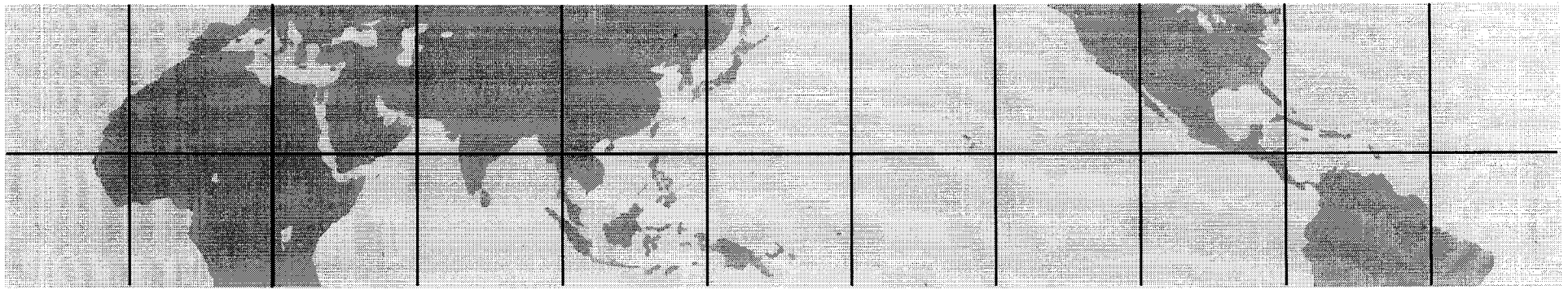
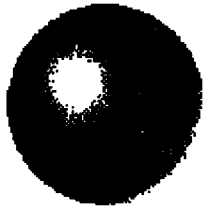
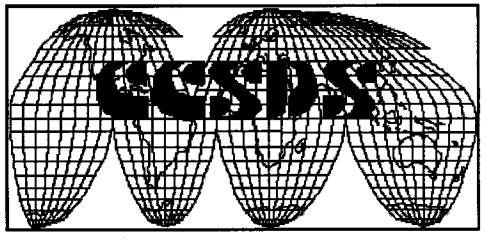




XML Workshop Report



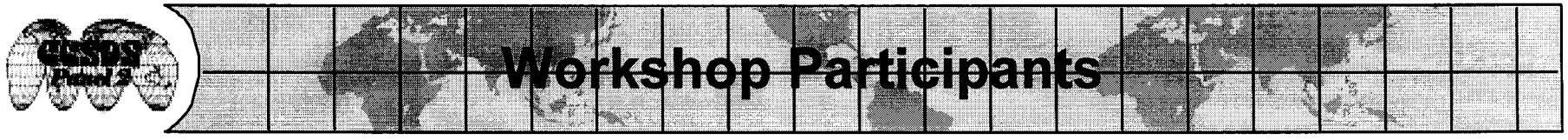
15 April 2002

David Giaretta, BNSC

Peter Shames, NASA/JPL

Workshop Motivation

- Interagency cross- support interfaces typically use manual interfaces and interchange of unstructured information
- CCSDS standards activities have developed some capabilities for electronic data exchange, particularly SLE transfer services and Panel 2 standards
- There are a number of commercial standards, such as XML and related standards, that can be usefully applied to automate the secure exchange of service requests and related information
- We wish to leverage these technical capabilities to provide secure interfaces for interagency interoperability and cross-support

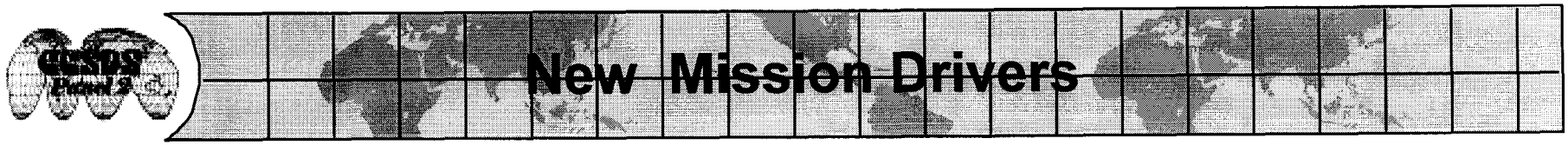


RAL, Oxford - 3-5 April 2002

- David Giaretta, BNSC, co-chair
- Peter Shames, JPL, co-chair
- Erik Barkley, JPL
- Dan Crichton, JPL
- Andy Dowen, NASA
- John Garrett, GSFC
- Adrian Hooke, JPL
- Steve Hughes, JPL
- Nicklas Lindstrom
- Arnaud Lucas, CNES
- Nestor Peccia, ESOC
- Lou Reich, GSFC
- Don Sawyer, GSFC
- Ed Shaya, GSFC
- Anthony Walsh, Vega

XML Workshop Overview

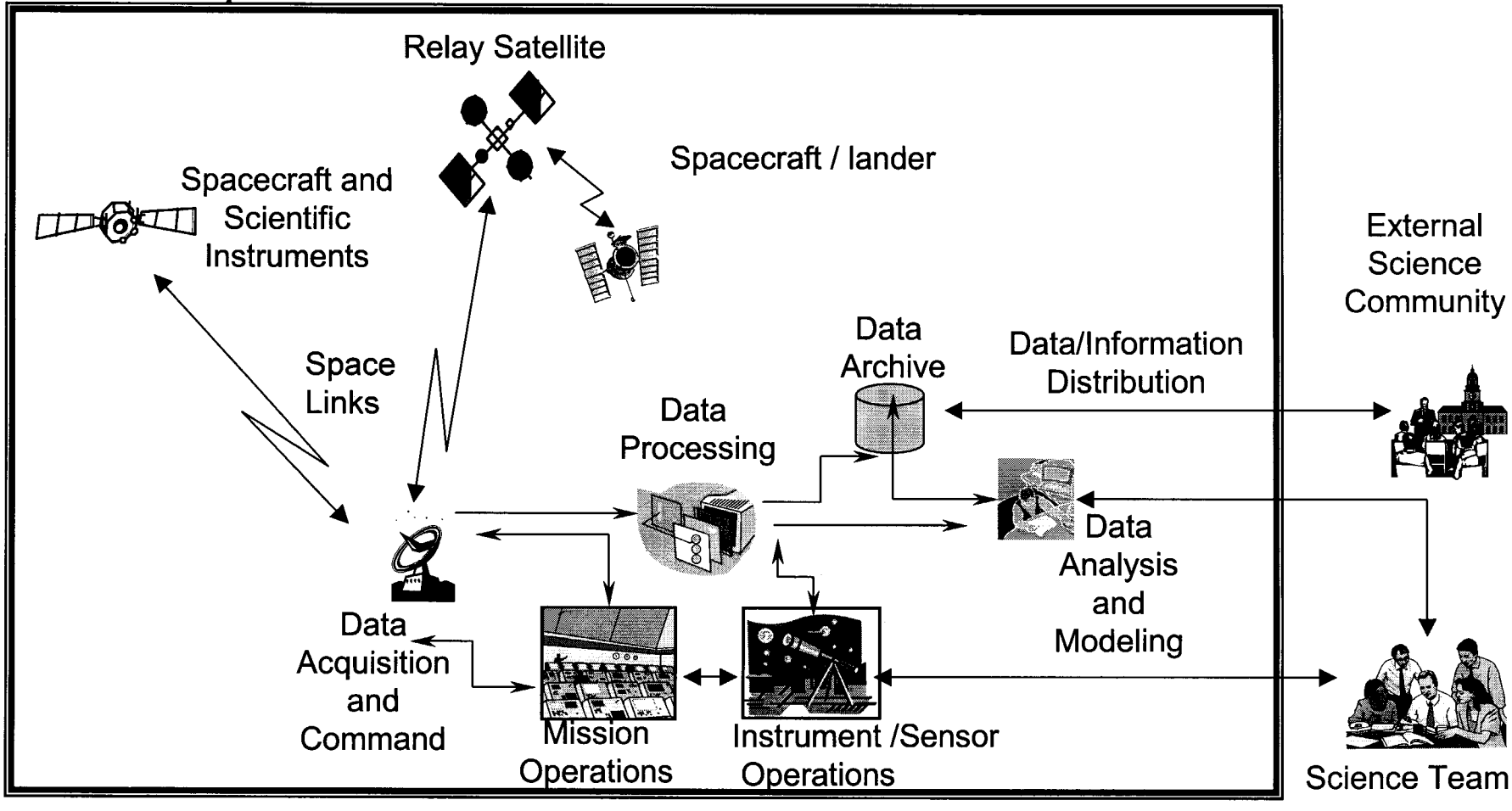
- Review & agree on general information framework needed for further definition of CCSDS standards for interfaces in the entire space domain.
- Review XML-related technologies
  - SOAP
  - WSDL
  - UDDI
  - XMLQUERY
  - Etc.
- Identify representative set of interfaces to provide goal for prototyping information architecture.
- Review current efforts underway
  - OODT (JPL)
  - XDF (GSFC)
  - XASTRO (ESA)
  - XML SLE SM (JPL/ESA)
- Identify information framework components needed for representative interfaces.
- First-cut at scope and approach for prototype information architecture



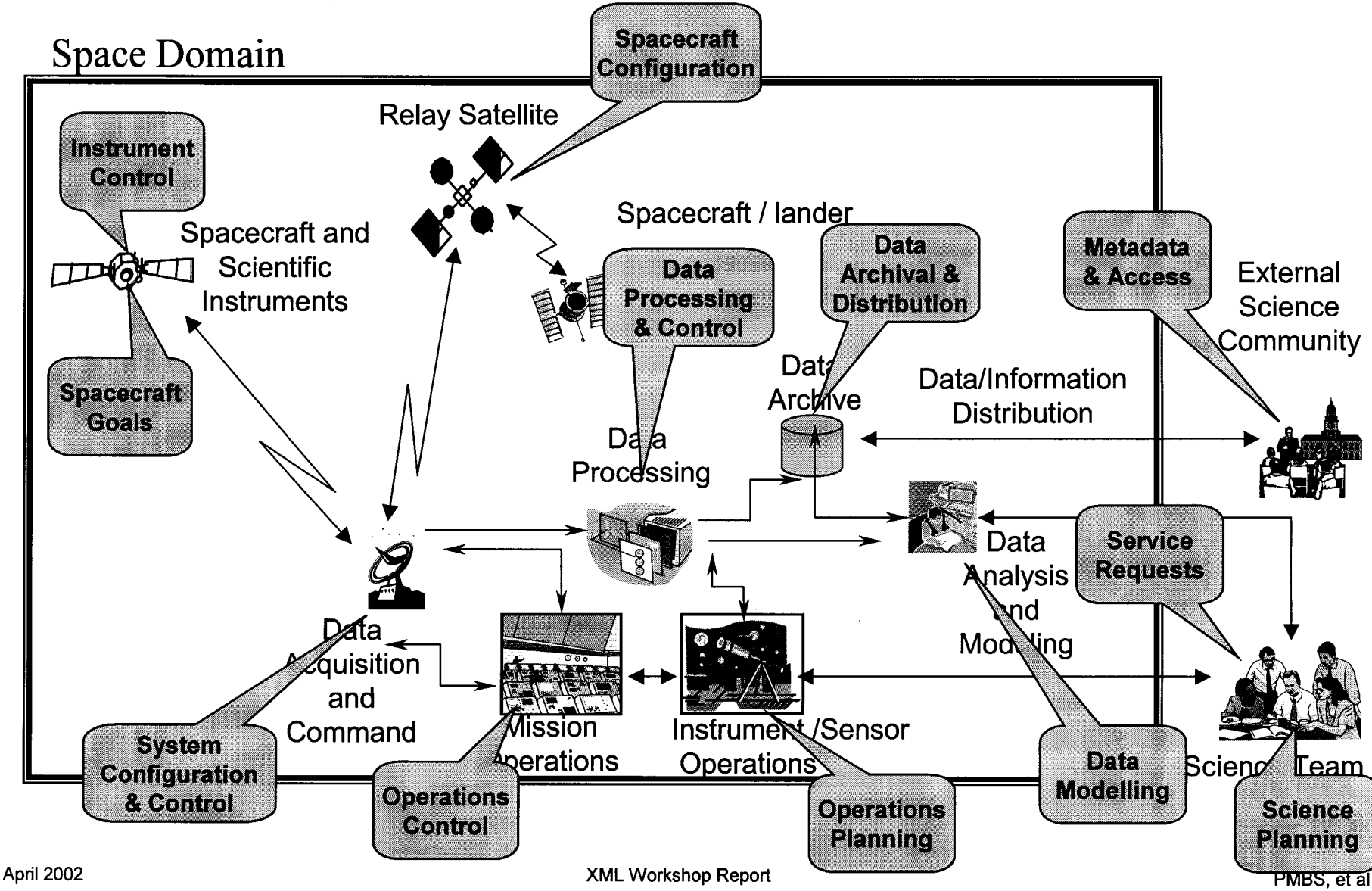
- **MORE, SMALLER MISSIONS**
  - Less power
  - Less weight
  - Reduced costs
- **HIGHLY DISTRIBUTED MULTI-ORGANIZATION OPERATIONS & SCIENCE TEAMS**
  - Lifecycle support issues
- **CHALLENGING MISSION SCENARIOS**
  - Constellation and Formation Flying Missions
    - Inter Spacecraft Communications
    - 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.
  - High volume data and data integration/fusion issues

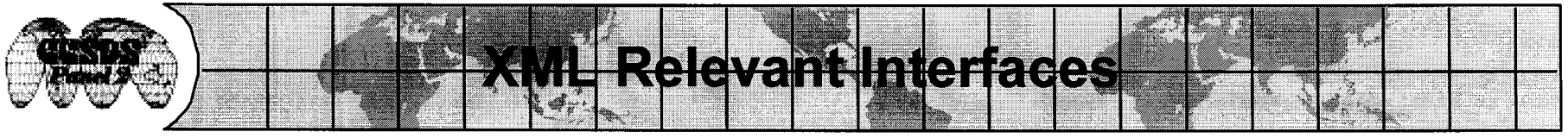
Space Domain
Functional Element View

Problem Space



Source: OMG Space DTF


Space Domain
Spacecraft Configuration
Relay Satellite
Instrument Control
Spacecraft and Scientific Instruments
Spacecraft / lander
Data Processing & Control
Data Archival & Distribution
Metadata & Access
External Science Community
Spacecraft Goals
Data Archive
Data/Information Distribution
Data Processing
Service Requests
Data Analysis and Modelling
Data Acquisition and Command
Mission Operations
Instrument /Sensor Operations
Science Team
System Configuration & Control
Operations Control
Operations Planning
Data Modelling
Science Planning



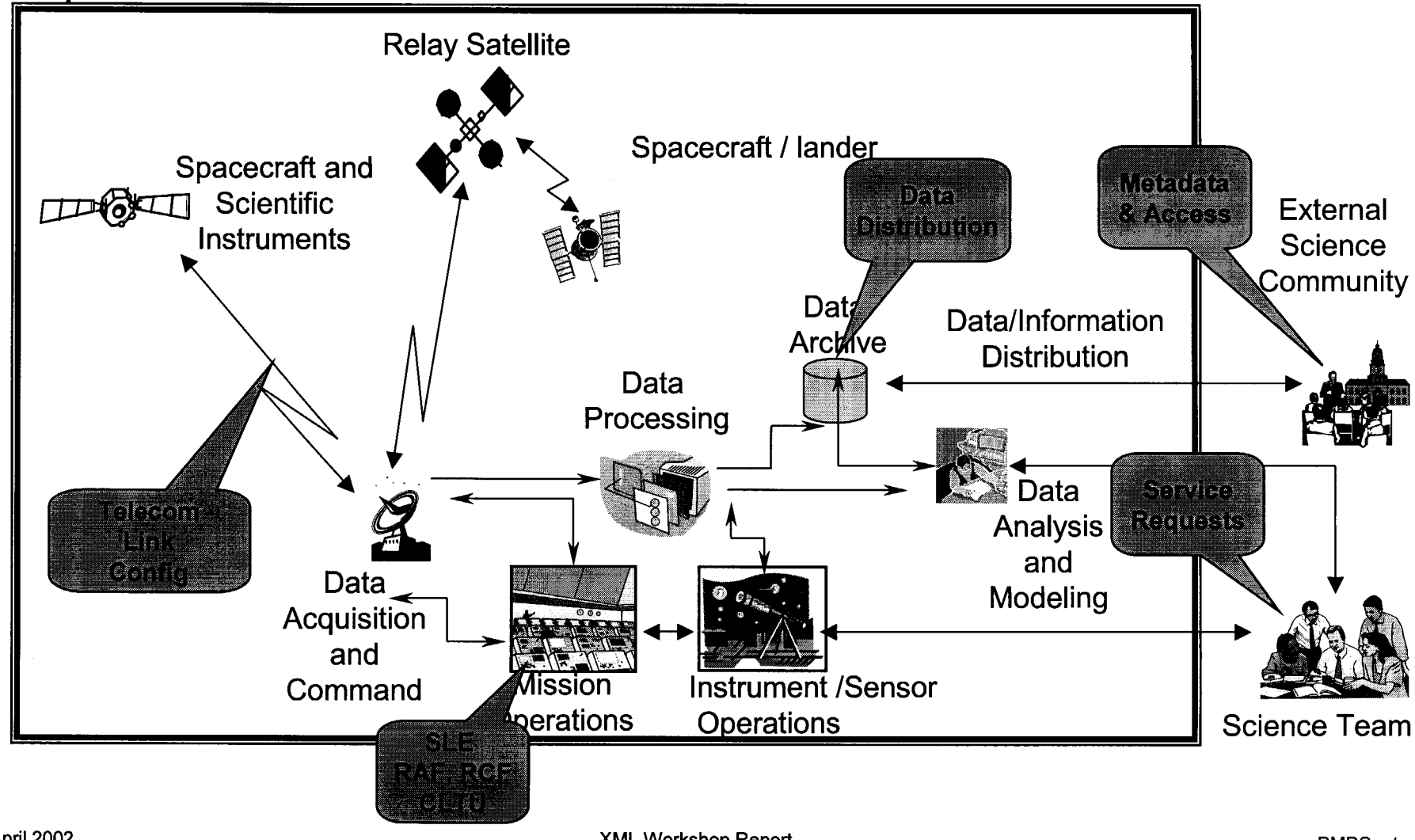
XML Relevant Interfaces

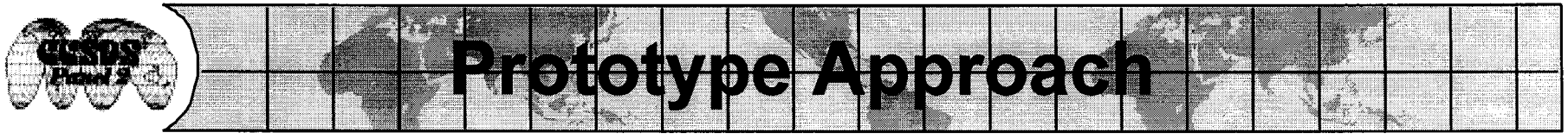
- Instrument to spacecraft interfaces
  - Instrument control & monitoring
  - Instrument data transfer
- Spacecraft to ground station
  - Command and data dictionary
  - Comm link characteristics
  - S/C monitor & control (common w/ Instr M&C?)
  - S/C functional configuration
- Spacecraft to spacecraft
  - Information exchange
- Ground station to mission operations center (MOC)
  - Ground station capabilities configuration
  - GS monitor & control (common w/ other M&C?)
- Science operations to mission operations
  - Service capabilities & requests (cmnd, telem, tracking)
  - Track/pass planning & scheduling
  - Observation requests, science planning (future)
- MOC data system to science data systems
  - Data access & retrieval, framework
  - Data description, packaging

XML Workshop
Recommended Development Approach

- Adopt high level vision of Space Mission Domain (Operations & Science)
- Develop use cases to define selected cross-support operational environment and user interactions
- Develop second level use cases that expose interactions among infrastructure elements
- Define data elements and structures that get exchanged across these interfaces
- Develop UML models, as appropriate, to describe information flows and system elements
- Evaluate viability of OODT, XDF, and other pieces from packaging study to provide infrastructure
- Leverage the selected components to prototype distributed data system framework
- Define distributed data system architecture, selected set of stds and interfaces, and data elements based on results of prototyping

Space Domain

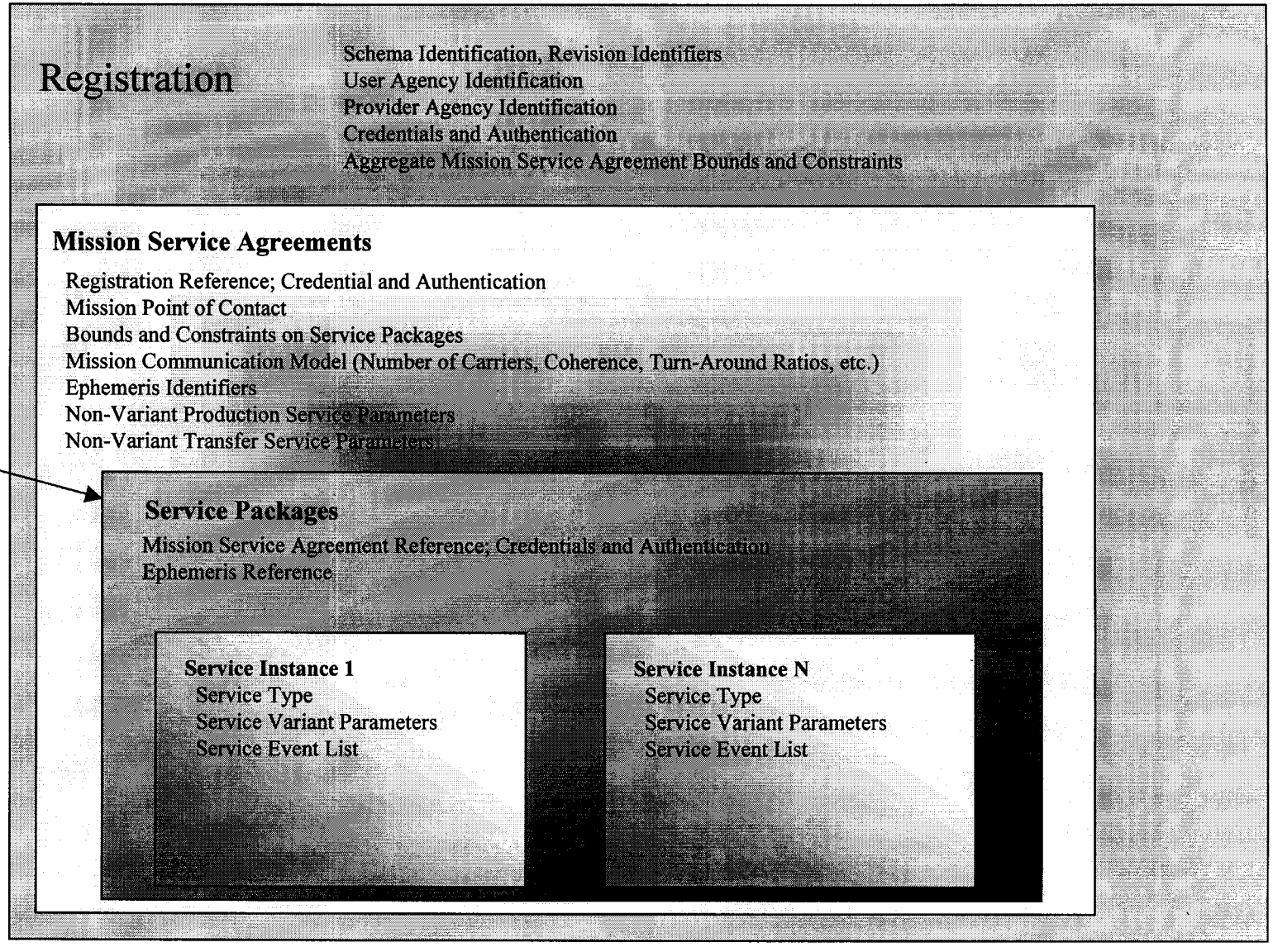




Prototype Approach

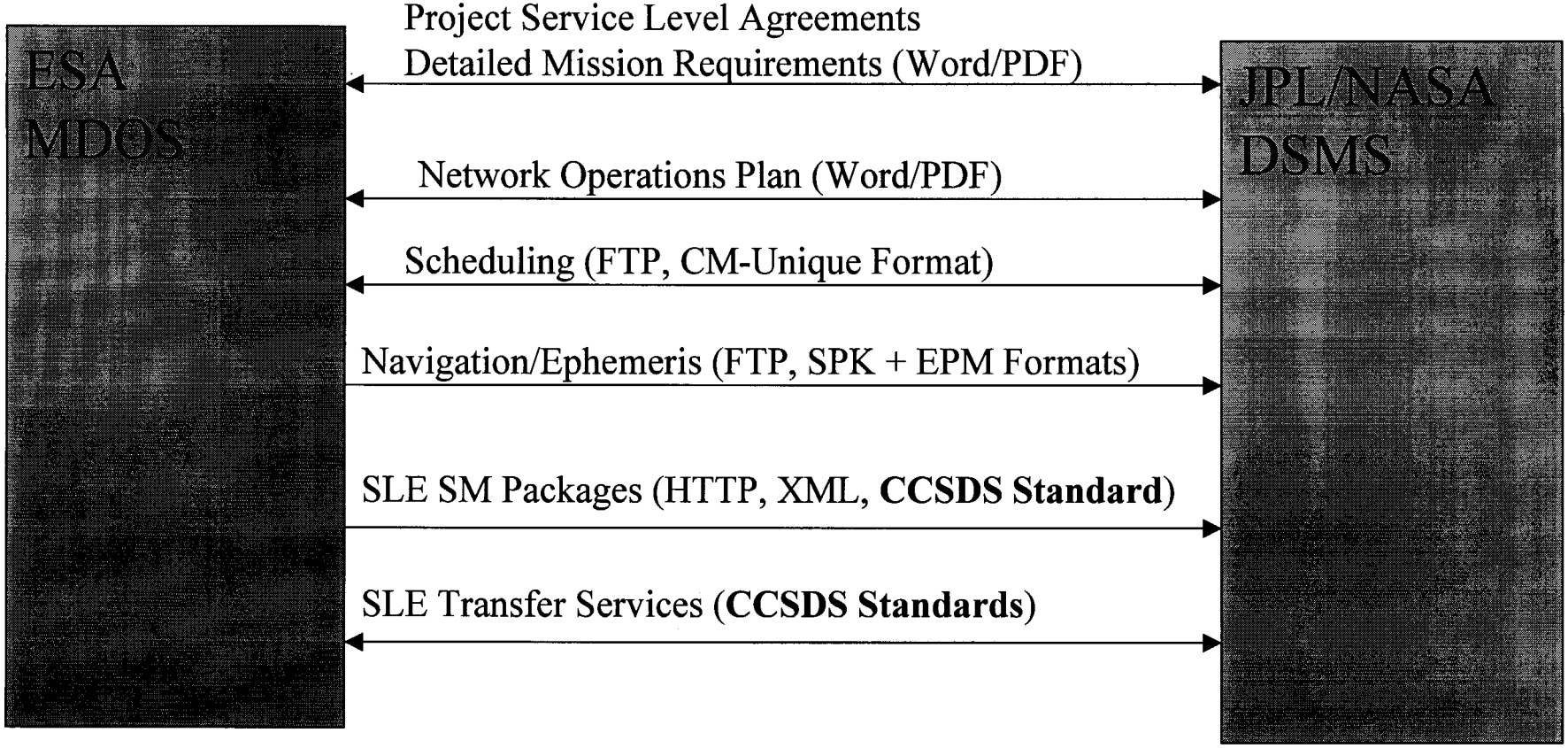
- **Develop relevant operational prototype**
- **Leverage existing efforts and capabilities**
  - **Xastro S/C modeling**
  - **JPL XML Service Request prototype**
  - **ESA Rosetta operations development**
  - **OODT distributed infrastructure**
- **Choose simple set of Use Cases to demonstrate feasibility**
- **Use rapid prototyping methodology**

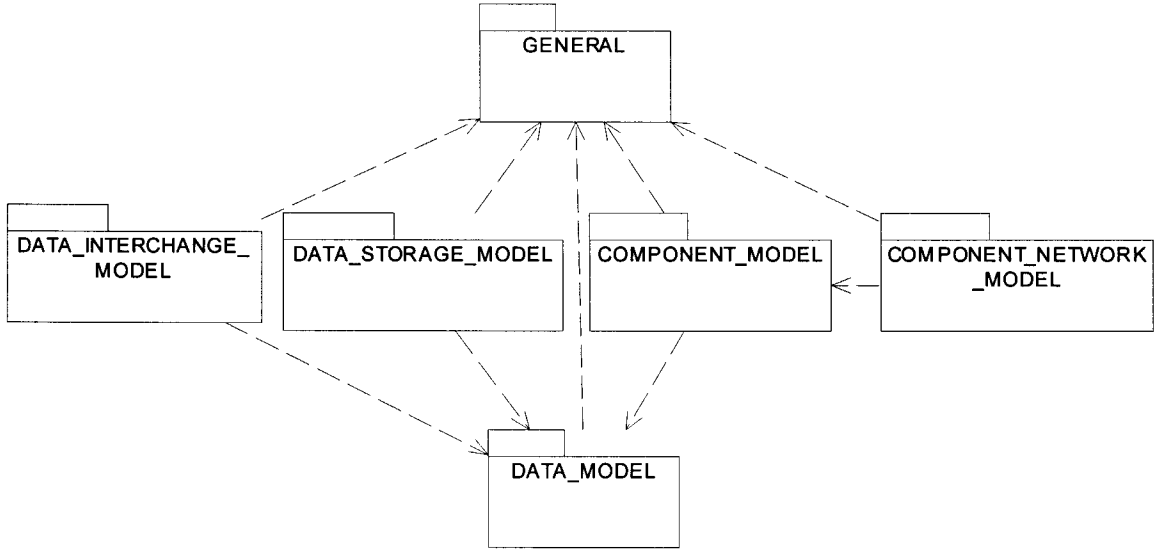
JPL XML Service Request Transaction Structuring/Containment



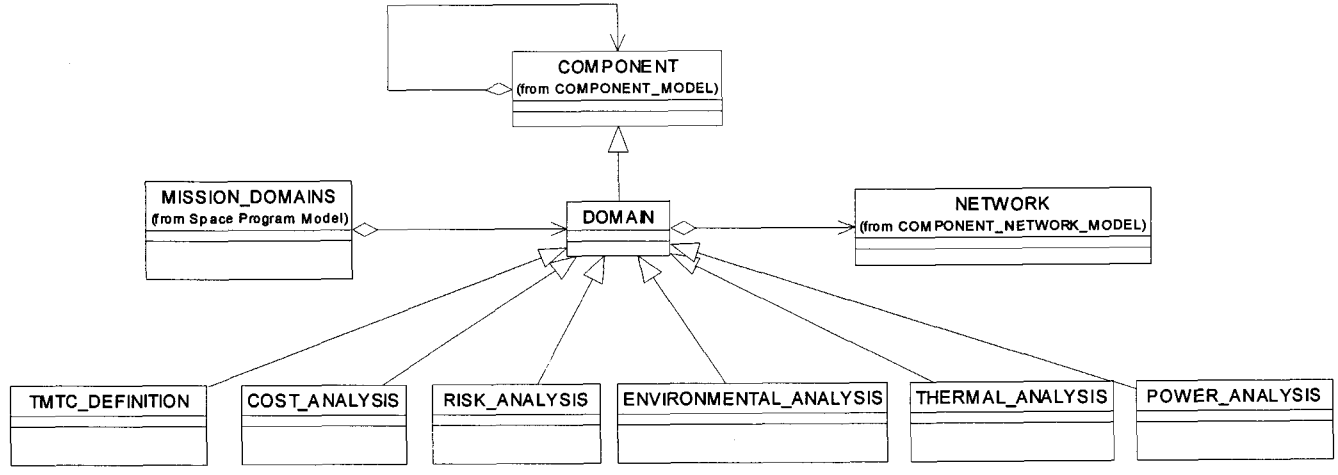
Main Focus For This Proposal

Prototype SLE SM Framework ESA/JPL



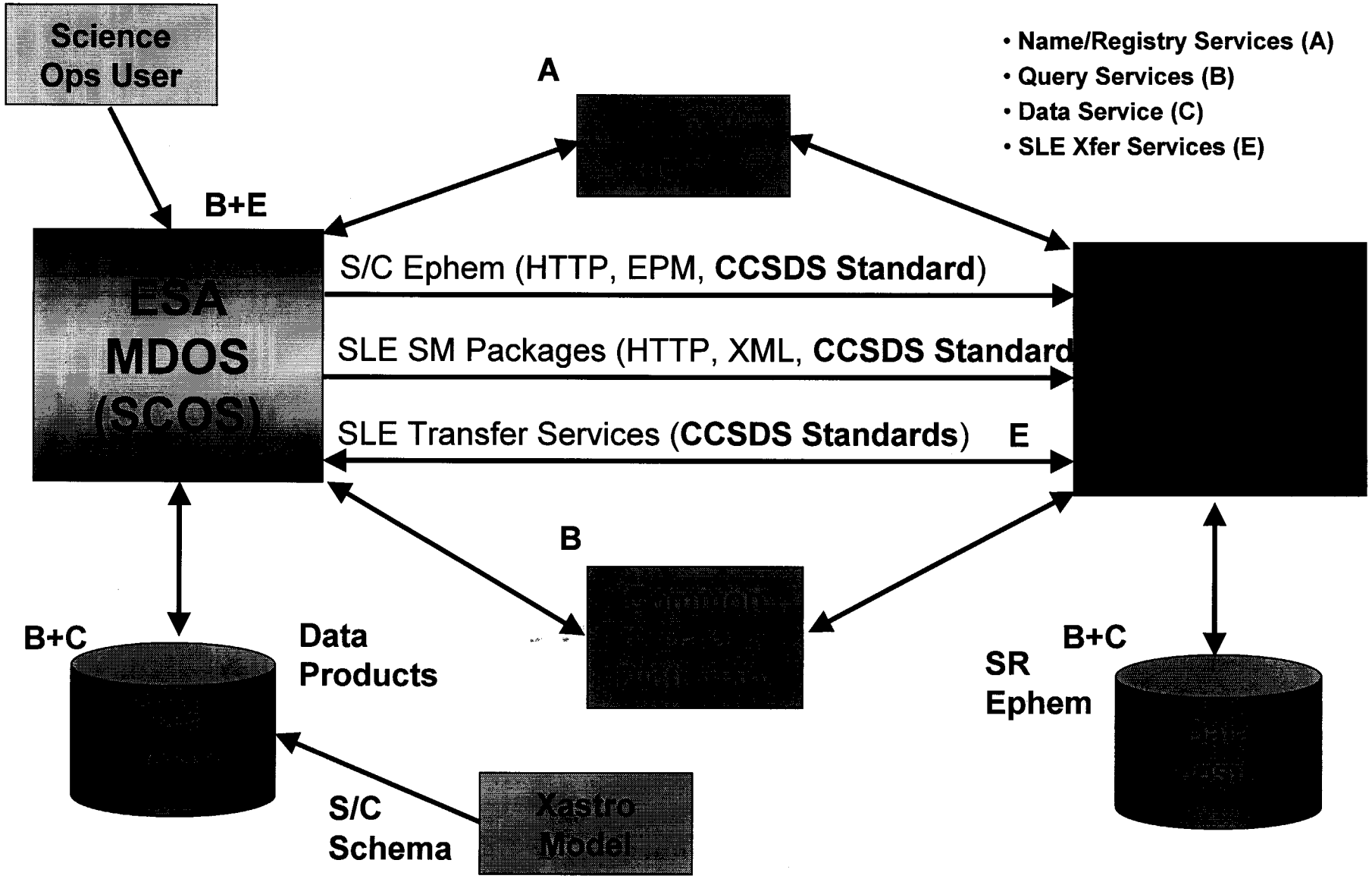


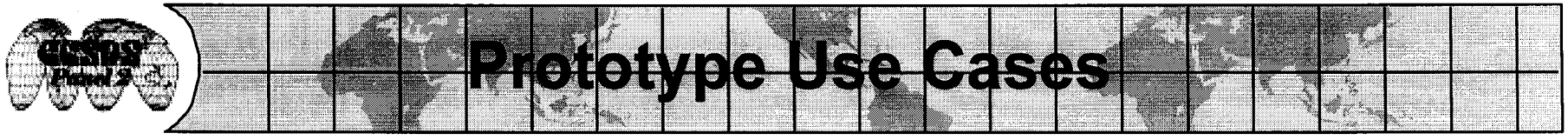
- **General system engineering model - not space system specific.**
- **Defining the basic entities of a system:**
  - **components**
  - **data**
  - **interchange formats**
  - **archive formats**
  - **component connectivity**



- **Defines the space application specific entities of the system.**
- **Space engineering domain specific models:**
  - **Thermal analysis**
  - **Power Budget**
  - **Link Budget**
  - **TM/TC definition**
  - **etc.**

Prototype Environment





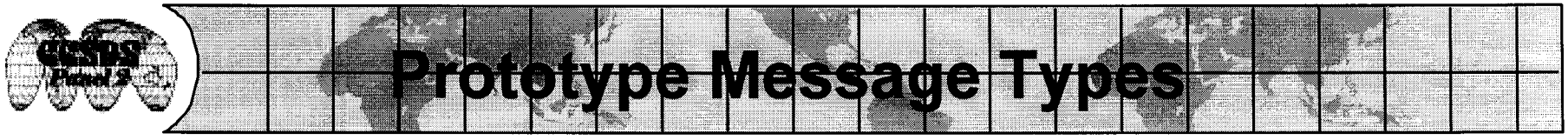
- Configure
  - Develop Data Schemas (S/C, Telecom, Service Request, …)
  - Populate System Data Dictionary - D
- Ops Scenario
  - Formulate Service Request (SR)
  - [Create Ephem]
  - Transfer SR & Ephem - D
  - Get Response - D
  - Bind to Xfer Service - E
  - Get/Put Data - E
- User Scenario
  - Query for data - B
  - Get Response - B
  - Request Data - E
  - Xfer Data - E

Prototype Service Interfaces

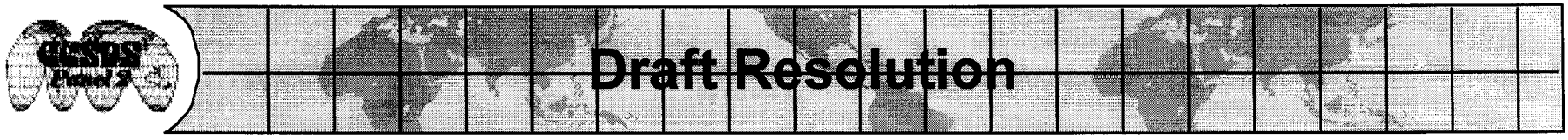
- Name Svc - (A)
  - In:Name
  - Out:Handle(ref)
- Query Svc - (B)
  - In:Metadata
  - Out:Metadata (IDs)
- Data Svc - C
  - In:ID
  - Out:Product
- Message (Sync & Async) - (D)
  - In:
  - Out:
- SLE Transfer – (E)
  - R-RAF
  - R-RCF
  - F-CLTU
- Security & Authorization - (F)
- Client Svc - (G)
  - Applets
  - Helper Apps
    - Validation

TBD Service & Interface Standards

- Name Svc
  - Maps service names to addresses
- Query Svc
  - Passes queries to servers
- Data Svc
  - Returns data from services, including query & data acces
- Message Svc
  - Provides Sync & Async message transfer service
- SLE Transfer Svcs
  - R-RAF
  - R-RCF
  - F-CLTU
- Security & Authorization
  - Provides global services for user indentification & access control
- Client Svcs
  - Support user web interface (applets, helper Apps, validation)
- Repository Interfaces
  - Provide global info on data location, description and access
- Common Data Elements
  - XML Schema
  - Glossary
  - Data Dictionary



- Query messages
- Package (Results)
  - Service Requests
  - Products
  - Schedule request / response
  - Ephemeris
  - Data Dictionary
  - Meta Data
  - Schema
  - Error messages
  - Reports
  - Monitor Data
- MIME messages
- Applets



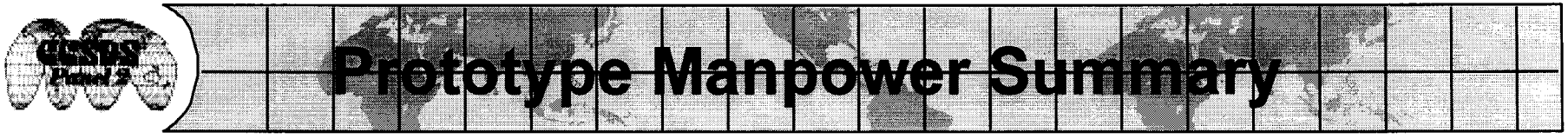
Draft Resolution

The TSG resolves to recommend creation of a new formal work item to define cross-support interfaces for secure access (web based and otherwise) to space mission operational and science data resources. The task would develop an architecture, specifications, and interfaces for a Distributed Data System framework, based upon XML and related technologies. This would result in the development of the identified standards and interfaces.

This approach would be validated by incrementally developing a prototype to demonstrate interoperability and cross support, using interfaces to existing space mission assets. Given the necessary resources, the prototype is to be demonstrated within the next 12 months, draft recommendations within 24 months,

Prototype Implementation Plan

- Consolidation Phase
  - 3 months (1st Sep 2002 – 1st Dec 2002)
  - Outputs
    - Prototype Software Requirements
    - Draft ICDs
    - Implementation Plan
  - Manpower required **12 mm**
- Implementation Phase
  - 6 months (1st Dec 2002 – 1st June 2003)
  - Outputs
    - Prototype
    - Documentation
  - Manpower required **30 mm**

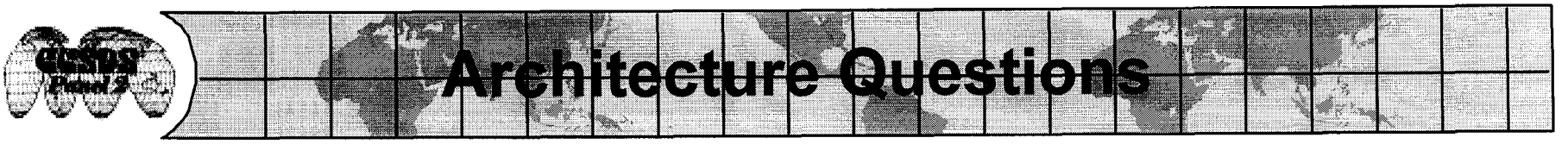


	ESA	NASA GSFC	JPL SLE	JPL OODT	Total mm
Consolidation Phase	3	3	3	3	12
Implementation Phase	6	6	9	9	30

ManMonths

Workshop Summary

- **Operational infrastructure lags technology**
  - **Current eBusiness tools could improve interoperability and cross support**
- **Leverage existing efforts and capabilities**
  - **Commercial XML tools and services**
  - **Agency prototype & development activities**
- **Use rapid prototyping methodology**
- **Demonstrate functionality in near term given adequate resources**



Q1) What is the purpose of your architecture?

- Support inter-agency cross support mission and science operations

Q2) Who uses your architecture?

- Standards developers, agencies, infrastructure developers, missions

Q3) What is directly generated from your architecture?

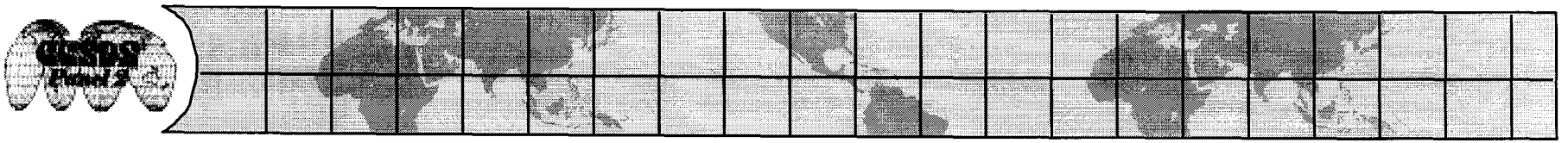
- Specifications, infrastructure, and mission support environment

Q4) How is your architecture documented?

- In a prototype, then White Book, leading to CCSDS Blue Book

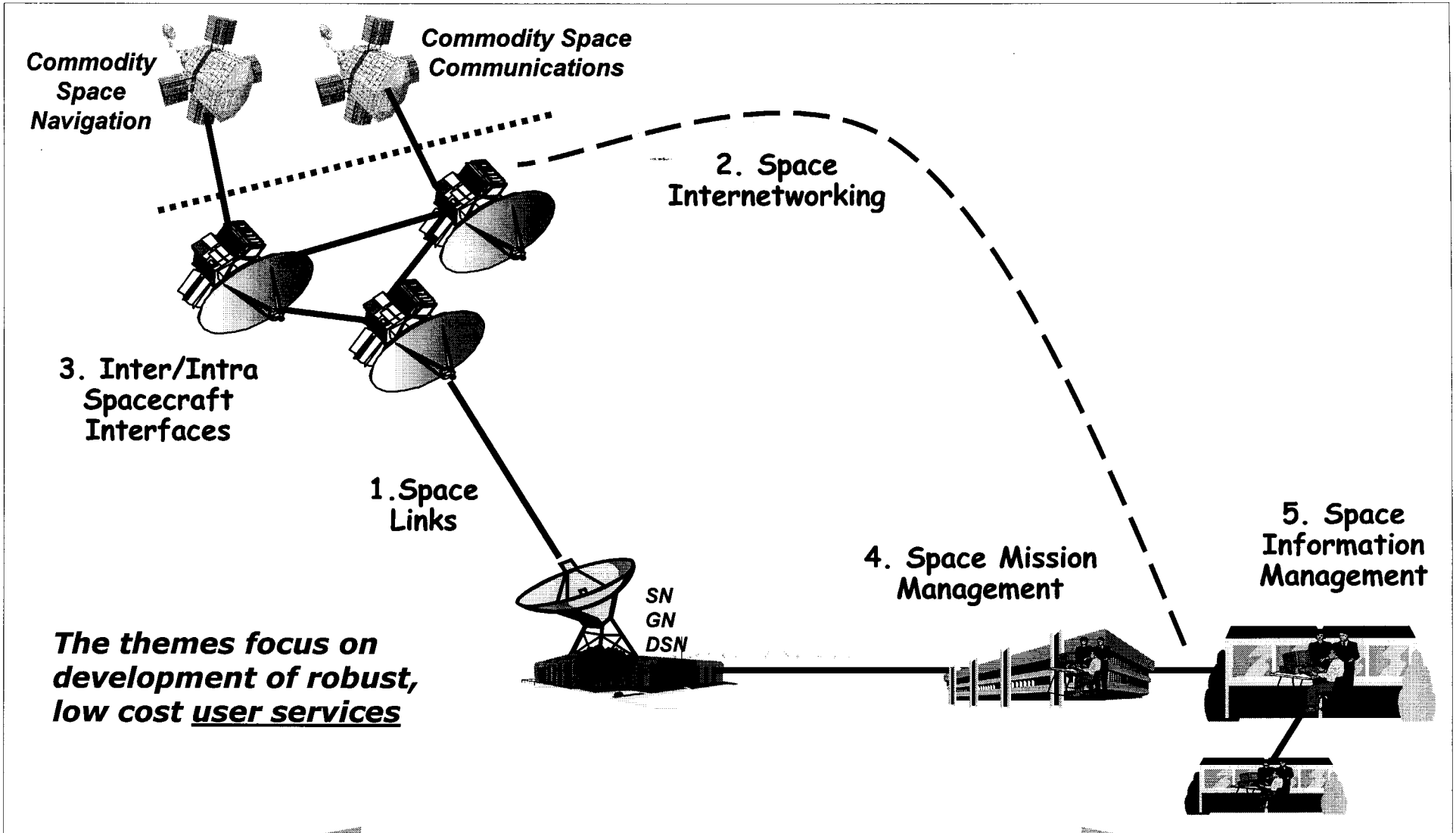
Q5) What is the definition of key terms?

- Architecture
- Model
- Repository
- Registry
- Data dictionary
- Query
- Security/authentication
- Name service
- Data service
- Message service



BACKUP SLIDES

Space Communications Architectural Themes



Source: A. Hooke, NASA/JPL

Space Mission Management: Theme 4

Operational conduct of a space mission, including the interface between the "real time" systems that deal with in-flight spacecraft and the "archival" systems that exist to support long term mission analysis.

1) **The provision of communications services to and from the spacecraft, including the mechanisms for accessing the spacecraft via the Space Link**
2) **The provision of common application services in support of spacecraft mission operations, including functions such as navigation & flight dynamics information exchange, spacecraft monitor and control, mission planning & scheduling, mission service requests, near term (real time & active archives) information management, and the production of data products for transfer to archival systems.**
3) **The definition of physical, service and information architectures that facilitate interoperability and cross support.**

Space Information Management: Theme 5

Archival information management systems that support long-term analysis of the results of space missions.

1) Data ingest, whereby data are accepted from the operational Space Mission Management systems (Theme 4) and are prepared for archiving.
2) Data archiving, where space-derived information are stored for permanent access.
3) Archival data description techniques and languages, which enable space information to be permanently described for future analysis
4) Information access interfaces between mission operation data systems and science domain activities

CCSDS Operating Themes for Standardization

Interfaces between payloads and onboard spacecraft networks, including special formation flying cases where a "spacecraft" may consist of several independent vehicles interconnected by short-range wireless links.

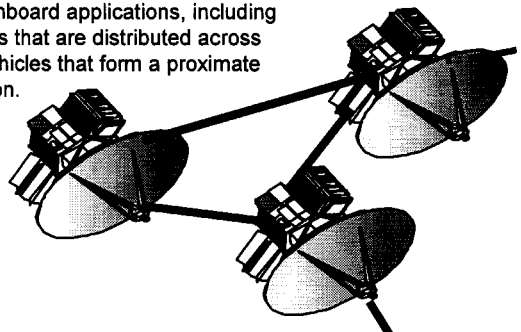
1) Spacecraft local area networking, including the various classifications of onboard buses and LANs.
2) The interface between payloads and onboard networking facilities.
3) The intercommunication of data between onboard applications, including applications that are distributed across multiple vehicles that form a proximate constellation.

3. Inter/Intra Spacecraft Interfaces

End-to-end flow of data through a space network, which contains a Space Link as one of the subnetworks in the end-to-end path.

1) Internetworking in short-delay environments, where the "conversational" Internet model of communications is applicable.
2) Internetworking in delay-prone environments, where long delays may be encountered as a function of propagation delay and/or disjoint connectivity.
3) Internetworking across heterogenous communications environments that include a commercial satellite link as a special instance of the space-to-ground subnetwork.
4) The provision of the Application layer data transfer services that are common to multiple space Applications.

2. Space Internetworking



Operational conduct of a space mission, including the interface between the "real time" systems that deal with in-flight spacecraft and the "archival" systems that exist to support long term mission analysis.

1) The provision of communications services to and from the spacecraft, including the mechanisms for accessing the spacecraft via the Space Link
2) The provision of common application services in support of spacecraft mission operations, including functions such as navigation, spacecraft monitor and control mission planning, real time information management, and the production of data products for transfer to archival systems.
3) The definition of physical, service and information architectures that facilitate interoperability and cross support.

4. Space Mission Management

Archival information management systems that support long-term analysis of the results of space missions.

1) Data ingest, whereby data are accepted from the operational Space Mission Management systems (Theme 4) and are prepared for archiving.
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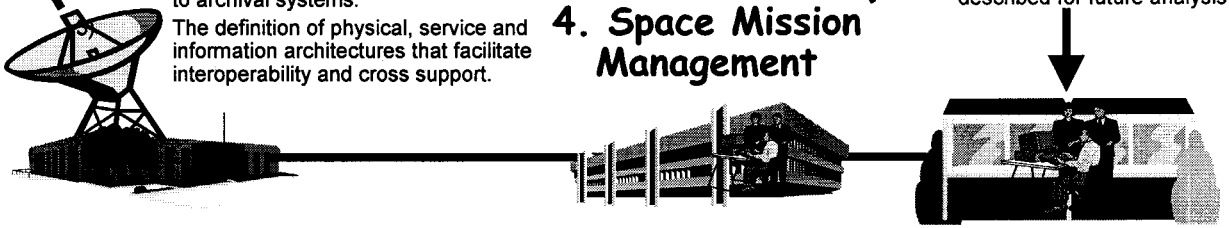


5. Space Information Management

Point-to-point Space Link that either interconnects two spacecraft or interconnects a spacecraft and a ground station on Earth.

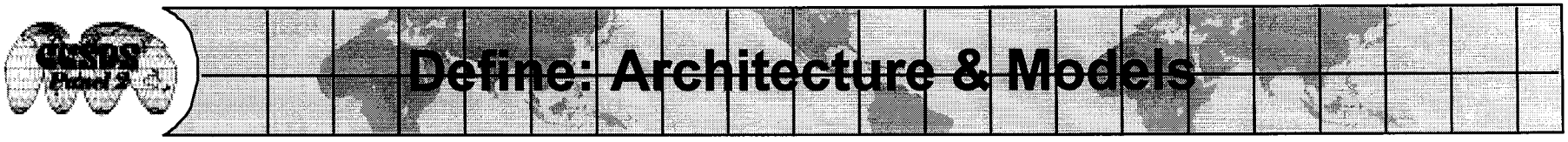
1) Efficient Modulation of space links to improve their performance and conserve power and/or bandwidth.
2) High performance coding of Space Links to improve their error performance,
3) Link layer data compression to improve the performance of Space links and conserve power and/or bandwidth.
4) Protocols to establish and maintain Space Links to support either proximity or long-haul point-to-point communications and navigation.

1. Space Links

6. Standardization Forum

1) Program management.
2) Secretariat services, including publishing, web presence and promotion.
3) Engineering tools, such as testbeds and technology incubators, which help with the assimilation of standards into the space mission community

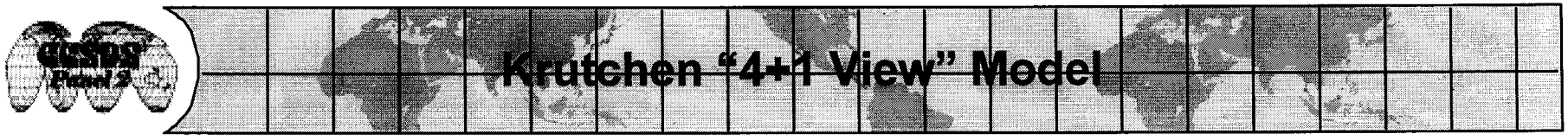
Source: A. Hooke, NASA/JPL



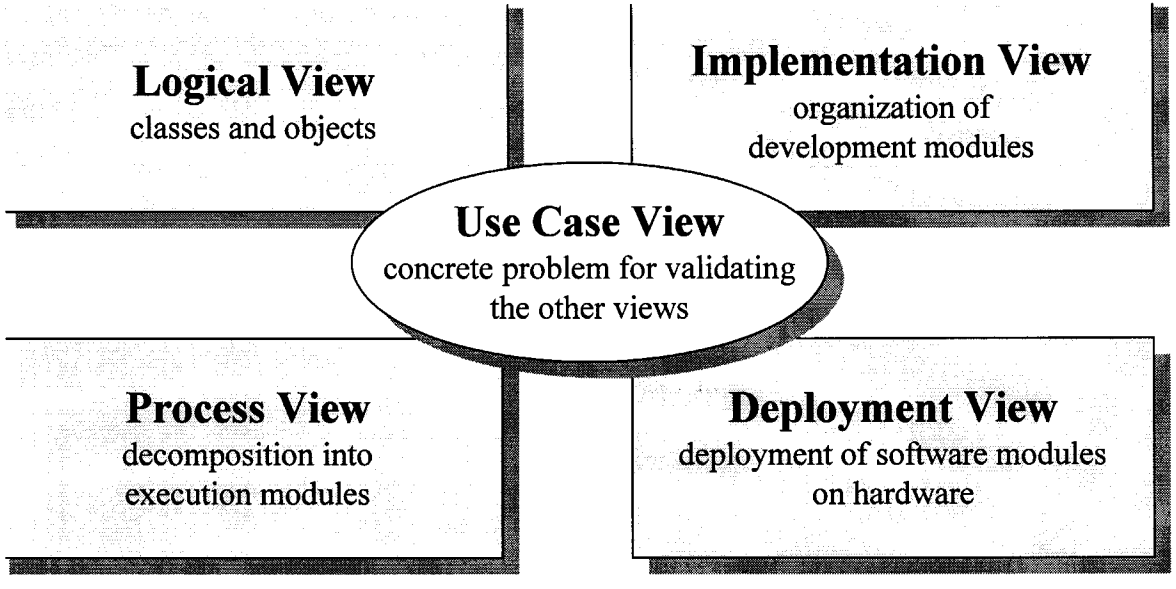
- An "architecture" is a conceptual representation of a system and its parts, and how they fit together.

- 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.

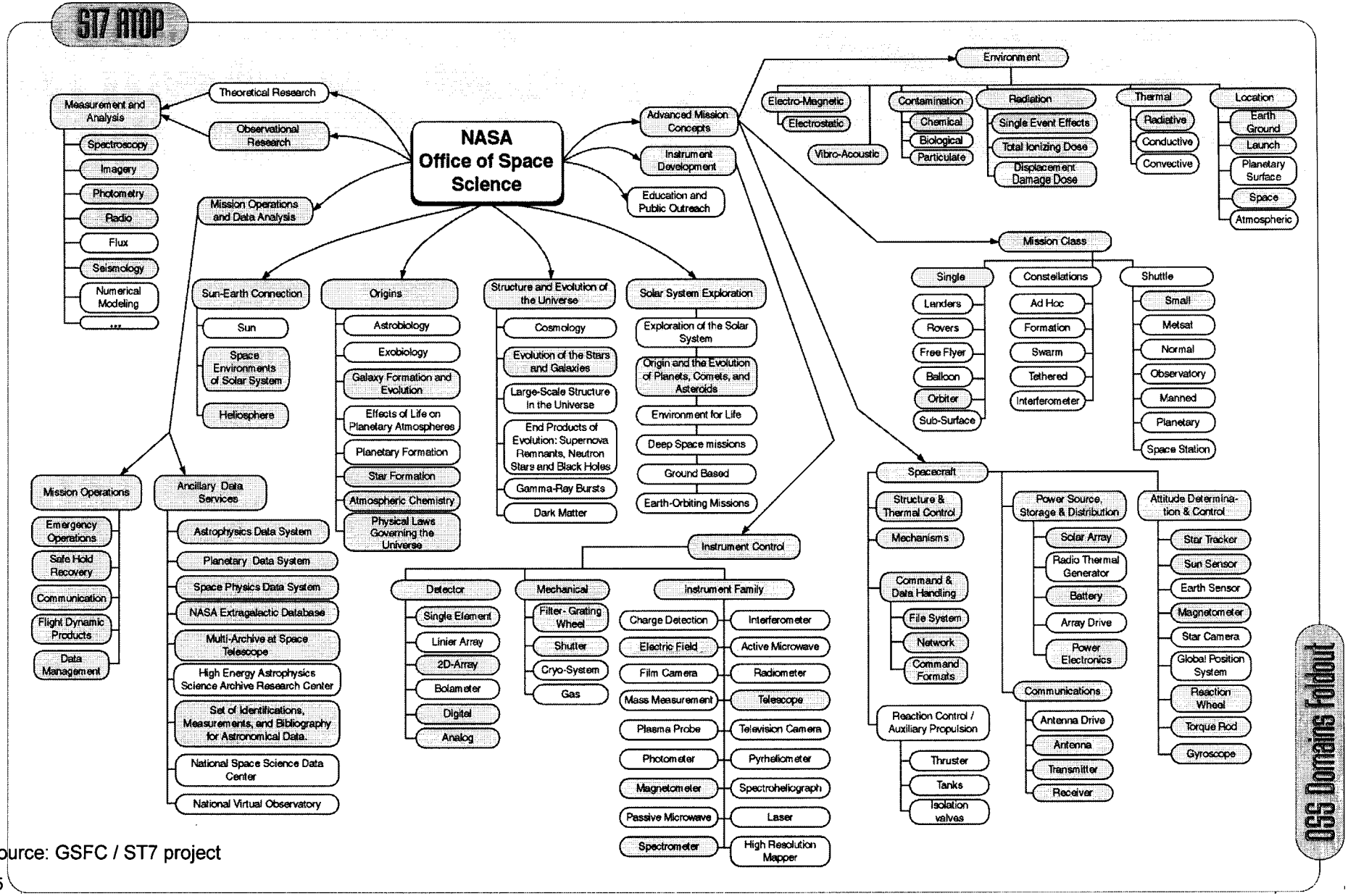


Five views of a system model intended to capture the system architecture



Logical view	classes, objects, collaborations, interactions
Implementation view	modules, subroutines, subsystems, packages
Process view	tasks, threads, processes
Deployment view	response time, bandwidth, geographic constraints, power requirements, resistance to failures for each node, module or program
Use case view	actors, use cases, classes, collaborations

NASA/ OSS "Domain Foldout" An Example Object Model

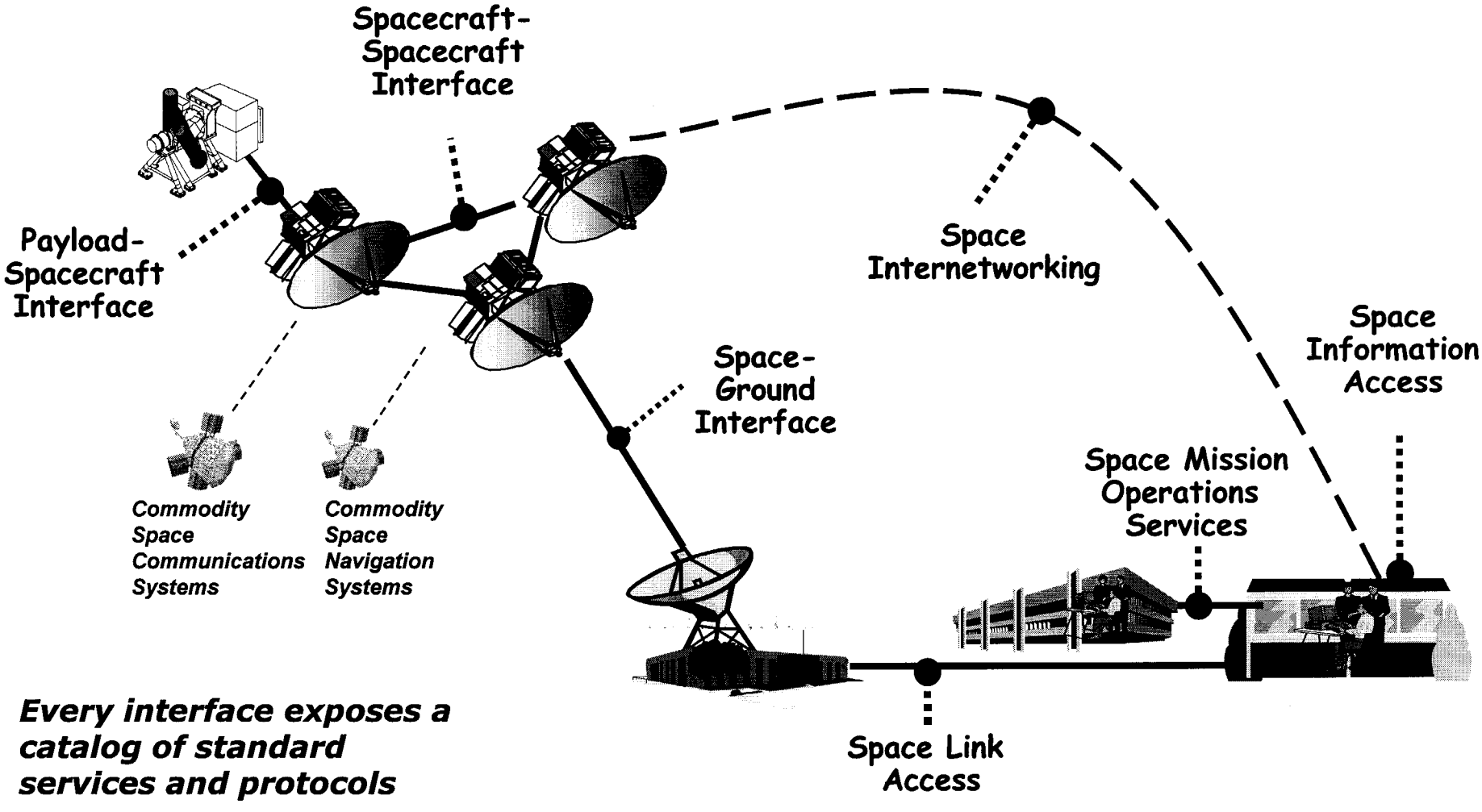


Source: GSFC / ST7 project

Summary - We need to Standardize ...

- Instrument to spacecraft interfaces
- Spacecraft to ground station
- Spacecraft to spacecraft
- Ground station to mission operations center (MOC)
- Science operations to mission operations
- MOC data system to science data systems

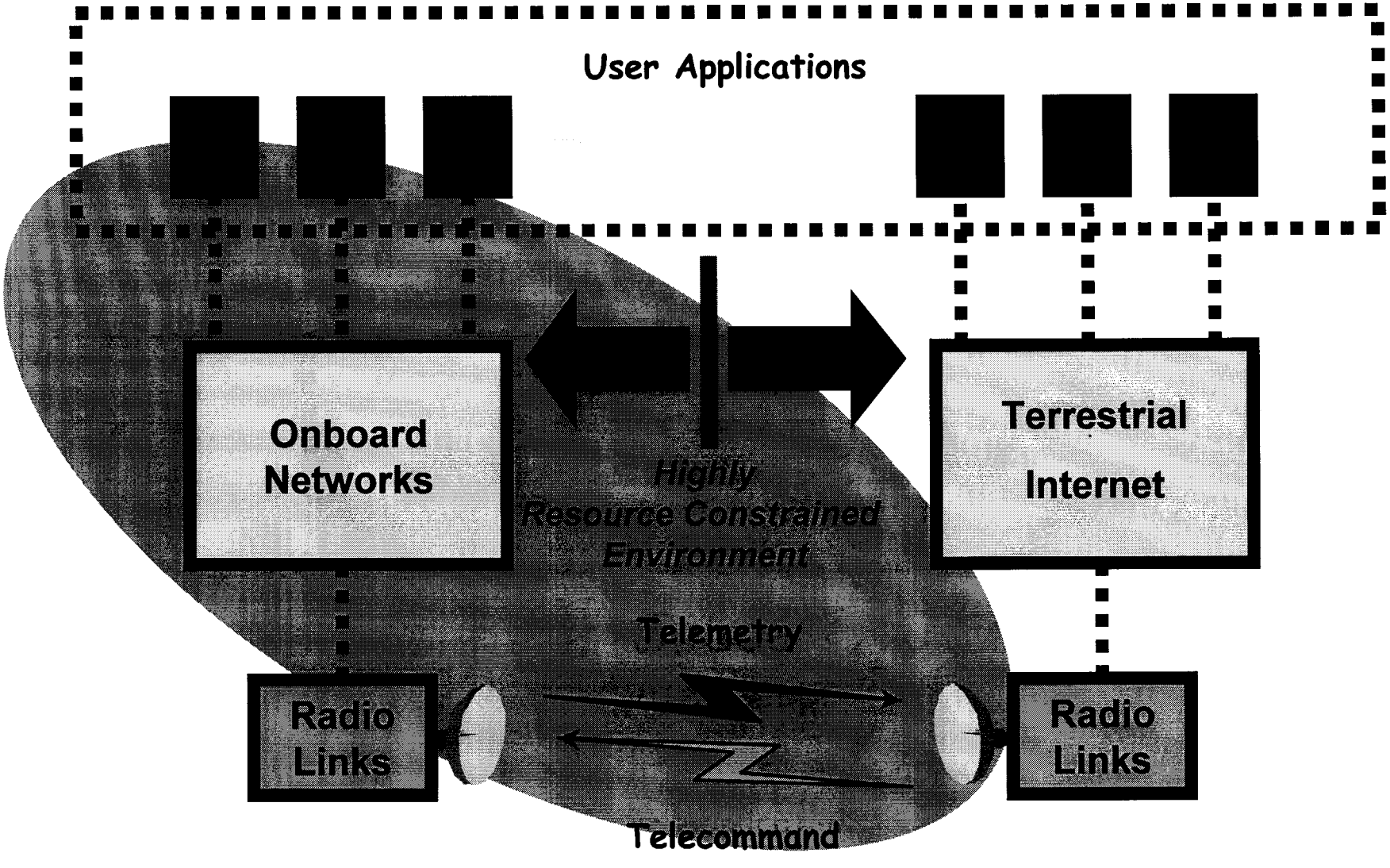
Space Communications Interoperability Points



Every interface exposes a catalog of standard services and protocols

Source: A. Hooke, NASA/JPL

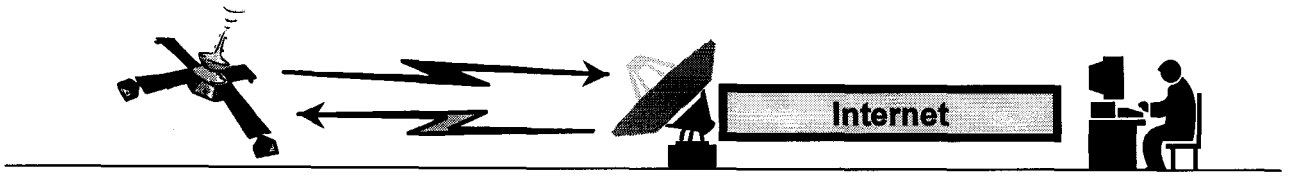
Model of Space Operations
(Distributed Applications)



Source: A. Hooke, CCSDS

User Operations Models

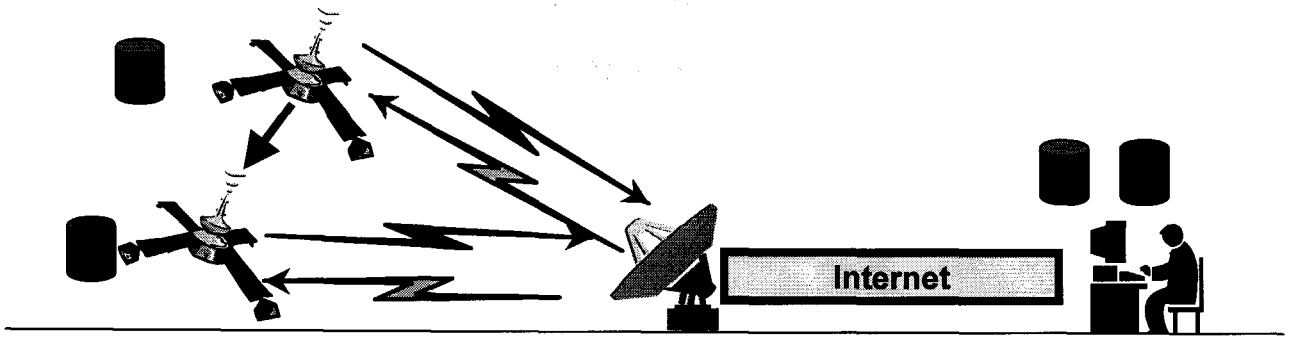
<< 1% of Mission Operations



Joysticking

Telecontrol: continuous, real-time, bi-directional end-to-end connectivity

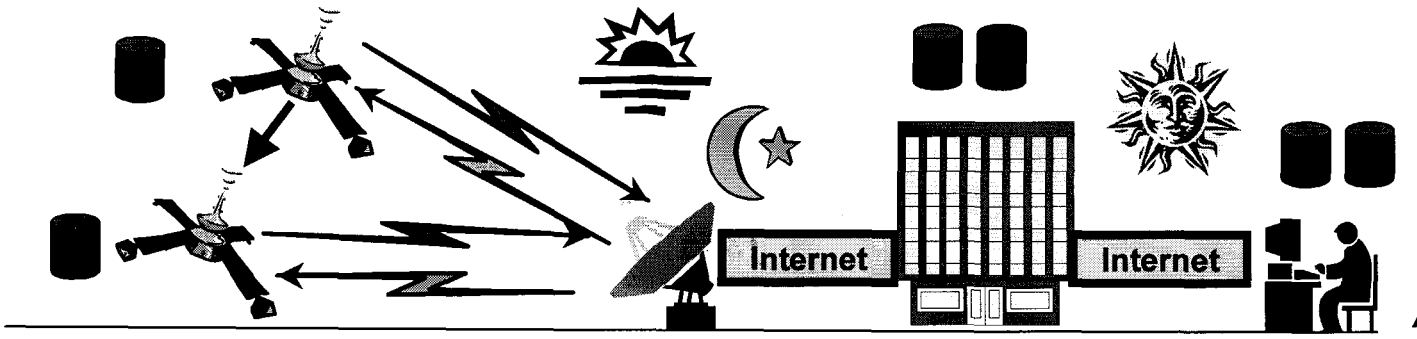
~ 5% of Mission Operations



Mission Control

Store-and-Forward: episodic, real-time, bi-directional end-to-end connectivity

~ 95% of Mission Operations

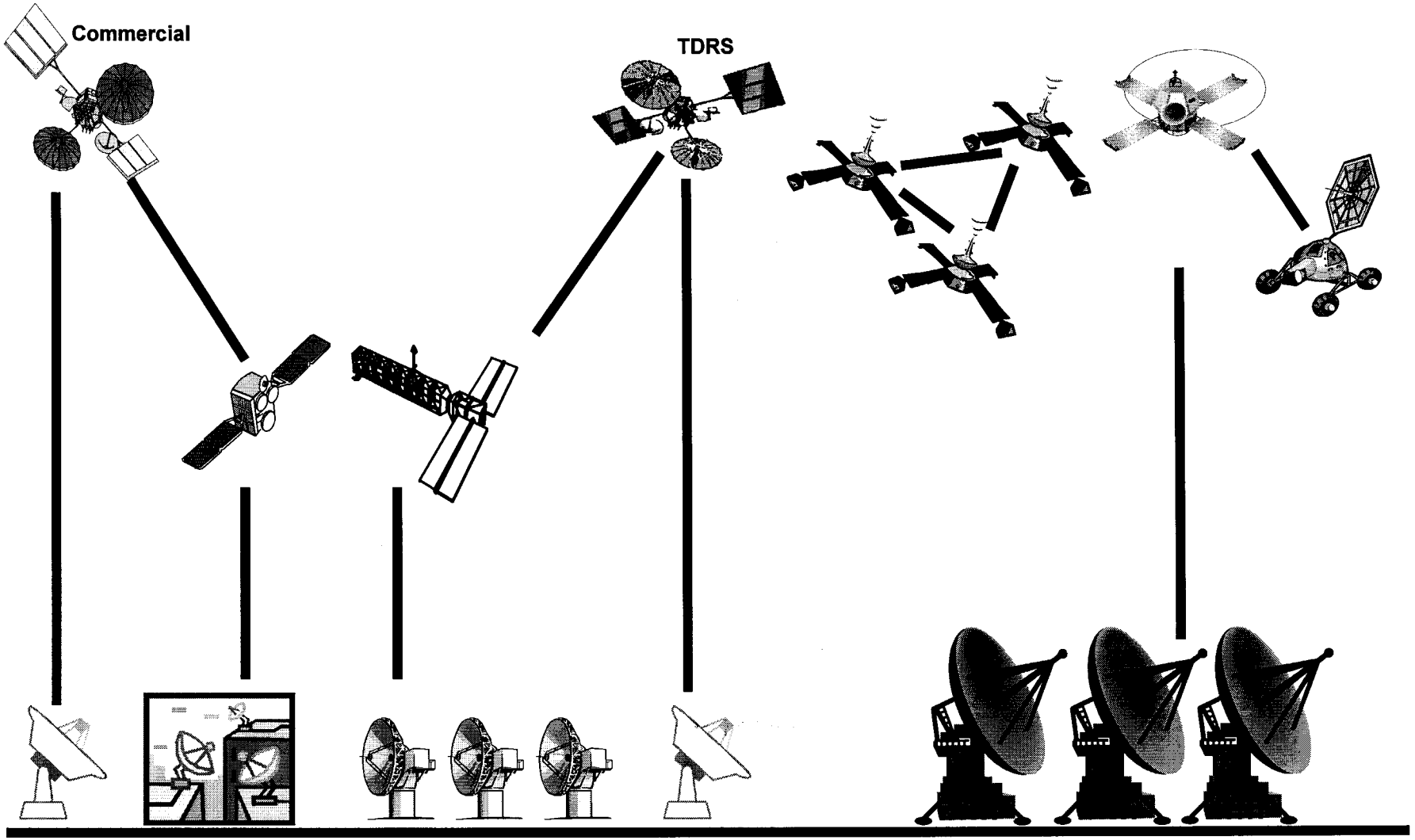


Mission Analysis

Proxy Store-and-Forward: episodic, non real-time, proxy connectivity

Source: A. Hooke, CCSDS

Types of Space Links



Near-Earth, LEON Direct

Near-Earth, TDRS Relay

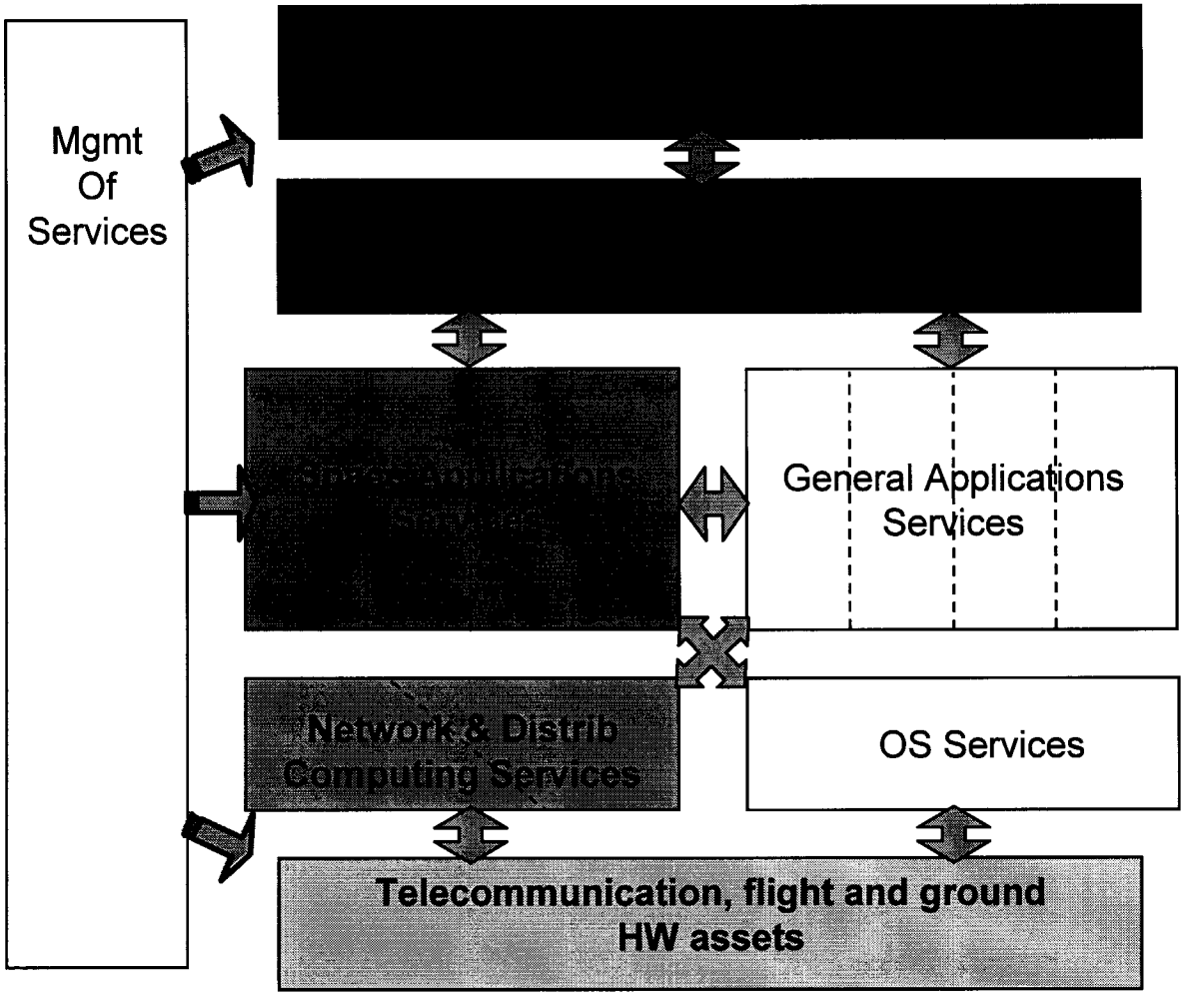
Near-Earth, Commercial Relay

Near-Earth, Direct Broadcast

Deep Space, DSN Direct

In-Space Proximity/Relay

Source: A. Hooke, CCSDS



Mission wide (horizontal) monitor & control services

System and subsystem (vertical) control services

Space Domain unique vertical applications

Standard vertical apps used by many systems

Foundation distributed system services (include network, OS, CORBA, ...)

Hardware & Physical assets

Source: OMG Space DTF

Orthogonal Communication Stack and Applications Stacks