

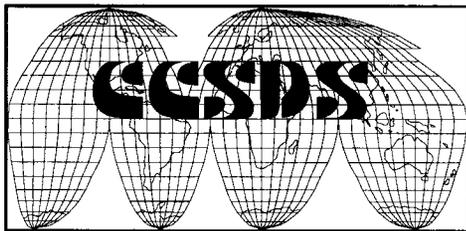
Interplanetary Network Directorate



Information System Standards CCSDS

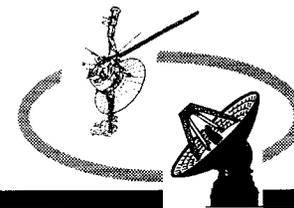
7 May 2002

Peter Shames

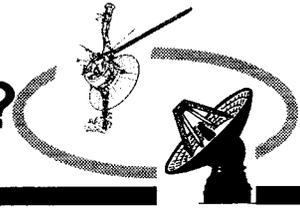
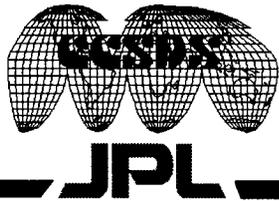




Agenda

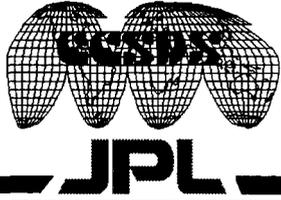


- **What “Standards” are really all about**
- **Motivation for Information System Standards Program**
- **Space Mission Environment**
- **End to End Space Architecture**
- **CCSDS Standards Program Content**



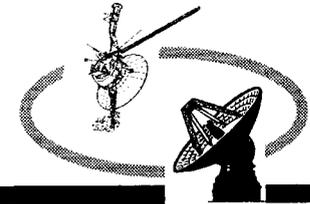
What is the Standards Program About?

- **Understanding the communications & information systems needs of a broad range of international space missions**
- **Defining an open architecture for space communications that meets the needs of these missions for service and cross support**
- **Developing standards, as a leading activity, with the intent of having them available as they are needed by missions**
- **Publishing standards and working with missions to infuse these standards**
- **Fostering development of compliant COTS products by commercial entities, S/C builders, suppliers, and component developers**

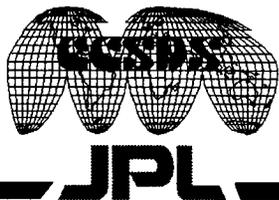


Rationale

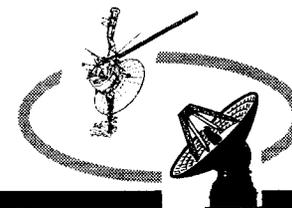
(or, Why do we need standards?)



- **Cross-support**
 - Ground assets (e.g. DSN)
 - Space assets (e.g. Mars relay)
- **Interoperability**
 - Multi-agency support agreements
 - Multi-mission support arrangements
- **Reduce costs**
 - Shared (expensive, scarce) resources
 - S/W and H/W reuse
 - Commercial implementations
- **Increase reliability / reduce risks**
 - See above



NASA Mission Drivers

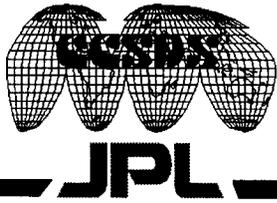


- **MORE, SMALLER MISSIONS**
 - Less power
 - Less weight
 - Reduced costs

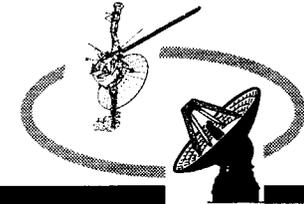
- **HIGHLY DISTRIBUTED MULTI-ORGANIZATION OPERATIONS TEAMS**

- **CHALLENGING MISSION SCENARIOS**
 - **Constellation and Formation Flying Missions**
 - Inter Spacecraft Communications
 - Positioning Relative to Each Other
 - **Autonomous Exploration**
 - Round Trip Light Time Prohibits “Joystick Operations.”
 - Dynamic Response to Environment (Precision EDL, Rendezvous & Docking)

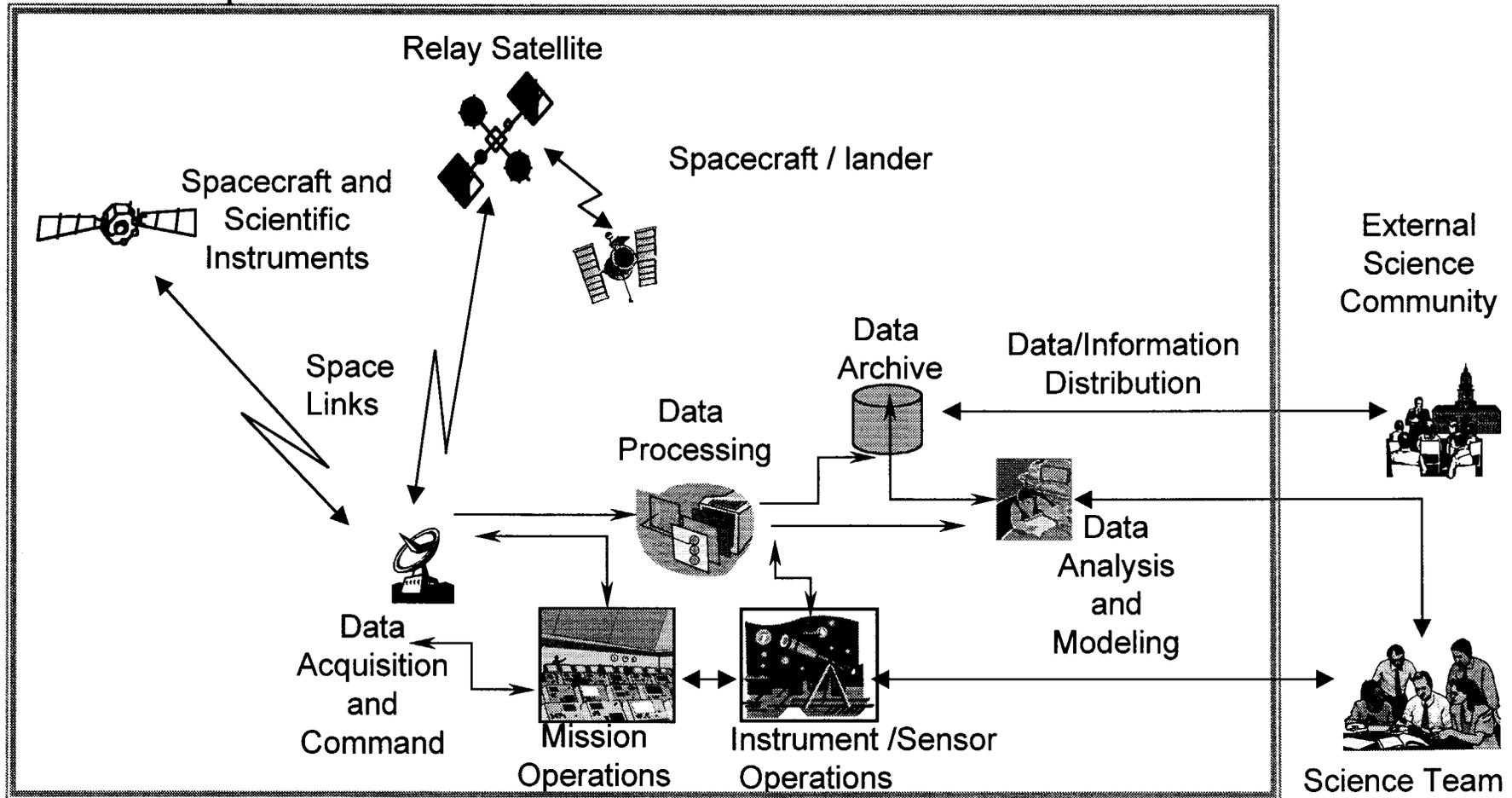
- **SENSOR WEB**
 - Re-configurable web of orbiting and landed sensors for in-situ, long-term and detailed observation, prediction and analysis.



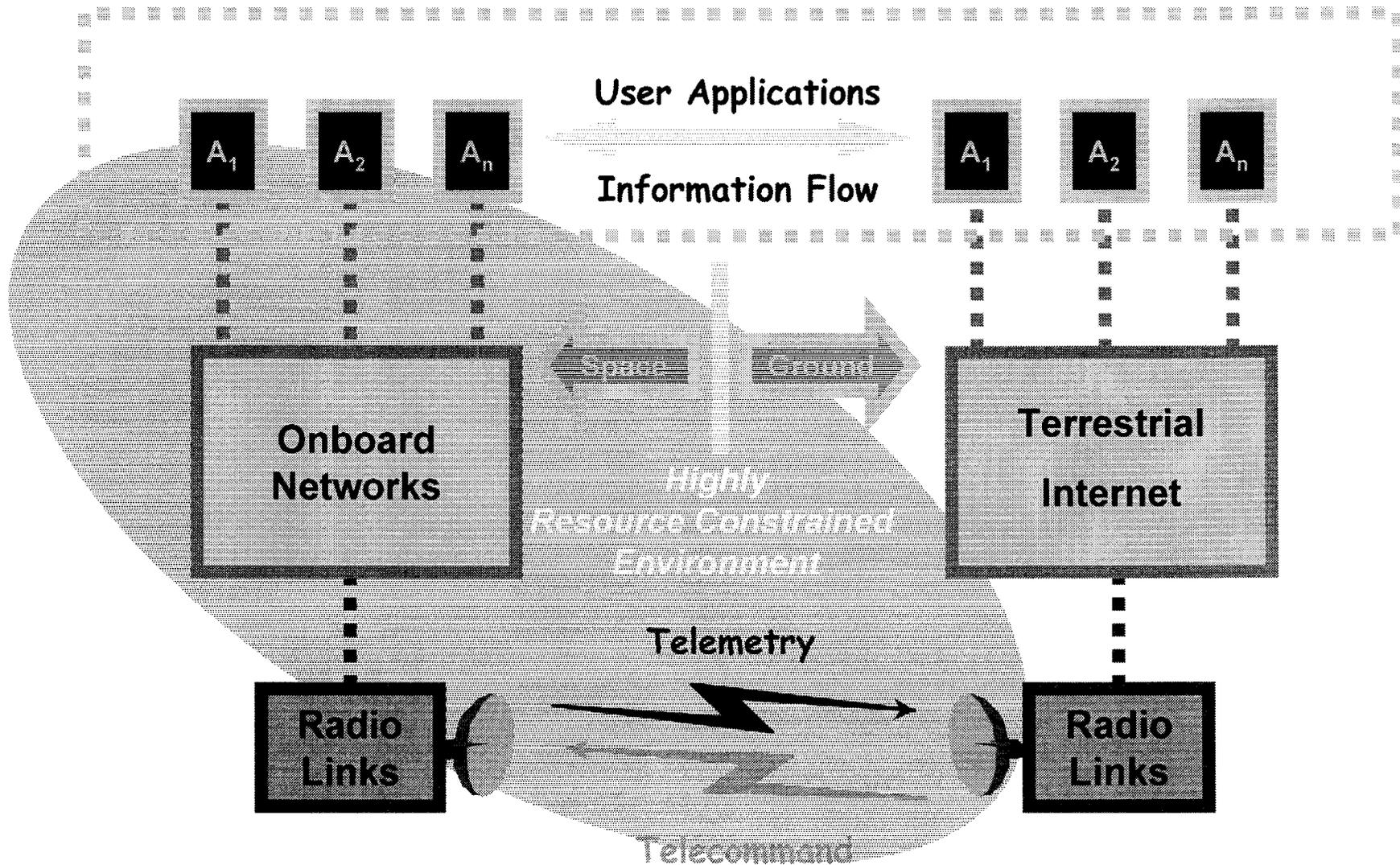
INTERPLANETARY NETWORK DIRECTORATE
Space Domain
Functional Element View



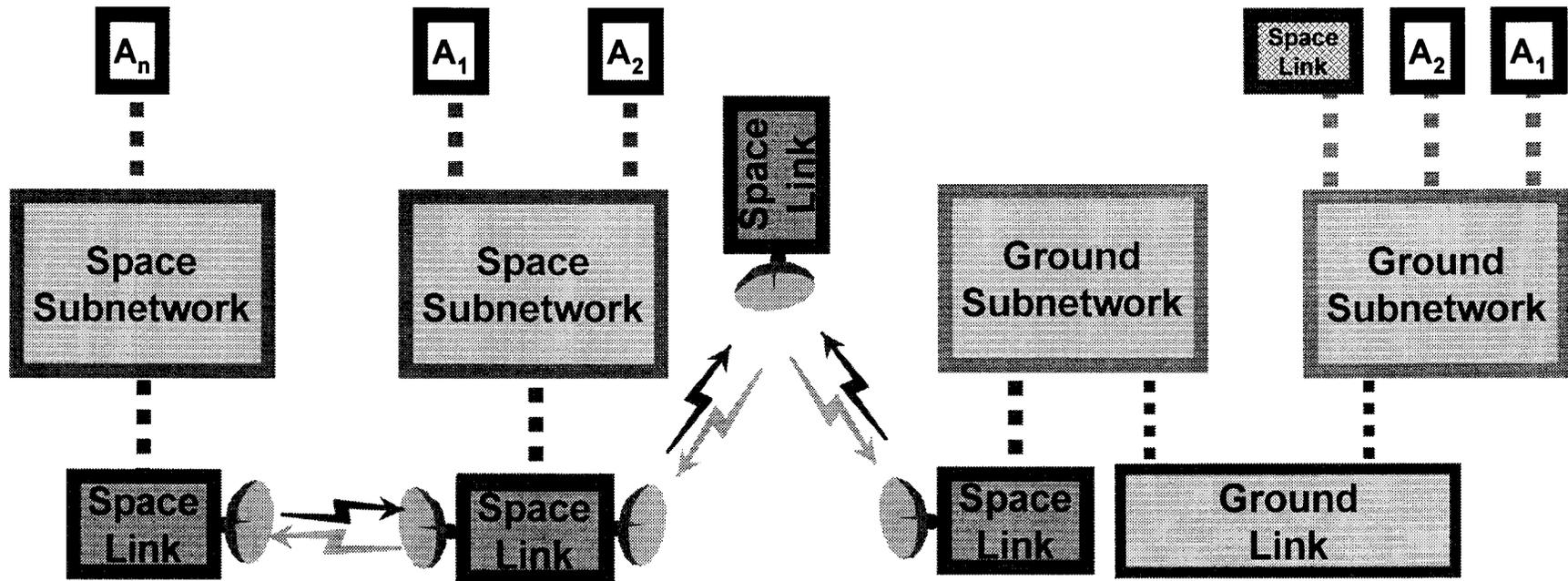
Problem Space



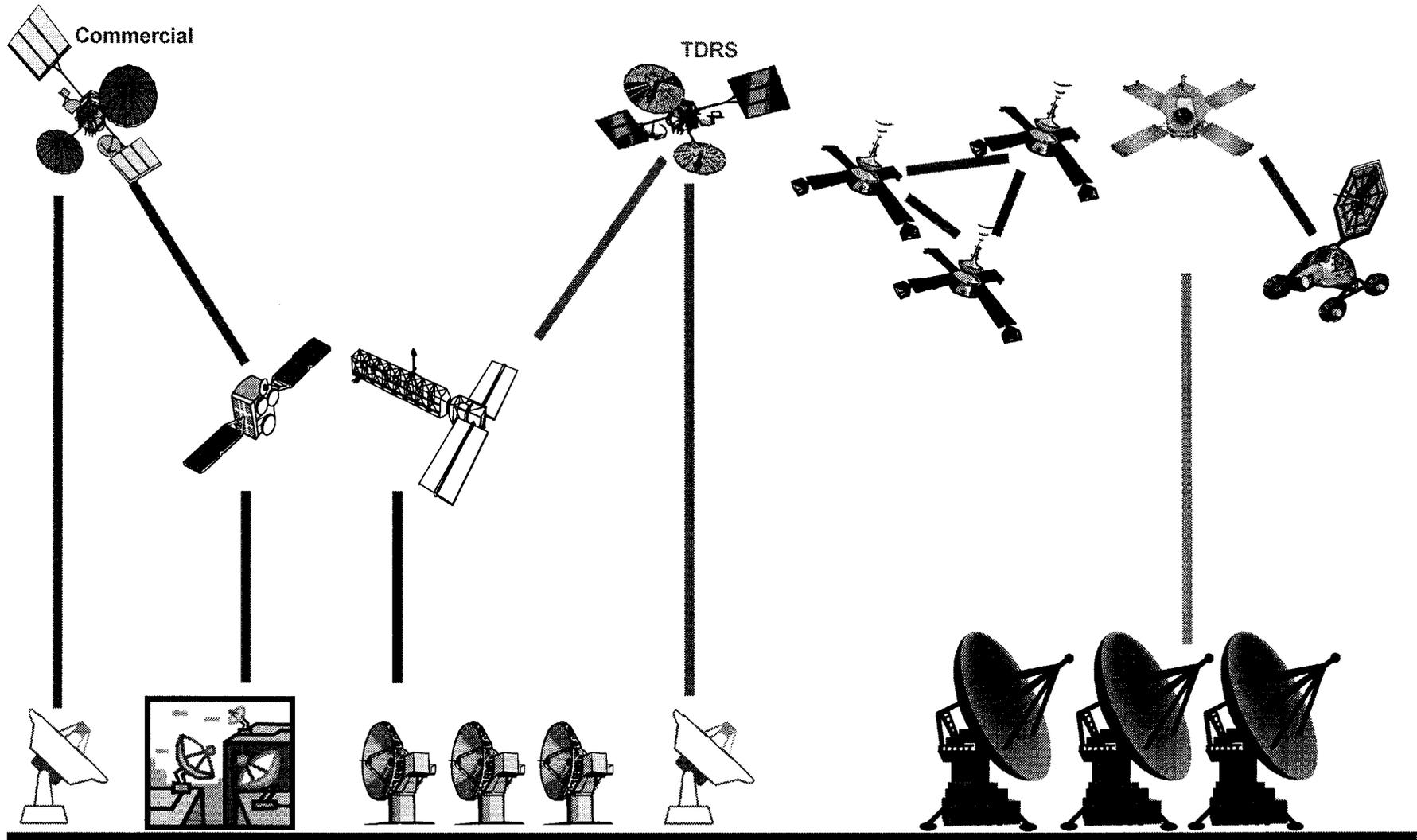
Model of Space Operations (Distributed Applications)



Variants of the Space Communications Model



Types of Space Links

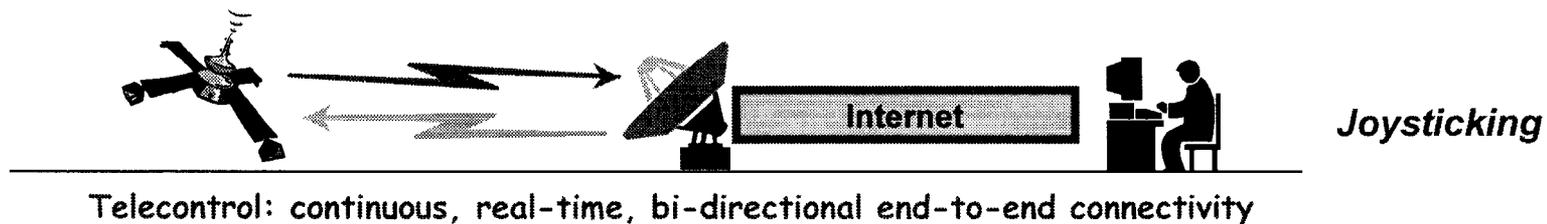


- Near-Earth, LEON Direct
- Near-Earth, TDRS Relay
- Near-Earth, Commercial Relay
- Near-Earth, Direct Broadcast

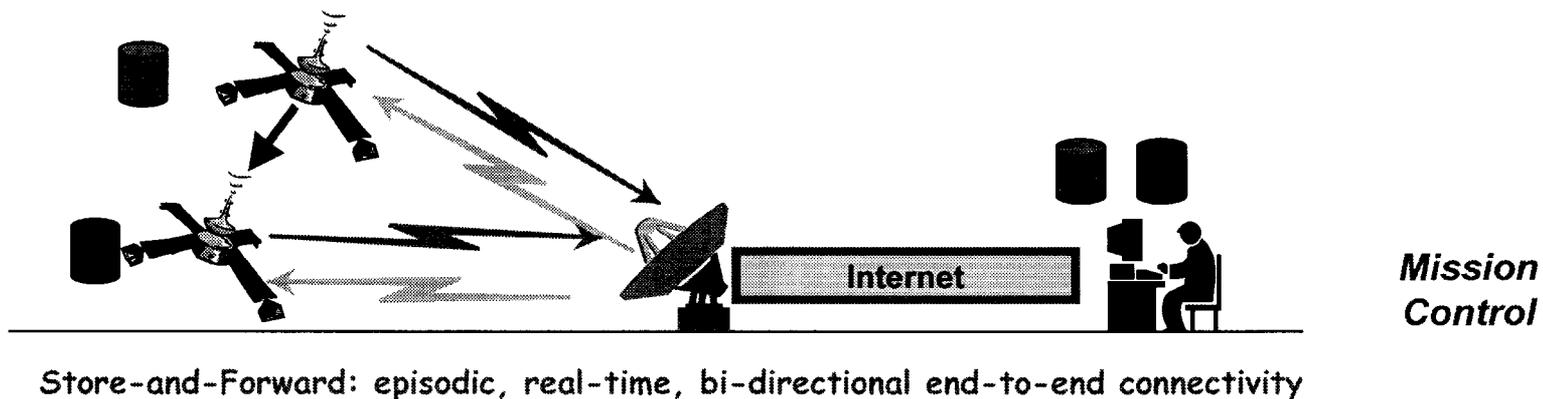
- Deep Space, DSN Direct
- In-Space Proximity/Relay

User Operations Models

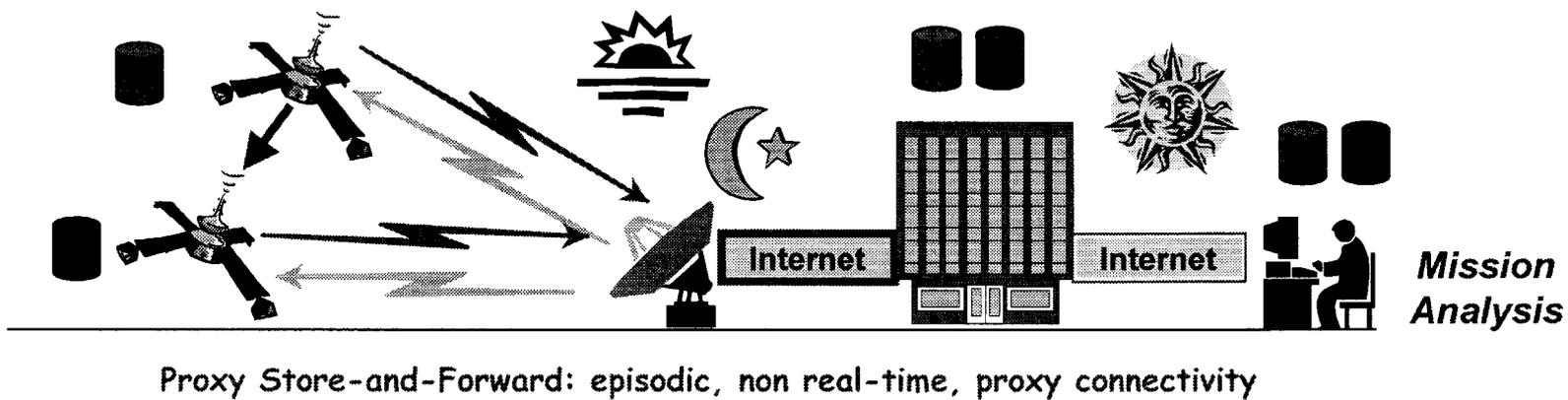
<< 1% of
Mission
Operations



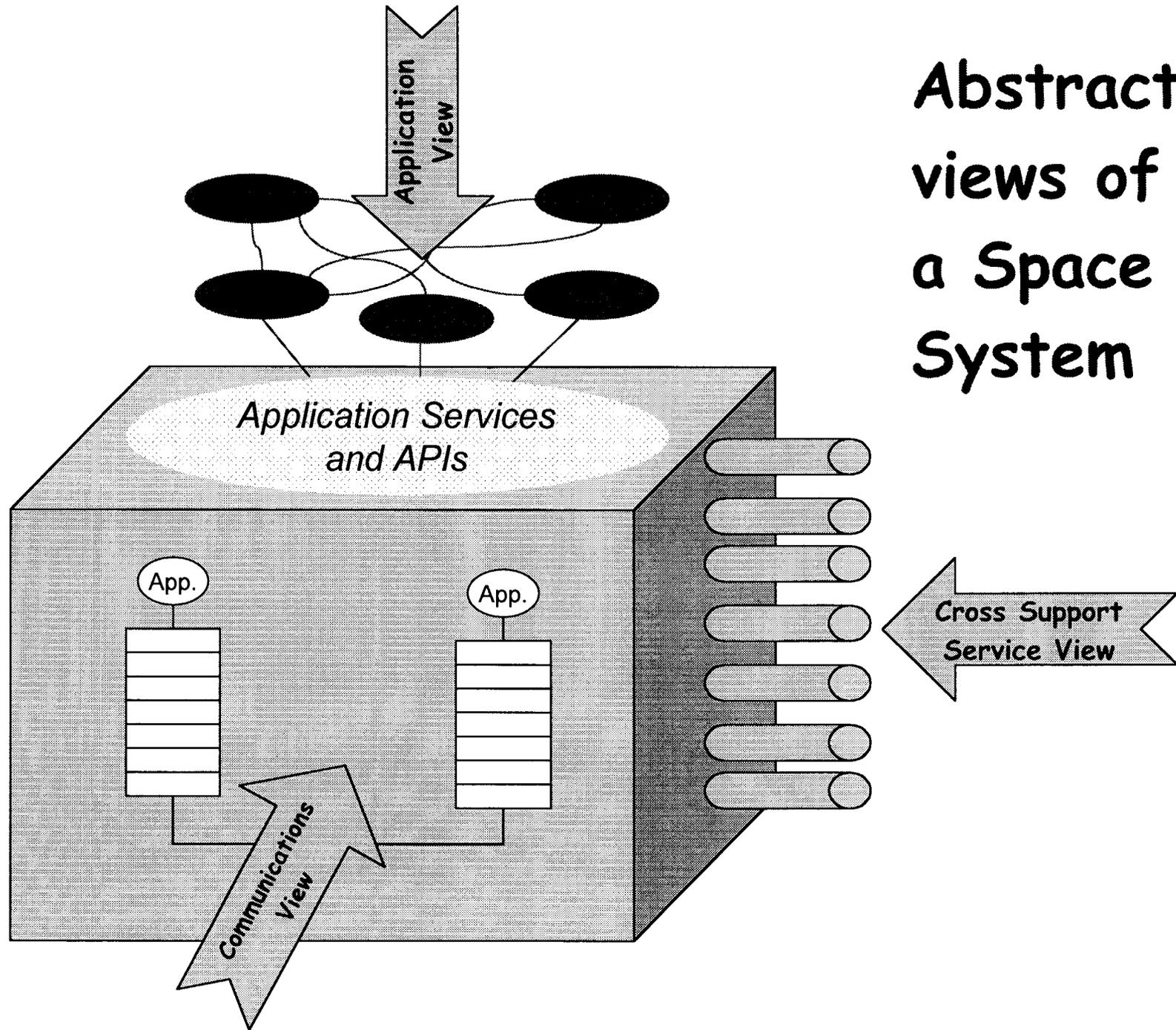
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Mission
Operations



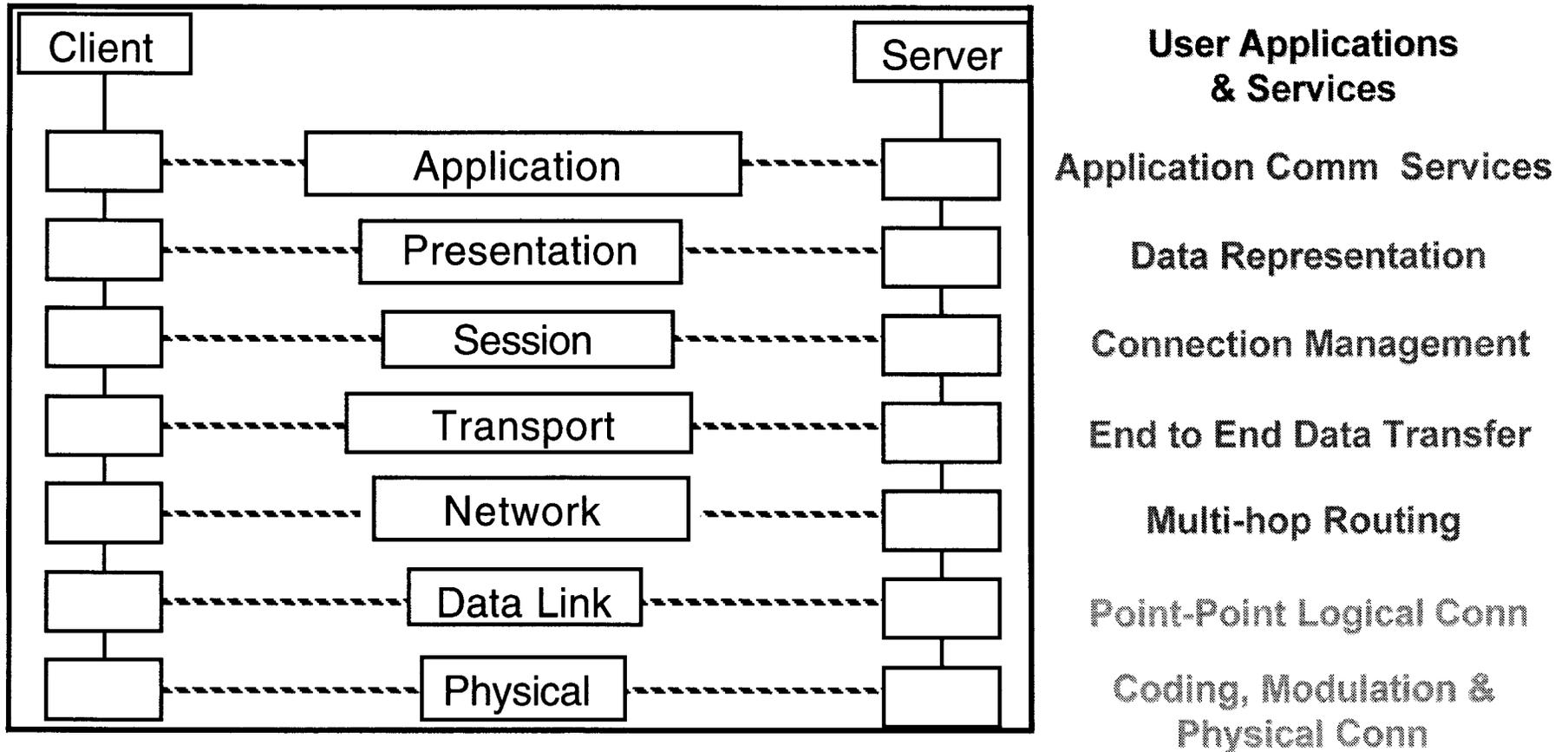
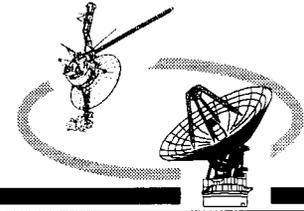
~ 95% of
Mission
Operations



Abstract views of a Space System

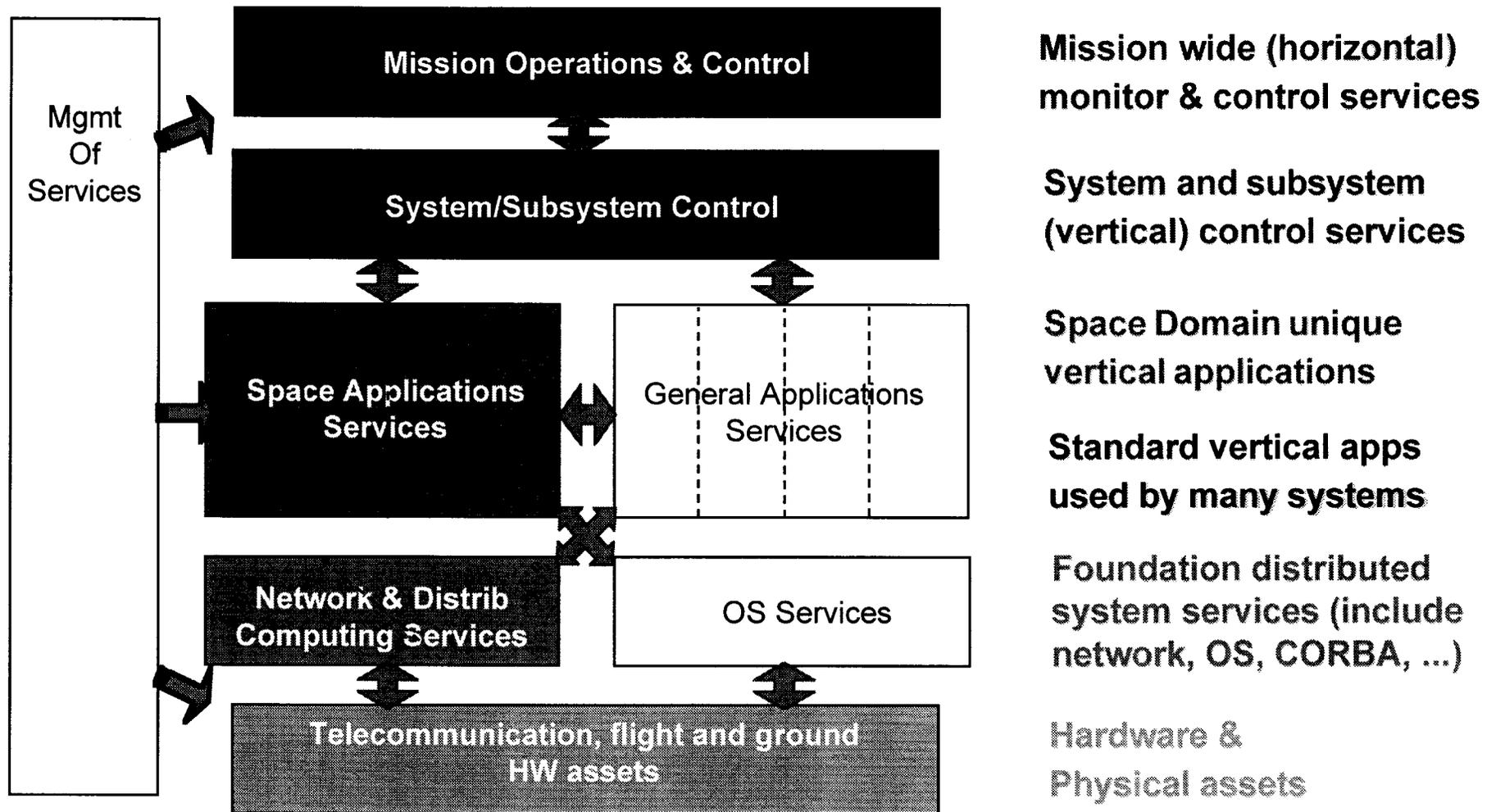
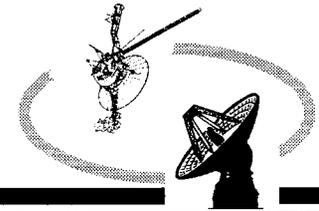


Canonical ISO "7 - Layer" Communications Model



Describes communication stack layers in terms of services provided to the layer above, services required from the layer below, and functions and protocols within the layer that provide the capabilities within the layer. This abstracts the layers, so as to allow each layer to be independent of the specific design of the other layers.

INTERPLANETARY NETWORK DIRECTORATE
OMG Reference Architecture
Generic Functional Structure

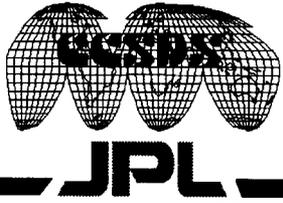


Source: OMG Space DTF

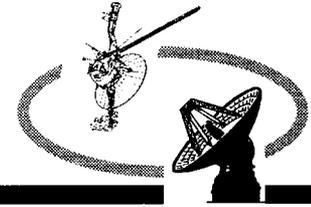
7 May 2002

4'th QMSW Workshop

PMBS Pg 13

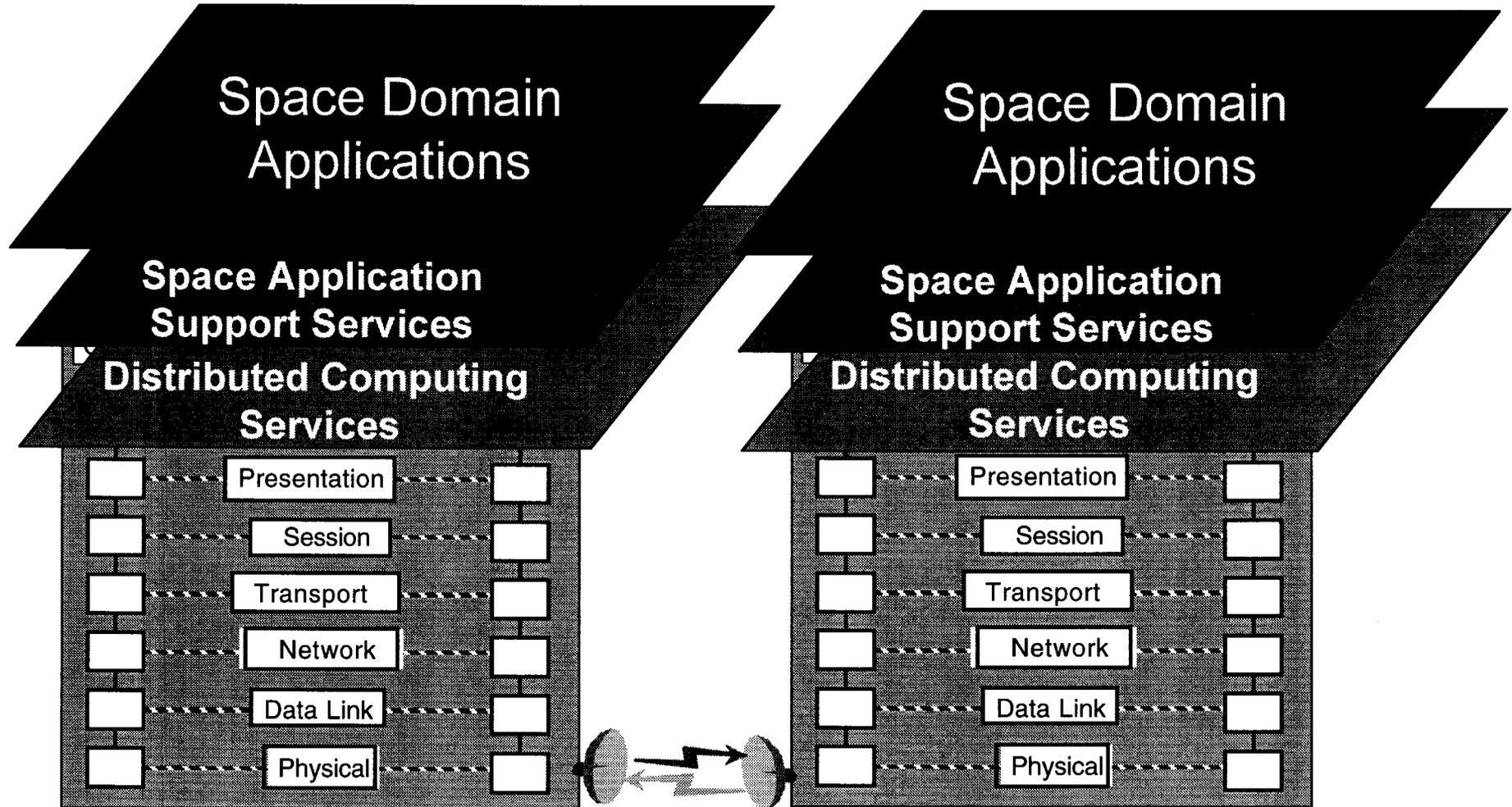


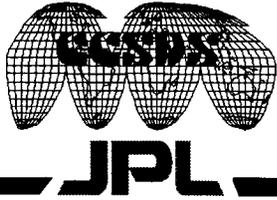
INTERPLANETARY NETWORK DIRECTORATE
**Orthogonal Communication Stack
and Applications Stacks**



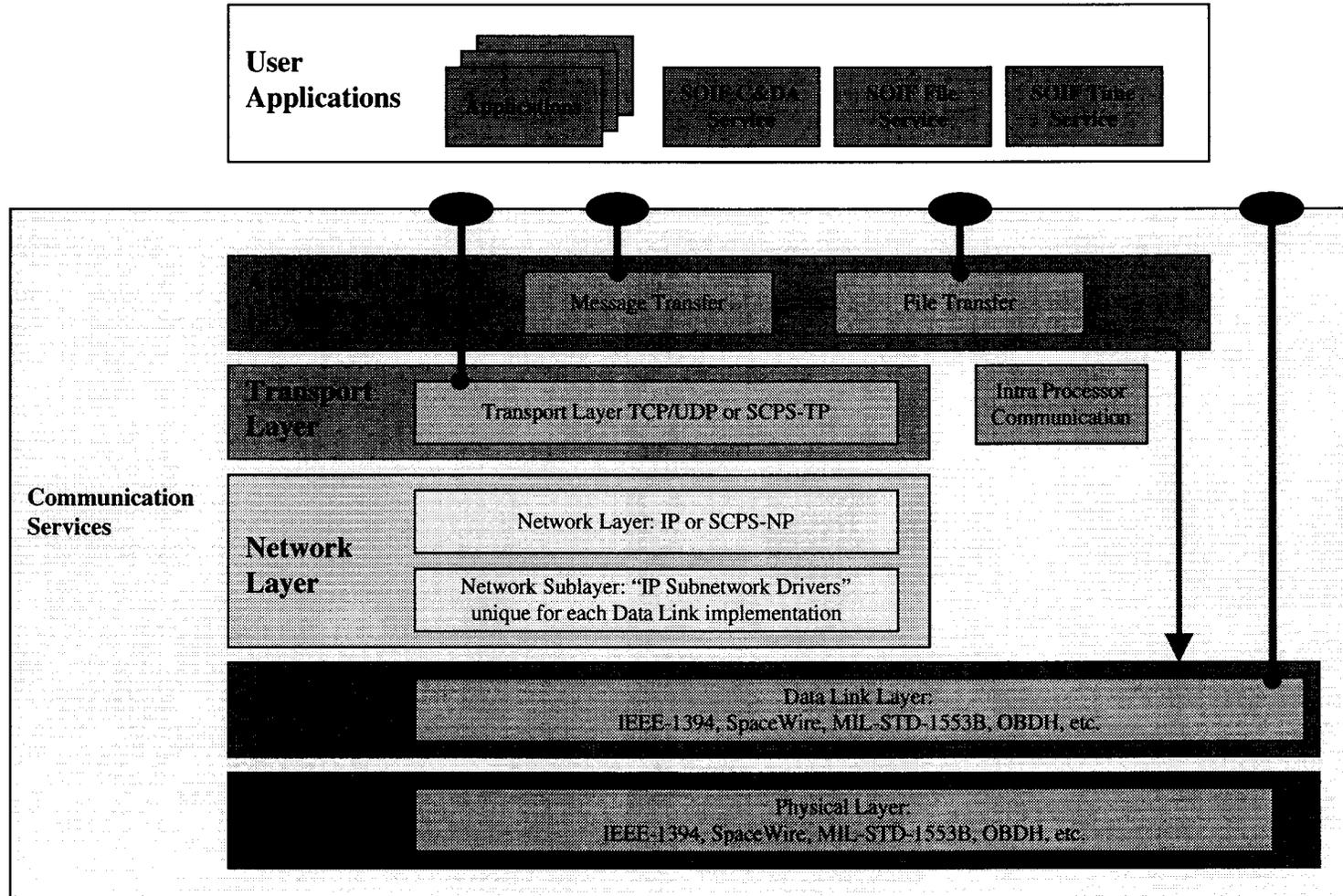
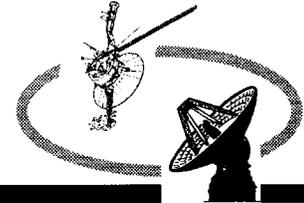
Flight

Ground





INTERPLANETARY NETWORK DIRECTORATE Spacecraft On-board InterFace (SOIF) Implementation Model

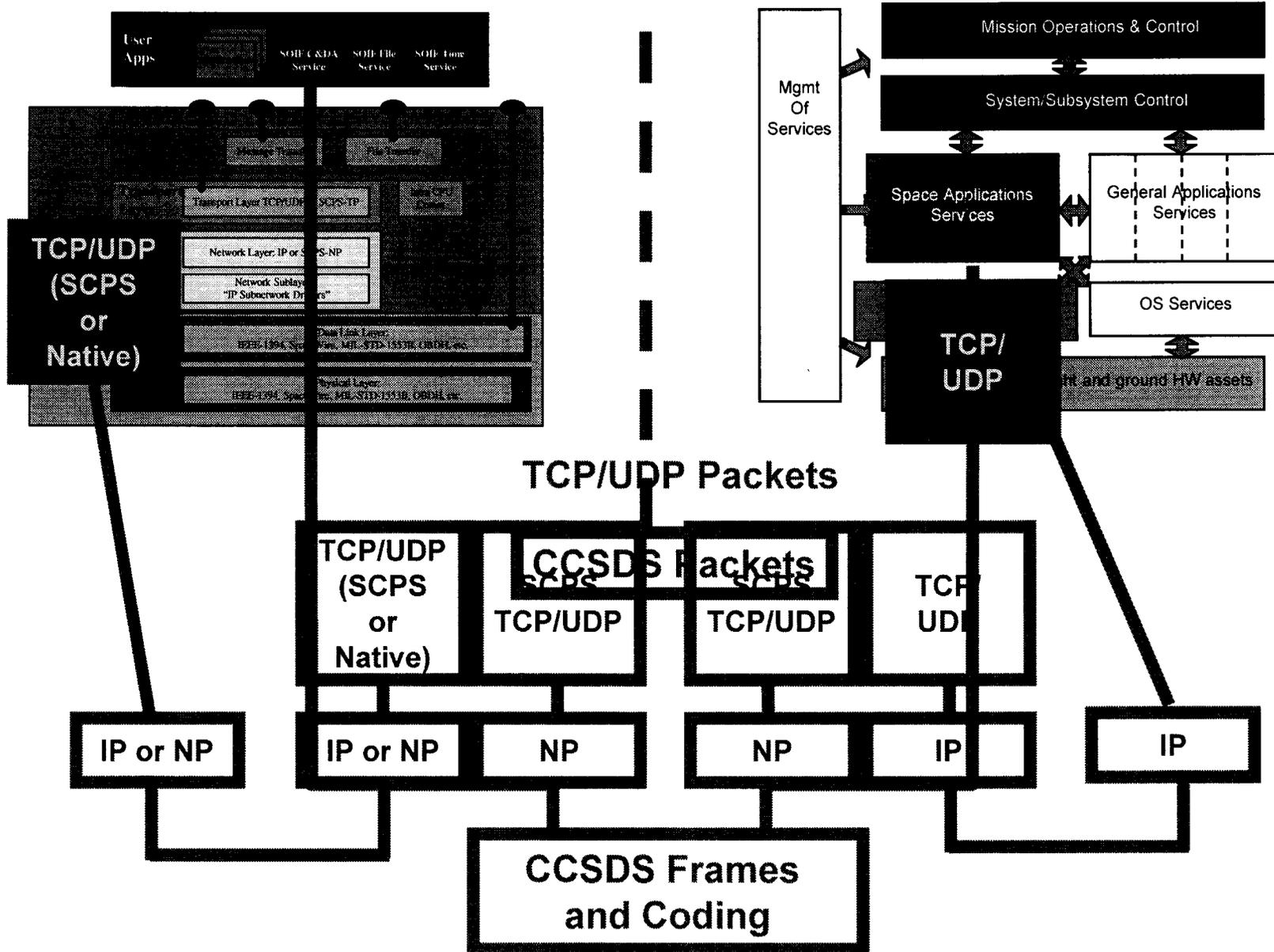


NOTE: No security protocol is shown in order to simplify this diagram

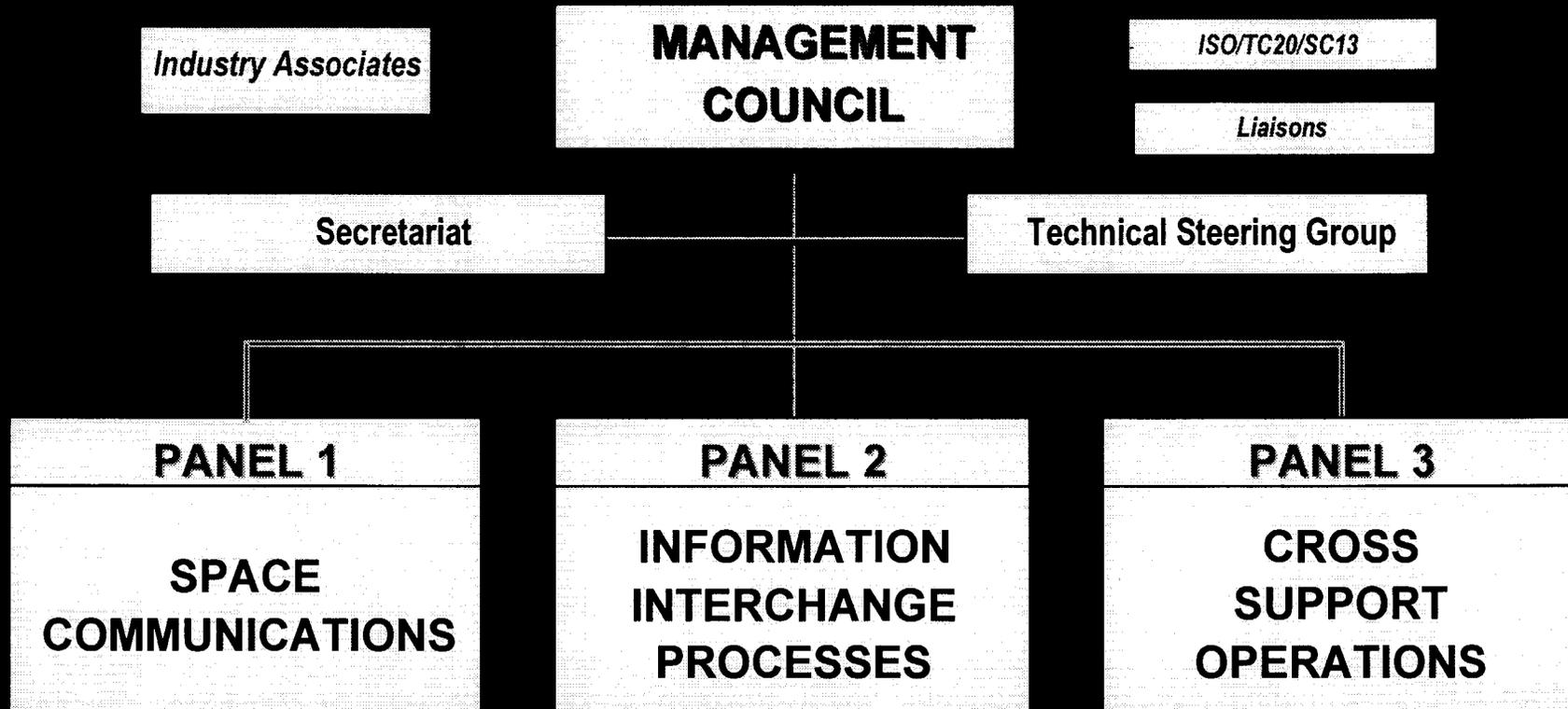
Some Views of Flight / Ground Integration

Flight

Ground



Consultative Committee for Space Data Systems (CCSDS)

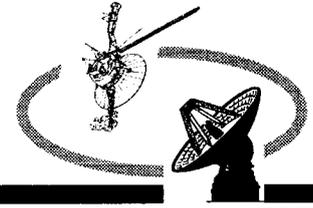
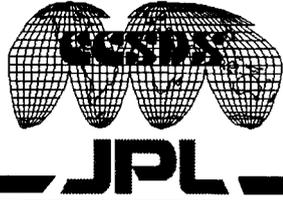


Member Agencies

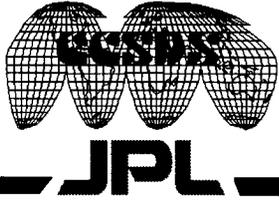
ASI/Italy *ESA/Europe*
BNSC/UK *INPE/Brazil*
CNES/France *NASA/USA*
CSA/Canada *NASDA/Japan*
DLR/Germany *RSA/Russia*

Observer Agencies

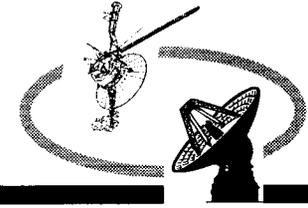
ASA/Austria *CTA/Brazil* *IKI/Russia* *NOAA/USA*
CAST/China *DSRI/Denmark* *ISAS/Japan* *NSPO/Taipei*
CRC/Canada *EUMETSAT/Europe* *ISRO/India* *SSC/Sweden*
CRL/Japan *EUTELSAT/Europe* *KARI/Korea* *TsNIIMash/Russia*
CSIR/South Africa *FSST&CA/Belgium* *KFKI/Hungary* *USGS/USA*
CSIRO/Australia *HNSC/Greece* *MOC/Israel*



Fleet Slide Goes Here



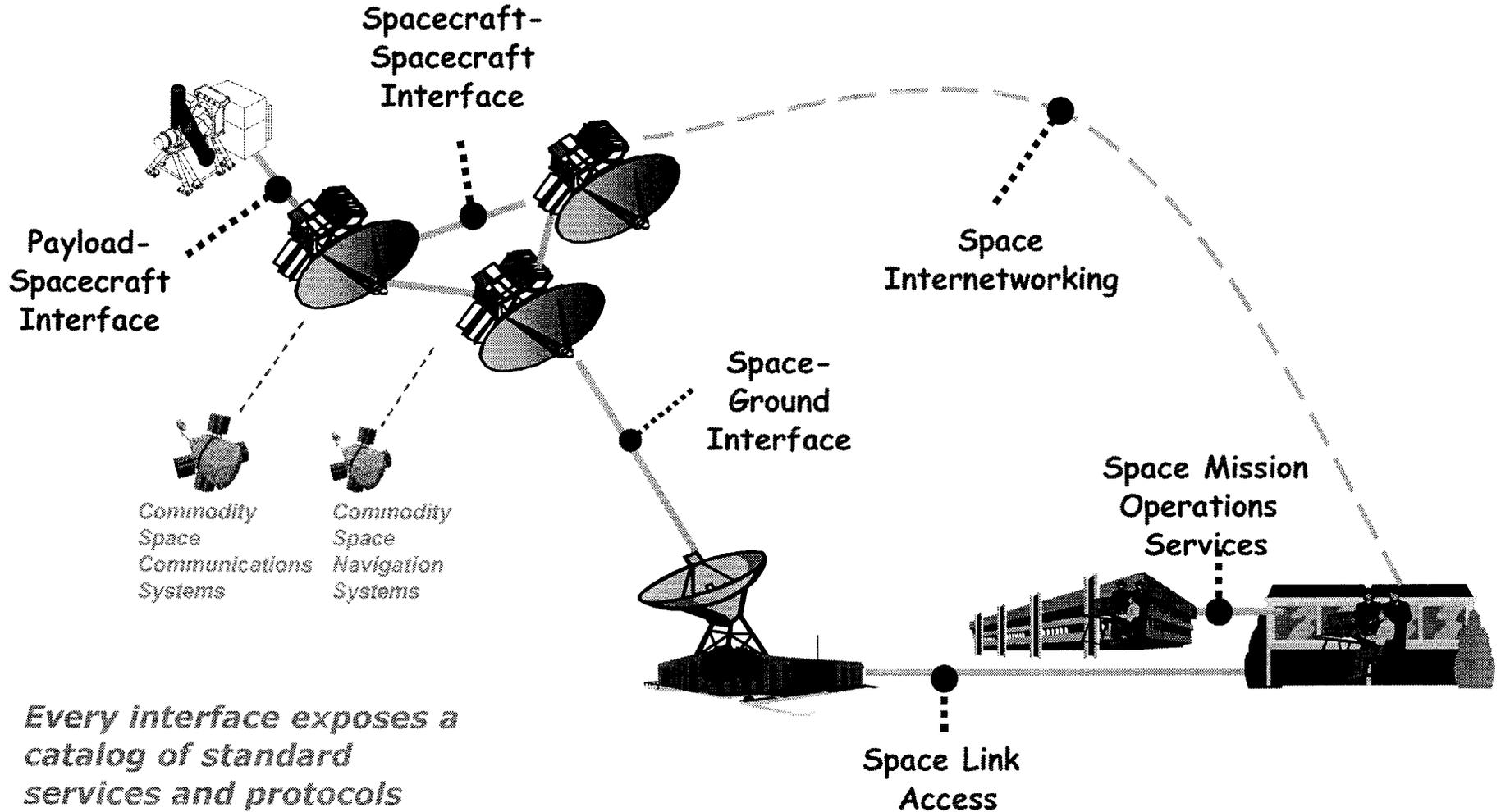
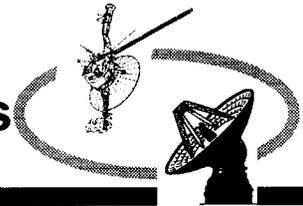
What do we need to standardize?



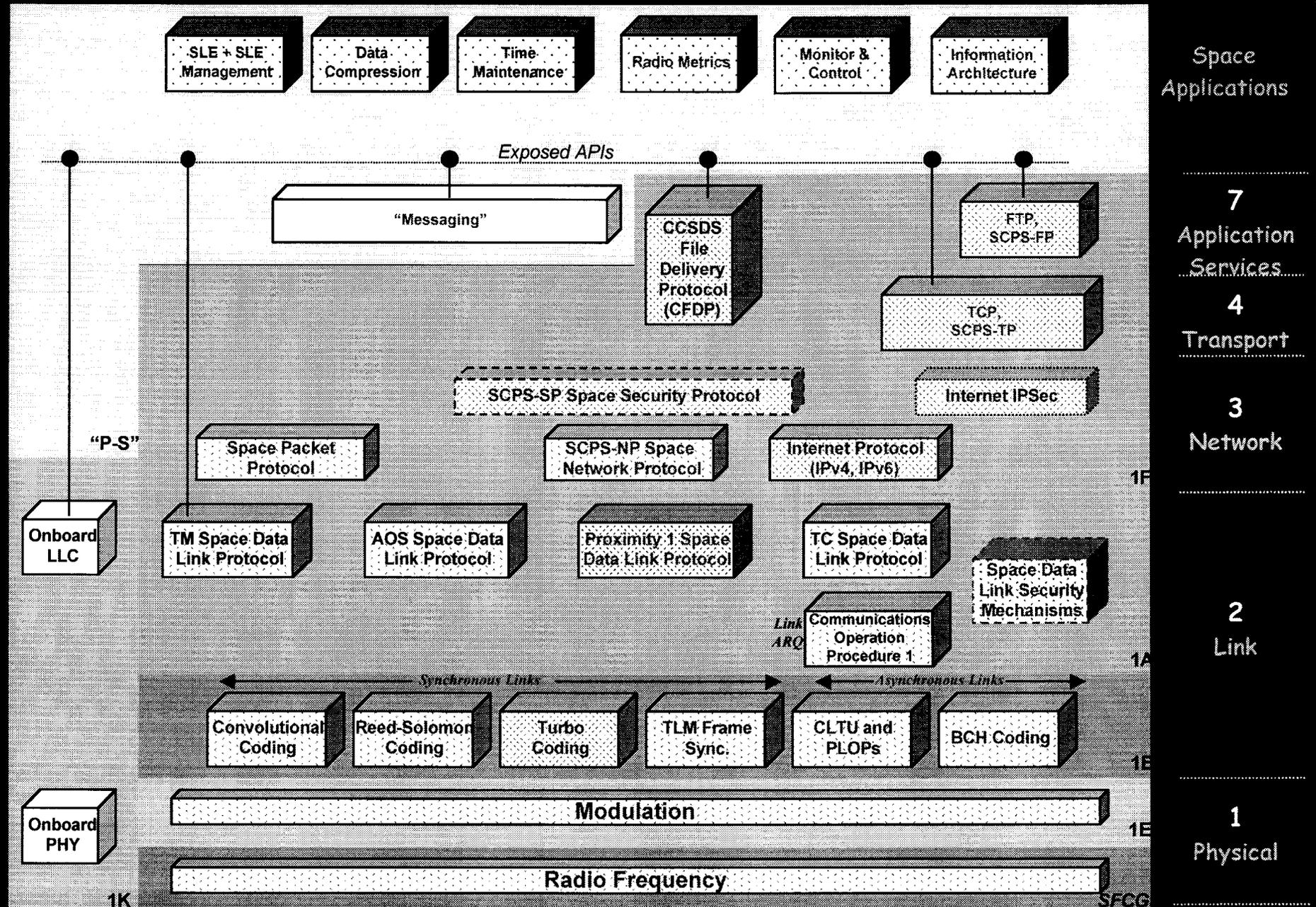
- **Instrument to spacecraft interfaces**
- **Spacecraft to ground station**
- **Spacecraft to spacecraft**
- **Ground station to mission operations center**
- **Science operations to mission operations**



Space Communications Interoperability Points

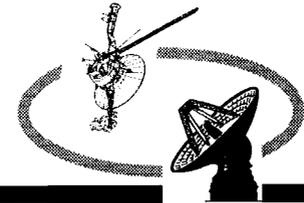


View of CCSDS Space Communications





INTERPLANETARY NETWORK DIRECTORATE
Current JPL Program Content
FY 02



- **CCSDS File Delivery Protocol (CFDP)**
 - Standard w/ core and extended procedures for relaying & product delivery
 - Flight / ground implementation for Deep Impact (w/ IND Engineering)
 - Mars relay , technology prototype

- **Proximity 1 Link Protocol**
 - Restructured Link Layer Space Protocol Documents
 - Adoption by Mars Exploration Program

- **Space Communication Protocol Standard (SCPS)**
 - Internet protocols augmented for near Earth use in space
 - Several commercial products now available for use over satellite links

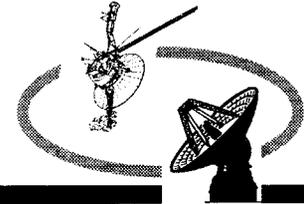
- **Space Link Extension (SLE)**
 - Telemetry & command transfer services for cross support
 - Service requests & service management

- **Spacecraft Onboard InterFace (SOIF) Definition**
 - SOIF Message Layer prototype

- **And several other tasks**
 - Navigation interchange standards
 - Bandwidth & spectrum efficient coding and modulation
 - Object Management Group (OMG) Space Domain Task Force
 - XML Space Application Study

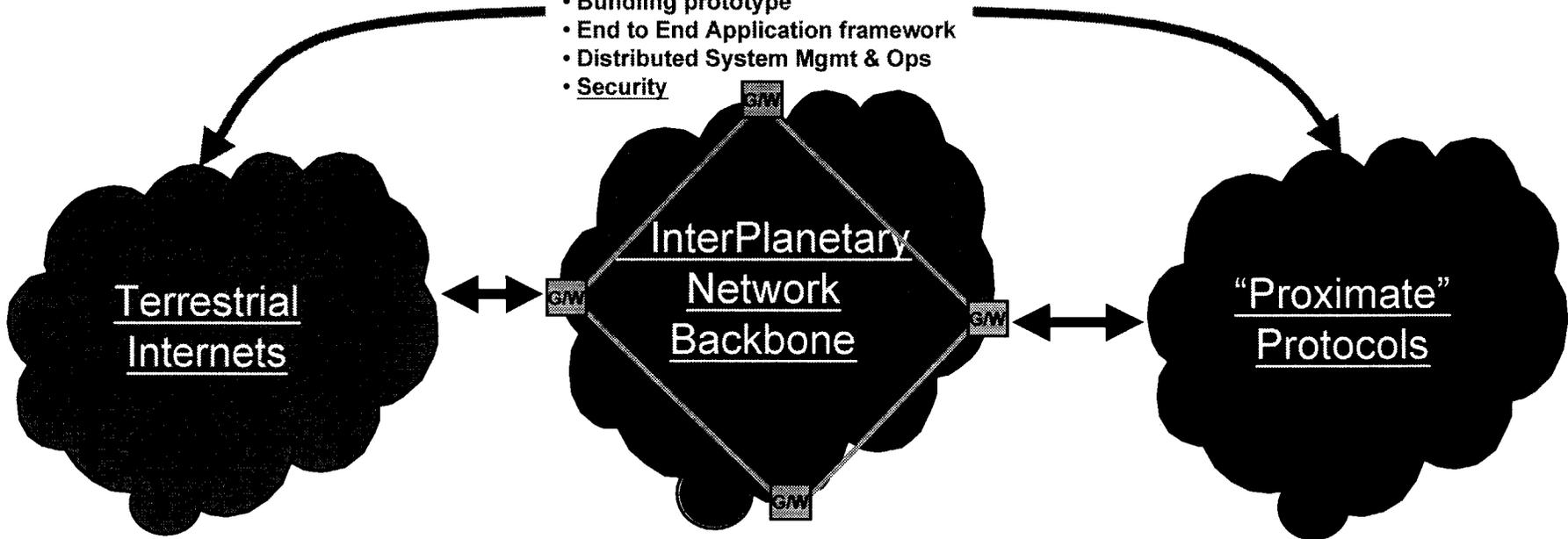


InterPlanetary Network Global Overview



End-to-End Protocols for IPN

- CFDP baseline completion
- Bundling prototype
- End to End Application framework
- Distributed System Mgmt & Ops
- Security



Internet Technologies

- IS Technologies (XML)
- Visualization
- Immersive environments
- Application component middleware (OMG & others)
- Web based applications
- SLE (transport, mgmt)

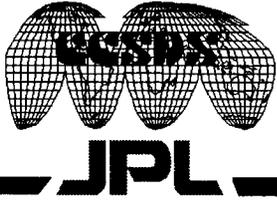
InterPlanetary Network "Backbone"

- RF (coding, modulation)
- Optical (coding, modulation, stds)
- Link (coding, modulation, interop)
- Navigation (stds, interop)
- Time (clocks, time svcs)

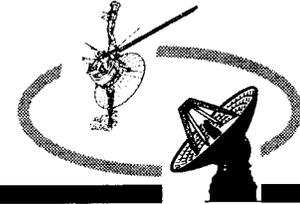
"Proximate" Internets

- Local wireless (include constellation & formation)
- Local wired (include S/C & surface)
- Local Internet (include near planet)





IPN Work Plan Summary



1) Unified Space Data Link Layer

- Develop single, unified, parameterized Space Data Link protocol that leverages existing work
- Ensure that the link protocols support X & Ka band as well as future advances such as optical comm
- Develop new state/model approach for defining, designing, evaluating and developing such protocols

2) End-to-end Protocols for IPN

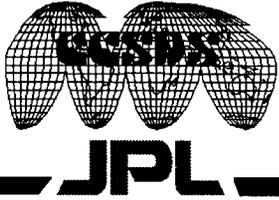
- Develop end to end protocol suite to enable future IPN implementation
- Leverage existing CFDP developments to provide near-term operational enhancements & graceful transition approach
- Augment well understood end to end protocols to provide clock synchronization, timing and ranging in deep space

3) Space Based Networks

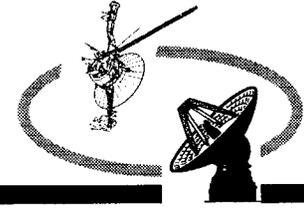
- Provide powerful & well tested space networking technologies for distributed system development
- Apply technologies to a variety of spacecraft on-board and inter S/C coordination problems
- Integrate ancillary protocols for time, clocks, ranging
- Integrate “Sensor Web” approaches with “long haul” transport

4) End-to-End Applications

- Adapt standardized “middle-ware” approaches to simplify system integration
- Identify methods for information exchange for space asset interoperability
- Evaluate application of widely adopted methods for control, monitoring and management of space assets
- Develop object oriented component architecture for plug and play re-usability

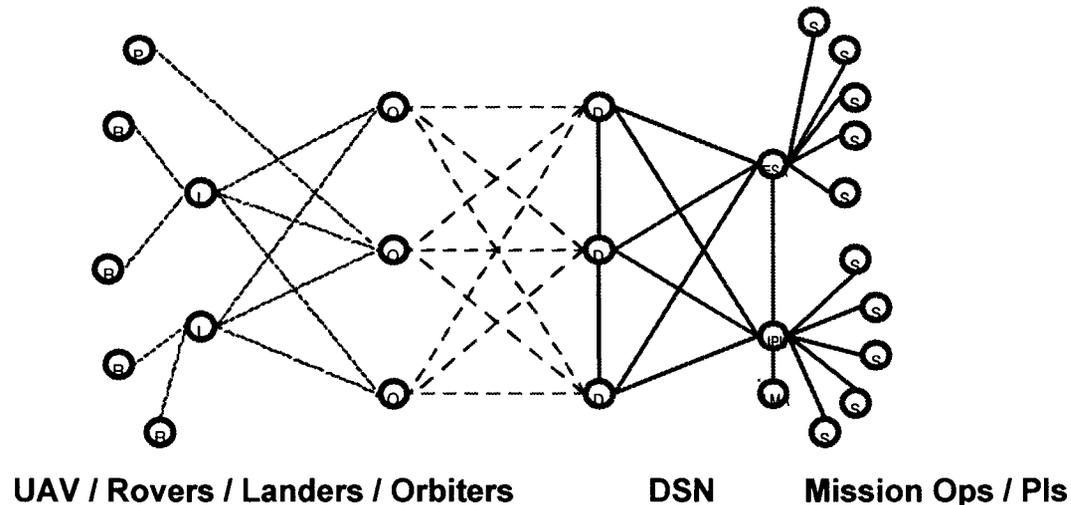


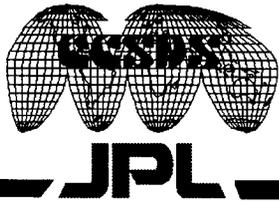
IPN Work Plan Summary, contd



5) Space Communication Protocol Incubator

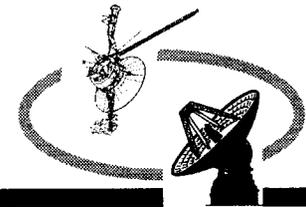
- Integrate & test space protocols at all layers in the “stack”
- Emulate many different operational and environmental configurations
- Supply physical assets, simulations, and technical resources to support multiple uses
- Provide a resource for many other elements in the overall process, perform demonstrations and simulations for mission & project evaluation





INTERPLANETARY NETWORK DIRECTORATE

FUTURE - "Web" and "Internet"



The web of applications that make information available to everyone

"The Worlds Wide Web"



The Internet

The Interplanetary Network

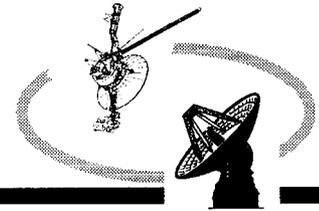


The communications systems that move data

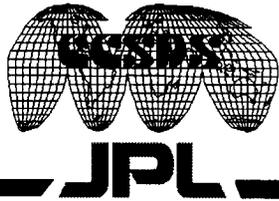
How Stuff Works



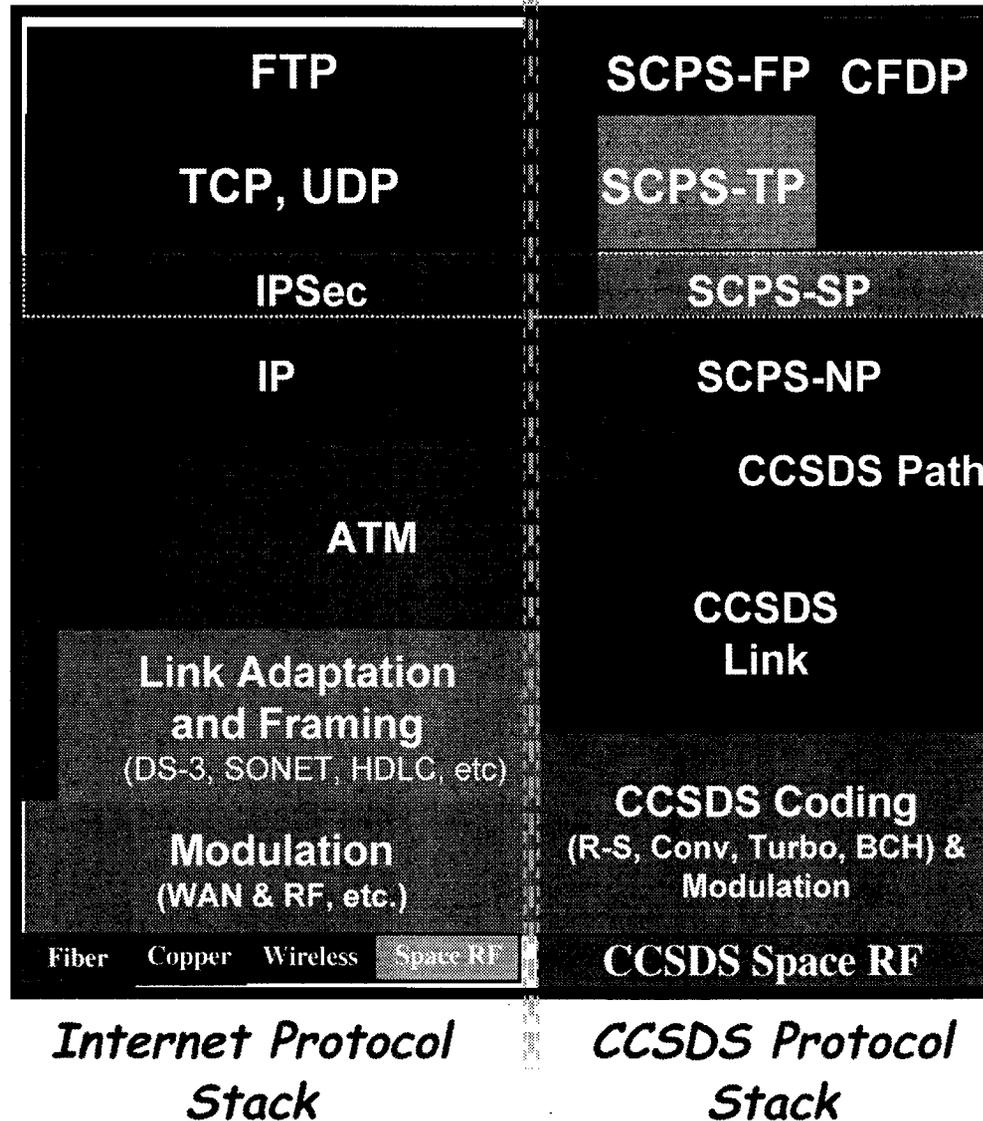
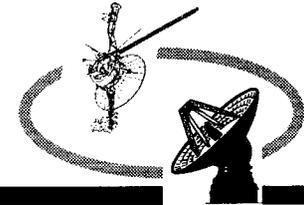
You

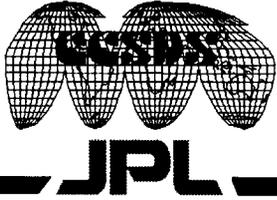


BACKUP SLIDES

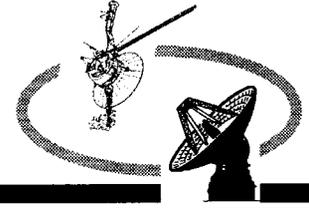


Mapping CCSDS & Internet Stacks





Define: Architecture & Models



- An "architecture" is a conceptual representation of a system and its parts, and how they fit together.
- A "system model" is an organized, internally consistent set of abstractions that collaborate to achieve system descriptions at a desired level of detail and maturity. Bruce Douglass
- A "model" is a representation of a specific abstraction to describe a system for a specific purpose.