAXA) – Y. Yamamoto
- Time Synchronization for space applications
    - Concept
    - How it is done
        - Method 1 a, b, c (NASA – DSN, SN, NEN) – J. Hamkins
        - Method 2 (ESA) – S. Mejri/M. Rovatti
        - Method 3 (CAST) - Zhang
        - Method 4 (DLR) – C. Stangl
        - Method 5 (JAXA) – Y. Yamamoto
- Applications (draw on existing documentation)
    - Science activities
        - Enumerate examples as they relate to timing accuracy/resolution needed
    - Entry/Descent/Landing (Lunar, Mars, etc.)
    - Docking
    - Commanding of spacecraft actions (comm, antenna pointing, heaters, etc.)
    - Ranging / Doppler
    - Spacecraft maneuvers
    - Multiple spacecraft coordination
- SANA, and patent considerations – J. Hamkins

3 TELECONFERENCE SCHEDULE

The WG agreed to teleconferences on

- November 21, 2019, 3 pm UTC
- January 9, 2020, 3 pm UTC
- February 13, 2020, 3 pm UTC

4 FREQUENCY STANDARDS

S. Mejri made a presentation on frequency standards. The presentation described concepts of what a clock is and an overview of how an atomic clock works in terms of atomic energy state superposition. Stability and accuracy were defined. Allan deviation was defined. An overview of the stability of clocks over time was presented. Clock accuracy below 1e-17 is possible. The definition of the second may be revised, using a different atomic species and optical lattice.

5 TIME MANAGEMENT ON A NASA MISSION

G. Kazz made a presentation on time management on a NASA mission. The mission described was the Mars Reconnaissance Orbiter, which is representative of how time is managed on a multitude of deep space missions. The spacecraft clock may drift as much as 10 ms relative to UTC over a single communications pass. This requires a need to monitor and predict spacecraft clock drift with respect to UTC.

The spacecraft clock is not changed once launched. Instead, the counter is allowed to run freely, and the ground maintains a correlation file to associate the spacecraft clock to UTC. The spacecraft generates a time tag, SCLK, and places in in a time correlation packet along with an indication of the reference frame. The Earth receive time, ERT, of this frame is measured on the ground. A series of (SCLK, ERT) pairs, is used to calculate the offset of the spacecraft clock with respect to the UTC. To make this computation, the known spacecraft position is used to remove the delay caused by the one-way light time, and any delays present in the spacecraft and ground station are also accounted for.

6 TIME CORRELATION/SYNCHRONIZATION METHODS

C. Stangl made a presentation on time correlation/synchronization methods at DLR. The presentation covered the following topics:

- EDRS-A, EDRAS-C (ECSS-PUS)
    - GEO
    - Time management: precision 0.1 ms EDRS-A, 1 ms EDRS-C
    - Accuracy end-to-end: 1s for EDRS-A, 0.5s EDRS-C
    - ECSS-E-70-41A = PUS standard
- DLR MORABA (sounding rockets)
    - Onboard oscillator is synchronized with GPS
    - Ground equipment synchronizes oscillator with the one on s/c

ANNEX A: LIST OF PARTICIPANTS

Name	Affiliation	Email
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