



IPNSIG Architecture and Governance Workshop



2023 May 30, 1700-1830 US Eastern

Speakers : Yosuke Kaneko, Vint Cerf, Marc Blanchet

Moderator: Jim Schier

Gateway Integrated Spacecraft

Co-manifested (PPE/HALO)
Launch Vehicle (not pictured)

SPACEX

Power and Propulsion
Element (PPE)

MAXAR

Gateway External
Robotic System (GERS)



Logistics Module

SPACEX

HTV-XG logistics
resupply capability



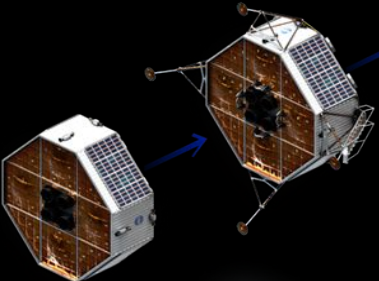
ESPRIT-Refueler



Airlock
Provider TBD

Human Landing
System (HLS)

(government reference
concept shown)



Habitation and Logistics
Outpost (HALO)

NORTHROP
GRUMMAN

International Habitat
(I-HAB)



Orion



Surface Habitat for
longer duration stays

ARTEMIS

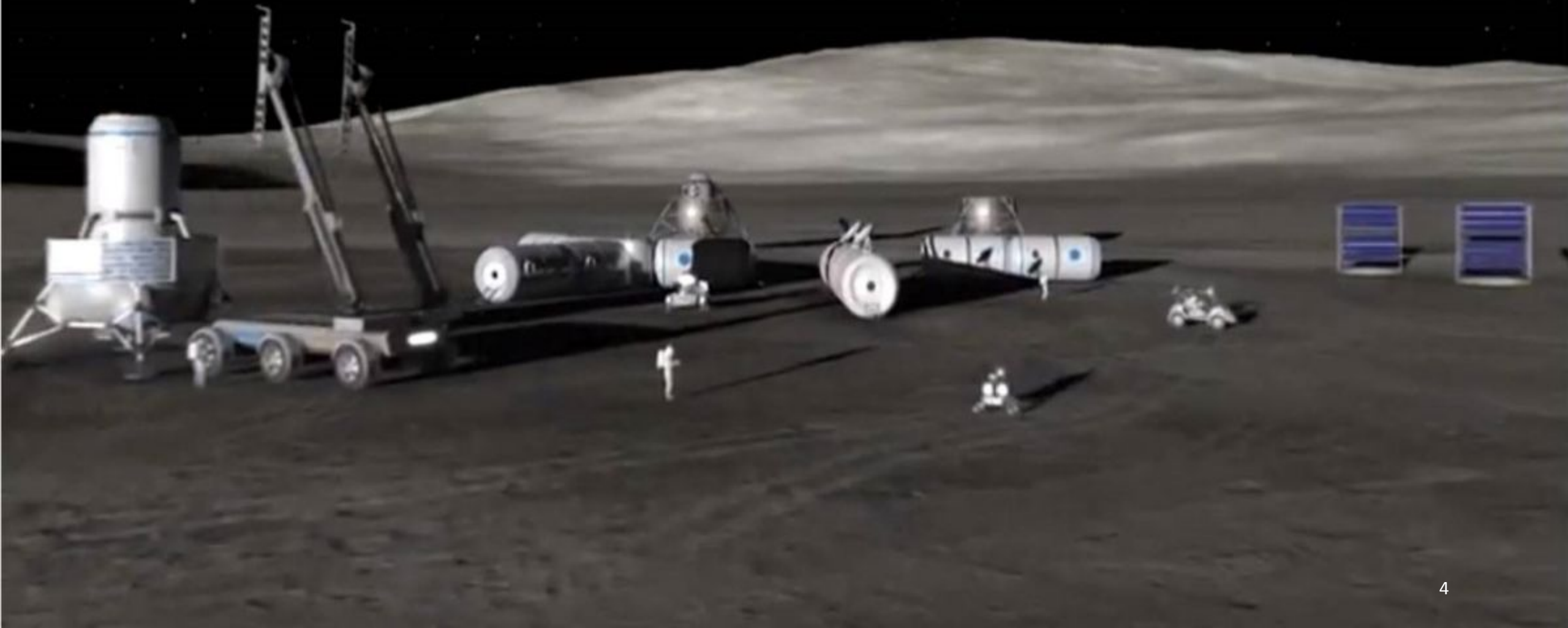
Base Camp

A truly sustainable infrastructure on the lunar surface

Pressurized rover
for longer range

Early unpressurized rover for
exploration and construction

ESA's Moon Village Concept



The Artemis Accords

Principles for a Safe, Peaceful, and Prosperous Future

PEACEFUL PURPOSES

Conduct activities for peaceful purposes, per the tenets of the Outer Space Treaty

TRANSPARENCY

Publicly describe space policies and plans in a transparent manner

INTEROPERABILITY

Use open international standards and support interoperability

EMERGENCY ASSISTANCE

Provide emergency assistance to those in need

REGISTRATION OF SPACE OBJECTS

Join the Registration Convention and register public and private activities in space to avoid harmful interference

RELEASE OF SCIENTIFIC DATA

Release scientific data publicly to ensure the entire world can benefit from space exploration and discovery

SPACE RESOURCES

Extract and use space resources under the auspices of the Outer Space Treaty

DECONFLICTION OF ACTIVITIES

Provide public information about the location and general operations of activities on the Moon to inform scale and scope of 'safety zones'

ORBITAL DEBRIS AND SPACECRAFT DISPOSAL

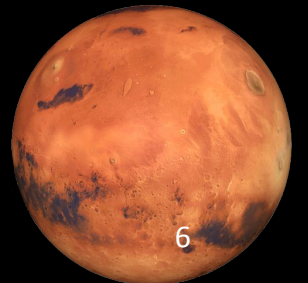
Plan for the mitigation of orbital debris

24 Current signatories: Australia, Bahrain, Brazil, Canada, Czech Republic, Columbia, France, Israel, Italy, Japan, Luxembourg, Mexico, New Zealand, Nigeria, Poland, Republic of Korea, Romania, Rwanda, Saudi Arabia, Singapore, Ukraine, United Arab Emirates, United Kingdom, United States of America

Architecture and Governance Workshop

Today, there are several efforts by the Government, Space Agencies and the private sector that expands communication capabilities off the planet, to the Moon, Mars and beyond.

How could we realize a “**Common Interplanetary Network**” from an Architectural and Governance perspective?



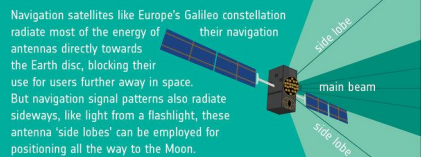
Lunar Exploration, mid 2020s -

LunaNet - Lunar Internet

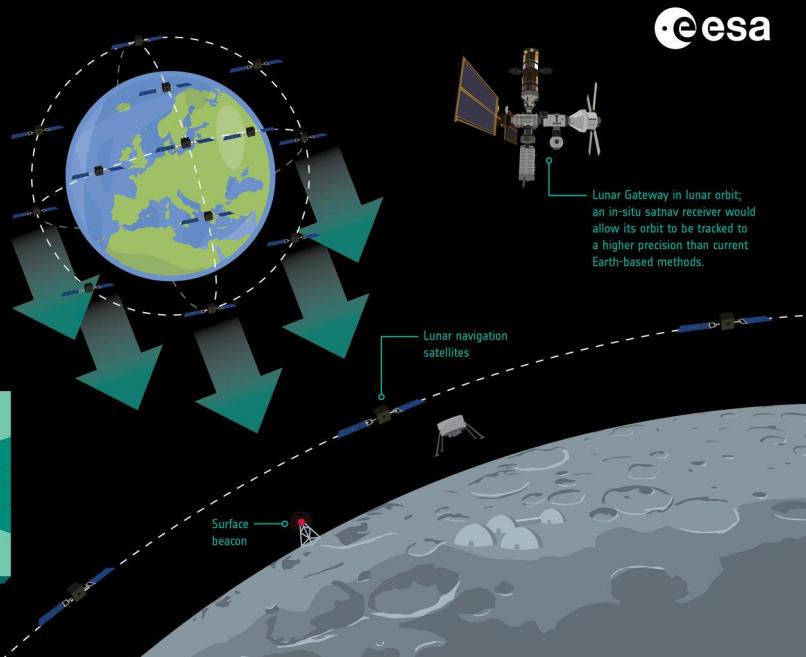
MOONLIGHT

Navigation and Telecommunications for the Moon

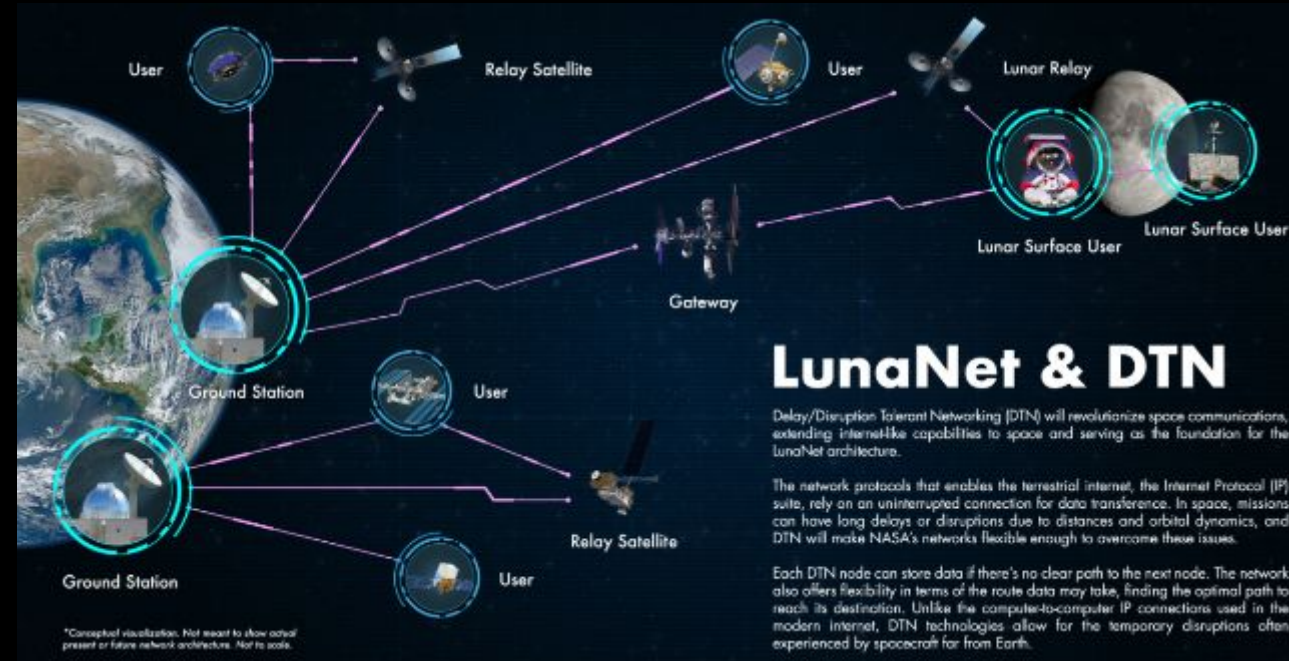
ESA's Moonlight initiative involves expanding satnav coverage and communication links to the Moon. The first stage involves demonstrating the use of current satnav signals around the Moon. This will be achieved with the Lunar Pathfinder satellite in 2024. The main challenge will be overcoming the limited geometry of satnav signals all coming from the same part of the sky, along with the low signal power. To overcome that limitation, the second stage, the core of the Moonlight system, will see dedicated lunar navigation satellites and lunar surface beacons providing additional ranging sources and extended coverage.



#Moonlight

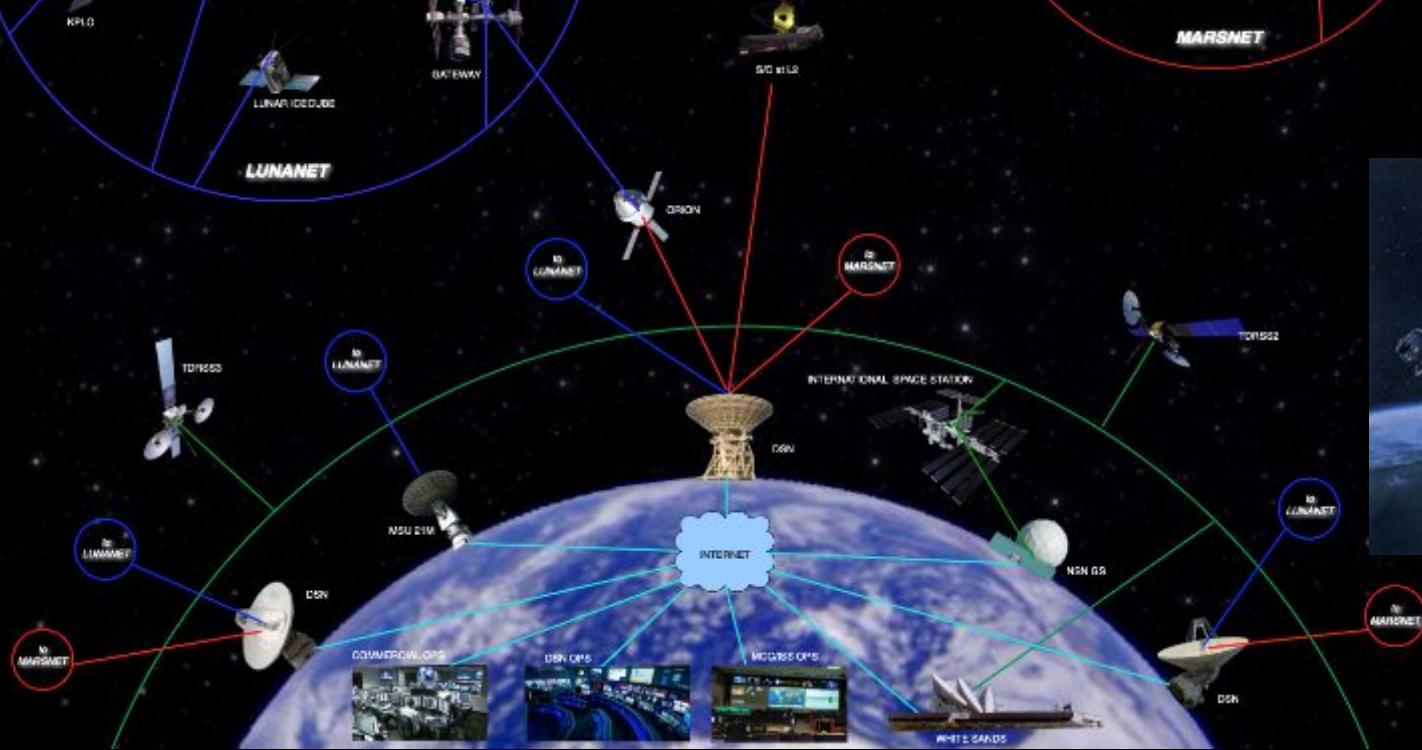
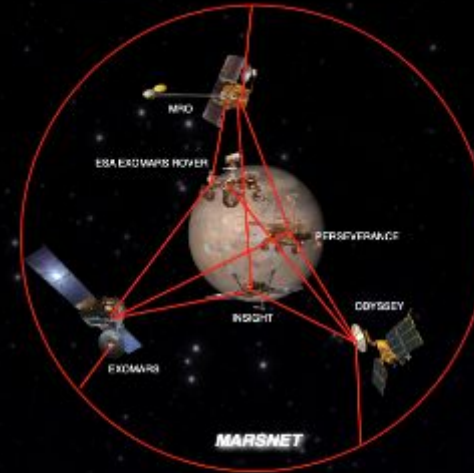


ESA's implementation

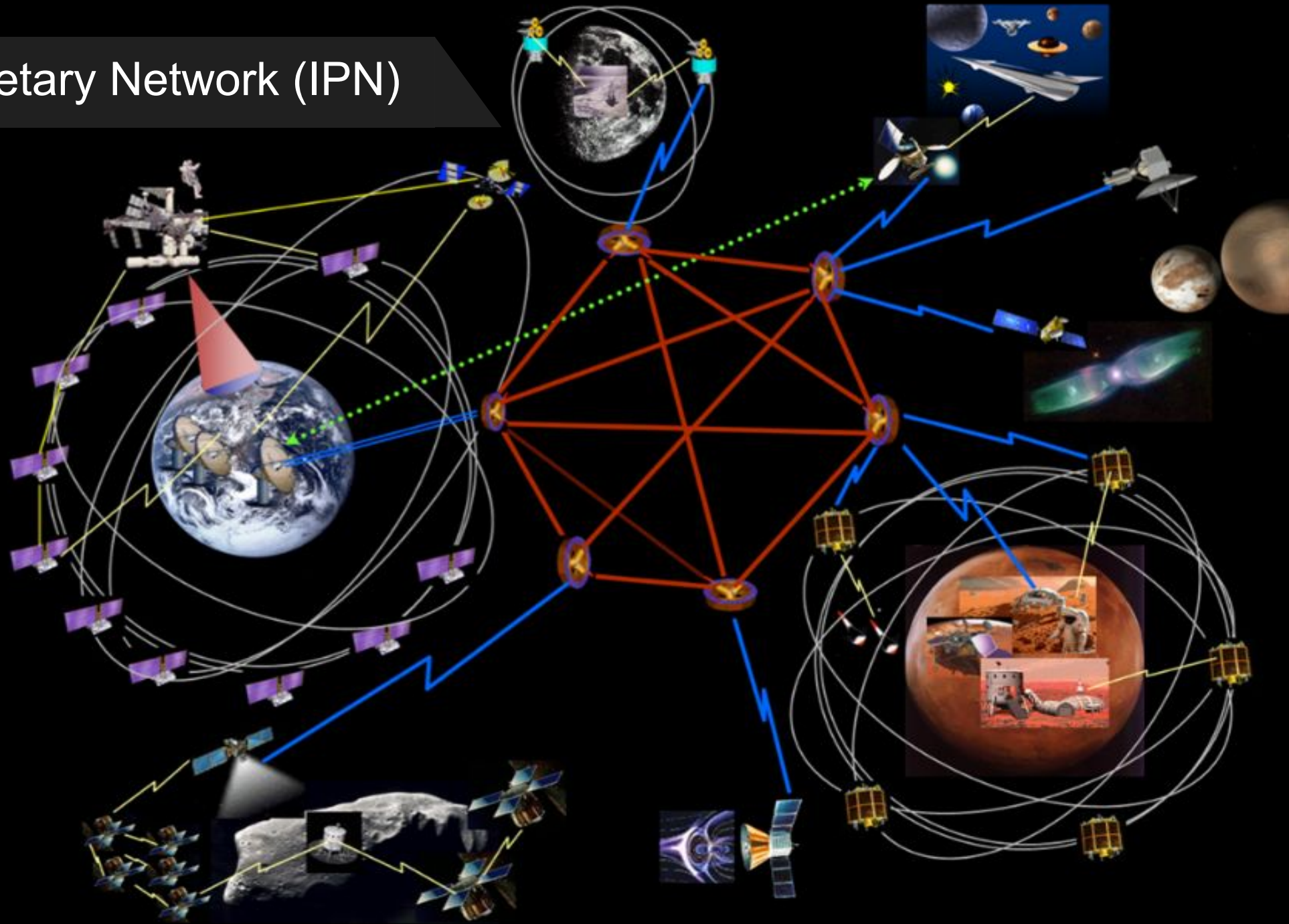


NASA's implementation

Earth – Lunar – Mars Network backbone, 2050s -



Interplanetary Network (IPN)





**VISION &
enabling
CONCEPTS**

IPN as a Common Structure that benefits humanity

- Leads to sustainable and resilient human and robotic activity
- Enables Innovation
- Sharing of Vision, Co-creation with Public & Private Sector is Key
- Coherence in architecture
- Collaborative Governance

Today - Impetus from around the globe



aws



TELESPAZIO
a LEONARDO and THALES company



Microsoft
Azure Orbital



hispasat



Google Cloud



KDDI



OneWeb



AIRBUS



STARLINK



SURREY



ThalesAlenia
Space
a Thales / Leonardo company

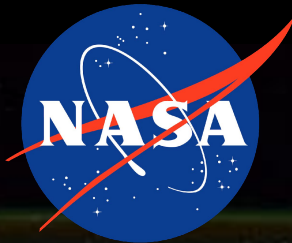
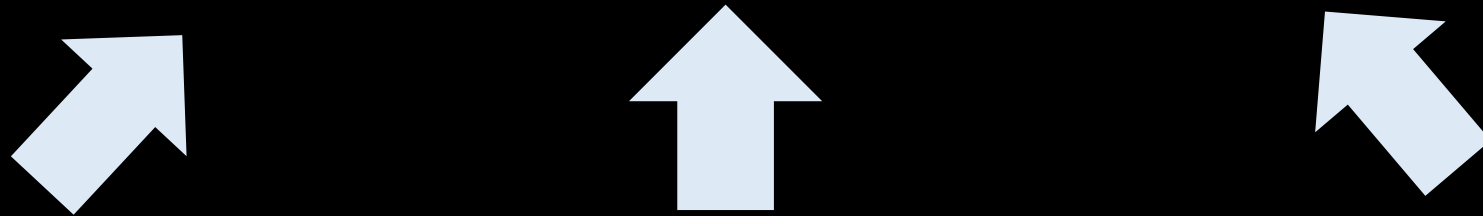


SES



NOKIA Bell Labs

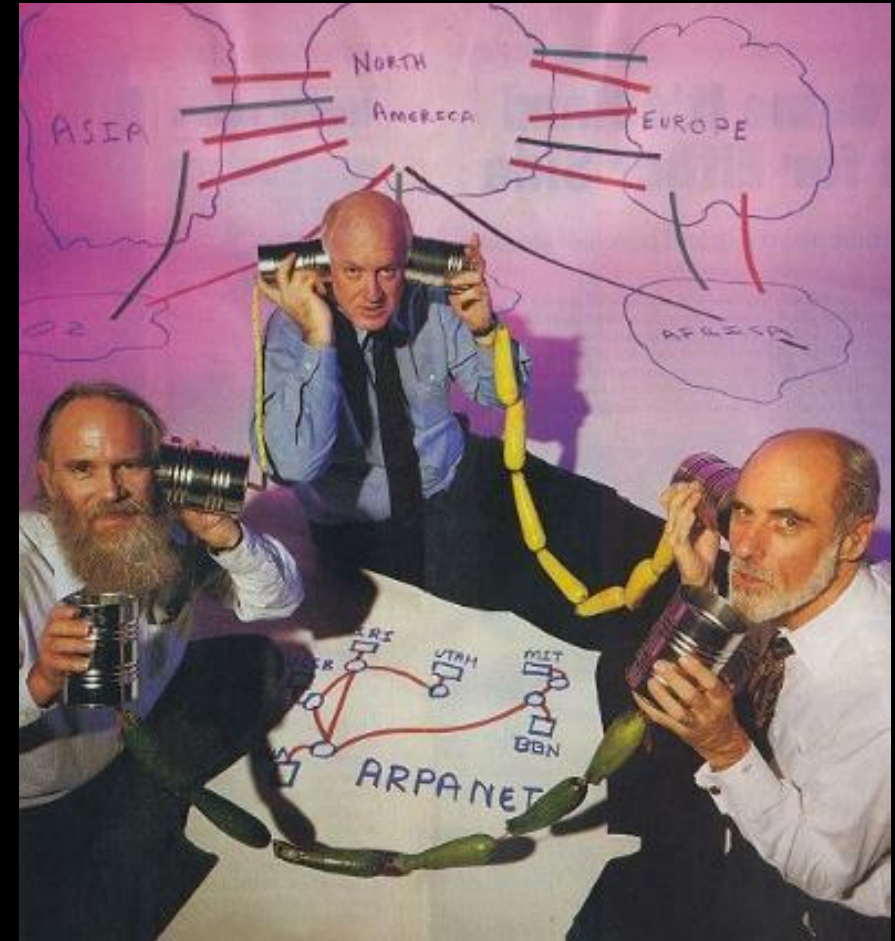
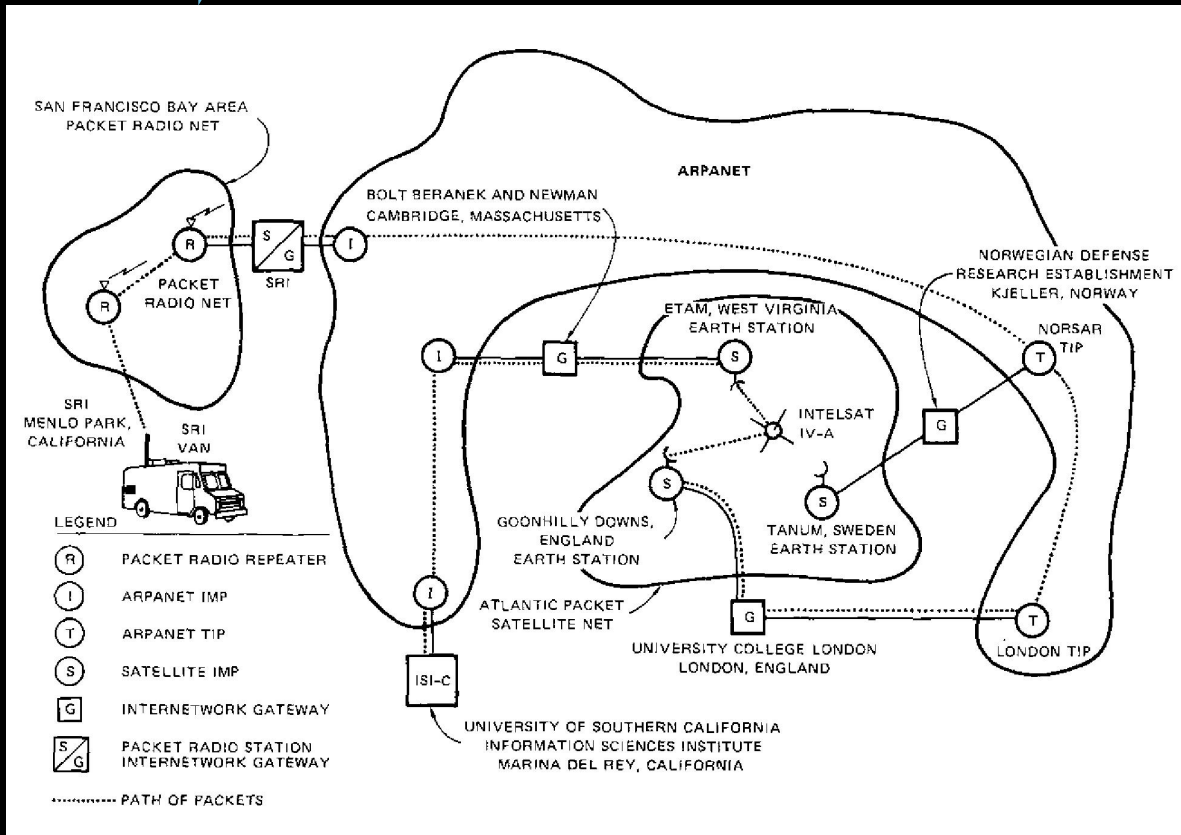
Could we achieve a Common Interplanetary Internet?



Analogy

- 1983 Jan 1st, TCP/IP protocol ran on ARPANET, SATNET, PRNET via Gateways.

➡ the “Internet” became Operational



Pictures provided by courtesy of Vinton G. Cerf (left) and Newsweek Magazine (right)

IPN Governance is a theme today

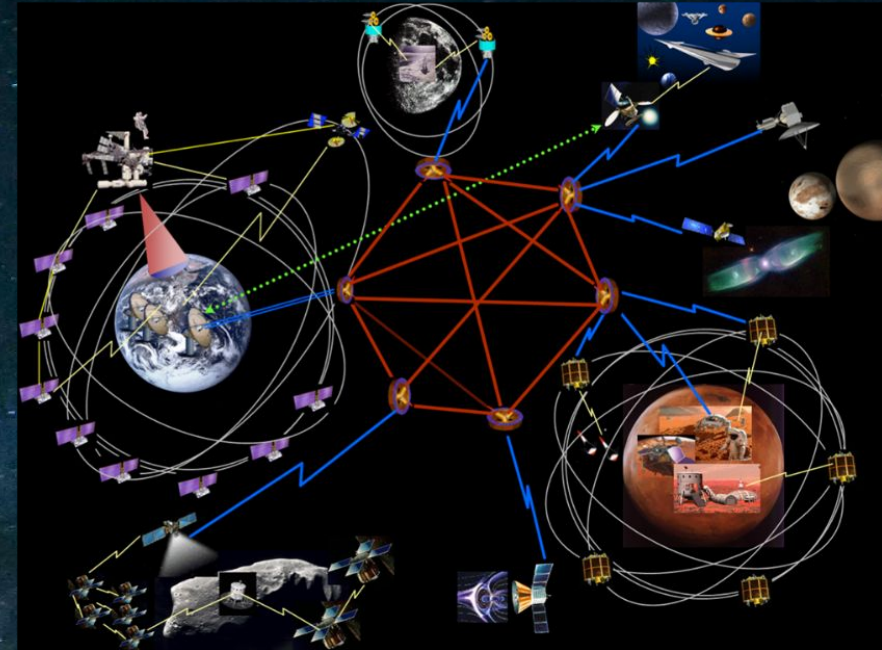
- Common IPN
- Build of IPN is already starting
- Lessons from the Internet

Internet's history,

“Technology first and Governance after”

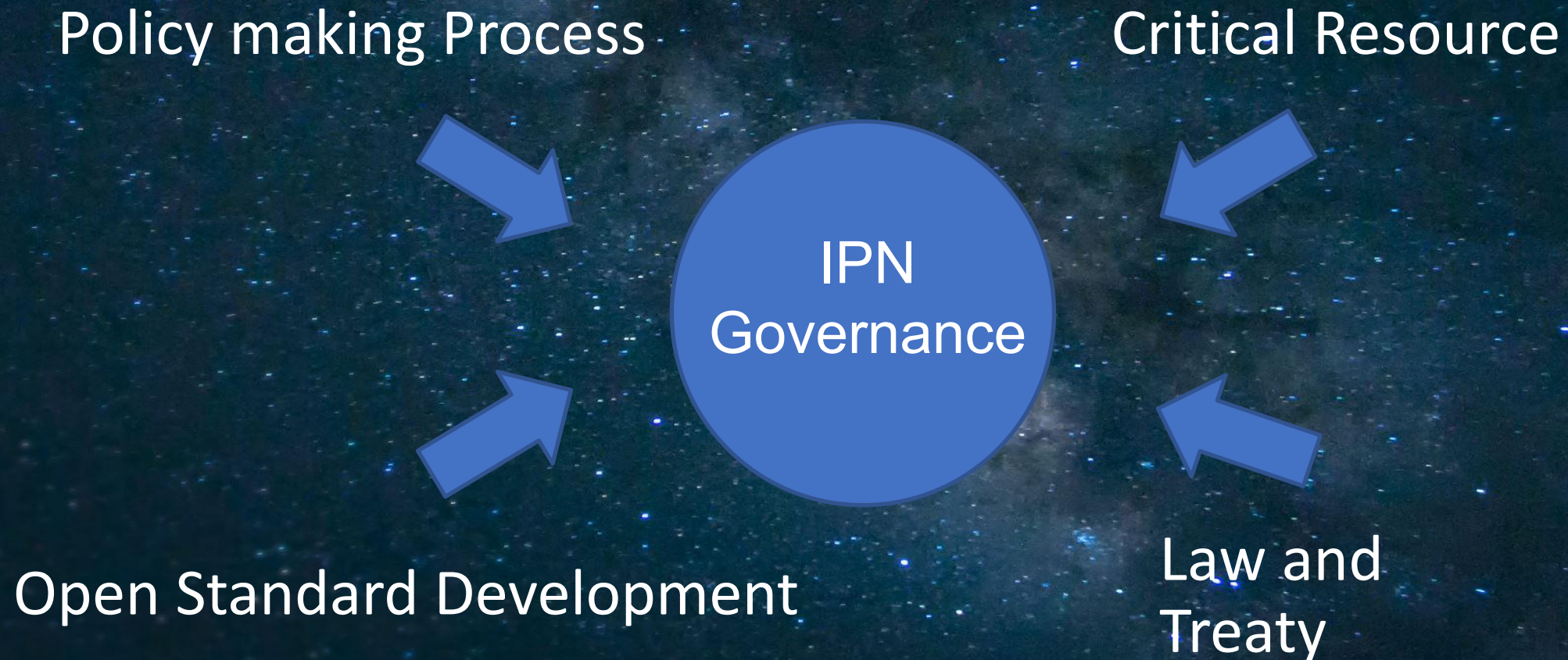
For IPN,

“Governance now a high priority as new era of Space Exploration begins”



IPN Governance -

“The administration and management mechanisms, its supporting institutions and their practices toward an open, accessible and common Interplanetary Network that is built, operated and used by the various entities.”



Architecture and Governance Working Group



Yosuke Kaneko
[IPNSIG Chair, AWG Lead]



Vint Cerf
[IPNSIG founder]



Scott Pace
[George Washington Univ.
Director of the Space Policy Institute]



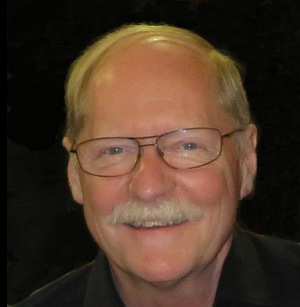
Marc Blanchet
[President, Viagenie]



Jim Green
[Formerly NASA chief scientist]



Scott Burleigh
[Formerly NASA/JPL]



Leigh Torgerson
[NASA/JPL]



Dave Israel
[NASA]



James Schier
[NASA SCAN]



Felix Flentge [ESA]



Ed Birrane
[IETF DTN WG Chair]



Kiyohisa Suzuki
[CCSDS, JAXA]



Ginny Spicer
[IPNSIG TDWG]



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Laura Chappell
[IPNSIG TDWG]



Oscar Garcia
[IPNSIG PWG lead]



Laura DeNardis
[Georgetown Univ.
Senior Fellow]



Keith Scott
[Former CCSDS, MITRE]



Henry Danielson
[IPNSIG TDWG]



Helen Tabunshchyk
[IPNSIG AWG Secretariat]

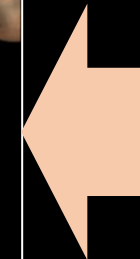
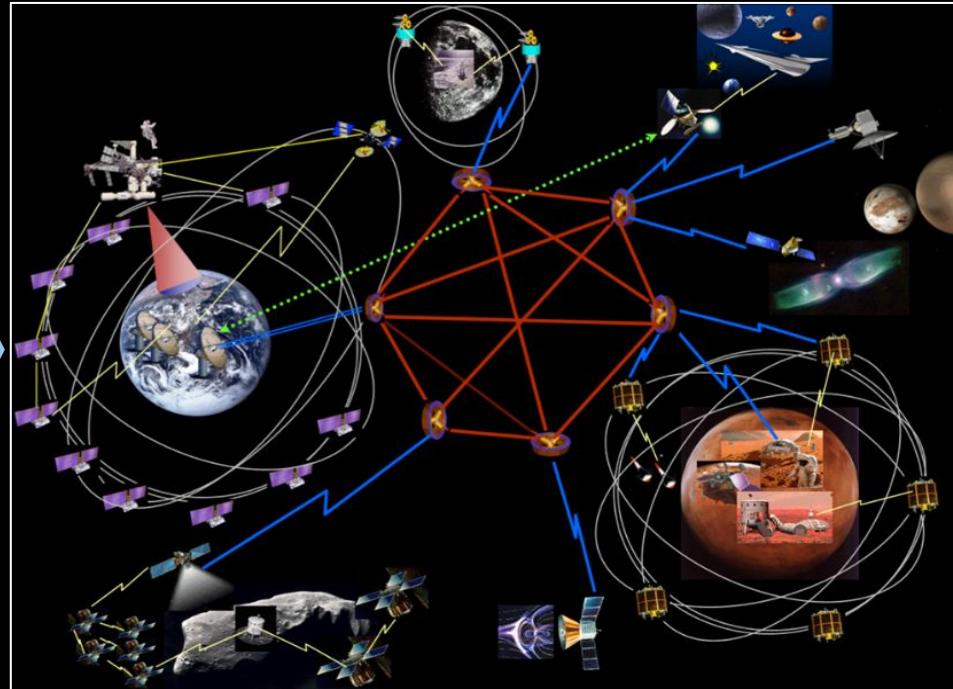
FRAMING THE ISSUE (CORE QUESTIONS)

The Interplanetary Internet could be made up of multiple, independent but interconnected networks requiring collaboration and coordination to function

ARCHITECTURE

How could the various networks work as a whole to form a Common Interplanetary Network?

- ◆ Space Agency NWs
- ◆ Private Sector NWs
- ◆ Academic NWs



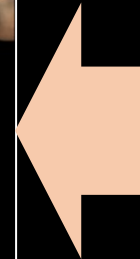
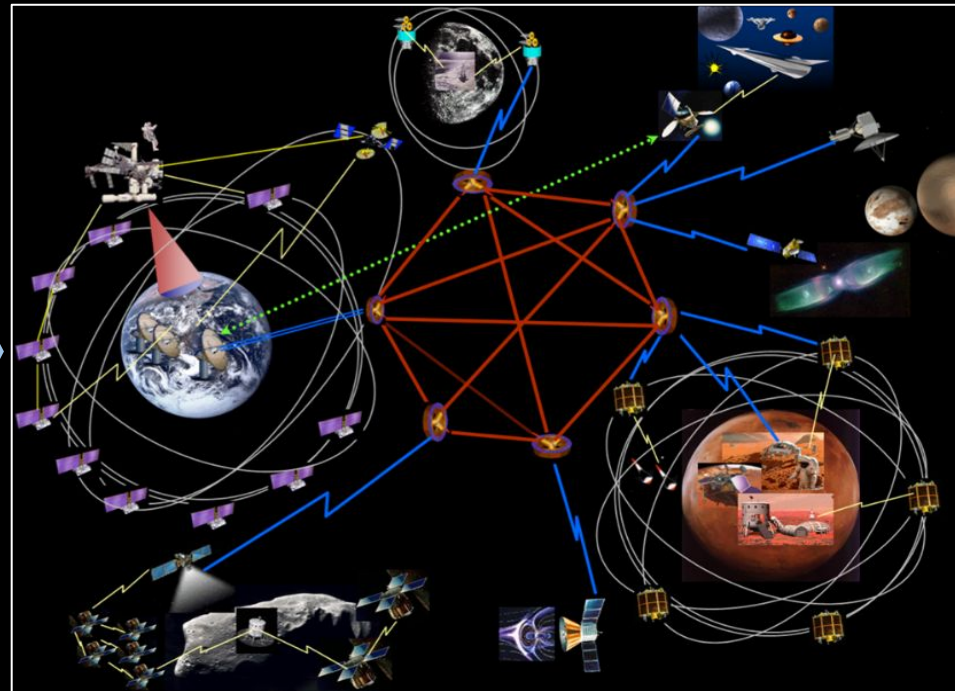
GOVERNANCE

- What institutions and governance practices would be needed to support such multi-party complexity?
- What do we need to govern anyway?
- Who does the job?
- What Governance model should it employ?

VIEW POINTS & CONSIDERATIONS

ARCHITECTURE

- IP and BP may coexist
- Workable strategy to deploy IP in Space
- Routing methods over Interplanetary distances
- Interoperability
- Scalability



GOVERNANCE

- Unique Space Challenges
- Space Governance Context
- Internet Governance Applicability
- Lessons from the Internet

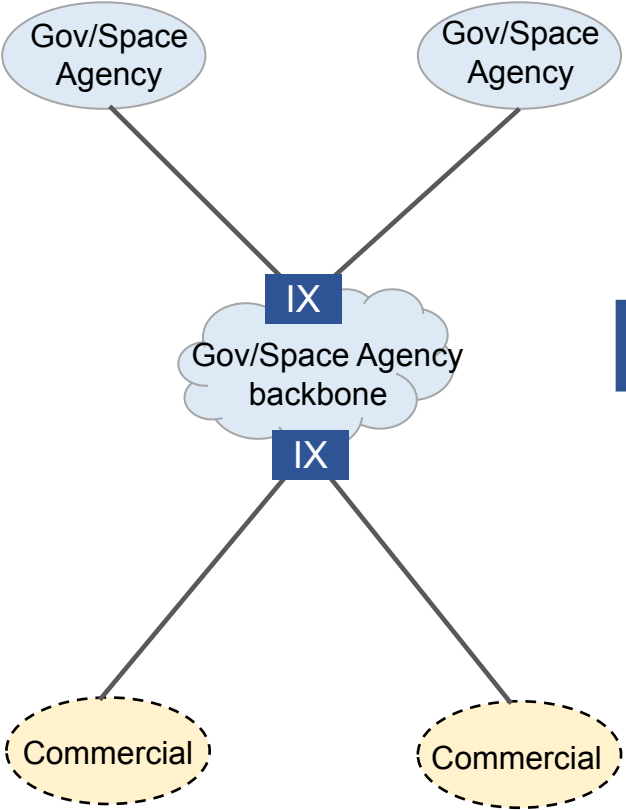


ARCHITECTURE

What's Ahead of us?

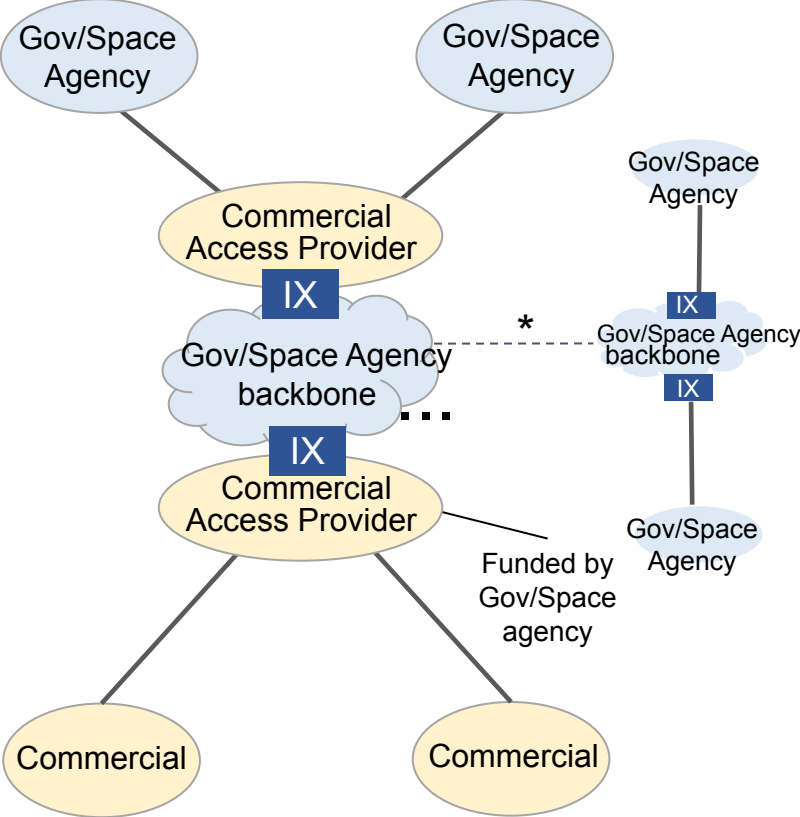
Possible IPN Evolution

Ph1 Today



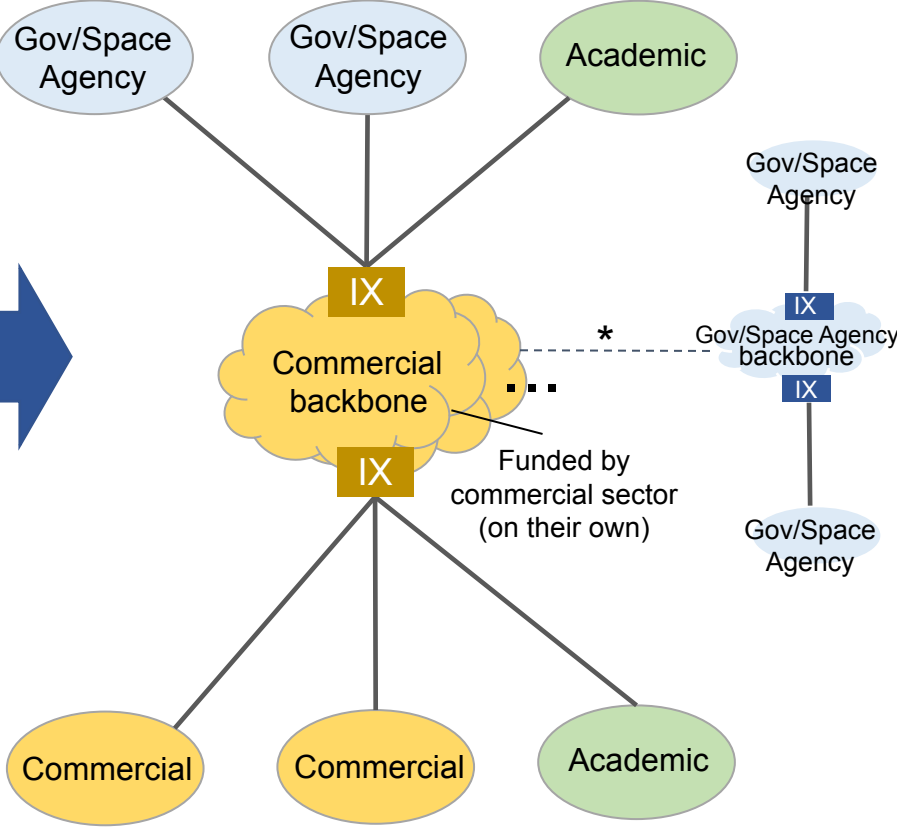
Gov/Space Agency funds its backbone to serve their own missions.
Commercial nodes are just users of the backbone.

Ph2 Transitional



Gov/Space Agency "funds" to commercial access providers to support their own missions and for commercial users.
* can be interconnected

Ph3 Mid-term (+10 to 15 years)



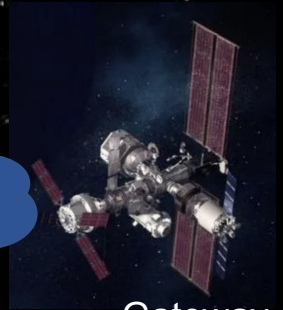
Various users to utilize the commercial backbones as a "service" to support their own mission/purpose.
Commercial backbones becomes operational (assuming there is sufficient market)
* can be interconnected

IP networks on the Moon?

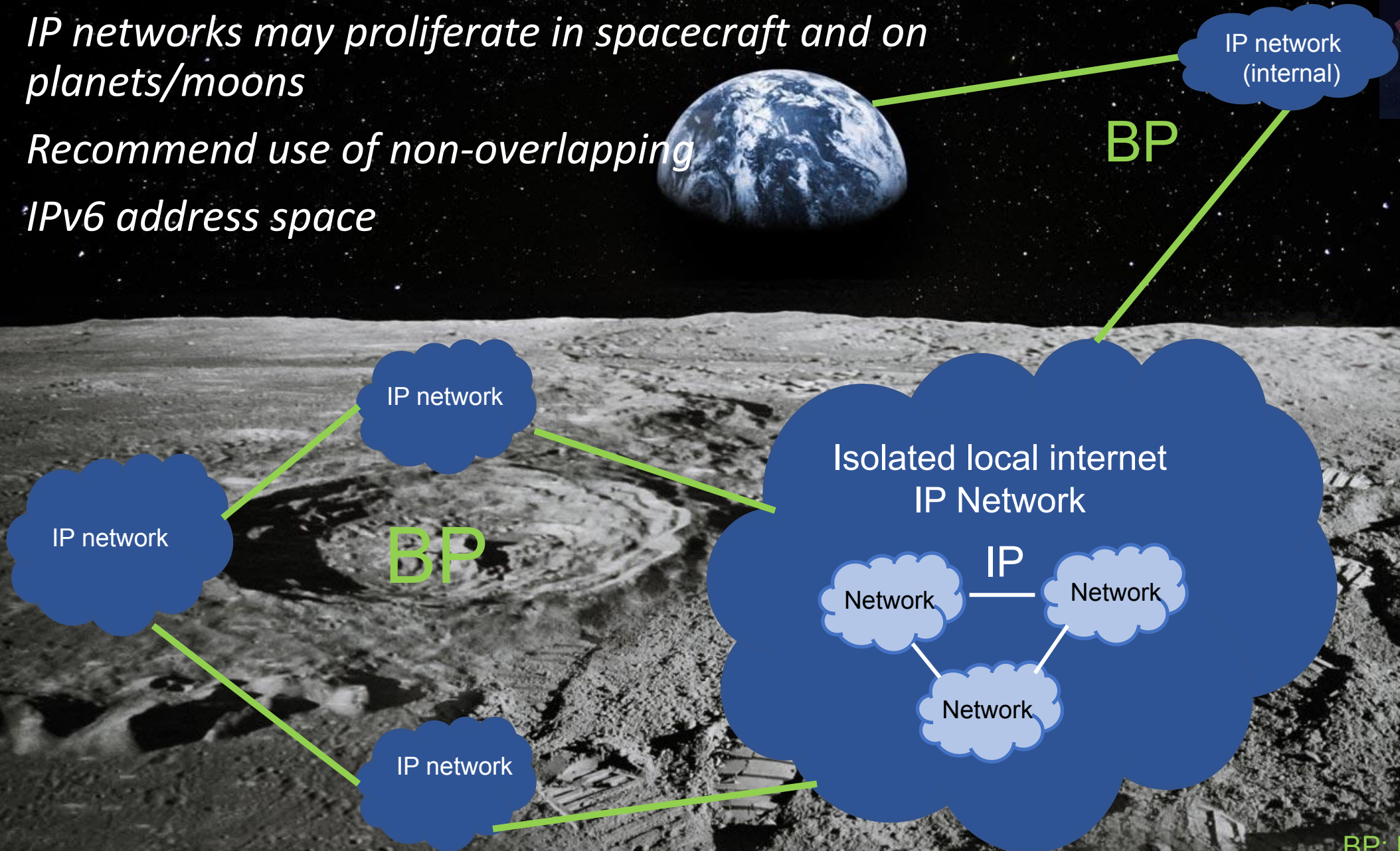
IP networks may proliferate in spacecraft and on planets/moons

Recommend use of non-overlapping

IPv6 address space



Gateway



IP deployment in Space

IP usage is a conceivable scenario

Due to its maturity on Earth and given its affordability, Internet Protocol (IP) can be a viable option to be used on & around the Moon and other planetary bodies.

However, IP network on one planetary body may not be IP reachable to another planetary body or IP network.



IP deployment in Space

Approach

- **Extend IPv6 Address space**
 - Leverage large address space, that is non overlapping
 - 2-way reachability (compared to NATed IPv4) - key to remote management
 - Avoids future conflicts or address leaks
 - Leverage existing Earth IP management system for organic transition
- **BGP for local Routing**
 - Within a planetary body IP network, there could be multiple networks owned and managed by different organizations
 - Their interconnections must use a policy-based AS routing protocol
- **Autonomous System Numbers (ASN)**
 - Must use non-overlapping numbering space
- **Domain Names**
 - Naming for IP nodes and services are needed - local deployment needed
 - Some binding with Earth DNS is desirable but requires careful design
 - Useful to provide service discovery of DTN services from the IP nodes and applications
 - Non-overlapping naming space must be used - Actual naming structure and hierarchy to be discussed
 - Leverage existing Earth IP management system for organic transition

IP deployment in Space

Our Challenge

- How to combine DTN (Bundle Protocol) use in conjunction with IP usage
- On the Moon, Mars and in transit to other planetary bodies
- Examples such as Email and HTTP, Media (such as Video transfer) over DTN would be a test case to validate the architecture
- Application Protocol Standards



Managing IPv6 networks in the Solar System

Views from Vint Cerf

(Chair of the Leadership Panel of the Internet Governance Forum)

- Bundle Protocol Suite forms the backbone of the Solar System Internet
- IPv6 networks may proliferate in spacecraft and on planets/moons
- Challenge: remote operation of IPv6 networks (e.g. from Earth)
- Response: new forms of network management via, e.g., HTTP(S) [?]
- Need an RIR function for unique IPv6 and AS assignments in space?
- Need local DNS for IPv6 networks in space [?]
- Need Bundle-aware application layer gateways for email, HTTP(S) and CDNs
- Need [ICANN-accredited] RIR, registries and registrars for space applications
- Other?

What do we need to Govern?

Critical Resource for IPN

- Spectrum allocations
- BP Node numbers
- IP address/ASN (on other planets)
- Domain Names (on other planets)

Universal Standards for IPN

- Time
- Coordinate systems (Physical)
- Routing/Forwarding methods
- Bundle Protocol
- Application Protocol



How should they be managed, governed?

An aerial, black and white photograph of a long, straight road stretching into the distance through a desert landscape. The road is flanked by sparse, low-lying vegetation and sandy terrain. The perspective is from a high angle, looking down the road as it recedes into the horizon. The road has a dashed center line and solid edge lines. A small vehicle is visible in the distance on the road.

GOVERNANCE

**What are the viewpoints that
shape our future?**

Anticipatory Governance Questions for an Interplanetary Internet

*From Laura's
Academy talks*

What anticipated governance functions and heliopolitical frameworks will be necessary to design, administer, and secure an interplanetary communication future that benefits all humankind?

Unique Space Challenges

What are the unique technical affordances and governance complexities that will shape interplanetary internet architecture and governance?

Space Governance Context

What are the space governance frameworks and treaties that now exist and what is their relevance to deep-space ICTs?

Terrestrial Internet Governance Applicability

What core layers of Internet governance on Earth are likely to extend into deep-space, which do not apply, and what is missing?

Anticipated Flashpoints

What lessons from terrestrial Internet governance can help inform structures of interplanetary Internet governance?

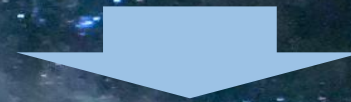
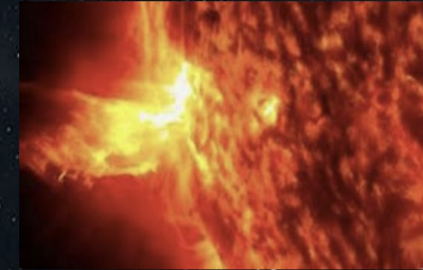
Unique Space Challenges

What are the unique technical affordances and governance complexities that will shape interplanetary internet architecture and governance?

Deep-Space Challenges to Internet Design and Governance



- SPACE DEBRIS
- ASTRONOMICAL DISTANCES
- NATURAL DISRUPTIONS
- PLANETARY MOTION
- CONSTRAINED RESOURCES
- TIME INCONSISTENCIES
- SOVEREIGNTY UPENDED



- Due to unique space challenges, use of DTN is highly recommended from the early phase of IPN
- Design principles will require greater autonomy in network nodes, link establishment etc

Space Governance Context

What are the space
governance
frameworks and
treaties that now exist
and what is their
relevance to deep-
space ICTs?

Observations

- No fundamental governance barriers to the creation of an Interplanetary Internet
 - Multiple international forums exist to explain and promote the concept, ranging from the ISECG and Artemis Accord signatories to UN COPUOS. No centralized authority but rather a set of technical standards, interfaces and protocols that must be tended and implemented.
 - The CCSDS is working on several standards relative to the interplanetary internet. Work may overlap with other standards bodies such as the IETF, the IOAG, and ITU-T.
- The Interplanetary Internet cannot be based on IP but must use DTN-BP. IP may continue to be used in very localized system: Determining time, to include relativistic corrections, is a pacing challenge.
- Spectrum for lunar communications and navigation systems needs to be recognized internationally.
 - The United States has proposed a specific agenda item for the next World Radiocommunications Conference on lunar RF spectrum allocations.

- No fundamental barriers at the moment
- Space Activity is a Nation State activity per the Outer Space Treaty (OST) - 1967, adopted by the UN General Assembly
- OST predates many things – does not take into account the proliferation of commercial space programs
- As commercialization in Space would expand overtime, clashes could occur between public and private interest

From Laura's Academy talks

Terrestrial Internet Governance Applicability

What core layers of Internet governance on Earth are likely to extend into deep-space, which do not apply, and what is missing?

Administration of Critical Internet Resources

Common Identifier System is Necessary for Success



Adopt a Common System, that distributes **Critical Resources**.
Recommend inheriting existing management models in terrestrial environment and adopt it for space.

Terrestrial Internet Governance Applicability

What core layers of Internet governance on Earth are likely to extend into deep-space, which do not apply, and what is missing?

- **Spectrum allocations** -- Current regime to be extended for Interplanetary use. That is, ITU-R to allocate frequencies to certain services and authorization (licensing) by each State, per domestic law & regulations.
- **Node Numbers** -- IANA to serve as the master depot. Under IANA, "Allocators" (they could be space agency, private sector etc). They act similar to RIRs in the Internet world; allocating numbers.
- **LNSP Numbers and/or Regions IDs?** --similar concept with AS Numbers in the Internet world. Recommend same management mechanism with Node Numbers if such need may arise.

Terrestrial Internet Governance Applicability

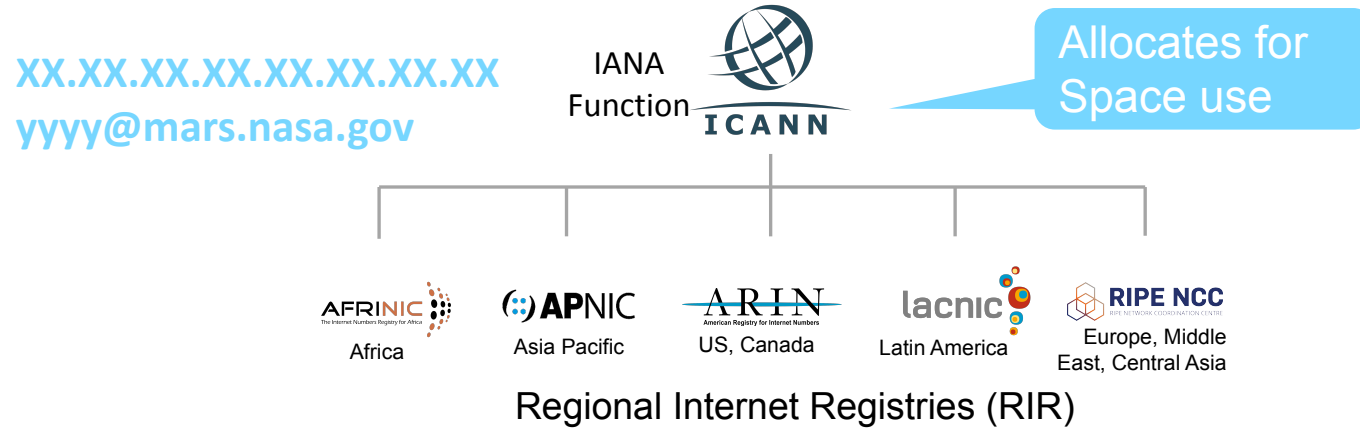
What core layers of Internet governance on Earth are likely to extend into deep-space, which do not apply, and what is missing?

Administration of Critical Internet Resources

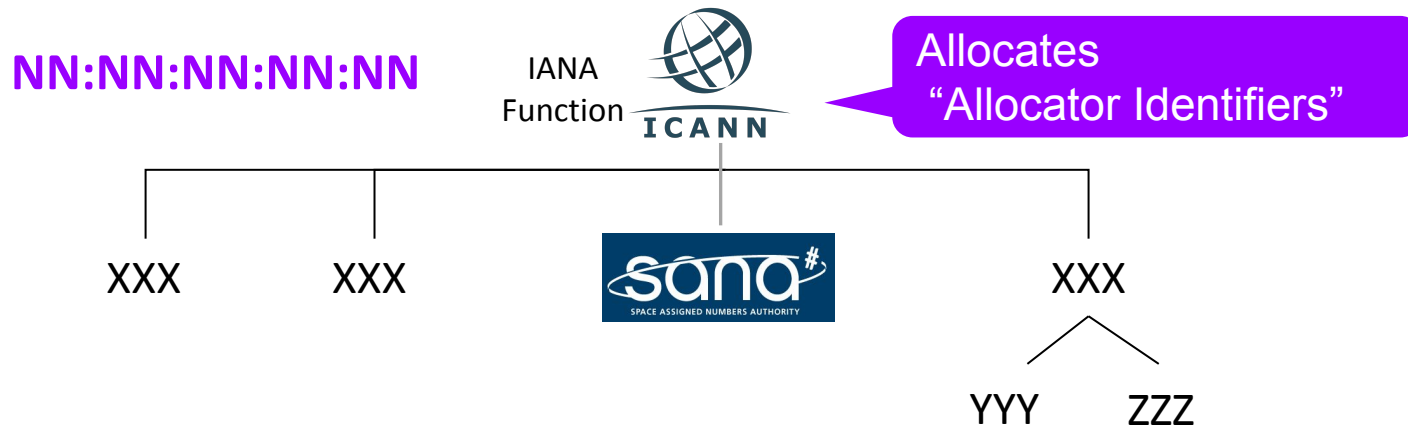
- **IP Addresses** - IP address spaces for space use. Recommendation to allocate existing IPv6 Address space using the current regime - IANA, RIRs
- **ASN** - ASN should be needed to enable BGP routing on planetary bodies. Recommend Allocation done by current regime – IANA, RIRs. Still the open question is when the Autonomous System Numbering is required on other planetary bodies.
- **Domain Names** -- Domain names are needed to identify BP nodes and IP destinations. Recommend Allocation done by current regime – IANA, RIRs.

Interplanetary Internet Critical Resource Management

IP Address/ASN/Domain Names

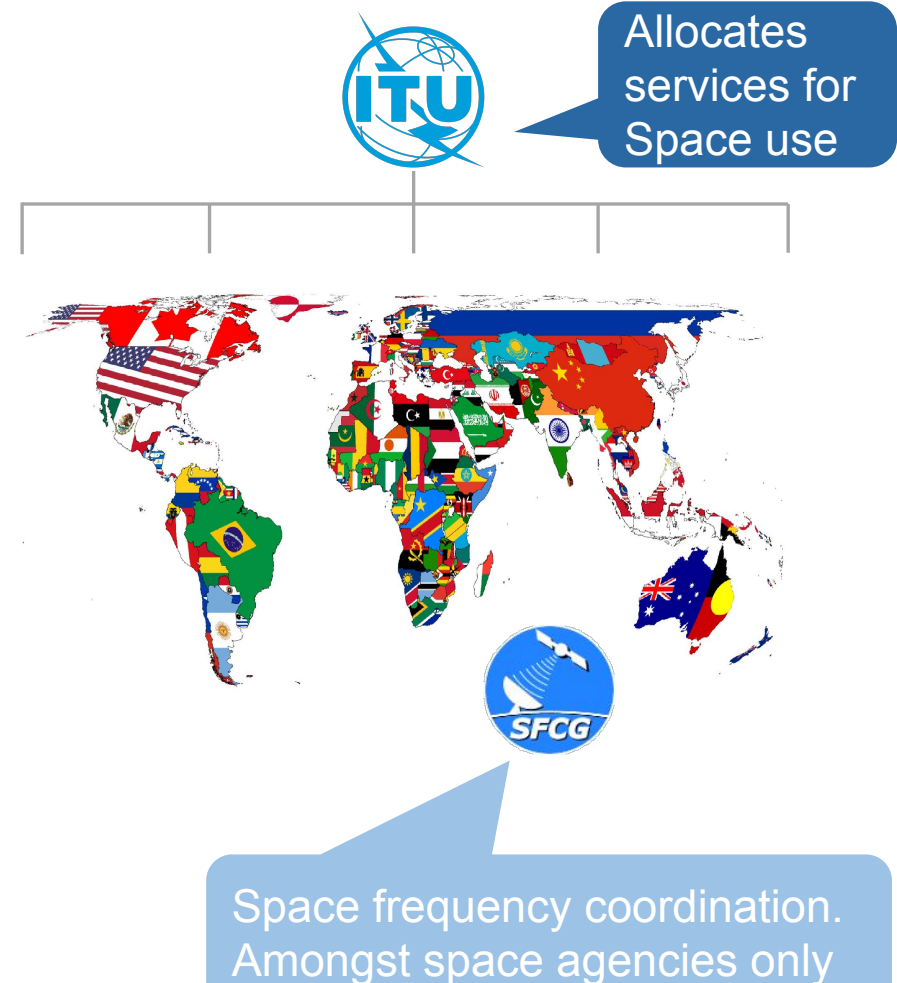


BP Node Numbers



XXX: Could be Space Agency, Private Sector, Academia (equiv to RIRs)

Spectrum

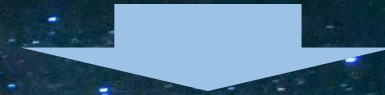


Terrestrial Internet Governance Applicability

What core layers of Internet governance on Earth are likely to extend into deep-space, which do not apply, and what is missing?

Setting Internet Standards

- *Open standards necessary for private investment Later*
- *Avoiding fragmentation requires standards harmonization*
- *Standardization does not assure implementation or Usage*



- Advocate open standards
 - ✓ Time
 - ✓ Coordinate systems (Physical)
 - ✓ Routing/Forwarding methods
 - ✓ Bundle Protocol
- IETF → CCSDS for tailoring should be continued.
- Backward compatibility is key.
- Adoption of standards by real space projects necessary to infuse implementation.

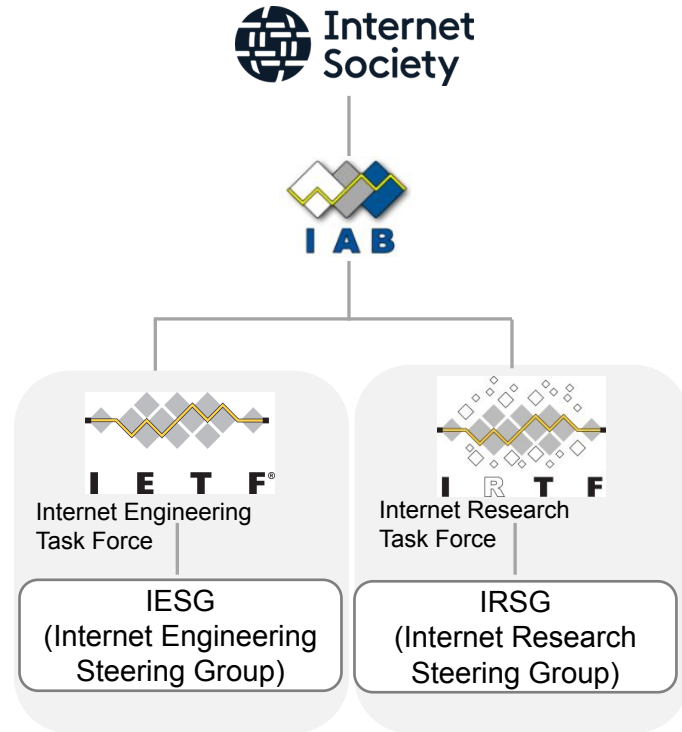


Universal Standards

Bundle Protocol

Time

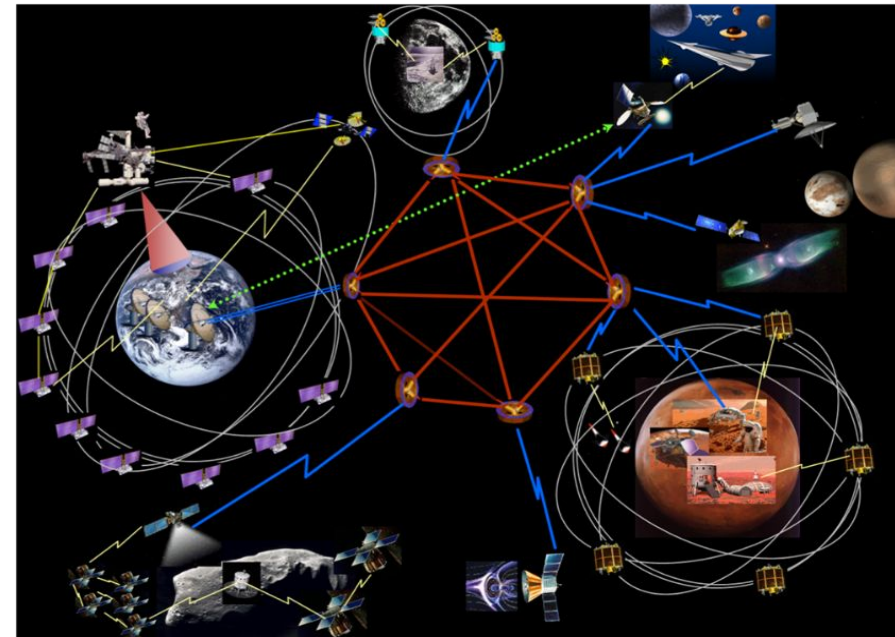
Coordinates



tailoring



What time is it? Where are we?



Standard? Who controls it?

Anticipated Flashpoints

What lessons from terrestrial Internet governance can help inform structures of interplanetary Internet governance?

A Common Identifier System is Necessary for Success

Conflicts Will Likely Emerge over Control of Identifiers

Classical IP could be used on other planetary bodies

BP protocol should run over/with Classical Internet (Convergence Layer)

Use of IP based “Applications” is conceivable on other planetary bodies

Avoiding Fragmentation Requires Standards Harmonization

Open Standards Necessary Now for Private Investment Later

Standardization Does Not Assure Implementation or Usage

Standardization in this Space May Become Highly Politicized

Infrastructure Will be Co-opted as a Proxy for Political Power

Tensions Will Exist between Multilateral vs Multistakeholder Models

Network Security may conflict with National Security

Cybersecurity Becomes the Great Human Rights Issue of Our Time

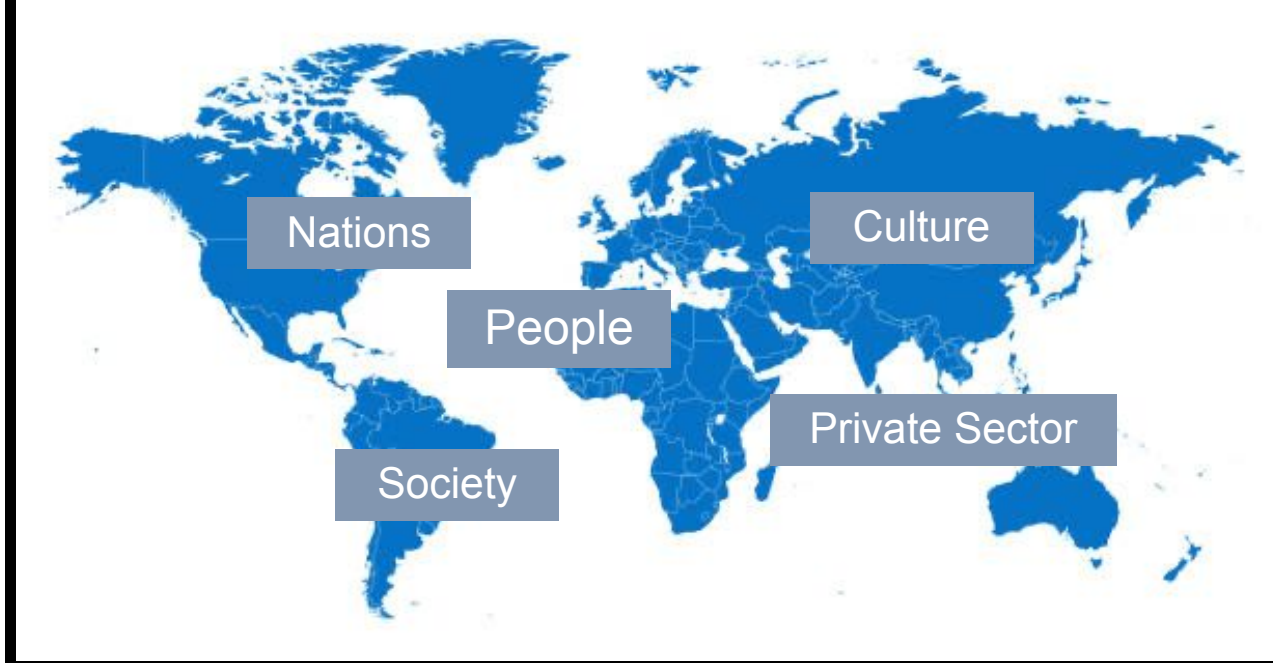
*Based on Laura's views
+ AWG modifications*

Governance Models



Space Activity

Nation State Activity - Sovereignty



Internet

Multistakeholder – Everyone has a Say

Governance Model equation?

Space x Internet = Interplanetary Internet



Sovereignty x Multistakeholder = ??

IPN Governance Model

The Internet did not dictate anything on configuration or business models.

It allowed “**Autonomy**”, which enabled autonomous growth of networks of networks, resulting in the Internet today.

The AWG concluded that the Interplanetary Internet should also employ the “**Multistakeholder**” Governance Model to enable **Autonomy, Scalability** because that is the most sustainable approach, as proven by the Internet today.

IPN Governance – Preliminary conclusions

Policy making Process

- Leverage Internet Model
- Governance at right levels



**Multistakeholder
IPN
Governance**

Critical Resource

- Spectrum allocations
- BP Node numbers
- IP address/ASN
- Domain Names



Open Standard Development

- Time
- Coordinate systems (Physical)
- Routing/Forwarding methods
- Bundle Protocol
- Application Protocol

Law and Treaty

- Space Law and Treaties
- Domestic Law
- Artemis Accords

Academy materials at:

➔ <https://ipnsig.org/events/>



IPNSIG
ACADEMY



Any questions to:

➔ secretariat@ipnsig.org

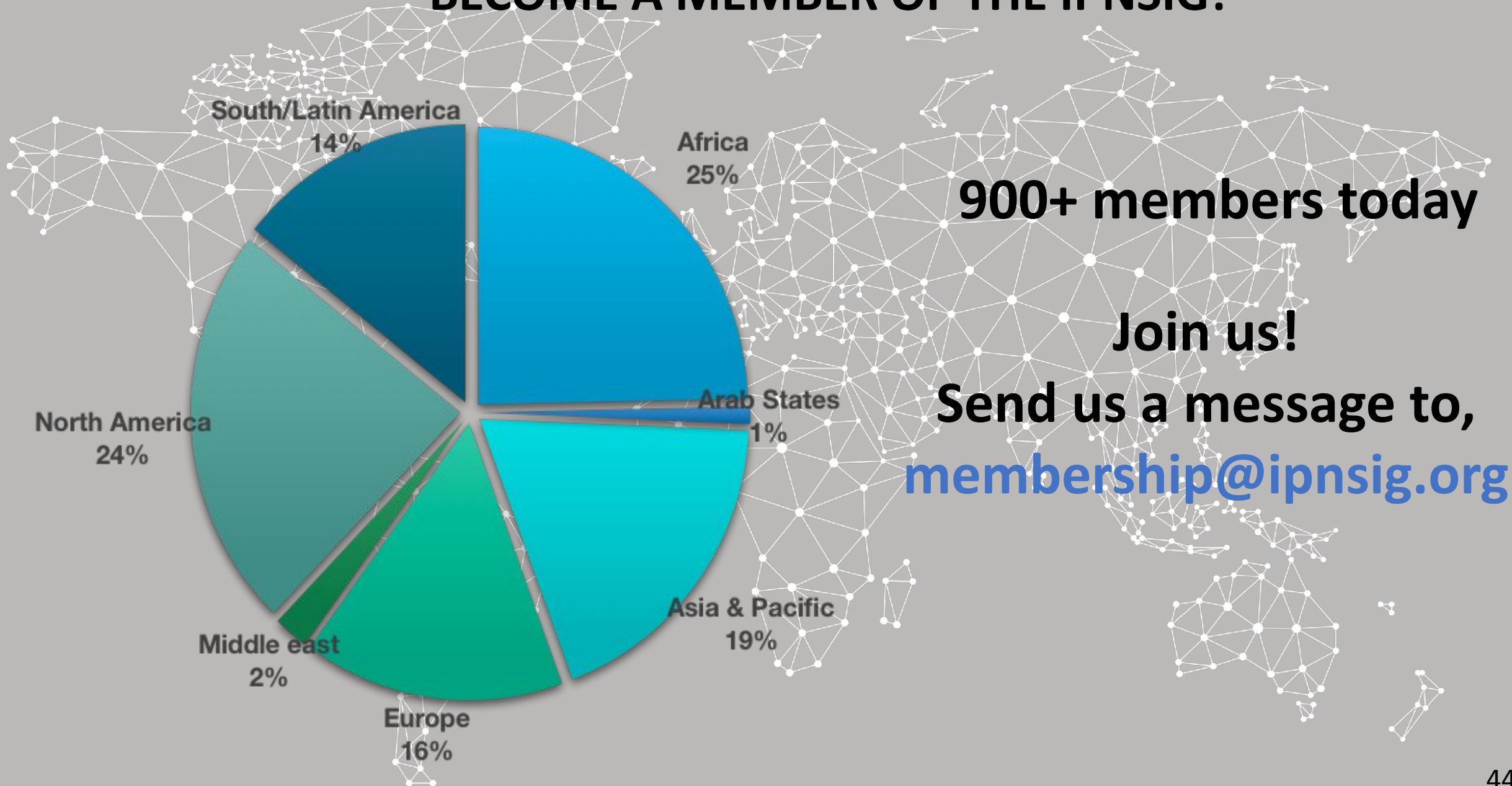


IPNSIG Academy – Program for 2023

Links to recordings - <https://ipnsig.org/ipnsig-academy-events/>

- May 30 • IPNSIG AWG Workshop
- ➔ June 28 • **Doreen Bogdan-Martin (ITU Secretary-General) ITU Governance and prospects on IPN**
- July xx • **Paul Twomey (former ICANN CEO) Internet Governance and prospects on IPN**
- Aug xx • **Preston Marshall (former DARPA) 5G/6G technology in collaboration with IPN**
- Sep xx • **Roberto Gaetano (EuroDig) Lessons from Internet and prospective on IPN**
- TBD • **TBD (Internet Society) ISOC's rôle in the venture of IPN development**
- TBD • **Jim Schier (NASA/HQ) IOAG's committee to study LunaNet governance**
- TBD • **Dave Israel (NASA) NASA's implementation of LunaNet**
- TBD • **David Gomez Otero (ESA) ESA's implementation of LunaNet**
- TBD • **TBD (NASA) Position, Navigation and Timing for Exploration**

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*Thank you.
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