

Interoperating Network Communications Architecture (INCA)

a Technology Development, Demonstration,
and Deployment (TD³) Mission to Extend
Commercial Networks to Cis-Lunar Space

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Strategy Discussion
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Presenter:

Gary Pearce Barnhard, President & CEO
Xtraordinary Innovative Space Partnerships, Inc.
(XISP-Inc)

gary.barnhard@xisp-inc.com
www.xisp-inc.com



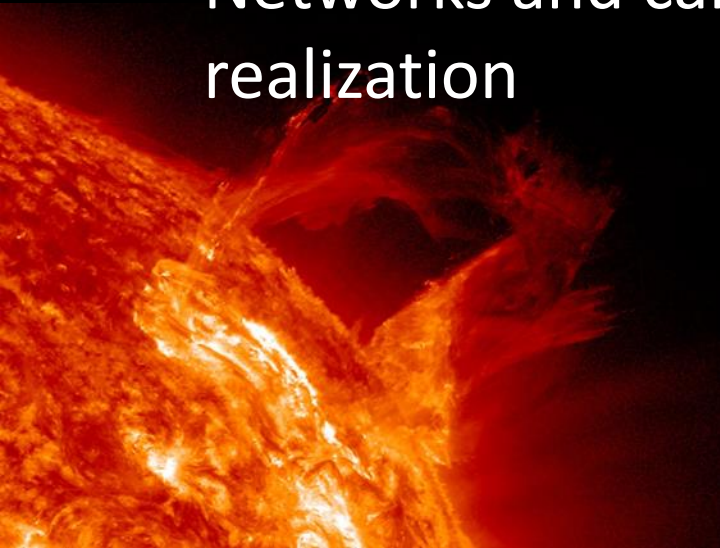
Outline

- Setting the Stage
- The Challenges . . .
- The Technology Development Push . . .
- The Mission Requirements Pull . . .
- The TD³ Mission Set
- The Path Forward . . .



Set the Stage . . .

- XISP-Inc is in the business of building extraordinary mission development partnerships
- Our evolving mission set requires the availability of ubiquitous dynamically allocatable Quality of Service (QoS) driven ancillary services (comm, data, navigation, time, etc.)
- We will be a user of NASA and Commercial Next Gen Networks and can contribute to their accelerated realization



Challenges . . .

- Technological windows are narrowing
- Quality of Service (QoS) will be the primary driver
 - performance, availability, and security
- Scheduled → Dynamic Allocation of Bandwidth
- Readily replaceable or repairable systems/elements
- Scale of the Market is growing in all sectors
- Flight systems are evolving in two directions simultaneously
 - Smallsat Constellations
 - Immortal Platforms



Challenges . . .

- Commercial Infrastructure for Cis-Lunar Space
→ Earth-LEO-MEO-HEO-GEO-L_x-HLO-MLO-LLO-Lunar
- Interoperability
 - Earth facing
 - On-orbit operations
 - Space facing
 - Beyond Earth orbit



Technology Development Push . . .

INCA can foster the following TD³ elements:

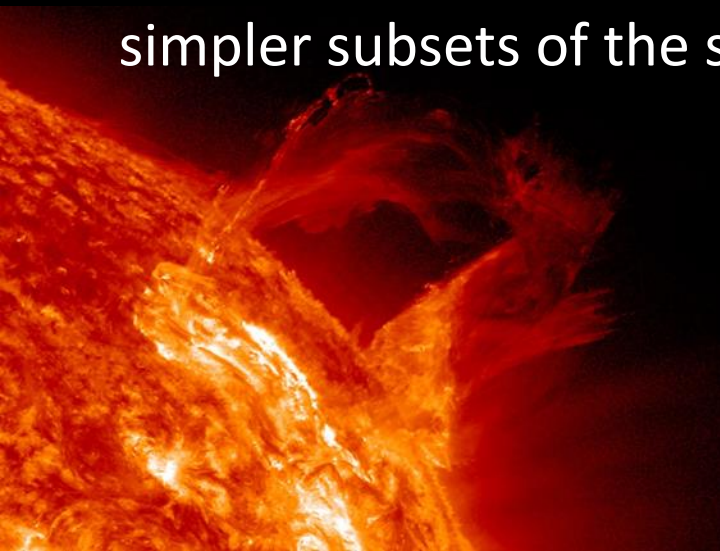
- Delay & Disturbance Tolerant Networking (DTN) as a service
- Software Defined Radio (SDR)
- Unification of RF & Optical Electronics Packages
- Near realtime link characterization
- Dynamic scheduling of links
- Web acceleration
- QoS routing & pervasively networked gateways
- multi-core thermally managed computer resources for virtualized functions,
- Xrosslink protocol for near-realtime state models,
- Interoperating node standardization & interface kits

Technology Development Push . . .

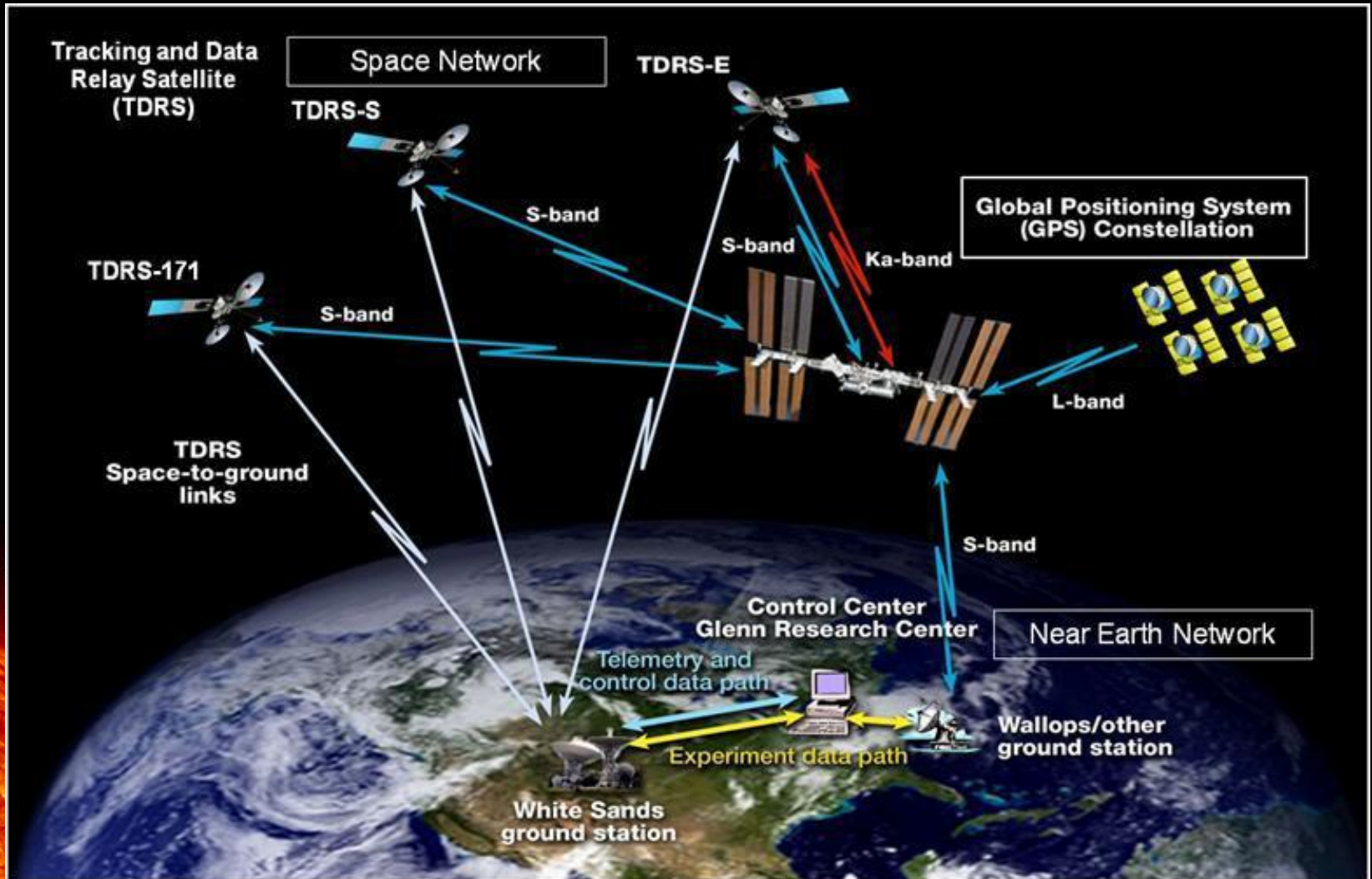
INCA nodes are defined as a combination of:

- Hardware
- Software
- Interface Specifications
- Operational Guidelines

If you can make the International Space Station an interoperating node all other potential nodes regardless of whether they are in space, flying, fixed, ground mobile, portable, or hand held are simpler subsets of the same problem.

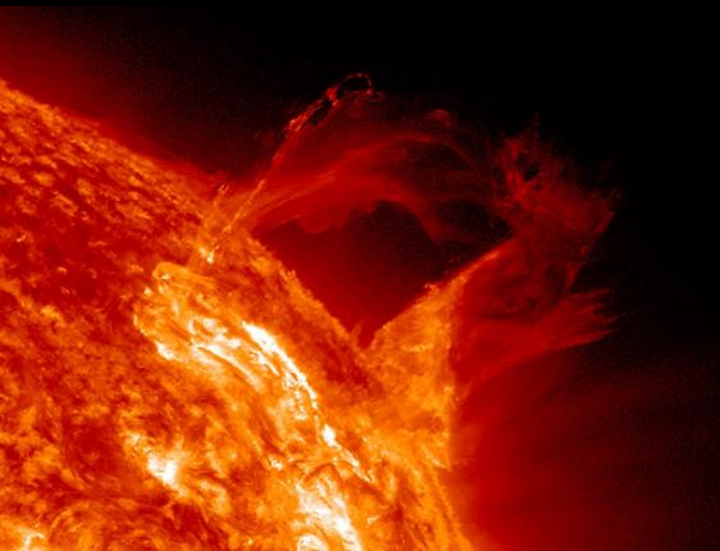


NASA SCaN & ISS Example



Mission Requirements Pull . . .

- Infrastructure is expensive
- Infrastructure is even more expensive if you do not build what is required the first time, and it becomes progressively more so
- Investment in TD³ missions can deliver real requirements and substantive mission enhancing if not mission enabling capability for each increment of resources invested
- TD³ missions allow for the buy down of cost, schedule, and technical risk associated with larger scale infrastructure



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

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

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

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.

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

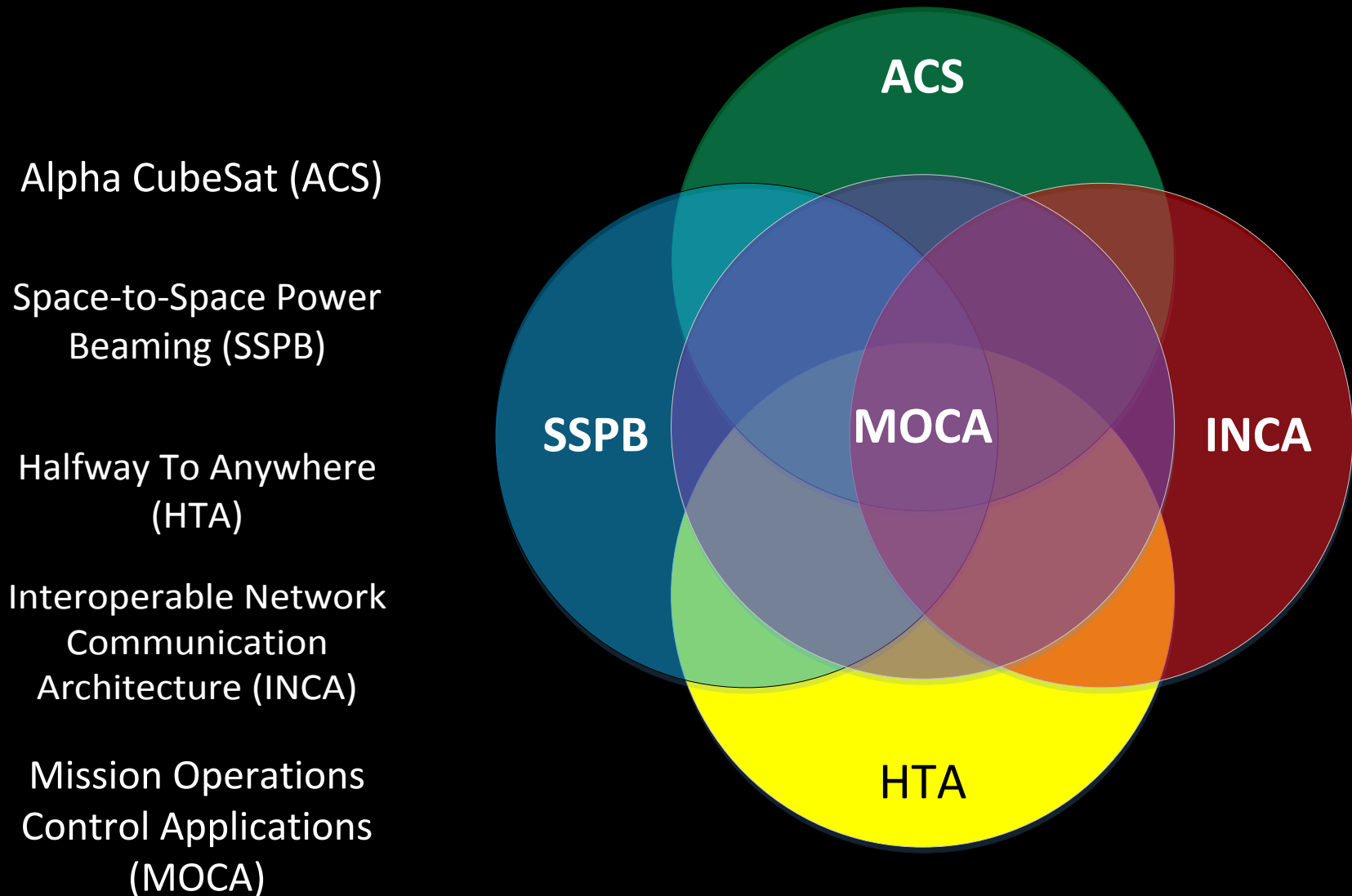
The Solution Proposed

A set of TD³ missions proposed for the International Space Station (ISS) which:

- leverages available resources to serve as a testbed,
Characterize → Optimize → Operationalize
- has an integral evolutionary path from experiment to infrastructure, and
- helps to mitigate perceived cost, schedule, and technical risk associated with the accommodation and use of new communications technologies.



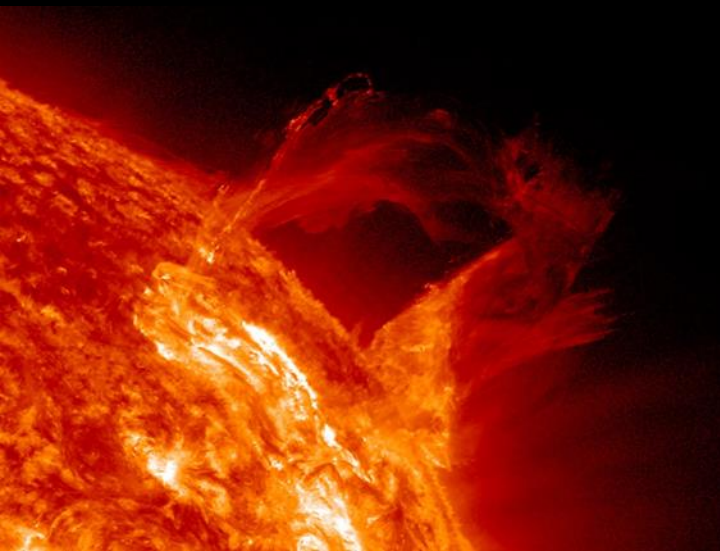
XISP-Inc Evolving TD³ Mission Set



Interoperable Network Communications Architecture (INCA)

INCA elements can support:

- Enhanced automated/autonomous Communications & Navigation state models,
- Dynamically assignable and characterizable resources,
- QoS driven virtualized function support , and
- Cost effective Earth facing, on-orbit, and beyond Earth ad hoc mesh mission support/networks.



Mission Operations Control Applications (MOCA)

- MOCA provides TD³ near realtime state models, mutable locus of control, and virtual operations center for ACS, HTA, INCA, and SSPB
- MOCA facilitates crewed, tele-operated/shared control, and autonomous in situ operations reducing crew time required for experiments and increasing ISS and ground operations productivity.

→ MOCA can be a resource for furthering the TD³ of “AutoNAV” and the evolution to dynamically scheduled QoS driven communications and navigation services.



Alpha Cube Satellite (ACS)

- ACS provides a technology development, demonstration, and deployment (TD3) spacecraft bus for HTA, INCA, MOCA, and SSPB
- ACS Low cost highly configurable small spacecraft for Earth facing, Cislunar infrastructure, and beyond Earth orbit applications.
- TD³ work includes: beyond Earth Orbit SDR through Ka Band and more (W band, laser, etc.), laser retroreflector host and testbed, user hardware & software extensible linux based avionics system (GN&C, ACS, Power, DMS), non-toxic propulsion systems, Virtual Operations Center (based on Open Web MCT & Xrosslink protocol), reflectarray solar/TX&Rx/Rectenna

→ ACS is low cost extensible Comm and Nav infrastructure suitable for prototyping applications/services on-orbit, in Cis-lunar space, and beyond.

Space-to-Space Power Beaming (SSPB)

- SSPB provides TD³ radiant energy beaming testbed, and electrical as well as other utilities (Comm, Nav, etc.) as applicable for ACS, HTA, INCA, and MOCA
- SSPB retire real and perceived technical, cost, and schedule risk associated with radiant energy beaming utilities
- SSPB mission evolution supports ISS co-orbiting free-flyers, Earth facing platforms and/or fractionated systems with LEO/MEO/GEO power augmentation and alternate bus systems, Cis-lunar and lunar surface operations, asteroidal assay mission operations and propulsion augmentation.

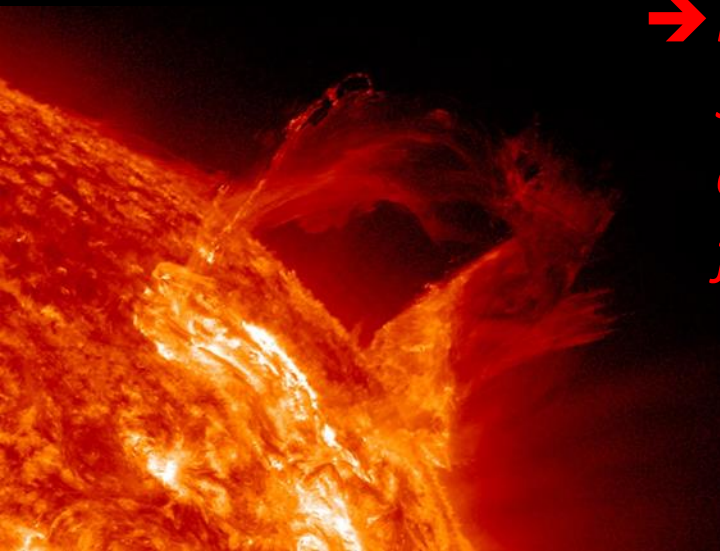
→ *SSPB forges a TD³ path to Space-to-Space and Space-to-Alternate surface electrical, communications, and navigation utilities.*

→ *SSPB work is intended to be frequency agnostic from Ka band through optical.*

Halfway To Anywhere (HTA)

- HTA provides TD³ propulsion testbed, trajectory insertion bus, alternate minimum energy trajectories, and resonance orbits for ACS, INCA, MOCA and SSPB.
- *HTA leads to the use of ISS as a transportation node for low cost, readily deployable Earth orbit, cislunar and beyond Earth orbit mission support.*

→ *HTA helps draws out the requirements for space-to-space electrical, communications, and navigation utilities for LEO/MEO/GEO, and beyond.*



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

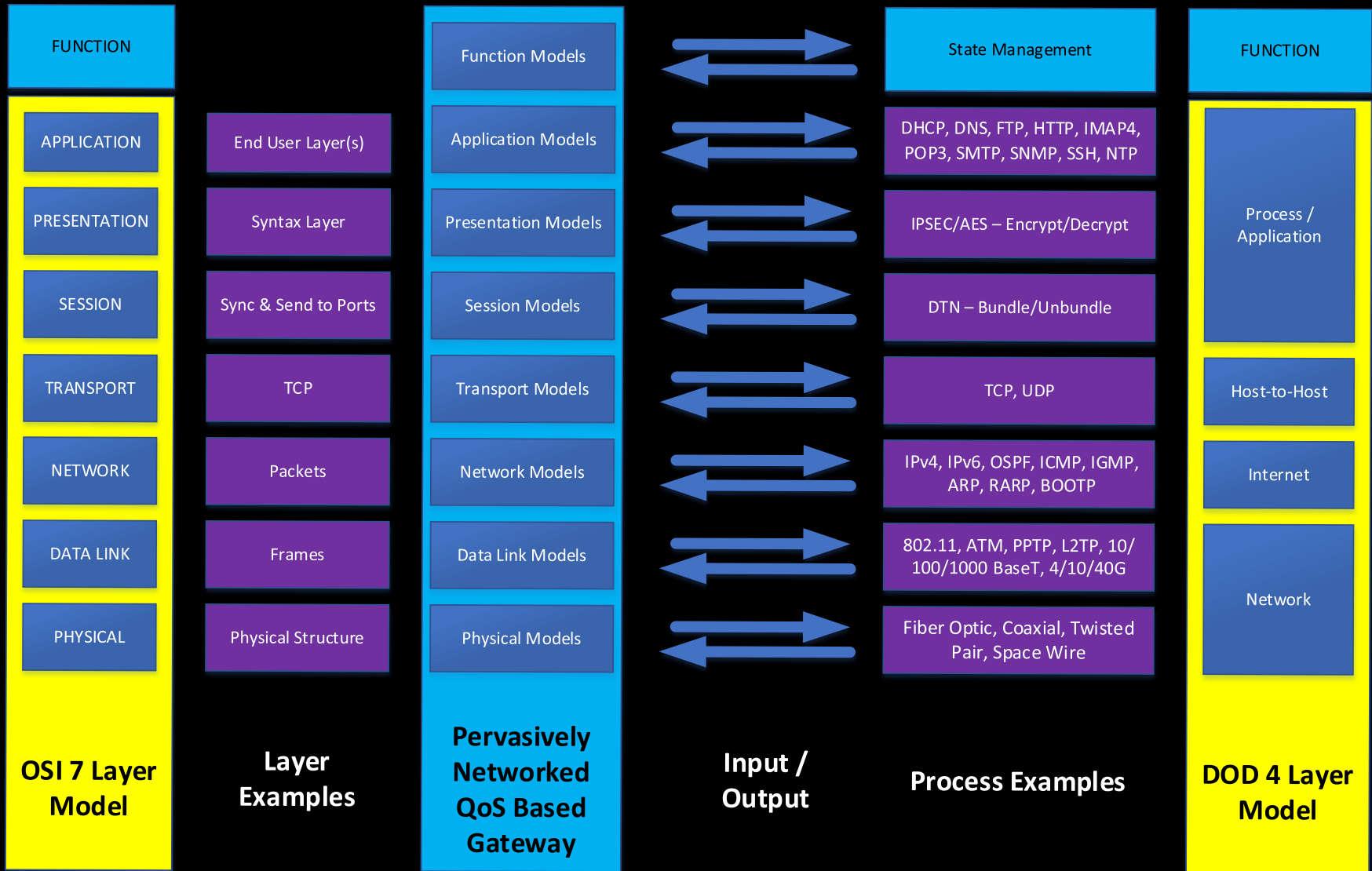
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RECURSIVE

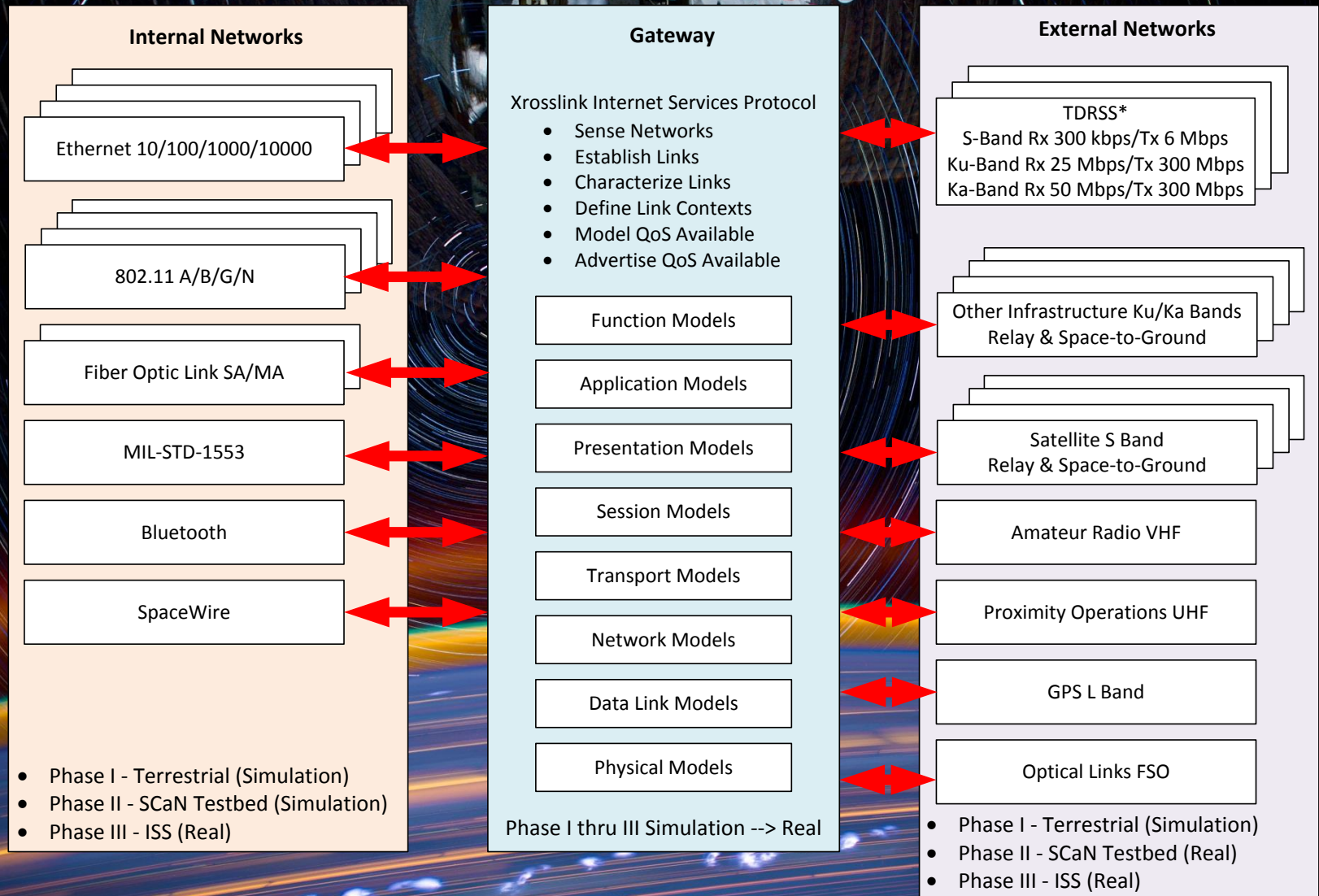
Function: Cis-Lunar Pervasively Networked Communications Interface
Purpose: Enables & Demonstrates BEO Application
Value: Testing INCA Architecture for BEO Flight Project Use

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

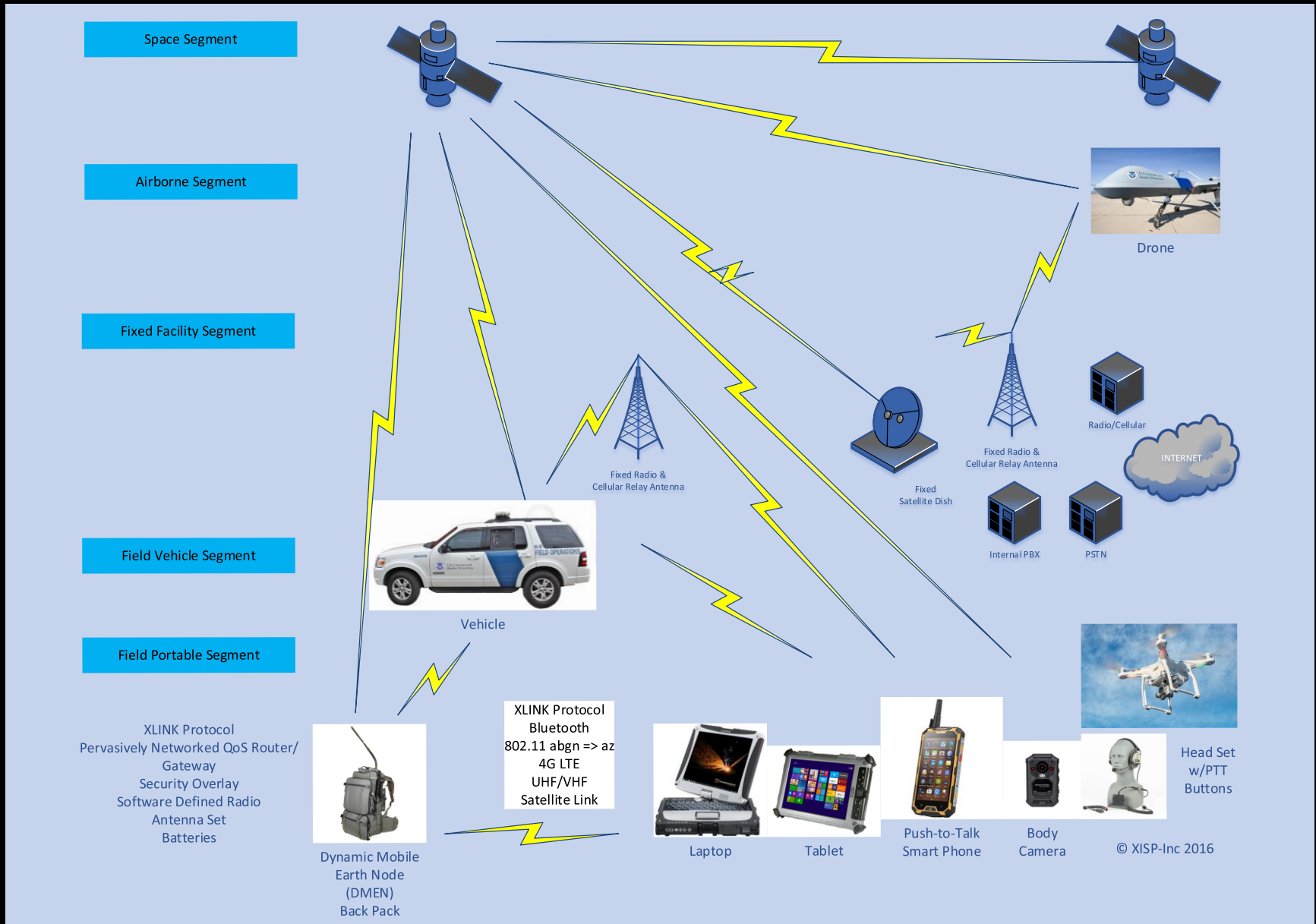
XISP-Inc Crosslink Protocol (XLINK)



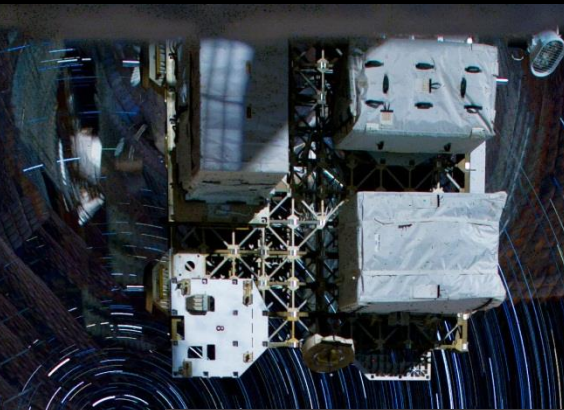
INCA Pervasively Networked Gateway w/QoS Based Routing



Earth Facing INCA System Concept of Operations Example



INCA Proposed 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 a combination of an existing Space Act Agreement with NASA ARC and additional authority under negotiation with the NASA Headquarters SCan office.