



INTERAGENCY OPERATIONS ADVISORY GROUP

IOAG LunaNet Coordination Study Preliminary Results

Jim Schier/NASA and Masaya Murata/JAXA
Cochairs, IOAG Committee to Study LunaNet Governance



Need for Lunar PNT Coordination and Introduction of the IOAG CSLG



- IOAG defined Communication & Navigation (C&N) architecture & some concepts of operation in “Lunar Communication Architecture” report, Feb 2022
 - Subsequently expanded to full PNT and renamed “LunaNet”
 - Update to report in progress reflecting work done by NASA on Artemis & SCan, ESA on Moonlight, and JAXA on LNSS including awards to industry
- IOAG established Committee to Study LunaNet Governance (CSLG) to recommend approach to “recommend an initial multi-stakeholder organizational governance structure, approach, and functions ... to develop guidelines, policies, and practices to help fulfill LunaNet's operational responsibilities” that will deliver a “publicly available (open) architecture to provide communications, position, navigation, and timing (CPNT) services to cislunar users” (CSLG ToR, June 2023)
 - Researched comparable examples of complex international systems
 - Establishing criteria for evaluating governance options
 - Defining governance options
 - Plan to score options, select recommended approach, develop implementation approach
 - *IOAG was unable to get participation from all members that would have broadened the scope*

Guiding Principles

Technical
Policy or Regulatory
Both

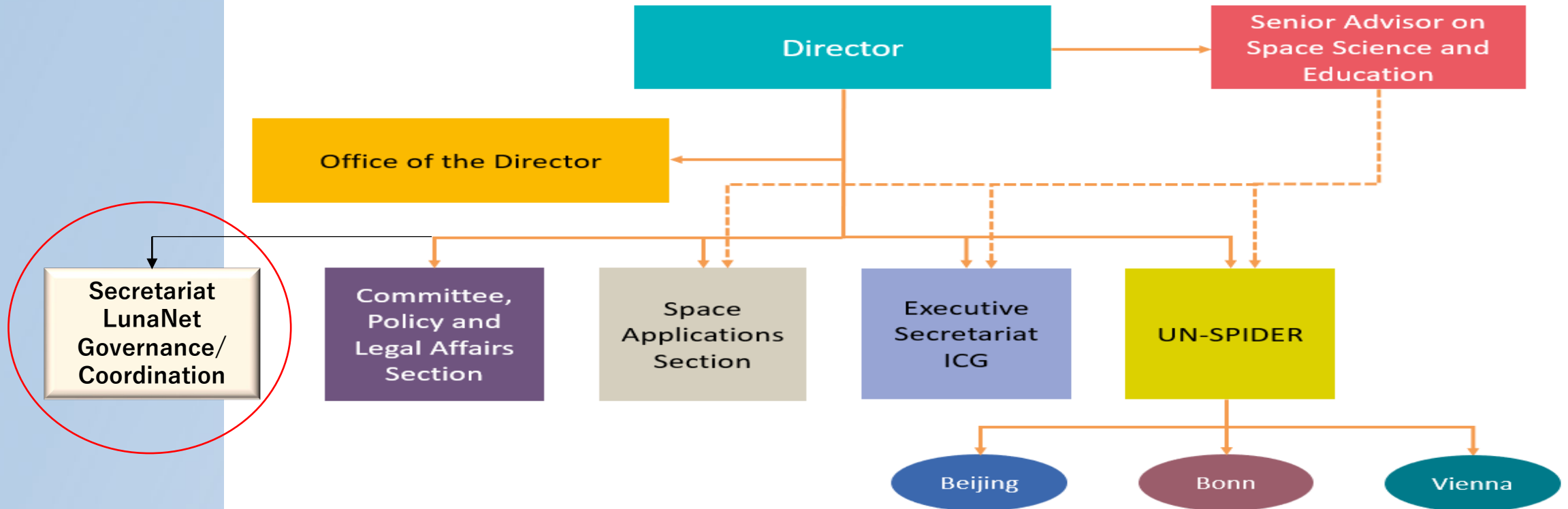


- **Open Architecture:** Open (publicly available) architecture is a LunaNet design principle for the network to enable an environment with voluntary collaboration to share innovative and sustainable ideas, designs, and plans, and to address specific challenges from concept through implementation and operations. LunaNet governance must recognize the technical management principles for efficient network operation and preserve the end-to-end nature of the network and PNT ecosystem. LunaNet's governance arrangements should enable the potential for innovation with respect to technologies and services.
- **Interoperability** via Open International Standards: LunaNet governance should promote development, adoption and use of open international standards to the greatest extent possible to define the architecture and govern the communication, networking, position, navigation, and timing functions of the LunaNet architecture, to allow for interoperable, resilient, secure, and interconnected networks and systems.
- **Scalability and Dynamic Connectivity:** LunaNet governance should preserve the architectural principle of scaling from a network with a single service provider node supporting a small number of users to an unbounded network-of-networks capable of supporting an ever-increasing number of users. The orbits of the Earth, Moon, and satellites as well as the motion of surface systems contribute to a constantly changing network topology that forms and reforms every time a node disconnects or reconnects.
- **Security and Resilience** of the LunaNet: Operational security and resilience are key objectives in LunaNet's architecture. To preserve the integrity of the LunaNet infrastructure, as well as users' trust in LunaNet, governance structures and principles should be developed that assess and mitigate threats and vulnerabilities while creating a robust architecture that operates through and recovers from incidents.
- **Consensus-based Decision-Making:** LunaNet policymaking, management processes and coordination should be achieved through broad representation of the LunaNet community, appropriate to its mission, and informed by practical experience and the individual and collective expertise of a range of stakeholders. Decisions should be reached through accountable processes that are based on consensus (multi-stakeholder model), where interested stakeholders can directly participate in the work and have access to its results.
- **Open and transparent peer participation:** The development and implementation of LunaNet governance should transpire in an open, transparent, and accountable manner. The full participation of governments, the private sector, academia, and the technical community as peers, considering their specific roles and responsibilities should ensure that outcomes are effective and accepted. The development of LunaNet governance policies and arrangements must allow and promote harmonization, ... and efficient use of LunaNet among stakeholders.
- **Extensibility** across the Solar System: LunaNet will be architected and implemented to be a much more advanced multi-service-providing network with integrated functionality, in contrast to the much simpler planetary networks that have been used in the past. The LunaNet architecture should be extensible to Mars and other instances in the Solar System, eventually forming the first planetary network of the Solar System Internet (SSI).*
- **Availability of Services for all Lunar Users:** LunaNet services are intended to be made available for all users in the lunar region – in transit to and from the Moon, in orbit around the Moon, in transit between orbit and surface, and on the surface. To the greatest extent possible, services should have the same provider/user interface and service characteristics regardless of user location. The fully developed architecture should be able to expand coverage and capacity to meet user demand anywhere within the lunar region.
- **Applicability of International Regulations:** Governance will be developed in accordance with applicable treaties such as the Outer Space Treaty and international regulations such as the ITU Radio Regulations while identifying possible changes to the international legal framework needed to govern LunaNet.

* CCSDS 730.1-G-1, Solar System Internetwork (SSI) Architecture, July 2014.

Example Option: Add Secretariat of Lunar/LunaNet Governance under the UN?

UNOOSA Organisational Chart



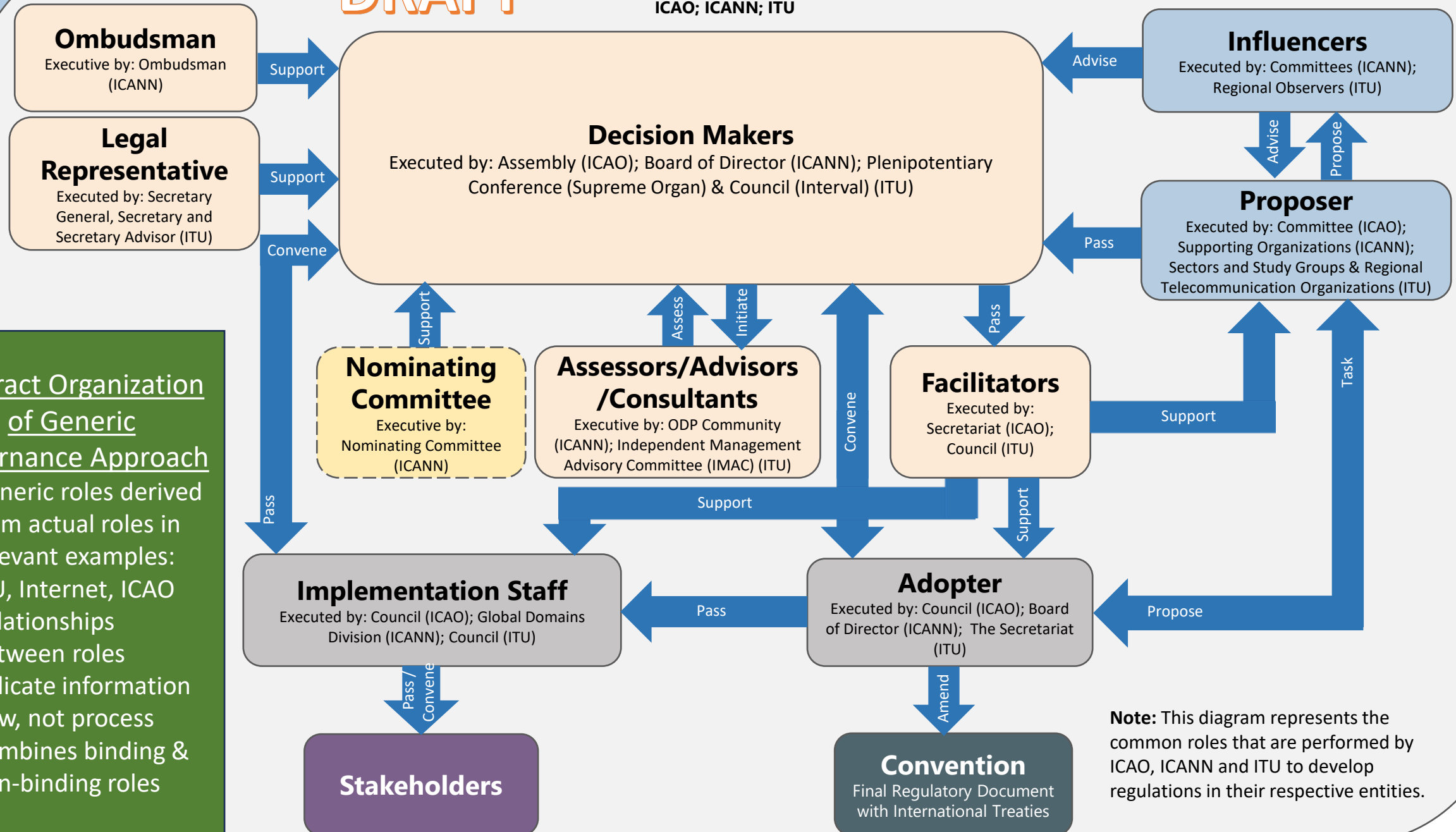
<https://www.unoosa.org/oosa/en/aboutus/structure.html>

UNOOSA is an office of the UN Secretariat that promotes and facilitates peaceful international cooperation in outer space and assists developing countries in using space science and technology for economic and sustainable development.

Top Level: Role-based Org Structure

DRAFT

Members
ICAO; ICANN; ITU



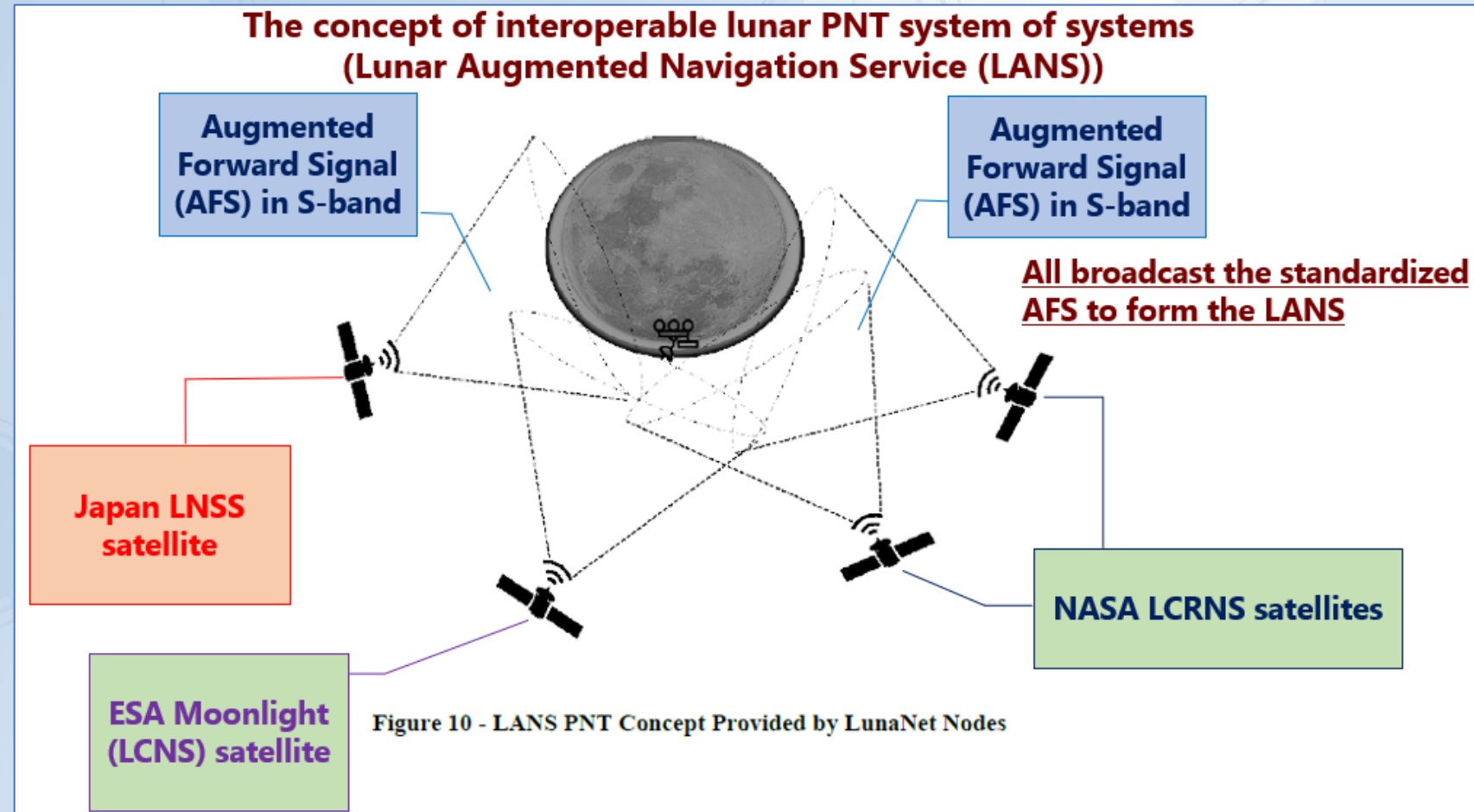
Abstract Organization of Generic Governance Approach

- Generic roles derived from actual roles in relevant examples: ITU, Internet, ICAO
- Relationships between roles indicate information flow, not process
- Combines binding & non-binding roles

Note: This diagram represents the common roles that are performed by ICAO, ICANN and ITU to develop regulations in their respective entities.

PNT Technical Coordination Needs

- Allocation and assignment of PRN Codes to LunaNet Service Provider (LNSP) nodes
- Allocation and assignment of subFrame ID (in SB3, SB4) among LNSP nodes
- Necessary data sharing among LNSP
- Service and Signal-in-Space-Error (SISE) monitoring
- Reference orbits to maximize the LANS performance



Initial PNT Services Pave the Road to Future Cislunar Space Traffic Management



Near-term Coordination Concept

- Need coordination among the Agencies committing funding to start efforts, optimize resources to meet early user needs, & establish a wider LunaNet community.
 - IOC operational period for PNT services starts 2026 for NASA, with additional ESA contribution in early 2028, & Japan in 2029.
- The proposed concept is to form the nonbinding coordinated LunaNet administration partners for self-administering critical topics in Communications & PNT amongst the Agencies and the commercial providers in a similar manner to how we have worked through the interoperability development.
 - Intent is to establish initial technical baseline documents, build or acquire initial operational capabilities for early users, & expand into or be replaced by a more permanent construct for long-term governance
 - NASA, ESA & JAXA have already produced the initial LunaNet Interoperability Specification (LNIS) and used it as the basis for awarding contracts

Long-term Coordination

- Research shows a significant gap between treaties and established international & national space law regarding cislunar PNT
- Similar to precedents like the Internet, establishing cislunar PNT capabilities as part of a broader lunar ecosystem will drive development of coordination mechanisms to support peaceful cooperation and competition that promote compatibility
- The result will include technical collaboration among LunaNet providers & users with well-defined architecture, services, and business environment including standards organizations, testing / validation to maintain interoperability, and processes for evolving systems as technologies & businesses change

Summary



- Based on principles of good neighbors
- Newly established ICG WG-L (Lunar PNT) will study international cooperation beyond the scope of LunaNet
 - WG-L tasks include Lunar PNT international cooperation models: Work with appropriate international organizations to investigate and recommend international cooperation models that enable sustainable development and operations of lunar PNT systems.
 - How will different cislunar PNT systems relate for compatibility (non-interference) and interoperability?
- IOAG currently only attempting to evaluate technical coordination needs for LunaNet community:
 - Early approach will rely heavily on extending scope of existing organizations like ITU, IAU, ICG, & IETF from terrestrial regulation & standards to address needs for new cislunar regime
 - Need holistic approach involving all major international actors
 - May be template for future Mars PNT efforts as current Mars Relay Network is refreshed