INTERAGENCY OPERATIONS ADVISORY GROUP

Cislunar Infrastructure: Convergence of Architecture, Governance and Interoperability

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For CCSDS-IOAG Lunar Interoperability Forum
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Interagency Operations Advisory Group

Since 1997, the IOAG has provided a forum for **identifying common needs across multiple international agencies** for coordinating space communications policy, high-level procedures, technical interfaces, and other matters related to **interoperability and space communications**. Its goals are to:

- Enable safe, secure, and **interoperable mission operations**;
- Foster **cross-support** between member agencies' space missions;
- Enable responsive **networks around the Earth, Moon, and Mars** to enable future exploration and science missions.

Lunar Communications & Navigation Working Group (LCNWG)

- Define and recommend a lunar communications and position/navigation/timing (PNT) **architecture** to provide an interoperable framework for IOAG member agencies and other participants in lunar exploration.

Committee for the Study of LunaNet Governance (CSLG)

- **Recommend an initial multi-stakeholder governance structure**, approach and functions with respective organizational structure to develop guidelines, policies, and practices that will enable effective LunaNet operations.
- Develop consensus within the government, industry, and academic LunaNet community in defining the implementation and operation of LunaNet governance, with a view to enabling principles, norms, and processes for making decisions and performing activities that shape the use and evolution of LunaNet.

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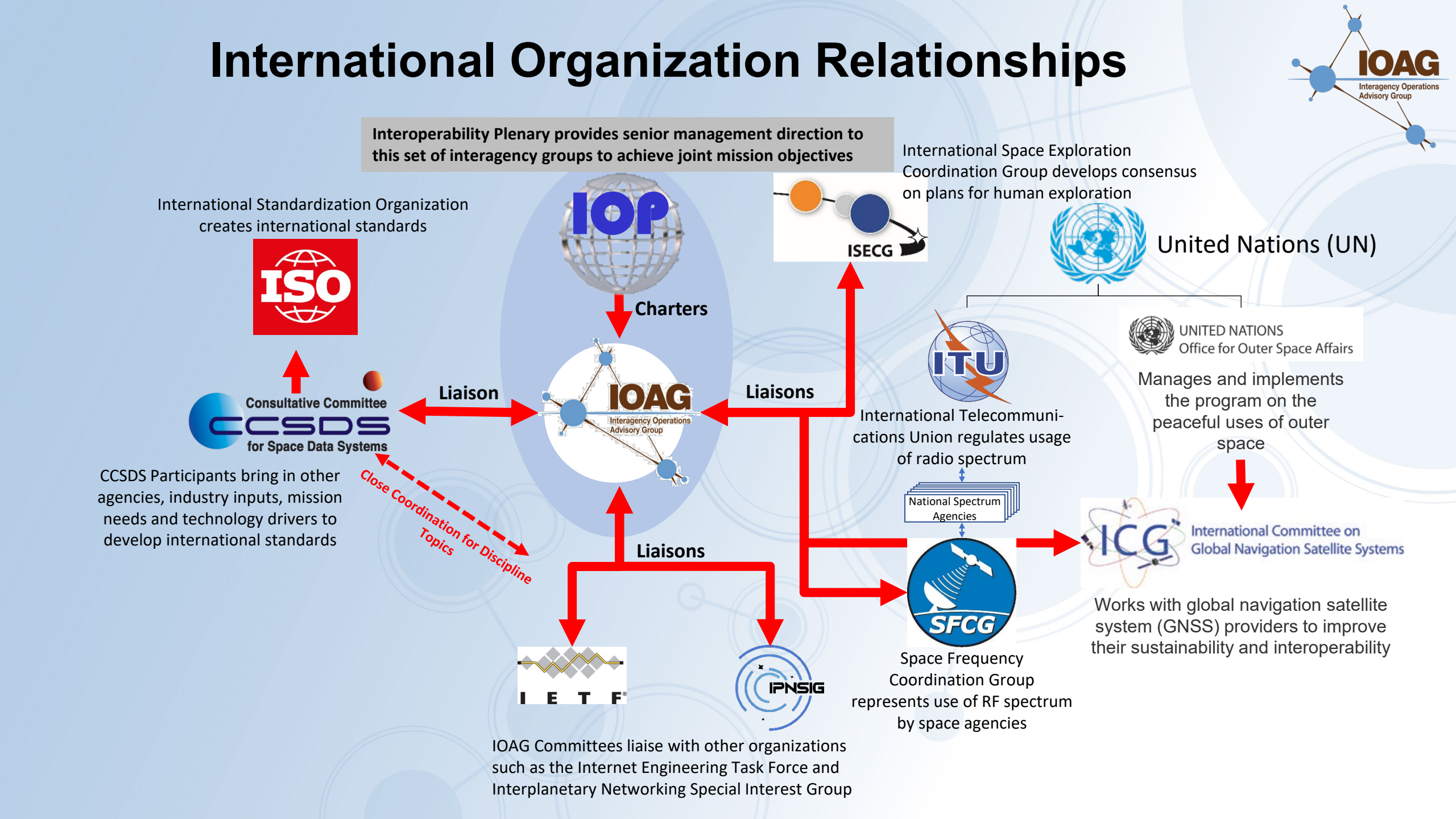
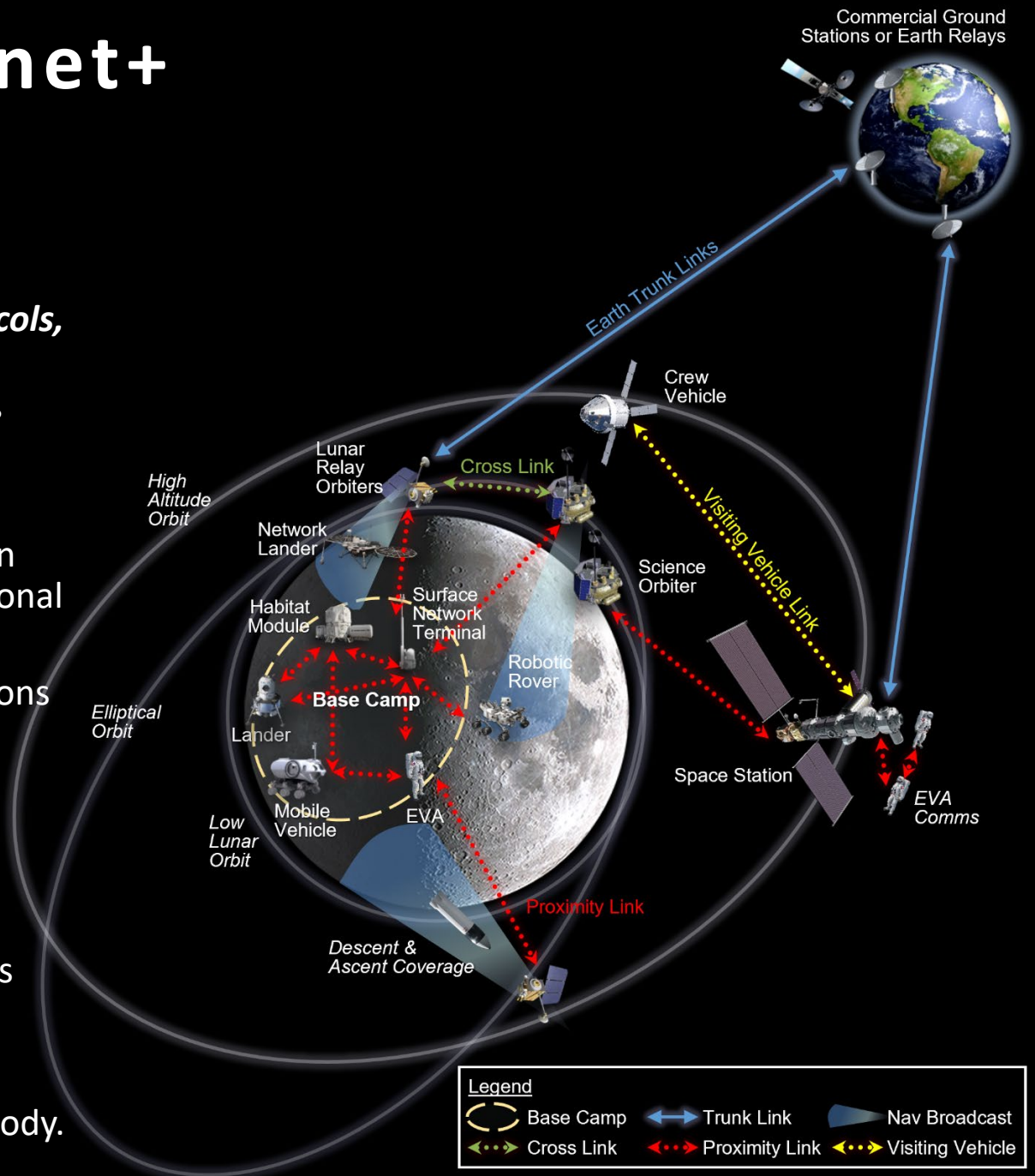


LunaNet, the Lunar Internet+

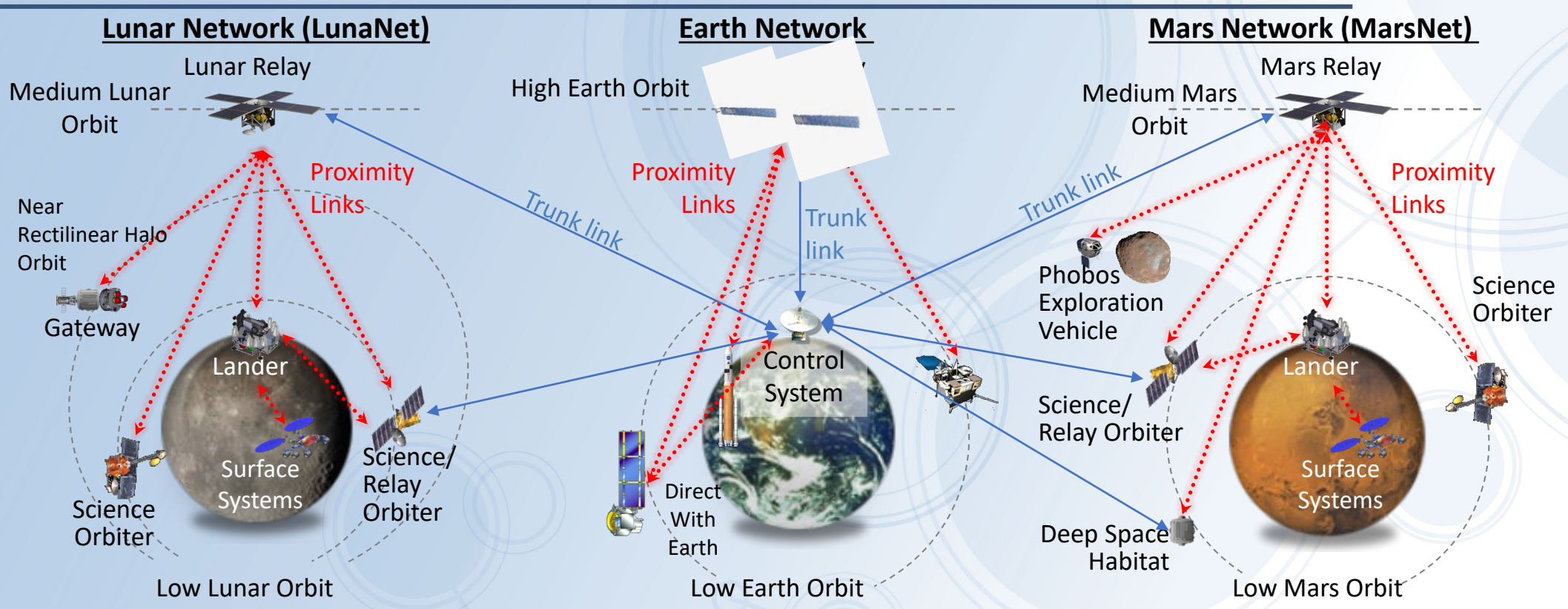
LunaNet is a set of cooperating networks providing interoperable communications and navigation services for users on and around the Moon.

- ***Based on a framework of mutually agreed-upon standards, protocols, and interface requirements that enable interoperability.***
- ***Allows many lunar mission users to engage the services of diverse commercial and government service providers in an open and evolvable architecture.***
  - **Service-Oriented**: LunaNet services can include data transmission and distribution of position, navigation, timing (PNT), and situational awareness information.
  - **Scalable**: LunaNet can be introduced as part of the earliest missions and accommodate expansion as new users and service providers come online.
  - **Open**: LunaNet is based on open international standards like the Internet
  - **Resilient**: As LunaNet grows into many networks and users, it becomes steadily more resilient to individual failures and outages
  - **Secure**: LunaNet protects sensitive and proprietary data while preventing or rapidly recovering from cyber threats
  - **Extensible**: The LunaNet concept is applicable to any planetary body.



LunaNet and Planetary Networks

Planetary Networks: Earth, Moon and Mars - One Architecture



- Strategy: Develop a flexible *planetary network* architecture adaptable to any celestial body to reduce development & operation cost
- User-network **proximity links** (space-space & space-ground/surface) provide standardized services & design for users of planetary networks
- Network-network **Trunk links** are internal network space-ground connections for long distance "back haul"

Governance Objectives

- **Definition:** Governance is the development and application by governments, the private sector and civil society, in their respective roles, of shared principles, norms, rules, decision-making procedures, and organizations that shape the evolution and use of LunaNet in the context of the relevant international legal framework.
  - International law: Outer Space Treaty, Rescue Agreement, Liability Convention, Registration convention, ITU Constitution & Radio Regulations
  - Norms: WTO Reference Paper providing guiding principles for national regulatory authorities in regulating basic telecommunications, Inter-Agency Space Debris Coordination Committee's Space Debris Mitigation Guidelines, Artemis Accords
  - Organizations – Internet: Internet Architecture Board, ICANN, IETF, IGF, etc.
- **Objective:** Recommend a LunaNet governance structure and approach, through which the coordination of architectural aspects can be addressed.
- **Objective 4:** Recommend initial steps to implement the recommended governance approach

➢ *How do technologies and architecture drive or influence governance?*

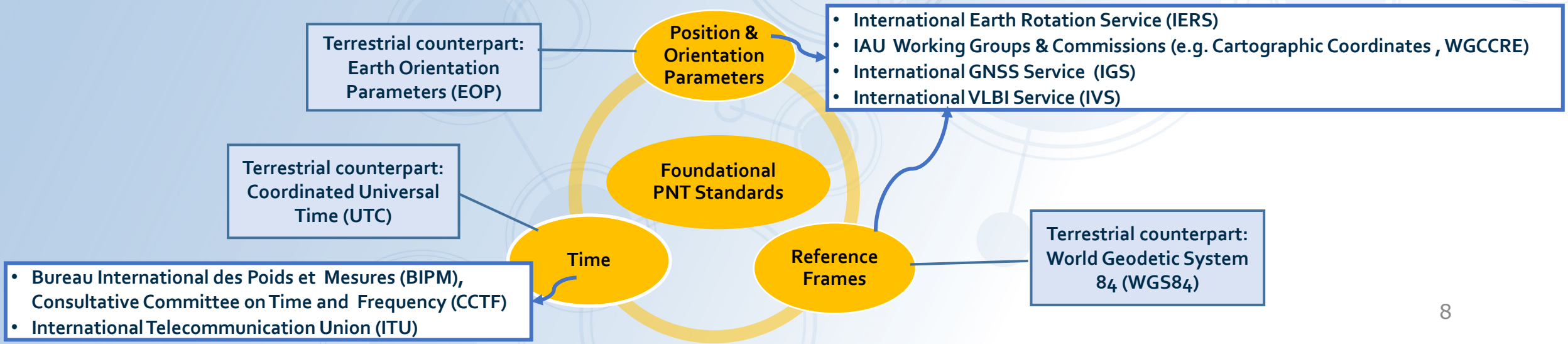
➢ *How does governance drive or influence technology and architecture?*

Guiding Principles for Governance

- Open Architecture
- Interoperability via Open International Standards
- Scalability and Dynamic Connectivity
- Security and Resilience
- Extensibility across the Solar System
- **Consensus-based Decision-Making**
- **Open, inclusive, and transparent peer participation**
- **Availability of Services for all Lunar Users**
- **Applicability of International Regulations**

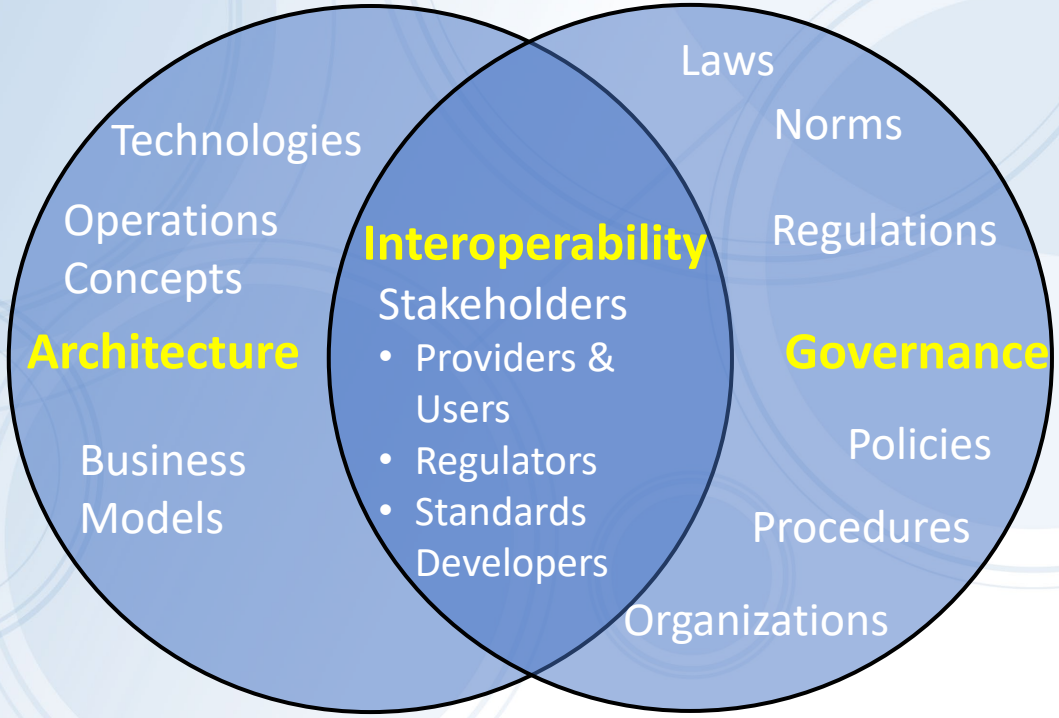
Foundational PNT Standards

- Humankind has enacted international standards for International Celestial Reference System (ICRF) & Int'l Terrestrial Reference System (ITRS)
- New Int'l Lunar Reference System (ILRS) is needed
- National positions need to be integrated into int'l standards
  - Ex: OSTP issued position on Coordinated Lunar Time (LTC)



Conclusion

- Achieving interoperability across cislunar Communications, Position, Navigation & Timing (CPNT) infrastructure (services & capabilities) will require adoption of common:
  - Architecture (& concepts of operation),
  - Development and operations coordination within the community of service providers, users, and other stakeholders
  - Interaction with national & international means of establishing laws, regulations, policies, norms, and standards
- These processes will take years to unfold



- ICG-IOAG Multilateral Cislunar PNT Workshop, February 2025 in Vienna, Austria
  - "The workshop shall: (1) serve as a mechanism to better understand the scope and depth of lunar PNT systems being developed, (2) propose recommendations that may be taken up by lunar PNT developers, and (3) facilitate refinement of interoperable, compatible, and available lunar PNT systems of the future." [ICG-17 Recommendation]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