Interoperating Network Communications Architecture

a Technology Development Mission to Extend Commercial Networks to Space and more

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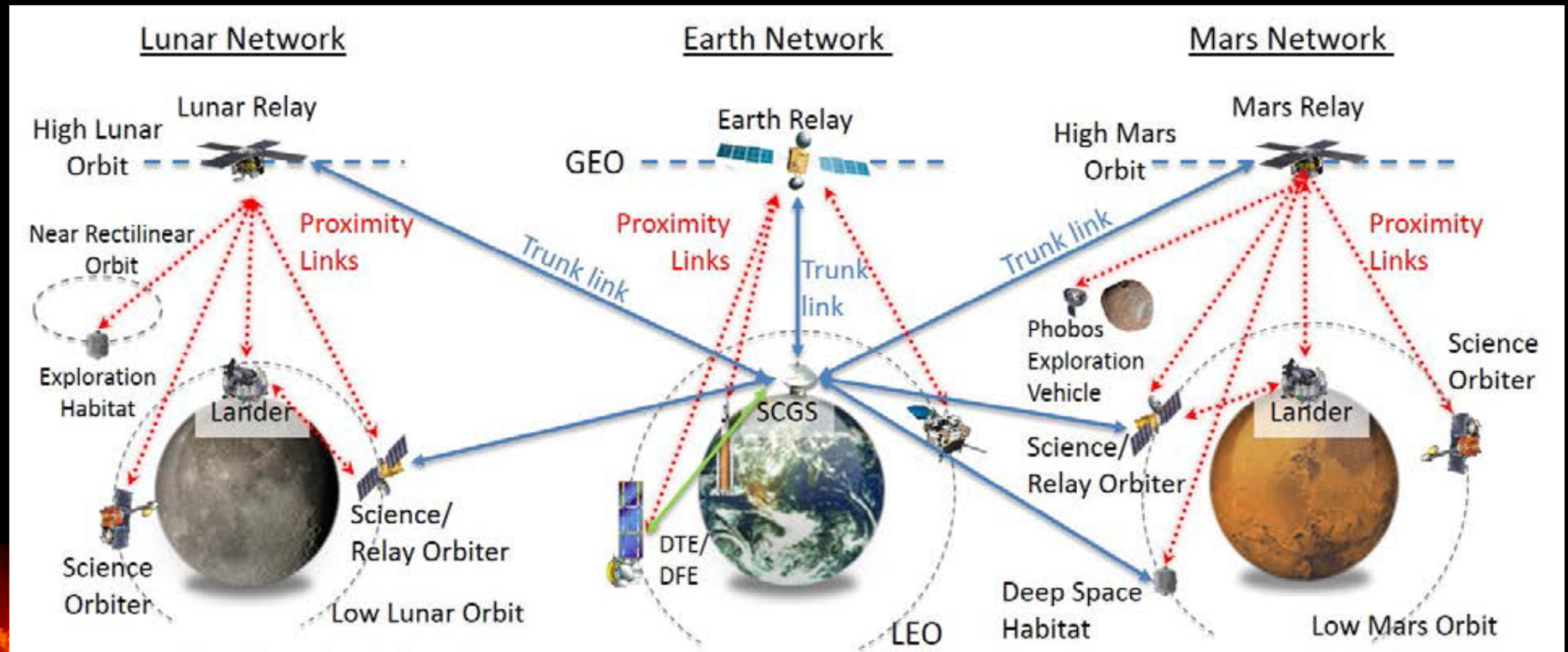gary.barnhard@xisp-inc.com
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Outline

- The Problems Addressed . . .
- The Solution Proposed . . .
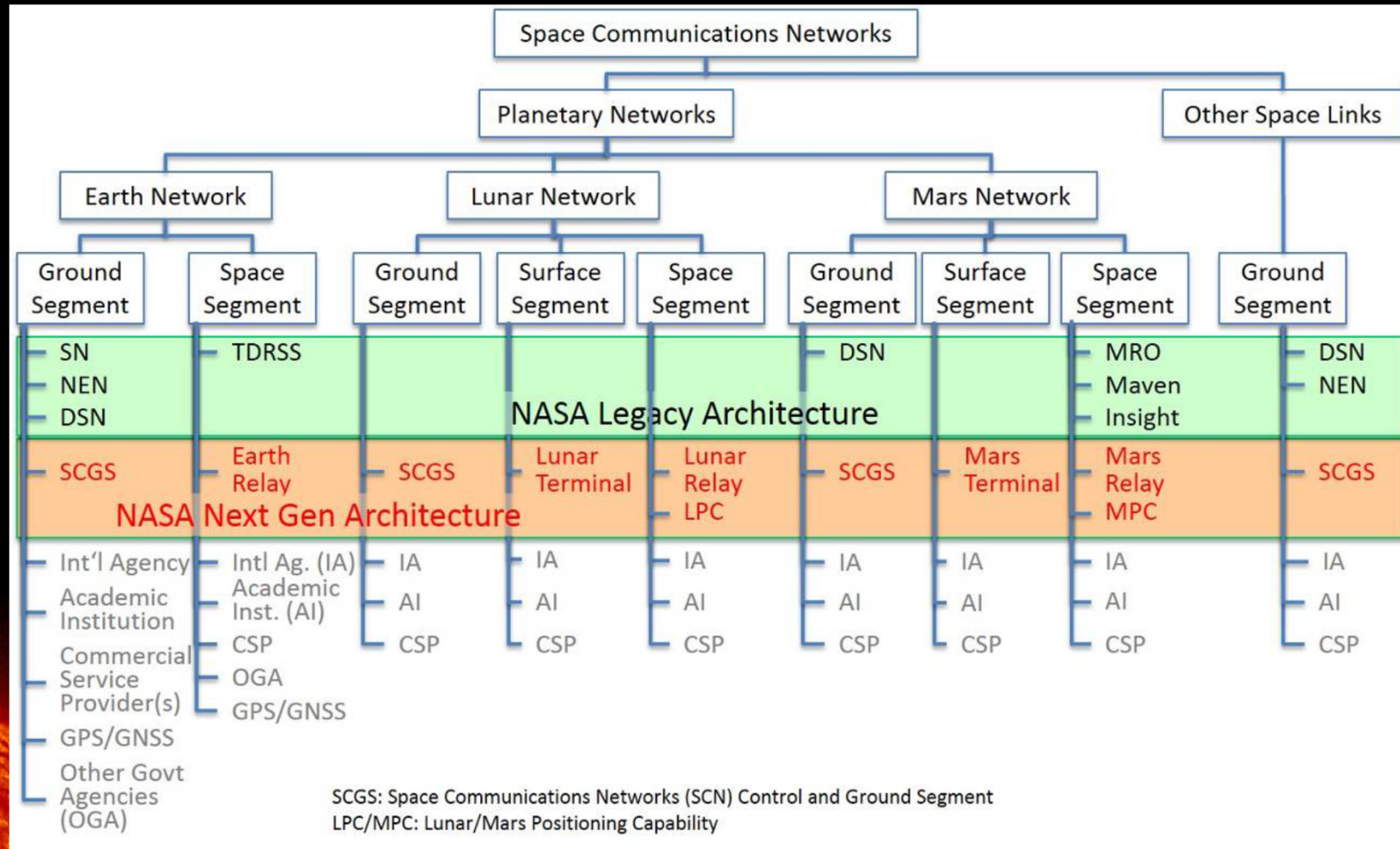- Possible Applications . . .
- Conclusions . . .
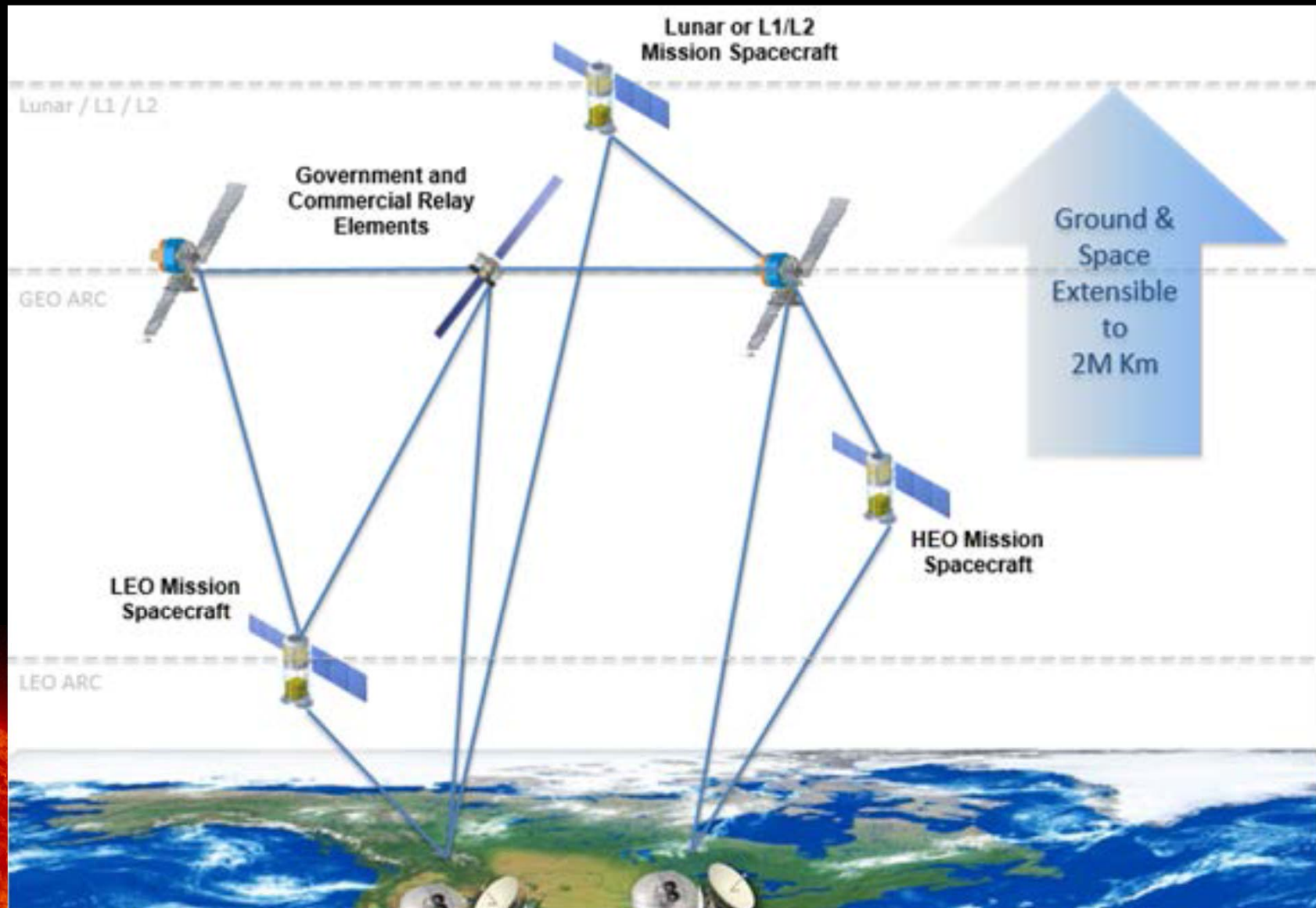
Near Earth, Mars, and Lunar Network Concept*

Lunar Network

High Lunar Orbit — Lunar Relay

Near Rectilinear Orbit

Proximity Links

Exploration Habitat — Lander

Science Orbiter

Science/Relay Orbiter

Low Lunar Orbit

Earth Network

Earth Relay

GEO

Proximity Links

Trunk link

SCGS

DTE/DFE

LEO

Mars Network

High Mars Orbit — Mars Relay

Proximity Links

Trunk link

Phobos Exploration Vehicle

Science/Relay Orbiter

Deep Space Habitat

Science Orbiter

Lander

Low Mars Orbit

** NASA Space Communication and Navigation (SCaN)
Office Preliminary Architecture Concept January 2016*

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Planetary Networks Concept*

Diagram contents:

Space Communications Networks
- Planetary Networks
  - Earth Network
  - Lunar Network
  - Mars Network
- Other Space Links

	Earth Network		Lunar Network			Mars Network			Other Space Links
	Ground Segment	Space Segment	Ground Segment	Surface Segment	Space Segment	Ground Segment	Surface Segment	Space Segment	Ground Segment
NASA Legacy Architecture	SN / NEN / DSN	TDRSS				DSN		MRO / Maven / Insight	DSN / NEN
NASA Next Gen Architecture	SCGS	Earth Relay	SCGS	Lunar Terminal	Lunar Relay / LPC	SCGS	Mars Terminal	Mars Relay / MPC	SCGS
	Int'l Agency / Academic Institution / Commercial Service Provider(s) / GPS/GNSS / Other Govt Agencies (OGA)	Intl Ag. (IA) / Academic Inst. (AI) / CSP / OGA / GPS/GNSS	IA / AI / CSP	IA / AI / CSP	IA / AI / CSP	IA / AI / CSP	IA / AI / CSP	IA / AI / CSP	IA / AI / CSP

SCGS: Space Communications Networks (SCN) Control and Ground Segment
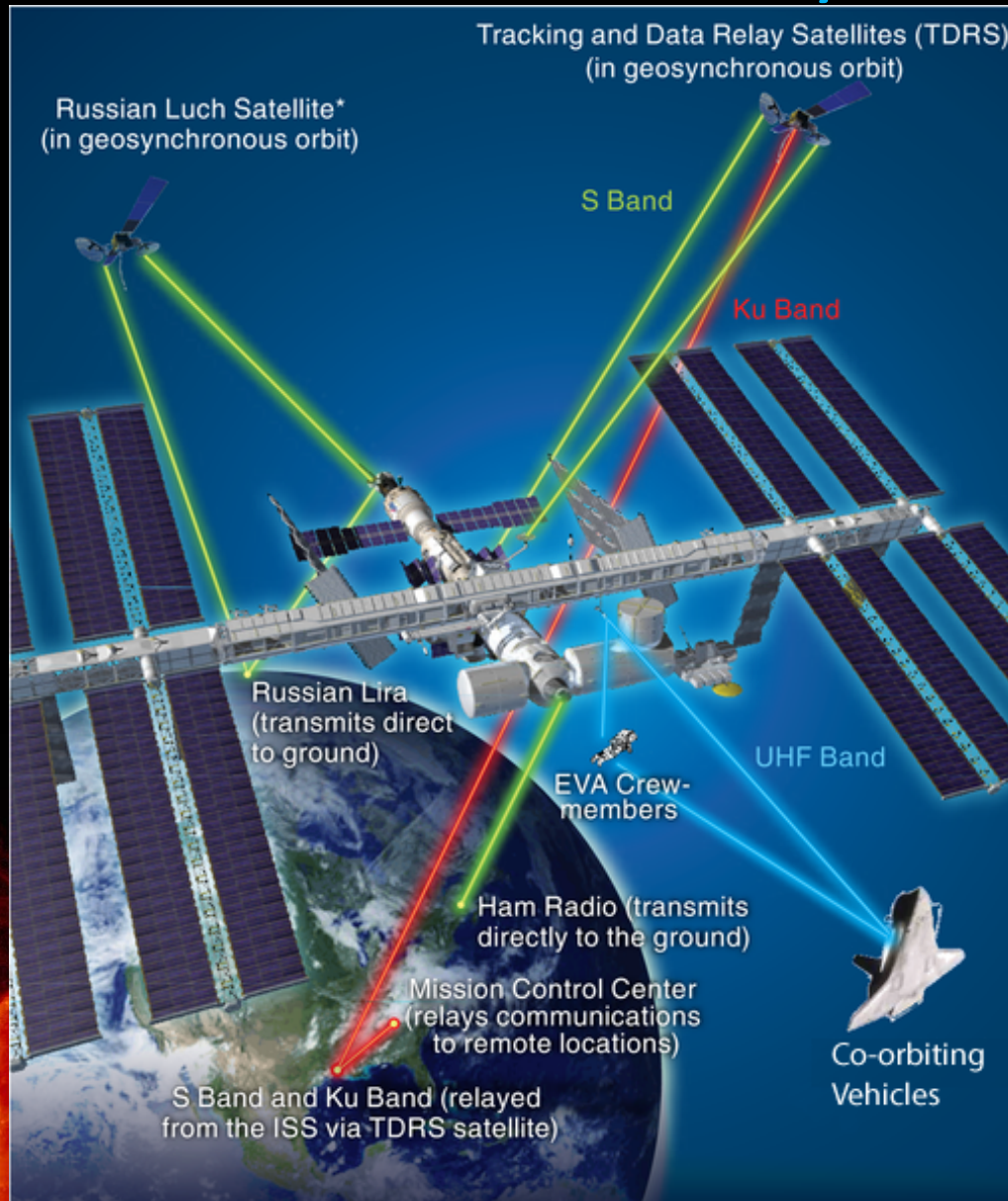LPC/MPC: Lunar/Mars Positioning Capability

** NASA Space Communication and Navigation (SCaN)
Office Preliminary Architecture Concept January 2016*

Near Earth Communications & Navigation Architecture*

Lunar or L1/L2 Mission Spacecraft

Lunar / L1 / L2

Government and Commercial Relay Elements

GEO ARC

Ground & Space Extensible to 2M Km

LEO Mission Spacecraft

HEO Mission Spacecraft

LEO ARC

ISS Communications System

Tracking and Data Relay Satellites (TDRS)
(in geosynchronous orbit)

Russian Luch Satellite*
(in geosynchronous orbit)

S Band

Ku Band

Russian Lira
(transmits direct
to ground)

EVA Crew-
members

UHF Band

Ham Radio (transmits
directly to the ground)

Mission Control Center
(relays communications
to remote locations)

Co-orbiting
Vehicles

S Band and Ku Band (relayed
from the ISS via TDRS satellite)

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The Problem Addressed – 1

Testing DTN Technology with Real World Requirements

Testing Delay Tolerant Networking Technology with Real World Requirements approaches the problem of maturation of Delay/Disturbance (DTN) technology and facilitating its use from an end-user requirements perspective.

Goal: Demonstrate that real world requirements can be accommodated by an operational implementation of DTN technology that allows it to be used as tool that meets customer requirements (performance, availability, and security) in a satisfactory and sufficient manner

Virtualize a Single Function and Test it's Efficacy in Near Realtime

The Problem Addressed – 2
Pervasively Networked DTN Gateway

A Pervasively Networked DTN Gateway approaches the problem of maturation of DTN technology and facilitating its use from an infrastructure perspective.

Goal: A pervasively networked point-of-presence gateway supporting quality of service based routing (performance, availability, and security) on all available internal and external networks accessible on the International Space Station for payload use consistent with operational guidelines.

Virtualize Multiple Functions and create an automated orbital telco central office prototype

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The Problem Addressed – 3
Near-Earth Emergency Preparedness and Response Network

Near-Earth Emergency Preparedness and Response Network Focal Point approaches the problem of maturation of DTN technology and facilitating its use from a cooperating / interoperating network interface perspective with an emphasis on terrestrial applications.

Goal: Support the development and implementation of a Near-Earth Emergency Preparedness and Response Network by prototyping and testing readily deployable pervasively networked highly mobile point-of-presence systems including dynamically schedulable space assets

Demonstrate Earth Facing Applications

The Problem Addressed – 4
Cislunar Pervasively Networked Communications

Cislunar Pervasively Networked Communications Technology Development approaches the problem of maturation of DTN technology and facilitating its use from a cooperating/interoperating network interface perspective with an emphasis on Cislunar applications.

Goal: Support the development and implementation of a Cislunar Communications Network by prototyping and testing readily integratable interface kits for allowing new - and where possible - existing space systems to be become cooperating / interoperating nodes interacting with pervasively networked point-of-presence systems.

*Demonstrate Space Facing Applications*

The Solution Proposed - 1

A set of technology development missions proposed for the International Space Station (ISS) which:

1. leverages available resources to serve as a testbed,
2. has an integral evolutionary path from experiment to infrastructure, and
3. helps to mitigate perceived cost, schedule, and technical risk associated with the accommodation and use of new communications technologies.
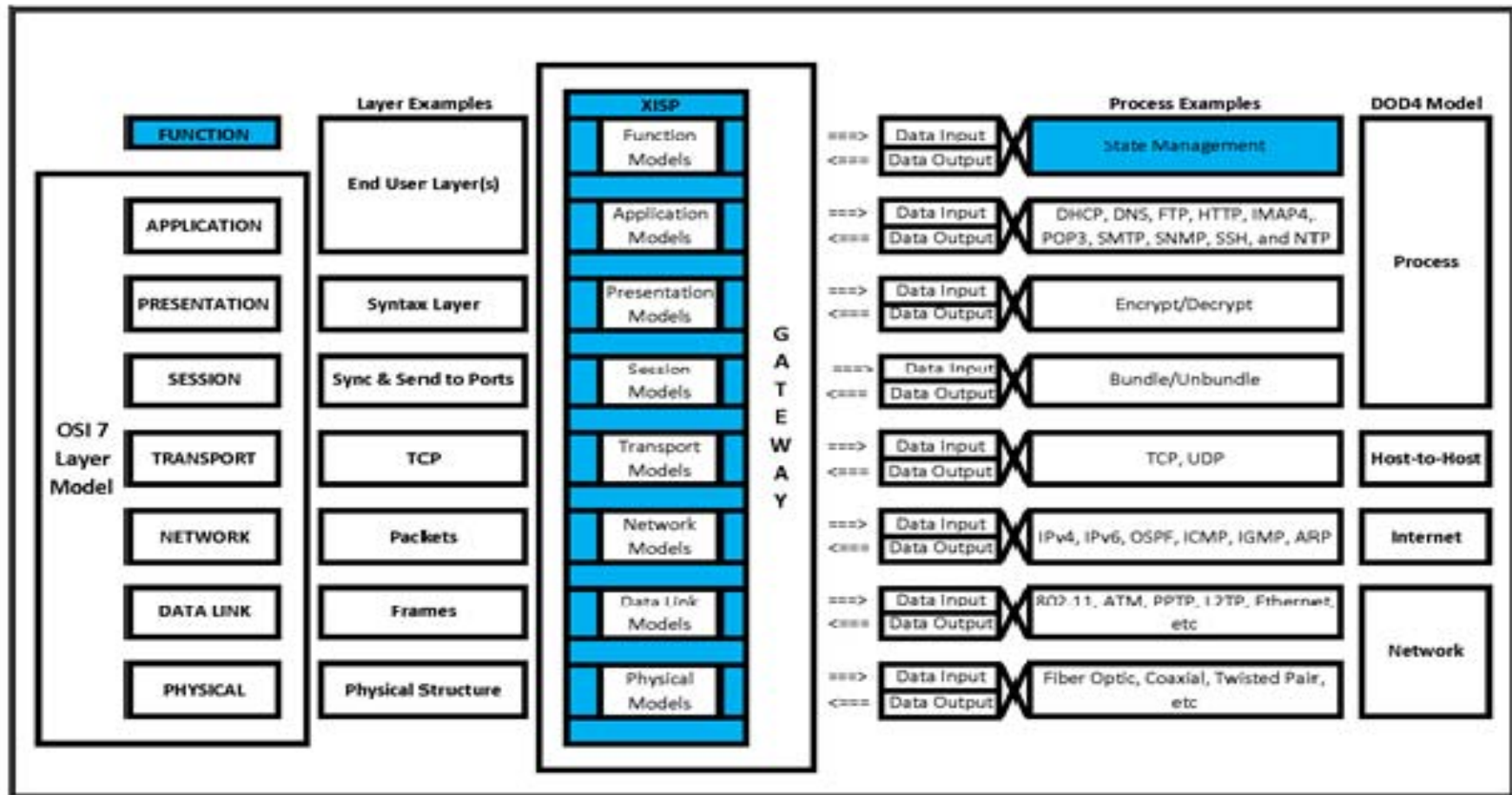
The Solution Proposed – 3
INCA Experiment Elements

Function: Internet Banking
Purpose: Source of Real World Performance/Availability/Security Requirements
Value: Testing, which supports the verification, and validation of INCA Architecture with real interoperating network requirements

Function: Pervasively Networked DTN Gateway
Purpose: Enables INCA QoS Based Routing
Value: Testing INCA Architecture for LEO/MEO/GEO Use
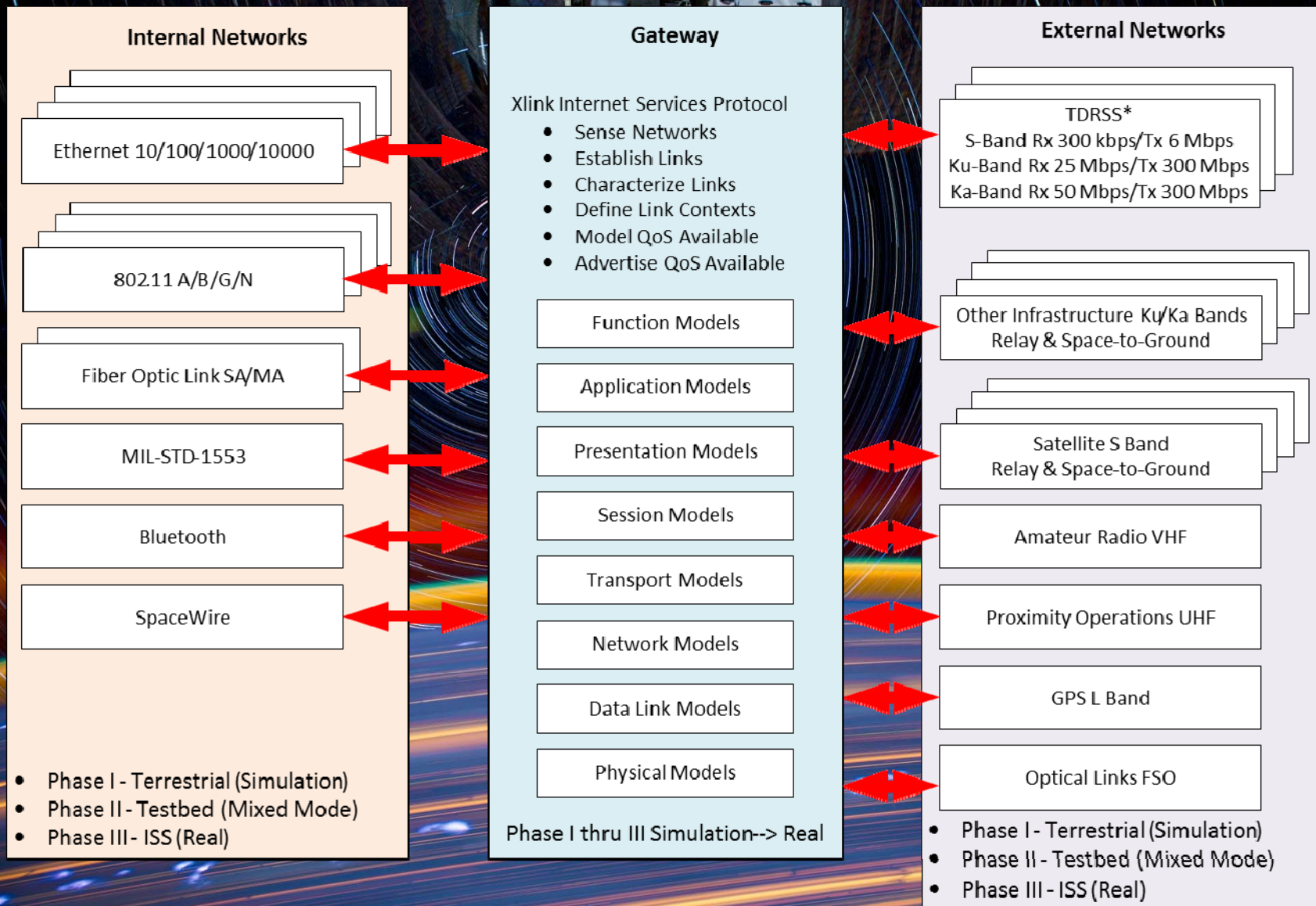
ITERATIVE **&** **RECURSIVE**

Function: Cis-Lunar Pervasively Networked Communications Interface
Purpose: Enables & Demonstrates BEO Application
Value: Testing INCA Architecture for BEO Flight Project Use

Function: Near-Earth Emergency Preparedness and Response Network
Purpose: Enables & Demonstrates Terrestrial Application
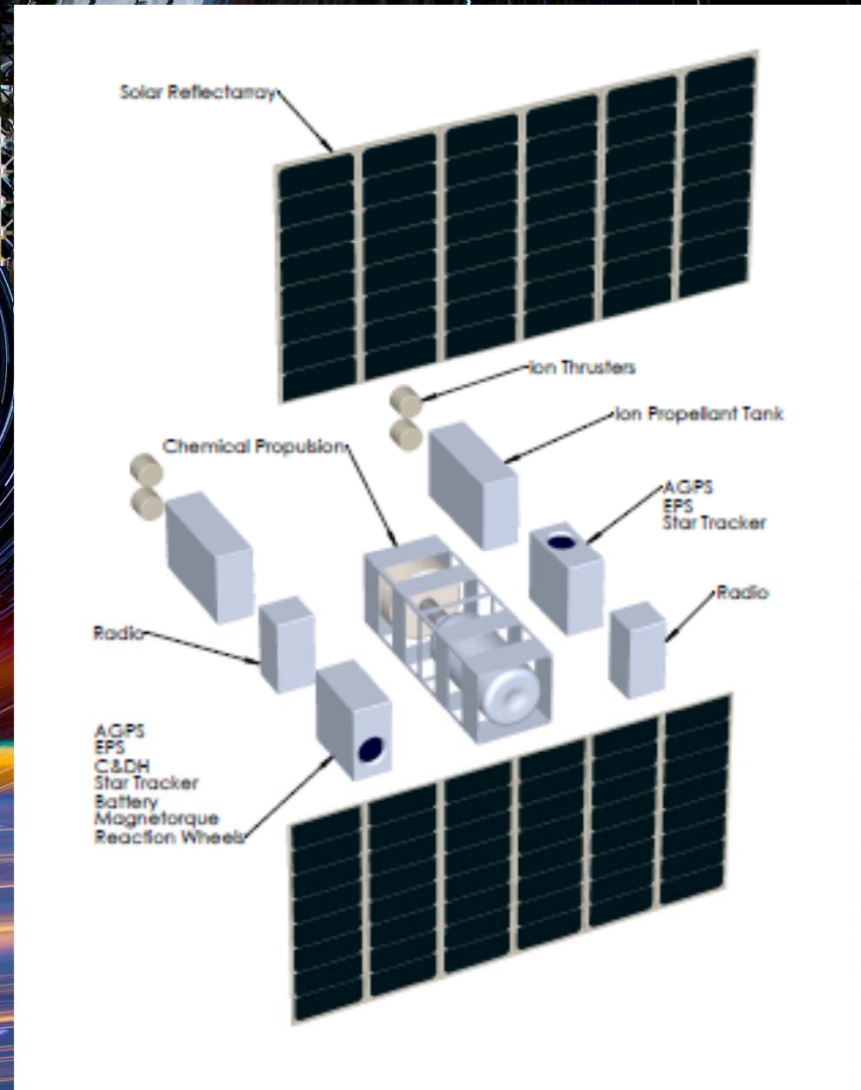**Value:** Testing INCA Architecture for Terrestrial Use

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The Solution Proposed – 4
INCA Pervasively Networked Gateway w/Quality of Service (QoS) Based Routing

Internal Networks

- Ethernet 10/100/1000/10000
- 802.11 A/B/G/N
- Fiber Optic Link SA/MA
- MIL-STD-1553
- Bluetooth
- SpaceWire

- Phase I - Terrestrial (Simulation)
- Phase II - Testbed (Mixed Mode)
- Phase III - ISS (Real)

Gateway

Xlink Internet Services Protocol
- Sense Networks
- Establish Links
- Characterize Links
- Define Link Contexts
- Model QoS Available
- Advertise QoS Available

- Function Models
- Application Models
- Presentation Models
- Session Models
- Transport Models
- Network Models
- Data Link Models
- Physical Models

Phase I thru III Simulation--> Real

External Networks

- TDRSS*
  S-Band Rx 300 kbps/Tx 6 Mbps
  Ku-Band Rx 25 Mbps/Tx 300 Mbps
  Ka-Band Rx 50 Mbps/Tx 300 Mbps
- Other Infrastructure Ku/Ka Bands
  Relay & Space-to-Ground
- Satellite S Band
  Relay & Space-to-Ground
- Amateur Radio VHF
- Proximity Operations UHF
- GPS L Band
- Optical Links FSO

- Phase I - Terrestrial (Simulation)
- Phase II - Testbed (Mixed Mode)
- Phase III - ISS (Real)

The Solution Proposed – 6

INCA Augmented Space Qualified Intel ® Next Unit of Computing (NUC)

Possible Applications– 1
INCA Proposed Function Implementation

MISSION ANNEX 1
Testing DTN with Real World Requirements

Function Model
Website Access w/ defined QoS Requirements
- End User Command Stream
- QoS Requirements Baseline
- QoS Measurement
Performance/Availability/Security
- State Models
- Operational Guidelines
- Processed Data Storage
- Linked Page Implementation

Xrosslink Internet Services Protocol
- Defined Network
- Establish Link
- Characterize Link
- Define Link Context
- Model QoS Available
- Advertise QoS Available

MISSION ANNEX 2
Pervasively Networked Gateway
w/QoS Based Routing

Function Model
Pervasively Networked Gateway w/ QoS
Based Routing
- End User Command Stream
- QoS Requirements Baseline
- QoS Measurement
Performance/Availability/Security
- State Models
- Operational Guidelines
- Processed Data Storage
- Linked Page Implementation

Xrosslink Internet Services Protocol
- Sense Networks
- Establish Links
- Characterize Links
- Define Link Contexts
- Model QoS Available
- Advertise QoS Available

Possible Applications – 2
INCA Proposed Function Implementation (Continued)

MISSION ANNEX 3
Near Earth Emergency Preparedness and Response Network

Function Model
Interoperating Earth Node Interface Kit
- Hardware Requirements
- Software Requirements
- Specifications
- Operational Guidelines

MISSION ANNEX 4
Cis-Lunar Pervasively Networked Communications Technology Development

Function Model
Interoperating Space Node Interface Kit
- Hardware Requirements
- Software Requirements
- Specifications
- Operational Guidelines

Conclusion

The path forward now entails:

- translating the narrative into actually building real systems that provide services of demonstrable value, and
- validating the same through peer review in the communities of interest.

It is through this cyclic process that maximum value can be derived from each increment of resources committed to this mission set as well as it's anticipated extensions and follow-ons.

The INCA mission is an XISP-Inc commercial mission moving forward as a supported mission under an existing Space Act Agreement with NASA ARC and a Space Act Umbrella Agreement under negotiation with NASA Headquarters.

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