ESA’s Perspective on the definition of Moon Time

Consultative Committee for Time and Frequency (CCTF)
Workshop on Moon Time

ESA - Team
D/OPS, D/NAV, D/TEC

18/11/2025

Recap of options being considered

Lunar Time TL is the reference coordinate timescale to be used on the moon: TL = (1 – L_L) TCL

Option 1: no scaling (L_L = 0) so that TL is actually TCL

- A perfect clock on the moon selenoid would drift of about ~3μs/day (~3e-11) wrt the reference

Option 2: scaling (L_L ~ 3e-11) so that TL is realised by a perfect clock located on the moon solenoid

- A perfect clock on the moon selenoid would not drift on average wrt the reference

Option 3: scaling (L_L ~ 7e-10) so that the offset between TL and TT has no linear drift, only periodic terms

- A perfect clock on the moon selenoid would not drift wrt TT but would drift of about ~58μs/day (~7e-10) wrt the reference → Option 3 is no longer considered

ESA's position

- We reaffirm the need to follow the resolutions of the relevant Scientific Institutional bodies
- We confirm Options 1 and 2 can be accommodated in the current Moonlight design

- We underline that **Option 1** is preferred on the grounds that:

1) The definition is independent of external inputs (moon selenoid) and can be already implemented as is
2) The de-facto equality between TCL and TL will not introduce yet another timescale, with possible risk of confusion and/or errors
3) The introduction of a new scaling for coordinate time results in a corresponding scaling of spatial coordinates and mass parameter of celestial bodies, which introduces additional complexity and risk for confusion/errors
4) The same simple and straightforward approach can be applied to other bodies under consideration (Mars,…)
5) The analogy with the situation on Earth (TCG, TT) is not applicable as the practical realisation will first be established on Earth. Even in the future, the link with the Earth will always be maintained.
6) There are no identified design nor operational drawbacks for the implementation of Navigation/Timing systems around the moon

ESA's future contributions to Lunar Time

Moonlight

- Will provide Lunar Connectivity and **Navigation** services
- Navigation service is the European contribution to LunaNet
- Constellation of satellites in moon orbit, providing ranging/timing signals to moon users
- In a first phase, the **Moonlight System Time** will be realised on Earth
- **Moonlight System Time** will be a continuous timescale, aligned to **Lunar Time**

NovaMoon

- A reference station on the moon surface
- Co-location of multiple ranging/timing techniques, including on-board atomic clock (Note: clock accuracy not sufficient to observe frequency offset)
- First experiment for the realisation and validation of Lunar Time on the moon surface
- First Lunar-time laboratory generating a lunar-based lunar time realisation. Opening the route towards international lunar-time laboratories cooperation (as we do on Earth)

ESA's future contributions to Lunar Navigation

ESA is preparing the groundwork for precise Lunar Navigation:

- Establishing an International Lunar Reference Frame (ILRF) Combination Centre
- Providing Earth Orientation Parameter Predictions
- NovaMoon - Developing a pioneering station to enable robust lunar geodesy, lunar time provision and high-accuracy navigation capabilities

ESA will also open NovaMoon for wide international scientific cooperation. The long nominal duration of the NovaMoon mission (5 years) will allow thorough, detailed and comprehensive experimentation opportunities. ESA intends to provide this experimentation data to the international community.

ESA will also count on the support of the GNSS Science Advisory Committee, an independent group of renowned scientists, which will provide guidance for experimentation and to maximise scientific return.