



EXECUTIVE OFFICE OF THE PRESIDENT  
OFFICE OF SCIENCE AND TECHNOLOGY POLICY  
WASHINGTON, D.C. 20502

April 2, 2024

MEMORANDUM FOR DEPARTMENTS AND AGENCIES PARTICIPATING IN THE WHITE HOUSE CISLUNAR TECHNOLOGY STRATEGY INTERAGENCY WORKING GROUP

FROM: Arati Prabhakar, Assistant to the President for Science and Technology and Director, Office of Science and Technology Policy

SUBJECT: Policy on Celestial Time Standardization in Support of the National Cislunar Science and Technology (S&T) Strategy

This memorandum outlines the Biden-Harris Administration's policy to establish time standards at and around celestial bodies other than Earth to advance the National Cislunar S&T Strategy.<sup>1</sup> OSTP directs federal departments and agencies to align their planning and policies with this memorandum.

The approach to establish time standards consists of the definition, development, and implementation of a distinct reference time at each celestial body and its surrounding space environment. Each new time standard developed will include the following features:

1. *Traceability* to Coordinated Universal Time (UTC);<sup>2</sup>
2. *Accuracy* sufficient to support precision navigation and science;
3. *Resilience* to loss of contact with Earth; and
4. *Scalability* to space environments beyond the Earth-Moon system

Federal agencies will develop celestial time standardization with an initial focus on the lunar surface and missions operating in Cislunar space, with sufficient traceability to support missions to other celestial bodies.

NASA will, in coordination with the Departments of Commerce, Defense, State, and Transportation, provide a finalized strategy to the Executive Office of the President to implement lunar timing standardization no later than December 31, 2026. NASA will also include consideration of Coordinated Lunar Time (LTC), as described in this memorandum, as part of its annual Moon-to-Mars Architecture Concept Review cycle no later than December 31, 2024. These tasks will be supported and informed by the National Cislunar S&T sub-Interagency Working Group, co-led by NASA and the National Space Council, and focused on Objective 4 of the National Cislunar S&T Strategy:

- *Implement Cislunar communications and positioning, navigation, and timing capabilities with scalable and interoperable approaches.*

---

<sup>1</sup> National Science and Technology Council, 2022. "National Cislunar Science and Technology Strategy" <https://www.whitehouse.gov/wp-content/uploads/2022/11/11-2022-NSTC-National-Cislunar-ST-Strategy.pdf>

<sup>2</sup> The United States maintains local approximations of UTC at the U.S. Naval Observatory (USNO) and the National Institute of Standards and Technology (NIST), designated as UTC(USNO) and UTC(NIST), respectively. Department of Defense (DOD) systems will continue to operate in accordance with DOD CJCSI 6130.01H and may interoperate with other systems as required.

## 1. Background and Challenges

Over the next decade, the United States will work with allies and partners to return humans to the Moon and develop capabilities to enable an enduring presence. During this same period, the U.S. government (USG) anticipates that many other actors, including governments and private industry, will also send spacecraft to operate in Cislunar space — namely to the lunar surface, in lunar orbits, and at the Earth-Moon Lagrange points.

A unified time standard will be foundational to these efforts. The National Cislunar S&T Strategy calls for the United States to establish a sustainable “Cislunar ecosystem” with scalable and interoperable position, navigation, and timing (PNT) infrastructure. U.S. leadership in defining a suitable standard — one that achieves the accuracy and resilience required for operating in the challenging lunar environment — will benefit all spacefaring nations.

Knowledge of time in distant operating regimes is fundamental to the scientific discovery, economic development, and international collaboration that form the basis of U.S. leadership in space. There will be an increasing need for the USG to collaborate with other entities interested in operating in Cislunar space on a broad range of capabilities, standards, and infrastructure. Time standardization will be a necessary foundation to enable interoperability across the USG and international partners, promote safe and sustainable operations, and simplify Space Situational Awareness (SSA) for safety of flight and operations. Key technical background information is summarized below:

**a) UTC is the primary time standard used by Earth-based systems today.**

The UTC standard is based on the theoretical ideal, Terrestrial Time, which is an analytical definition for time at mean sea level, taking into account the Earth’s center of mass.<sup>3</sup> International Atomic Time (TAI) is the primary realization of this ideal time, produced through a weighted average of hundreds of atomic clocks around the world. UTC differs from TAI by an integer number of “leap seconds” inserted periodically to keep UTC aligned with Earth solar days, despite changes in the rate of Earth’s rotation.

**b) Relativity poses challenges to extending operations into Cislunar space and beyond.**

Due to general and special relativity, the length of a second defined on Earth will appear distorted to an observer under different gravitational conditions, or to an observer moving at a high relative velocity. For example, to an observer on the Moon, an Earth-based clock will appear to lose on average 58.7 microseconds per Earth-day with additional periodic variations. This holds important implications for developing standards and capabilities for operating on or around the Moon.

Additionally, the navigation accuracy a system can achieve with signals from multiple space-based assets, such as a person navigating on Earth with signals from Global Positioning System satellites, depends on the synchronization of those assets *with each other*. At the Moon, synchronizing each lunar asset with an Earth-based time standard is difficult — due to relativistic effects, events that appear simultaneous at the Earth (e.g., the start of a broadcast signal) are not simultaneous to an observer at the Moon.

Safety of navigation in Cislunar space also relies on a consistent definition of time among users. This includes SSA and continuity of time knowledge during transit operations. PNT systems

---

<sup>3</sup> [Resolution B1.9](#), IAU 2000 24<sup>th</sup> General Assembly (Manchester) and [Resolution A4](#), IAU 1991 21<sup>st</sup> General Assembly (Buenos Aires)

provide distance measurements by multiplying the time of flight of the signal by the speed of light. Failing to account for the discrepancy between a transmitter clock on the Earth and how it is perceived by a receiver on the Moon will result in a ranging error. Precision applications such as spacecraft docking or landing will require greater accuracy than current methods allow.

Beyond these operational challenges, the direct use of UTC at the Moon (i.e., without correction) as the local time scale would have cascading effects for applications that require precise metrology.<sup>4</sup> International System of Units (SI) core unit definitions, including the meter and kilogram, rely on the SI definition of time. Due to relativistic effects, a non-SI unit would introduce uncertainty in core unit definitions. These types of errors will have undesired impacts, such as reducing the accuracy of mapping and inertial navigation products. Defining a local time scale can provide a stable reference point for these base units and conversions that must be independently realized on the surface of the Moon.

## 2. Policy Guidance

This policy requires federal agencies to develop celestial time standardization according to the following directions.

a. **Coordinated Lunar Time (LTC) will act as the established standard to enable Cislunar operations and maintain traceability to UTC.**

The concept of Lunar Time is analogous to the ideal Terrestrial Time scale on Earth. Just as Terrestrial Time is set through an ensemble of atomic clocks on Earth, an ensemble of clocks on the Moon might set Lunar Time. This operational time standard, LTC, may directly employ or distribute the UTC offsets required to maintain both local time and UTC time within specific tolerances.

By establishing LTC, users in Cislunar space can reference a time standard defined near the gravitational environment in which they operate. This approach supports compatible standards between users in Cislunar space and the Earth; assets can synchronize with an accuracy that supports precision PNT and precision science; and the reference time will survive loss of contact with the Earth. This approach will still support conversion to UTC for operations that interact with the Earth and is extensible to space environments beyond the Earth-Moon system.

b. **NASA, in coordination with the Departments of Commerce, Defense, State, and Transportation, will study, define, and implement a Coordinated Lunar Time (LTC) to support the gradual establishment of lunar infrastructure.**

As the pace of activity at the Moon increases, the United States will define its strategy for scalable lunar time standardization. Implementation will occur in parallel with infrastructure build-up, but agreement on the conceptual approach must happen in advance. The definition of LTC and underlying ideal time standards such as Lunar Time are critical. Interagency collaboration and international agreements will be necessary to define the approach for realizing LTC.

---

<sup>4</sup> The SI second is defined based on the oscillations of a Cs-133 atom, specifically the unperturbed ground-state hyperfine transition frequency which is defined to occur at 9,192,631,770 s<sup>-1</sup>.

As such:

- USG leads will define the expected phases of lunar and Cislunar exploration and habitation, while ensuring a traceable, accurate, resilient, and scalable timing standard is in place.
- NASA will determine the schedule and implementation of this deployment in coordination with partnering departments and agencies based on the requirements of expected missions (including operational suitability) and resourced through the regular annual budget process.
- NASA, with support from partnering departments and agencies, will establish the approach to LTC as the international standard through existing standards bodies, and among the Artemis Accords signatories.
- NASA will provide OSTP with a milestone-based approach to establish LTC in line with this guidance no later than December 31, 2024.

### **3. Conclusion**

Exploration of Cislunar space opens a new sphere of human activity and offers opportunities to advance scientific understanding, exploration, and economic growth. With a shared vision and unity of purpose across departments and agencies, the United States will lead the responsible, peaceful, and sustainable exploration of Cislunar space and application of discoveries in this area. OSTP will lead and support the implementation of this policy and guidance. We are grateful to those across the community who have contributed to date, and to those who continue to share their valuable knowledge to shape our collective understanding of this topic as we move forward.