CGPM

Introduction to Draft Resolution D:

On the definition of an international lunar reference time scale and its traceability to UTC

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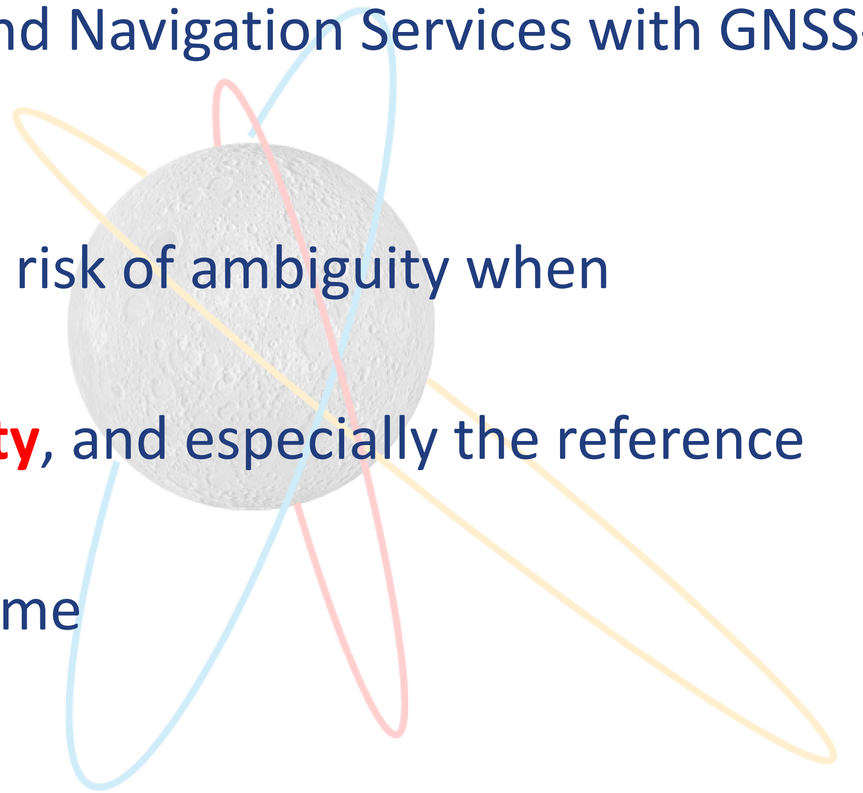
Context

Several **Moon programs** including Lunar Communication and Navigation Services with GNSS-like **Positioning, Navigation and Timing** (PNT)



Proliferation of time scales should be avoided, to limit the risk of ambiguity when exchanging time-tagged data, so there is a need to:

- **Fix the space-time reference systems for interoperability**, and especially the reference time scale for Moon operations
- **Ensure the traceability to UTC** for the Lunar reference time
- Extension to Mars and other planets

Requirements on the **accuracy of future Moon PNT will not allow the direct use of UTC**, due to the important relativistic time difference between a clock on the Lunar geoid and a clock on the Earth geoid

Decisions on reference systems involve multiple actors

Fruitful collaborations between BIPM-CCTF and space agencies / communities, International Organizations / Associations about a possible lunar reference time scale.

International Astronomical Union (IAU)

International Union of Geophysics and Geodesy (IUGG)

International Association of Geodesy (IAG)

International Telecommunication Union (ITU)

United Nations International Committee on GNSS (ICG)

Interagency Operations Advisory Group (IOAG)

Current situation

- A few options for the Lunar reference time have been analyzed (pro and cons) and discussed, especially solutions related to reference frames based on the “center” or to the “surface” of the Moon.

→ **No consensus on a preferred option**, considering both fundamental and practical aspects.

→ **Consensus:**

- **to pursue collaborative activities and exploit the future results** of pioneering Lunar missions, with the aim to converge to a preferred option;
- to confirm that the **Lunar reference time must be traceable to UTC**;
- on the need to determine a **conventional fixed value of the gravitational potential based on international consensus** if the reference time scale “on the Lunar surface” is chosen (as fixed for UTC on the Earth by Resolution 2 of the 26th CGPM, 2018);
- the contribution of BIPM-CCTF has been decisive and is highly appreciated, and there is a need now to **define the possible BIPM’s role** for the future measurement of (UTC-Lunar time) and the coordination of different realizations of the national Lunar reference time.

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The CGPM, at its 28th meeting,

encourages space agencies operating pioneering lunar projects to share their practical experience with the scientific community and, when a realization of the lunar time scale is **measured with respect to UTC to obtain traceability**, to describe in full the model used to determine the relativistic effects, the input ephemerides, and the associated uncertainties,

recommends that

if a scaled version of TCL corresponding to the lunar geoid is considered, its frequency offset with respect to TCL is chosen according to a **conventional fixed value of the gravitational potential, established by the relevant international organizations** such as IAU and IAG, and its origin is in agreement with the TCL origin defined by IAU,

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further recommends that

- **the CIPM** consistently considers the results of such pioneering projects and takes action, as necessary, concerning the **definition of a lunar reference time scale and the BIPM's role in relation to lunar time coordination and comparison with UTC**,

- **the BIPM and the National Metrology Institutes** (NMIs) **work in collaboration with space agencies and international organizations to support the realizations of the lunar reference time scale**, and their measurement with respect to UTC, with the involvement of the UTC community.

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Thank you
for your attention