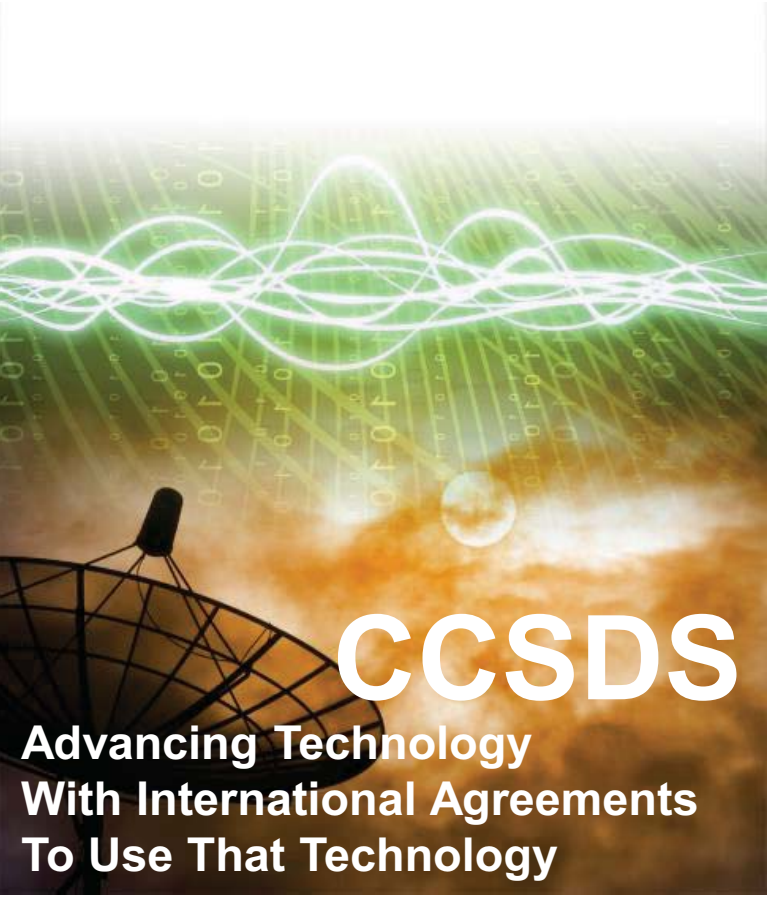
Consultative Committee for Space Data Systems

CCSDS Overview

Presentation to NSPO in Taiwan
November 2013



Mike Kearney
CCSDS Chair & General Secretary
NASA MSFC EO-01
256-544-2029
Mike.Kearney@nasa.gov

Agenda

- CCSDS Background (scope, participation, etc.)
- CCSDS Architecture, Organization, Processes
- Access to CCSDS Online
- CCSDS Strategic Goals by Technical Area
- Closeup on CCSDS Activities in Select Working Groups

CCSDS Overview

Advancing Technology
simultaneous with international agreements
to use that technology

CCSDS – Scope and Origins

- CCSDS = The Consultative Committee for Space Data Systems
- The primary goal of CCSDS is ***interoperability*** between communications and data systems of space agencies' vehicles, facilities, missions and programs.
- Of all of the technologies used in spaceflight, standardization of ***communications and data systems*** brings the most benefit to multi-agency interoperability.
- CCSDS Started in 1982 developing standards at the lower layers of the protocol stack. The CCSDS scope has grown to cover standards throughout the entire ISO communications stack, plus other Data Systems areas (architecture, archive, security, XML exchange formats, etc.

MYTHBUSTERS On CCSDS Standards

MYTH

Standards stifle innovation

FACT

CCSDS stimulates advanced technology by adopting, adapting, developing and solidifying innovations with exposure to a wider community

When an innovative technology is rapidly brought to the standards community, it is vetted with a larger user base, facilitating widespread adoption of innovative technology.

This **reduces the risk** of new technology with “more eyes on the problem.”

MYTH

Standards delay implementation

FACT

Not if the innovation is brought into the standards process early. Delays result from reluctance to standardize, not from standardization

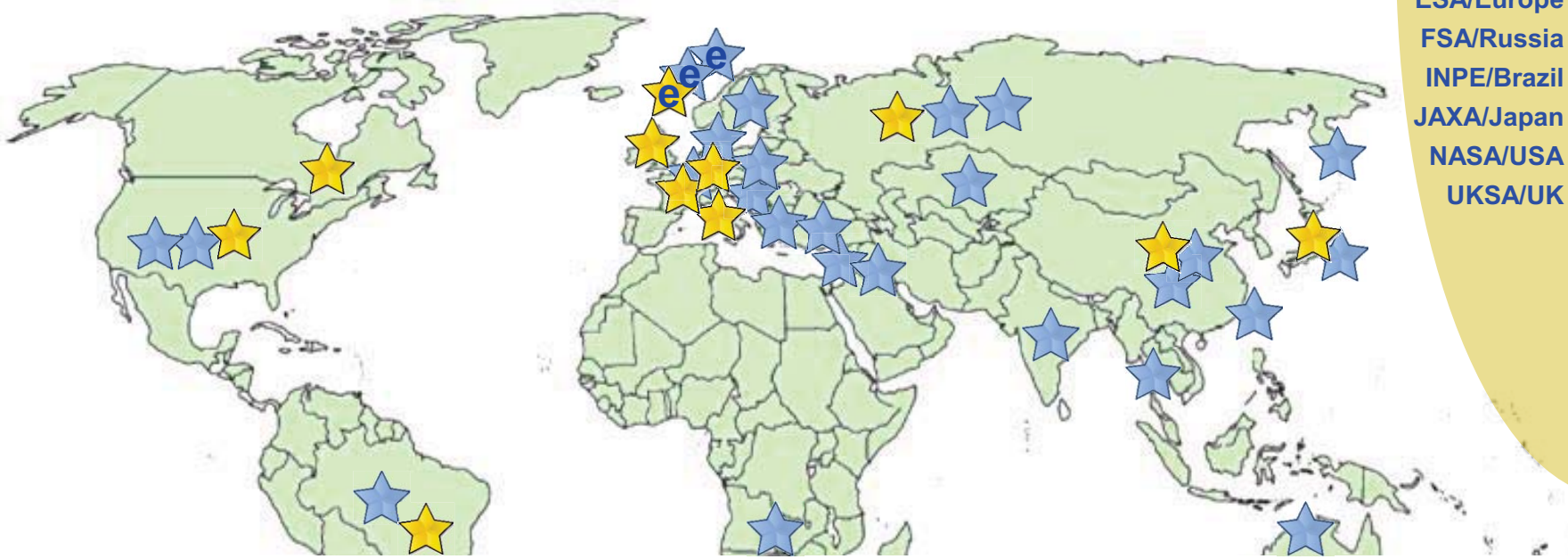
This **spreads the cost** of technology development over a larger user base.

This **enables joint missions**, for cost sharing and increased capabilities.

This **improves operations**, with familiar interfaces and more options for contingency recovery.

CCSDS Overview - Participation

- CCSDS – An Agency-Led International Committee
  - Currently 11 Member agencies
  - Currently 28 Observer Agencies
  - Agencies represent 26 nations
  - Currently 151 Commercial Associates
  - ~160-180 attendees at Spring/Fall meetings
- Also functions as an ISO Subcommittee
  - TC20/SC13 - Space Data & Info Transfer Systems
  - Represents 20 nations



MEMBER AGENCIES

ASI/Italy
CNES/France
CNSA/China
CSA/Canada
DLR/Germany
ESA/Europe
FSA/Russia
INPE/Brazil
JAXA/Japan
NASA/USA
UKSA/UK

OBSERVER AGENCIES

ASA/Austria
BFSPO/Belgium
CAS/China
CAST/China
CLTC/China
CSIR/South Africa
CSIRO/Australia
DCTA/Brazil
DNSC/Denmark
EUMETSAT/Europe
EUTELSAT/Europe
GISTDA/Thailand
HNSC/Greece
IKI/Russia
ISRO/India
KARI/Korea
KFKI/Hungary
MOC/Israel
NCST/USA
NICT/Japan
NOAA/USA
NSARK/Kazakhstan
NSPO/Taipei
SSC/Sweden
SUPARCO/Pakistan
TsNIIMash/Russia
TUBITAK/Turkey
USGS/USA

Consultative Committee for Space Data Systems

CCSDS Overview
End-to-End Architecture

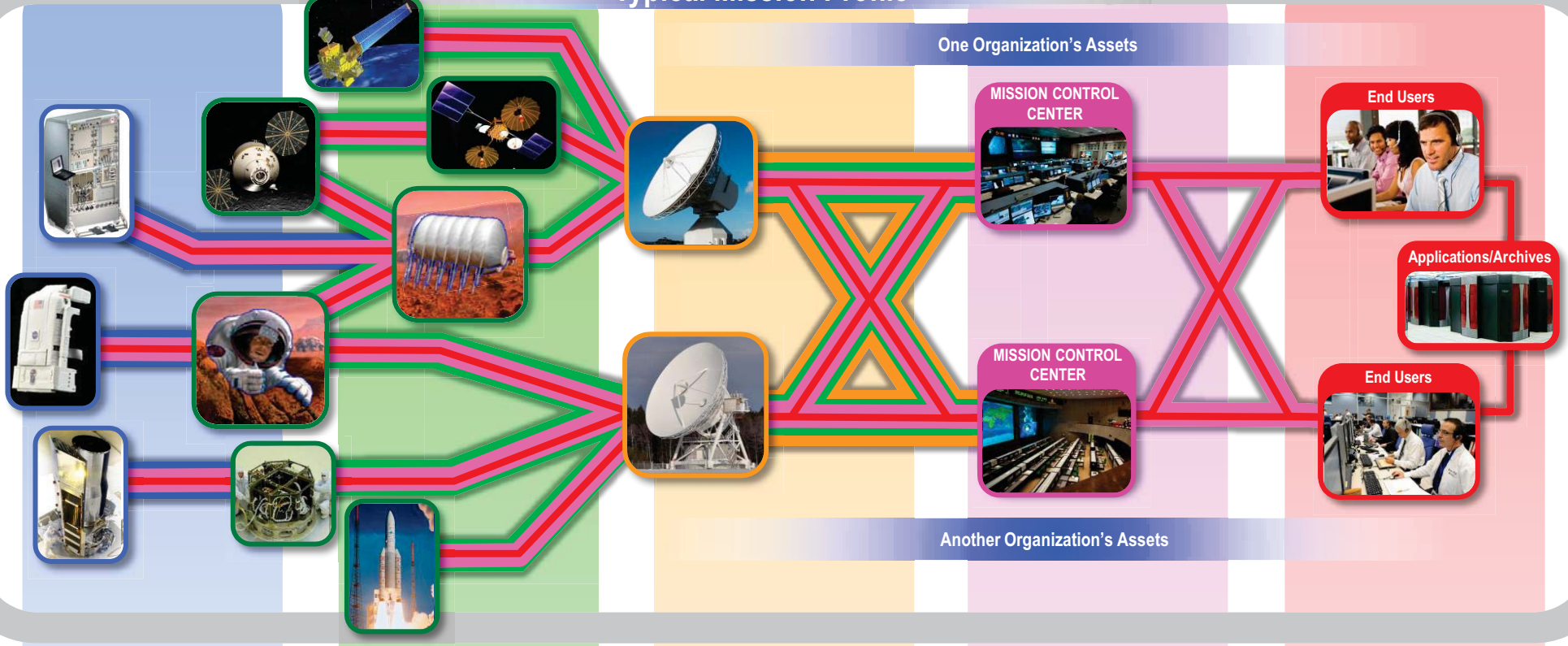
Six Technical Areas, Twenty-Nine Teams

- Working Group (producing standards)
- Birds-Of-a-Feather stage (pre-approval)
- Special Interest Group (integration forum)

Systems Engineering

- Security
- Space Assigned Numbers Auth.
- Delta-DOR
- Timeline Data Exchange
- XML Standards and Guidelines

Typical Mission Profile



Spacecraft Onboard Interface Services

- Onboard Wireless WG
- Application Supt Services (incl. Plug-n-Play)

Space Link Services

- RF & Modulation
- Space Link Coding & Sync.
- Multi/Hyper Data Compress.
- Space Link Protocols
- Next Generation Uplink
- Space Data Link Security
- Planetary Communications
- Optical Coding and Mod

Cross Support Services

- CS Service Management
- CS Transfer Services
- Cross Supt Service Arch.
- Generic Gnd-to-Gnd File Transfer

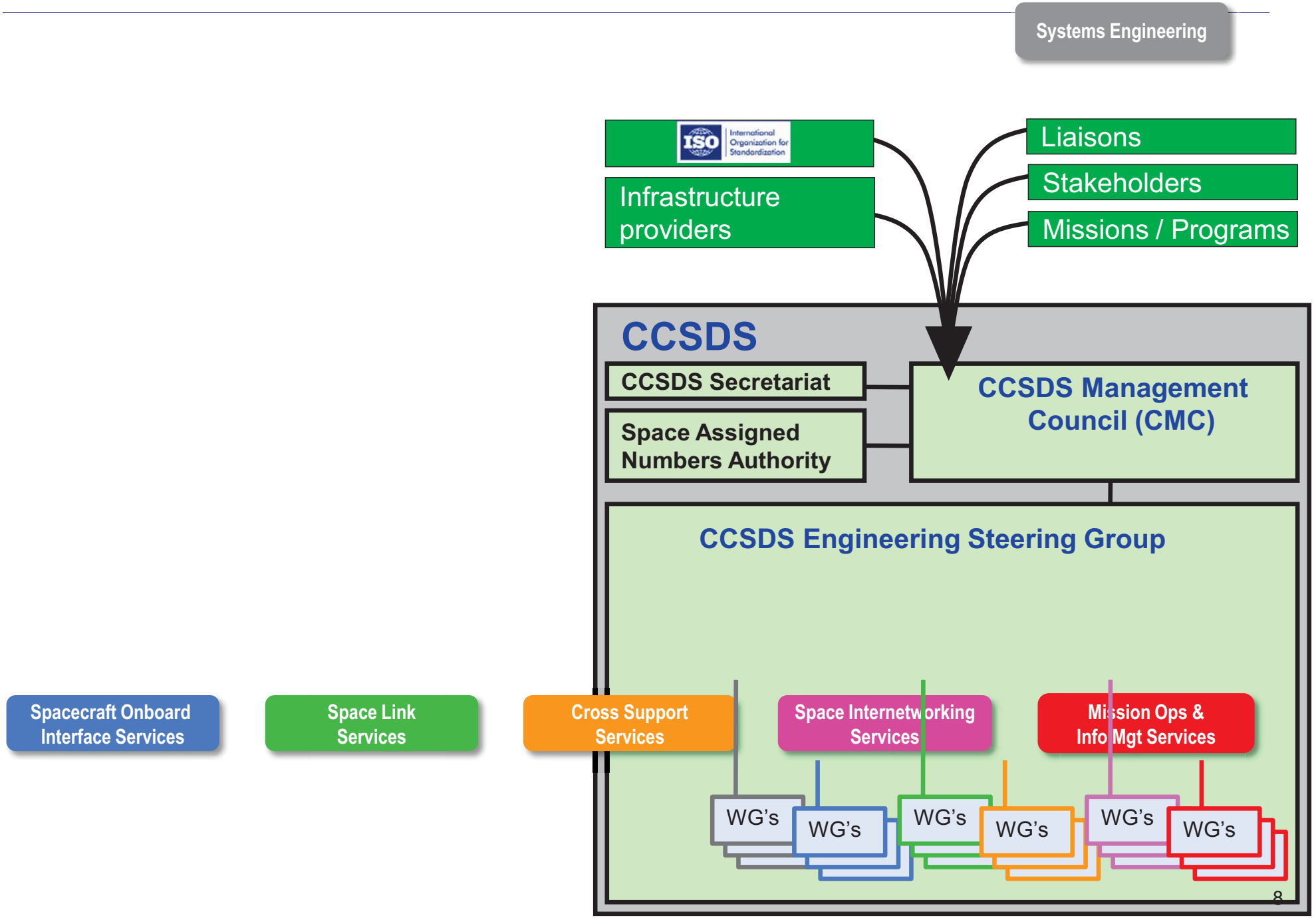
Space Internetworking Services

- Motion Imagery & Apps
- Delay Tolerant Networking
- Voice
- CFDP over Encap
- CFDP Revisions

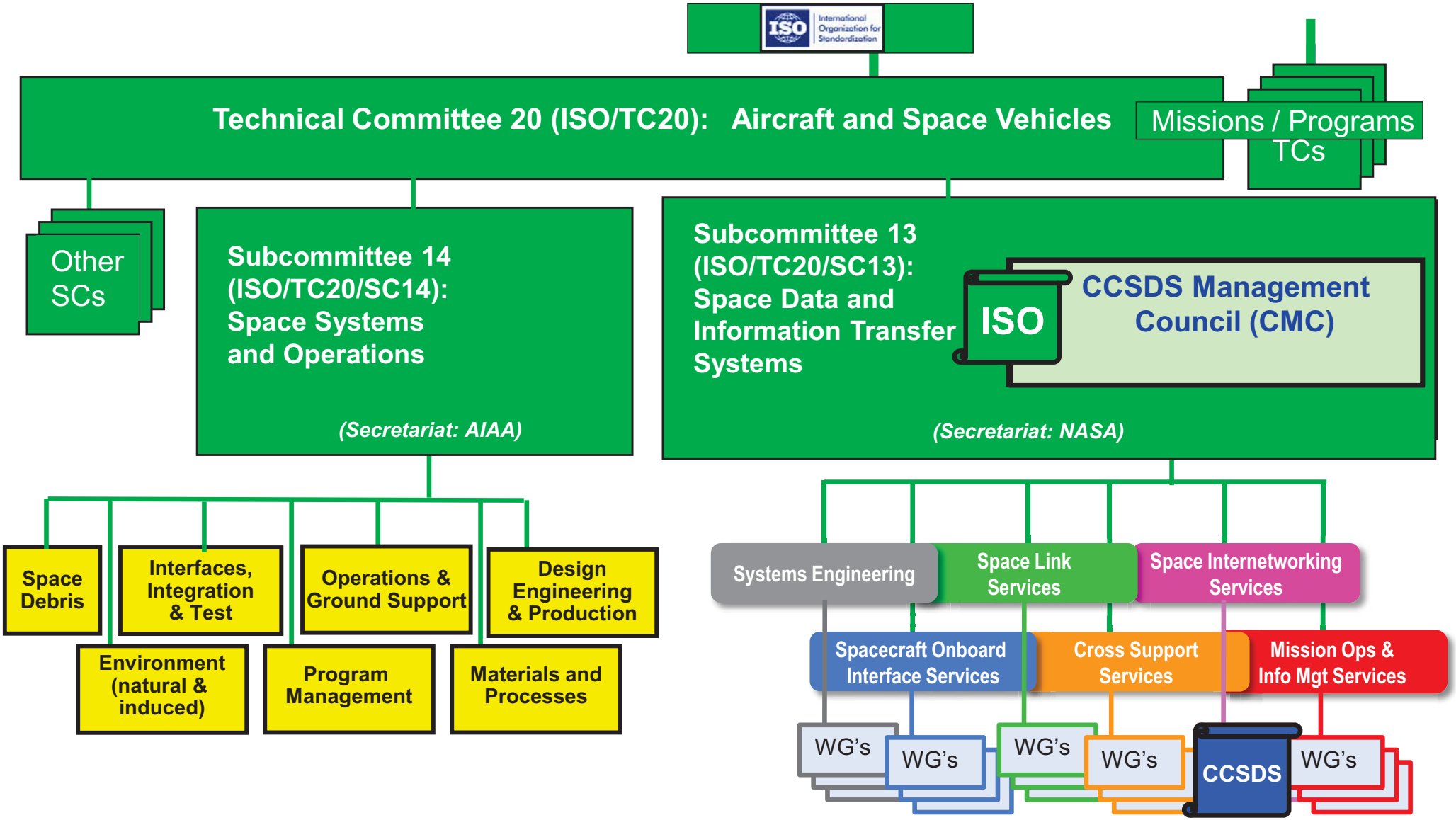
Mission Ops & Info Mgt Services

- Data Archive Ingestion
- Navigation
- Spacecraft Monitor & Control
- Digital Repository Audit/Certification
- Telerobotics

CCSDS Structure and Organization



CCSDS Relationships with ISO



CCSDS Strategic Plan

The CCSDS Plan for the Future

1. Towards Cross-cutting functions and coherent architecture-wide integration
2. Towards standardized Onboard Interfaces and Services
3. Towards Standardized Mission Operations Services and complete Navigation Message Standardization
4. Towards an extensible Space Communications Cross Support Service Management and Transfer Services (Cross Support of Communications Assets)
5. Towards an unified Space Data Link Protocol, optical links, new sync and c… compression
6. Towards standardized Space System Internetworking Services and the Solar System Internet (SSI)

Consultative Committee for Space Data Systems

Future Mission Drivers

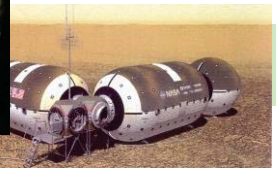
PAST → PRESENT → DRIVERS FOR THE FUTURE

Shuttle/SpaceLab
CCSDS packets

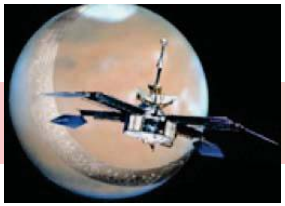
International Space Station
Adv. Orbital Sys (AOS)
Early DTN Prototyping

In Situ Exploration

- Human Expeditions
- Long Duration, High Reliability
- Mobile comm protocols
- Voice, Video, Medical handling
- Onboard Autonomy
- Highly integrated ops



Asteroid/Surface Exploration
Autonomy, High bandwidth
Multi-Agency Mission Ops

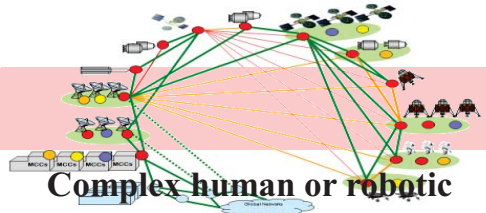


Brief Recon Flyby,
Short-Lived Probes
Direct-to-Earth links

Missions designed for orbital relays,
Longer duration

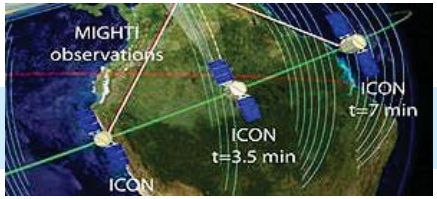
Complex Deep Space Missions

- Human ***or*** robotic exploration
- Longer Duration
- Mobile comm protocols
- Fully automated routing
- Network-Managed DTN
- Optical Communications



Complex human or robotic
Scenarios for remote surface missions
Fully automated Space Internetworking

Single-Spacecraft
Survey/Sensors



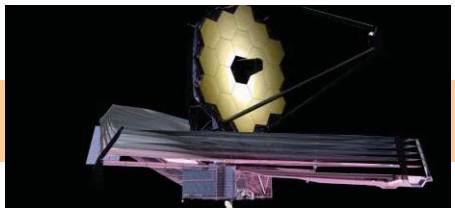
Spacecraft Constellations
and formation flying

Orbital Remote Sensing

- Long Duration, high bandwidth
- High Spatial, Spectral, & Temporal Resolution
- Low Latency Comm
- Complex link topologies
- *SensorWebs for synchronized remote sensing*

Multi-Discipline and
Multi-Resource SensorWebs

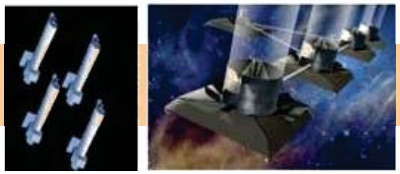
Single-Spacecraft
Observatories in LEO



Greater Distances
Higher bandwidth

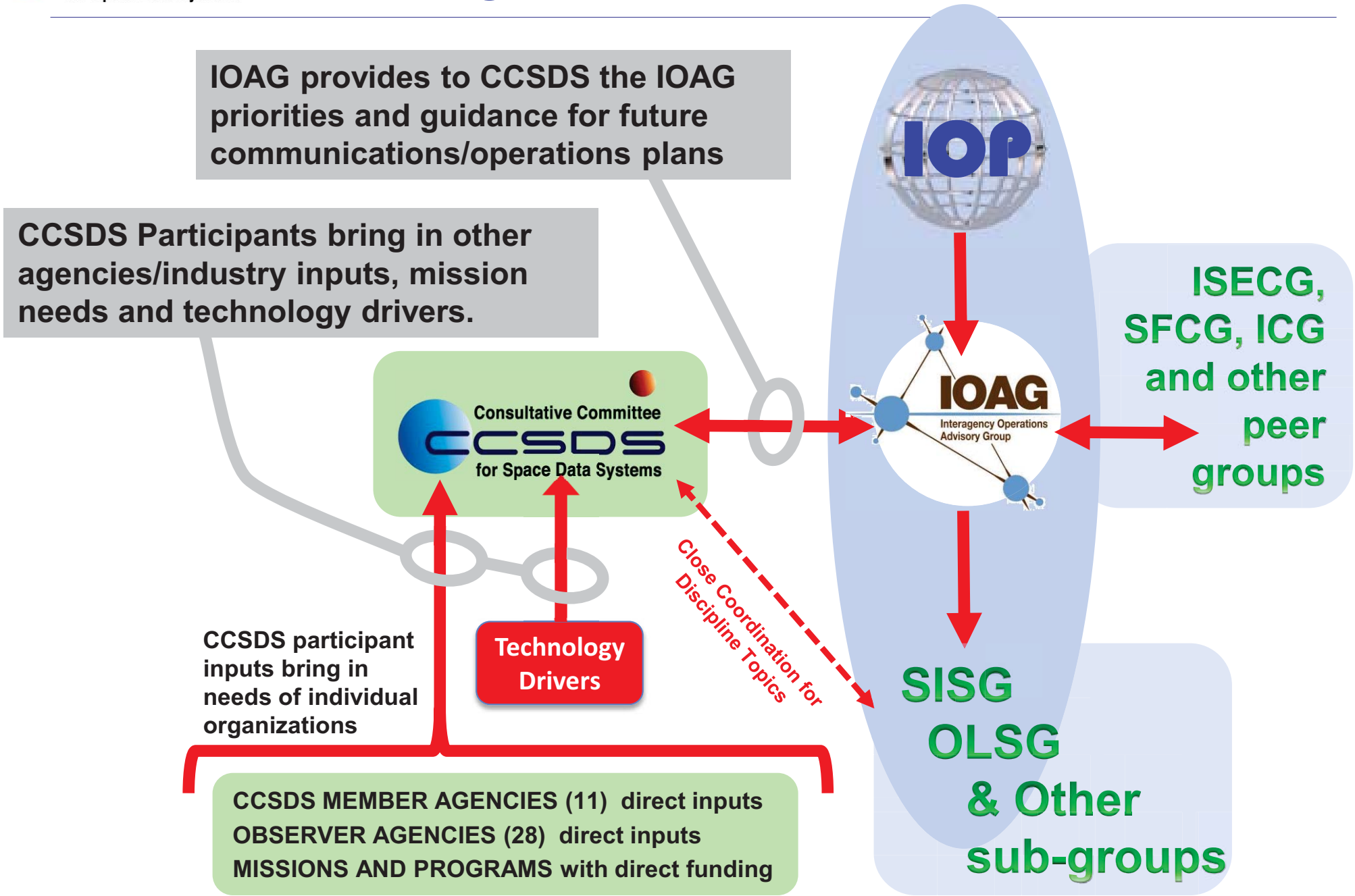
Next Generation Observatories

- More Capability
- Multiple Spacecraft drive network needs
- Even Greater Capacities require new coding schemes
- Located Even Farther from Earth



Next Generation
Observatory Complexes

CCSDS Overview
Organizational Interrelationships

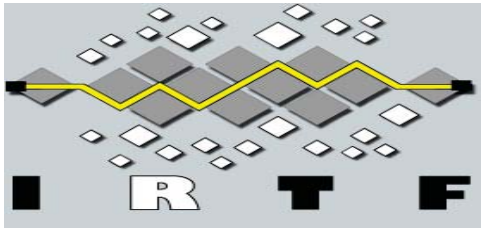


Some Organizational Interrelationships

OMG: Object Management Group

Industry standards for exchange of application information among vendor products

CCSDS/OMG have some common standards and periodic joint meetings

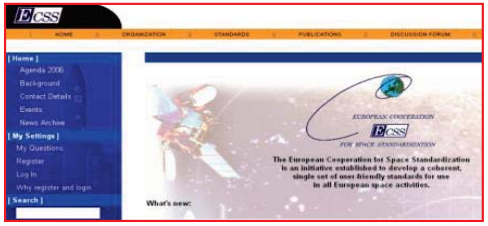


IETF: Internet Engineering Task Force

IRTF: Internet Research Task Force

Open international standards for IP suite and DTN

CCSDS uses such industry standards as a basis, whenever possible



ECSS: European Consortium for Space Standards -

European regional standards for space mission support

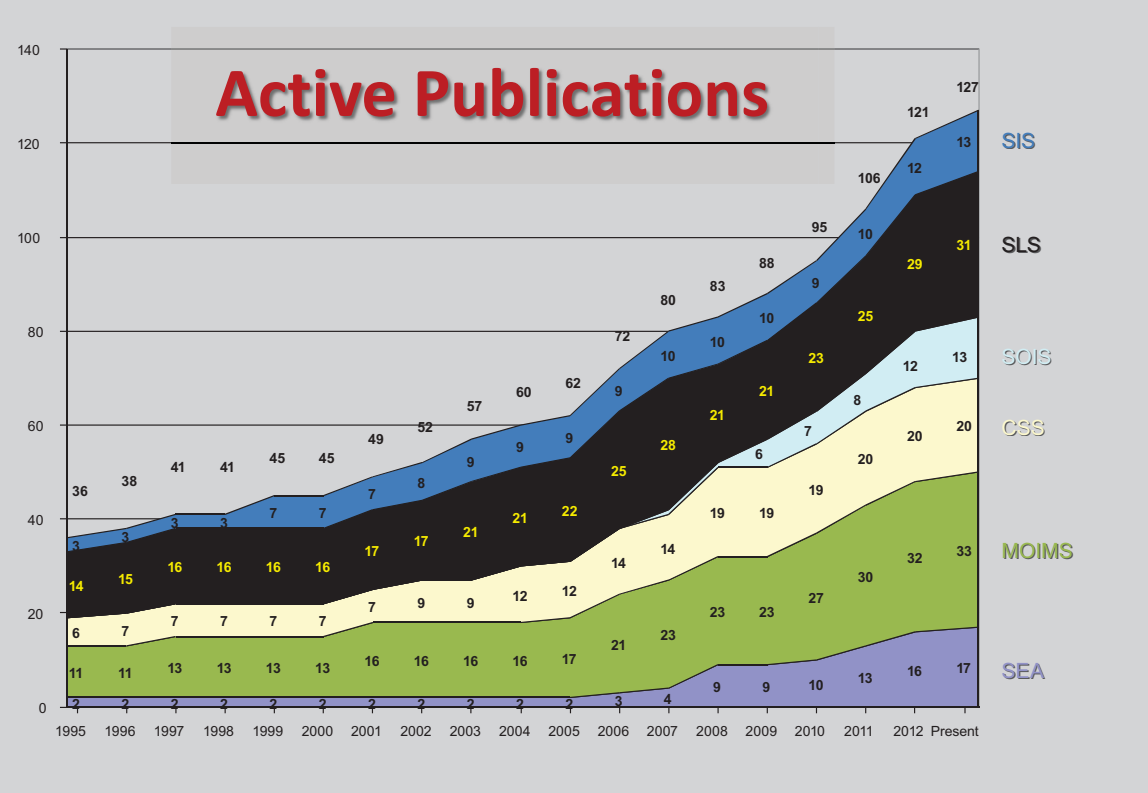
CCSDS/ECSS coordinate on compatible standards

AIAA: American Institute of Aeronautics and Astronautics

North American regional standards for space mission support

Regional Standards coordination, and AIAA provides Secretariat support for CCSDS, ISO TC20/SC13 and SC14

CCSDS Overview
Adoption by Missions



Currently Active Publications: 127

***Normative*: 78**

***Informative*: 49**

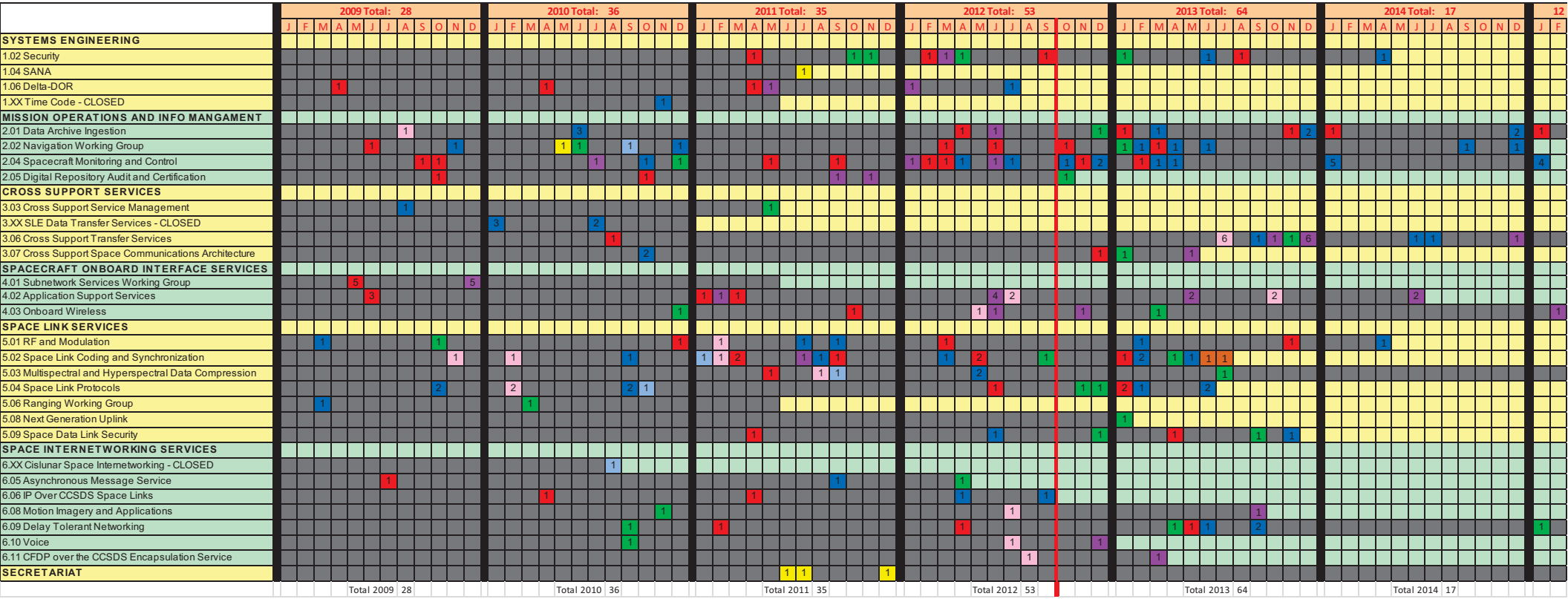
Downloadable for free from www.ccsds.org

All major pubs since 1982: 275
Some were historical mission needs or superseded technology

609 space missions have adopted and used various CCSDS standards

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cumulative Missions	108	155	205	221	271	308	330	371	387	416	435	461	544	596

CCSDS Summary Schedule Chart



Total Books

2009	28 (done)
2010	36 (done)
2011	35 (done)
2012	53 (done)
2013	64 (planned)
2014	17 (planned)
2015	12 (planned)

More efforts expected in the future.

When will CCSDS be done?
When technology stops changing.

Access to CCSDS Publications
www.ccsds.org > Publications

About | Publications | Review Documents | Meetings | Press Room | Participation | Implementations | Search

CCSDS Approved Documents
- Blue: Recommended Standards
- Magenta: Recommended Practices
- Green: Informational Reports
- Orange: Experimental
- Yellow: Record
- Silver: Historical
- All Active Publications

Other
- Review Documents
- Reference Models
- Non-English Versions of Documents

Blue Books: Recommended Standards

CCSDS Recommended Standards (Blue Books) define specific interfaces, technical capabilities or protocols, or provide prescriptive and/or normative definitions of interfaces, protocols, or other controlling standards such as encoding approaches. Standards must be complete, unambiguous and at a sufficient level of technical detail that they can be directly implemented and used for space mission interoperability and cross support. Standards must say very clearly, "this is how you must build something if you want it to be compliant".

Currently 47 Books Listed

CCSDS 121.0-B-1
File size: 256,280 Bytes

Lossless Data Compression. **Blue Book. Issue 1. May 1997.**
This Recommendation defines a source-coding data-compression algorithm and specifies how data compressed using the algorithm are inserted into source packets for retrieval and decoding.This document has been reconfirmed by the CCSDS Management Council through November 2011. The current version of this document contains all updates through Technical Corrigendum 2, dated September 2007.
ISO Number : 15887

CCSDS 121.0-B-1 Cor. 1
File size: 84,329 Bytes

Technical Corrigendum 1 to CCSDS 121.0-B-1, Issued May 1997. **Blue Book. Issue 1 Cor. 1. November 2006.**
This Technical Corrigendum documents changes to CCSDS 121.0-B-1, Lossless Data Compression (Blue Book, Issue 1, May 1997)

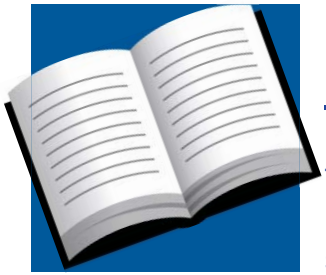
CCSDS 121.0-B-1 Cor. 2
File size: 19,978 Bytes

Technical Corrigendum 2 to CCSDS 121.0-B-1, Issued May 1997. **Blue Book. Issue 1 Cor. 2. September 2007.**
This Technical Corrigendum documents changes to CCSDS 121.0-B-1, Lossless Data Compression (Blue Book, Issue 1, May 1997)

CCSDS 122.0-B-1
File size: 1,121,448 Bytes

Image Data Compression. **Blue Book. Issue 1. November 2005.**
This Recommended Standard defines an image-data compression algorithm applicable to digital data from payload instruments and specifies means to control compression rate and how

Field Guide to CCSDS Book Colors



BLUE BOOKS

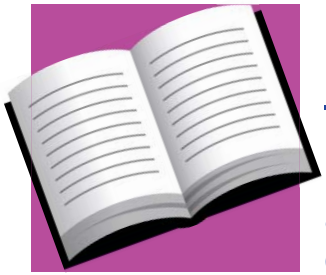
Recommended Standards

Normative and sufficiently detailed (and pre-tested) so they can be used to directly and independently implement interoperable systems (given that options are specified).

ORANGE BOOKS

Experimental

Normative, but may be very new technology that does not **yet** have consensus of enough agencies to standardize.



MAGENTA BOOKS

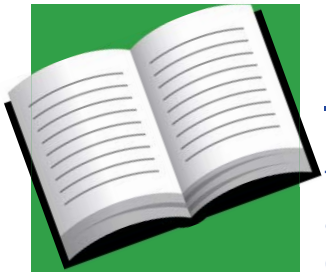
Recommended Practices

Normative, but at a level that is not directly implementable for interoperability. These are Reference Architectures, APIs, operational practices, etc.

YELLOW BOOKS

Administrative

CCSDS Procedures, Proceedings, Test reports, etc.



GREEN BOOKS

Informative Documents

Not normative. These may be foundational for Blue/Magenta books, describing their applicability, overall archtecture, ops concept, etc.

SILVER BOOKS

Historical

Deprecated and retired documents that are kept available to support existing or legacy implementations. Implication is that other agencies may not cross-support.

RED BOOKS

Draft Standards/Practices

Drafts of future Blue/Magenta books that are in agency review. Use caution with these… they can change before release.

PINK BOOKS/SHEETS

Draft Revisions For Review

Draft Revisions to Blue or Magenta books that are circulated for agency review. Pink Books are reissues of the full book, Pink Sheets are change pages only.

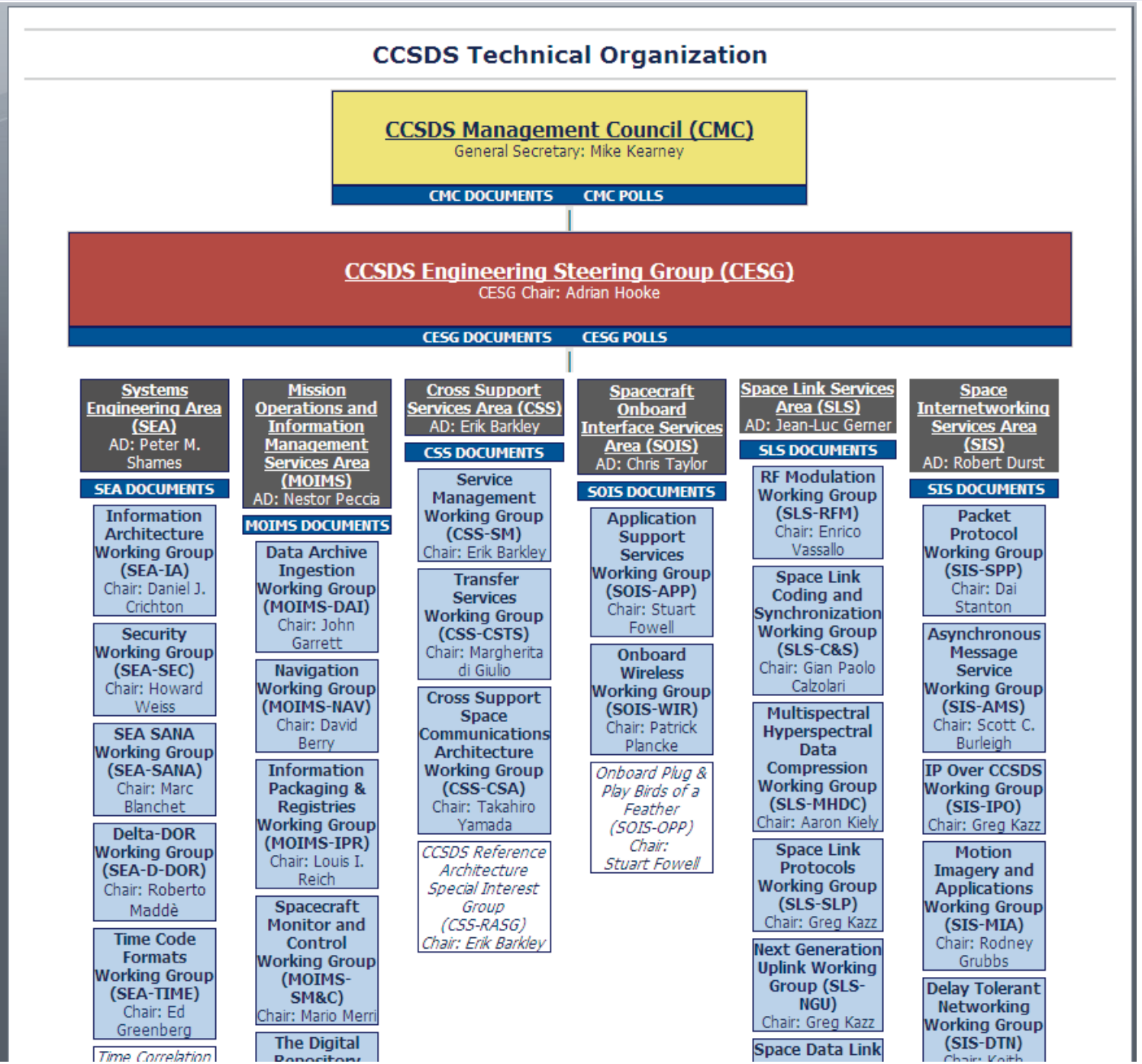
Access to CCSDS Technical WG info: www.ccsds.org > CWE

Welcome to the CCSDS Collaborative Work Environment (CWE)

The interactive graph to the right represents the CCSDS Technical Organization. The CCSDS Engineering Group (CESG) is composed of 6 areas. Within these areas there are Working Groups (WG), Birds of a Feather (BOF), and Special Interest Groups (SIG) that collaborate.

To access more information please click on the CMC, CESG, Area, WG, or BOF name.

To review the status of documents and projects being developed in these WGs, **Click Here**.



Access to CCSDS General Announcements

New Work Item Announcements
Find out about new initiatives and technology developments that you can contribute to, and you missions can benefit from.

The CCSDS Blog
General events, meetings, new publications, etc.

Under Construction: The CCSDS WIKI
Soon to come

Consultative Committee
CCSDS
for Space Data Systems

CCSDS Strategic Goals by Technical Area

CCSDS Strategic Plan

The CCSDS Plan for the Future

Systems Engineering

1. Towards Cross-cutting functions and coherent architecture-wide integration

Spacecraft Onboard Interface Services

2. Towards Standardized Onboard Interfaces and Services

Mission Ops & Info Mgt Services

3. Towards Standardized Mission Operations Services and complete Navigation Message Standardization

Cross Support Services

4. Towards an Extensible Space Communications Cross Support Service Management and Transfer Services (Cross Support of Communications Assets)

Space Link Services

5. Towards a Unified Space Data Link Protocol, optical links, new sync and channel coding schemes and compression

Space Internetworking Services

6. Towards Standardized Space System Internetworking Services and the Solar System Internet (SSI)

Systems Engineering Area Goals

Systems Engineering

1. Define cross-cutting functions and end-to-end system architectures, in support of interoperability and cross support, overarching and underpinning the above goals and that facilitate addressing global challenges, including:
   - ✧Cyber security;
   - ✧Reference system architectures;
   - ✧Information models and architectures;
   - ✧Systems-of-systems interoperability;
   - ✧CCSDS support services and capabilities.

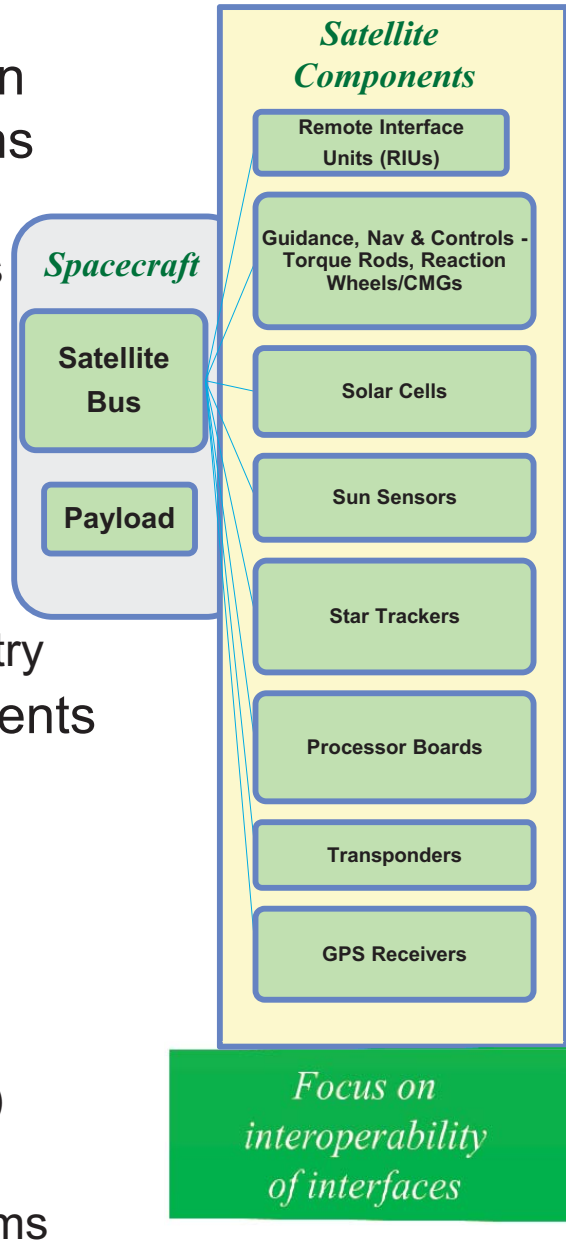
Spacecraft Onboard Area Goals

- To define reference onboard communications architectures and services supporting efficient data ...g applications and future system evolution, including:
  - Standardized avionics architectures;
  - Advanced technologies, such as wireless communications and software defined radios;
  - Innovative approaches such as Plug-and-play approaches and Electronic Data Sheets.
  - Onboard Autonomy Capabilities

Spacecraft Onboard Interface Services 2.

Spacecraft Universal Modular Arch. (SUMO)

- Interoperable spacecraft components from "bounding" design characteristics/features, test environments, and specifications
  - Standard electrical interfaces
  - Standard testing that applies LEO to GEO and Minotaur to Atlas
  - Benefits: cost savings, innovation & improvement, mission assurance and assembly time
- Modular architecture with plug & play (P&P)
  - High speed data bus; pin out and data definitions
- Leverages existing initiatives and standard development
  - Space Modular and P&P standards from ESA, NASA and industry
- Focus on satellite bus interface with sub-systems & components
  - Data & electrical interoperability; avoid defining mechanical I/Fs
  - Emphasize capabilities over requirements
  - Potential benefits for payload interoperability
  - Retain intellectual property and unique designs "inside the box"
- SUMO Standards Progress
  - Broad support achieved during CCSDS Fall Plenary (Cleveland)
  - Initially considered as a new CCSDS WG proposal
  - Now, Discussing how to integrate SUMO into existing SOIS teams



Mission Ops & Info Mgt Area Goals

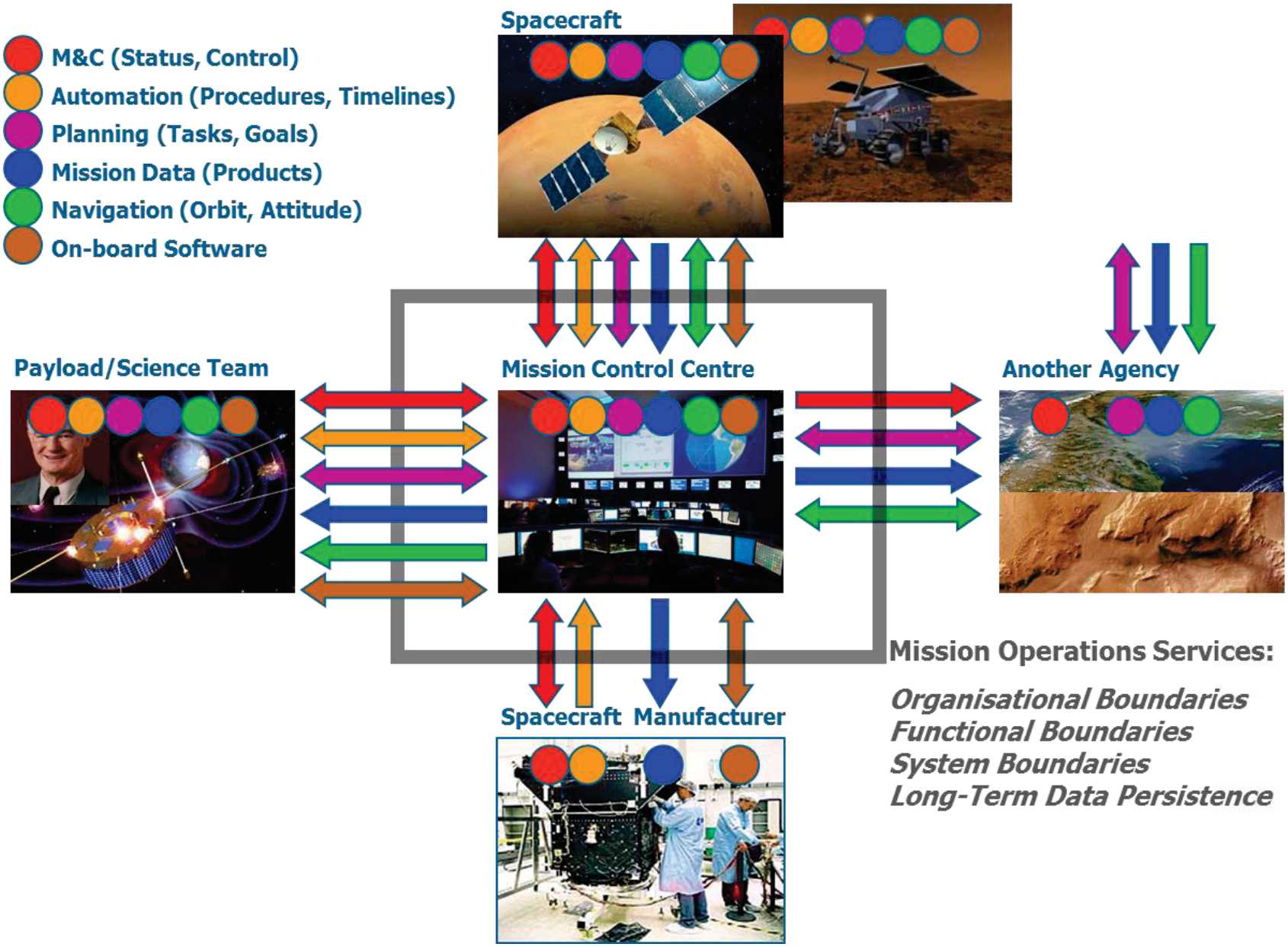
Mission Ops & Info Mgt Services

3.

- To define the full suite of mission operations standard functions and services to enable ground and on-board interoperability at the application layer level in support of standardization of the corresponding ground data systems, including:
  - Implementation of multimission spacecraft and instrument Monitoring and Control systems;
  - Exchange of mission plans between cooperating agencies;
  - Conjunction assessment, navigation and trajectory prediction;
  - Interoperability of robotic systems for cross-agency support.

Consultative Committee for Space Data Systems

Distributable Mission Operations Functions

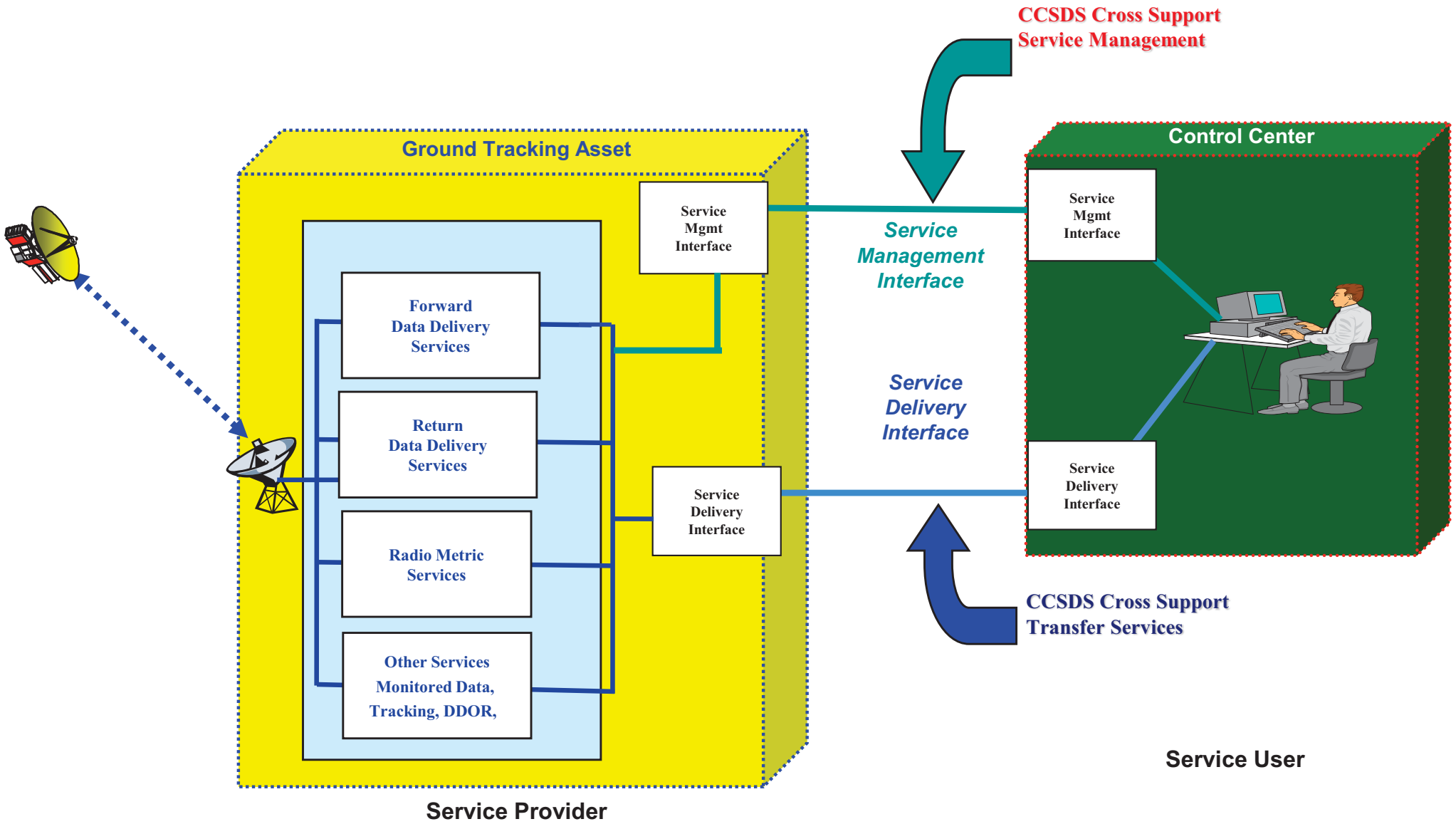


Cross Support Services Area Goals

- To define a complete suite of interoperable, cross support planning, data delivery, and control service interfaces, implementing an efficient management of the cross support services, providing end to end solutions, and meeting mission challenges, including:
  - Integrated mission planning for combined interagency operations taking into account resource needs;
  - Simplification and improved efficiency of cross support service request, delivery and governance;
  - Call-up of international cross-support during spacecraft emergencies.
  - A complete suite of cross support interfaces supporting forward and return data transfers, radiometric data, monitor data and service control;
  - End-to-end file transfer operations

Cross Support Services 4.

Framework for extensible Space Communications Cross Support Service

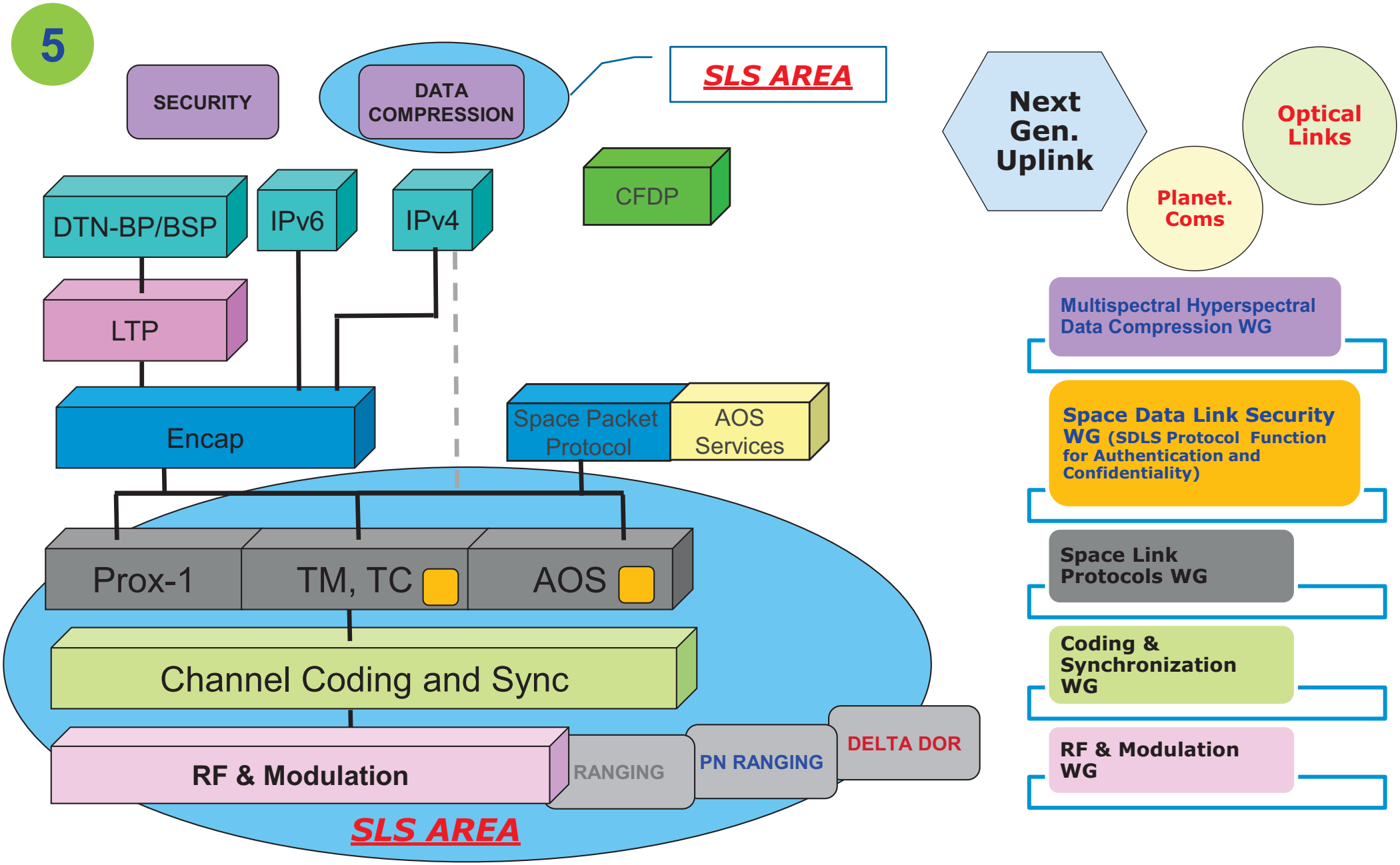


Space Link Services Area Goals

- To define innovative, secure, widely applicable communication standards and related architectures that facilitate interoperability and cross support and meet the challenges and anticipated needs of the future projects, including:
  - Increased bandwidth capacity approaches (radio frequency and optical);
  - The achievement of higher information data rates and greater spectral efficiency
  - more capable protocols, modulation, coding and compression techniques;
  - Introduction of advanced physical and link layer communications technology providing significantly higher data return;
  - The use of secure communication protocols and links, to protect associated systems and information flows.

Space Link Services 5.

Space Link Services
Layered approach



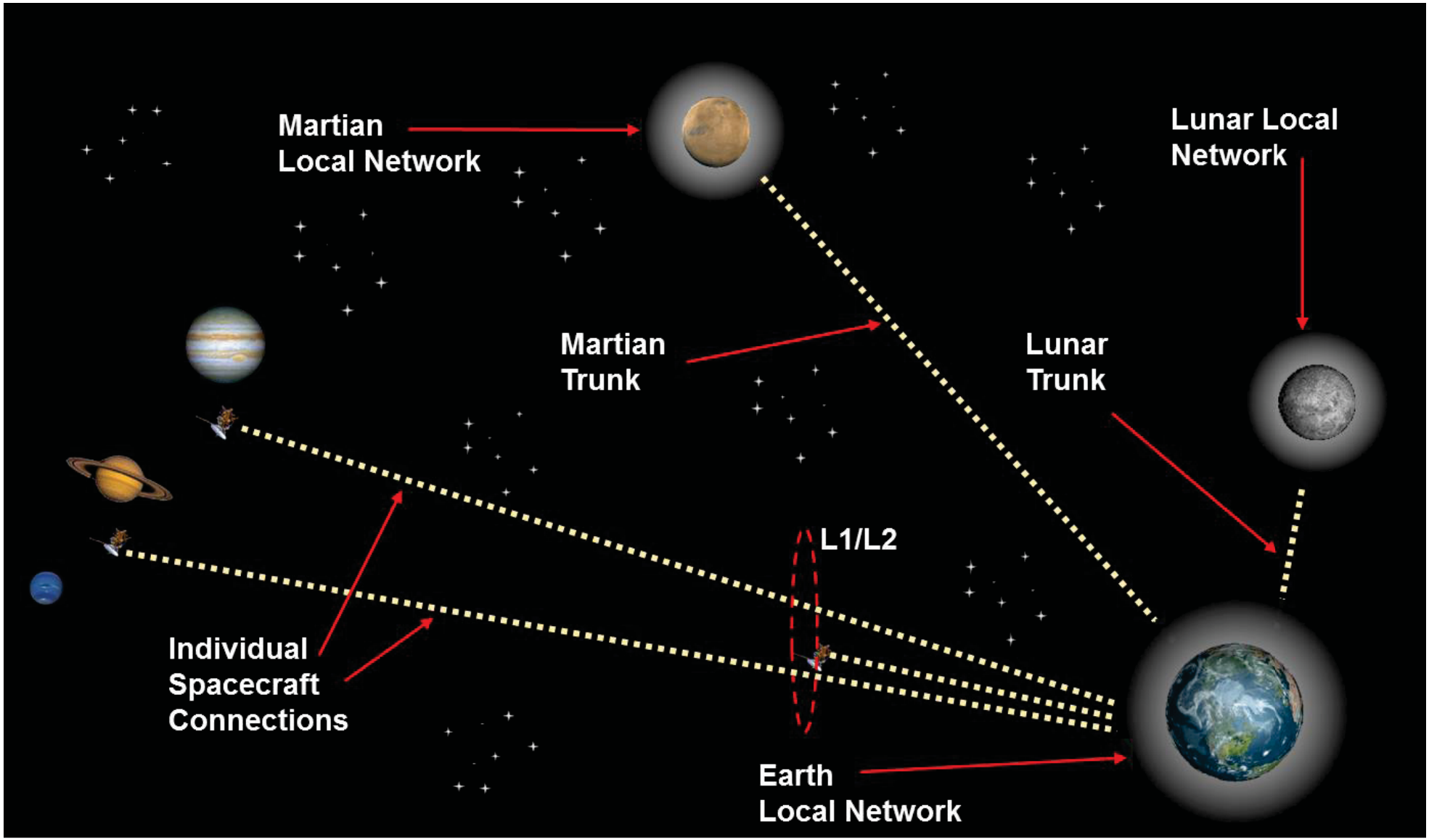
Space Internetworking Area Goals

- To define an integrated set of Space Internetworking standard services in support of end-to-end communications between applications covering the entire solar system and meeting future project needs, including:
  - Jointly conducted human and robotic operations;
  - Management of space-to-space and direct-to-earth links as part of the network;
  - Sensorweb and other innovative technologies for LEO operations;
  - Application to the space domain of well-established internetworking technologies.

Space Internetworking Services

6. Automated Routing across networks end-to-end.

Top Level Comm/Nav Architecture
The Solar System Internet



Consultative Committee
CCSDS
for Space Data Systems

CLOSEUP on CCSDS Activities In Select Working Groups

Security Working Group

- The CCSDS Security Working Group:
  - Develops CCSDS security recommendations (standards)
  - Develops security guides and informative documents
  - Provides security advice and guidance to CCSDS working group for security factors and practices in other CCSDS standards.
- Documents developed:
  - Green Book on use of security in CCSDS
  - CCSDS Security Architecture
  - Algorithm trade studies for encryption and authentication
  - System interconnection guide
  - Threat guide
  - Key management guide and standard
  - Mission planner's security guide
- On-going work:
  - Encryption and authentication algorithm standard
  - CCSDS Encryption Algorithms (blue book)
  - Network layer security profile
  - Information security glossary

Onboard Wireless Working Group

- Overview of Onboard Wireless activity
  - For basic spacecraft design, reduces launch mass of vehicles
  - For operations concepts, allows untethered mobility of crew and instruments
  - On the ground, potential utility for standards in test and integration
- Approved documents:
  - Green Book: *Wireless Network Communications Overview for Space Mission Operations*
    - Examines the possibilities and advantages of the application of *wireless communications technology* to space missions
  - Magenta Book: *RFID-Based Inventory Management Systems*
    - Improve ground system and spaceflight vehicle inventory tracking & visibility
  - Magenta Book: *Low Data-Rate Wireless Communications for Spacecraft Monitoring and Control*
    - targeted towards low data-rate and low-power applications transmitting in the 850 MHz – 950 MHz and 2.45 GHz (ISM) radio frequency band
- Future work:
  - High data rate wireless communications for space missions:
    - Focus is on high-rate wireless for voice, video, medical service provision.

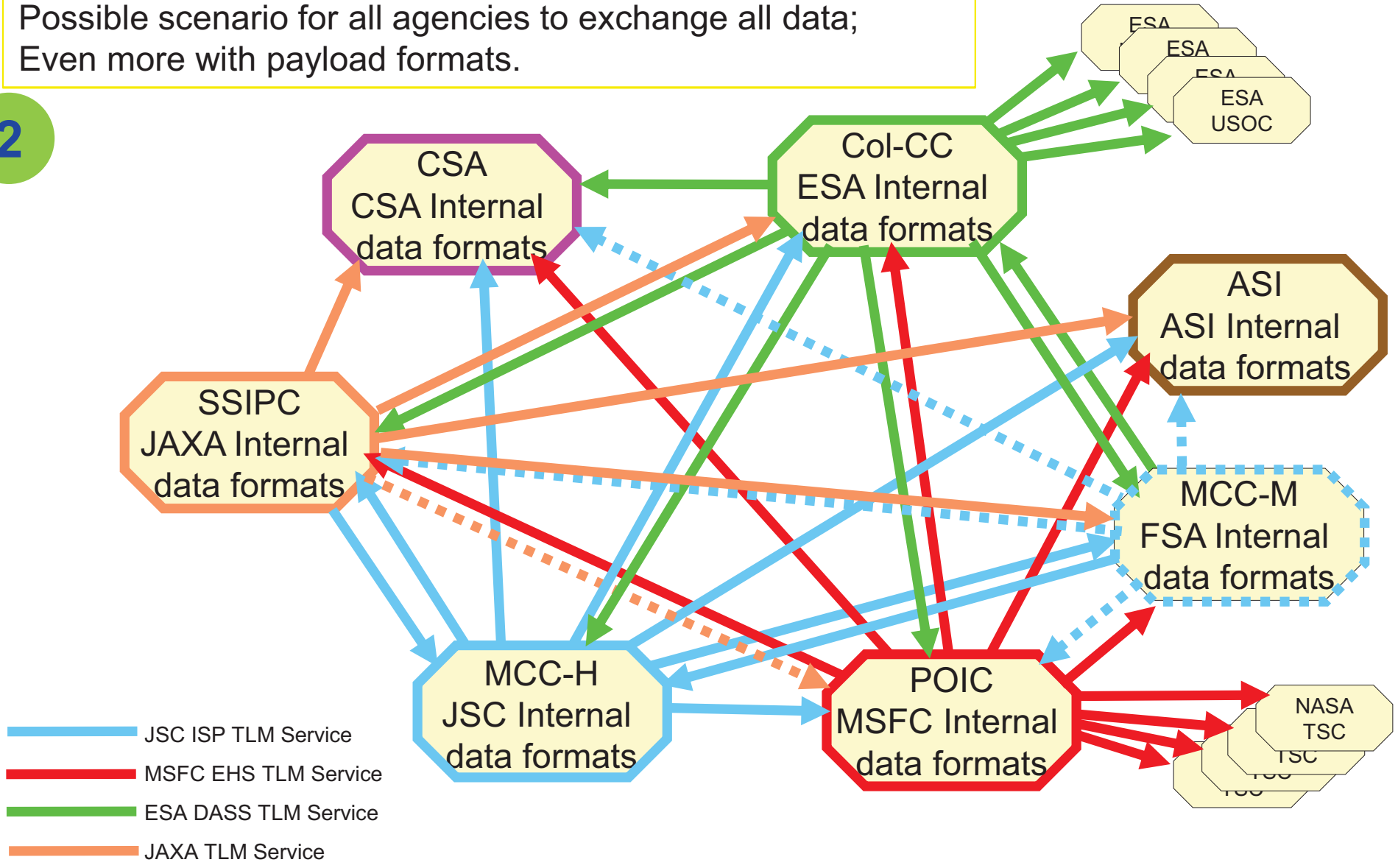
Spacecraft Monitor and Control

- Emphasis is on standardizing service interfaces for common functions that are in every mission, at the ***application level***
  - Early emphasis is for ground-to-ground interfaces
  - Starting testing for flight systems interfaces as well
- Capitalizes on industry-accepted approach of a SOA (Service Oriented Architecture)
  - Standardizing interactions of providers and consumers of service
  - Includes discovery of services (auto-configuring interfaces)
  - Plug-n-play characteristics: Finally allowing operational/management decisions to be independent of software development projects
  - Provides application portability as well as interoperability
- Progress to date:
  - Basic framework (Message Abstraction Layer, etc.) is published.
  - First applications (Telemetry, Command, common services) published
  - Alerts (alarm limits, etc.) currently in review cycle
  - Some future work will be spin-offs (Telerobotics, Planning, etc.)
- New Development: IOAG committee considering oversight of MO Services (note – SM&C protocols and MO Services are equivalent)

Mission Ops TLM Services
ISS Current formats

Possible scenario for all agencies to exchange all data;
Even more with payload formats.

2

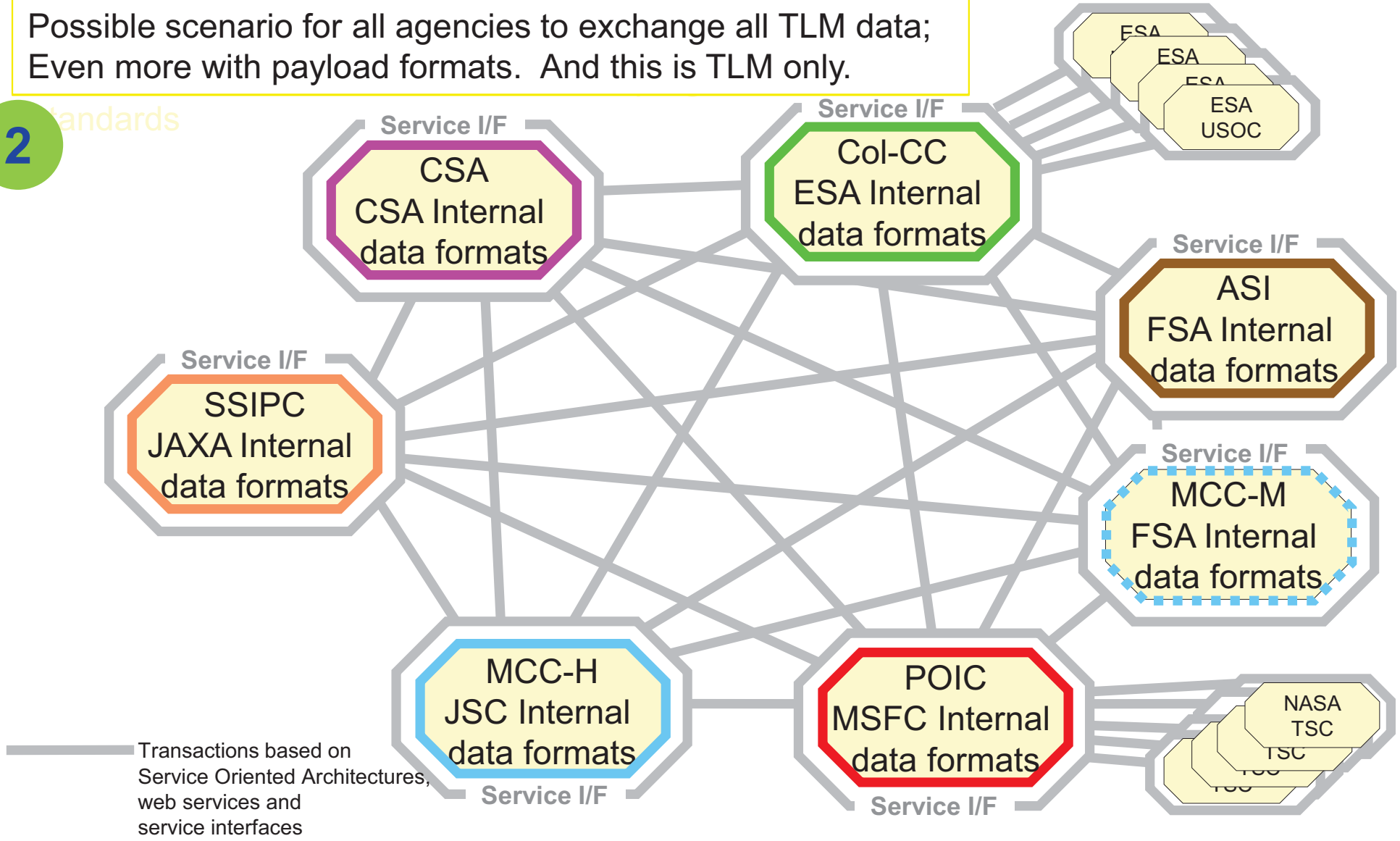


Mission Ops TLM Services Future Harmony

Mission Ops & Info Mgt Services 3.

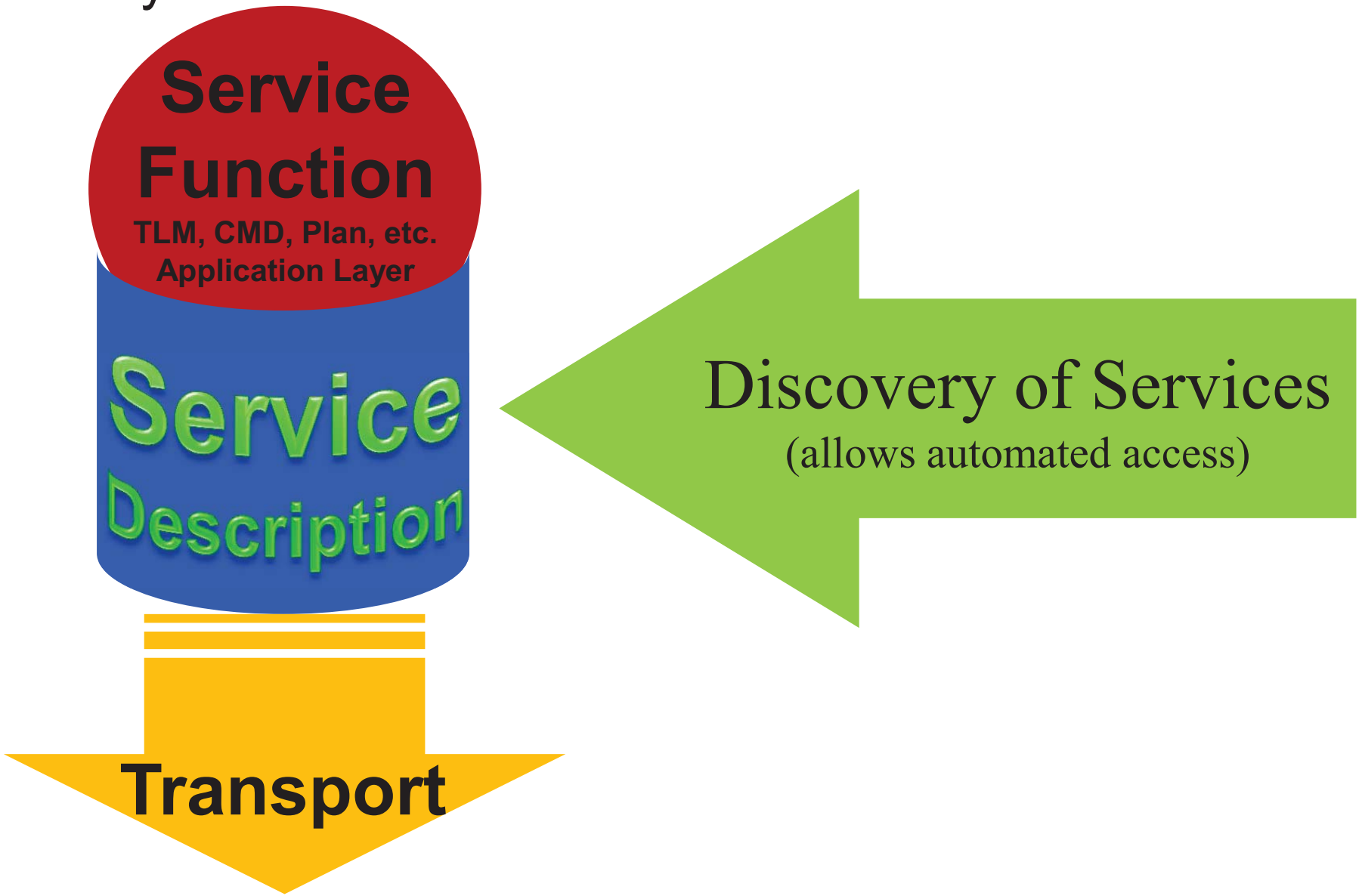
Possible scenario for all agencies to exchange all TLM data;
Even more with payload formats. And this is TLM only.

2



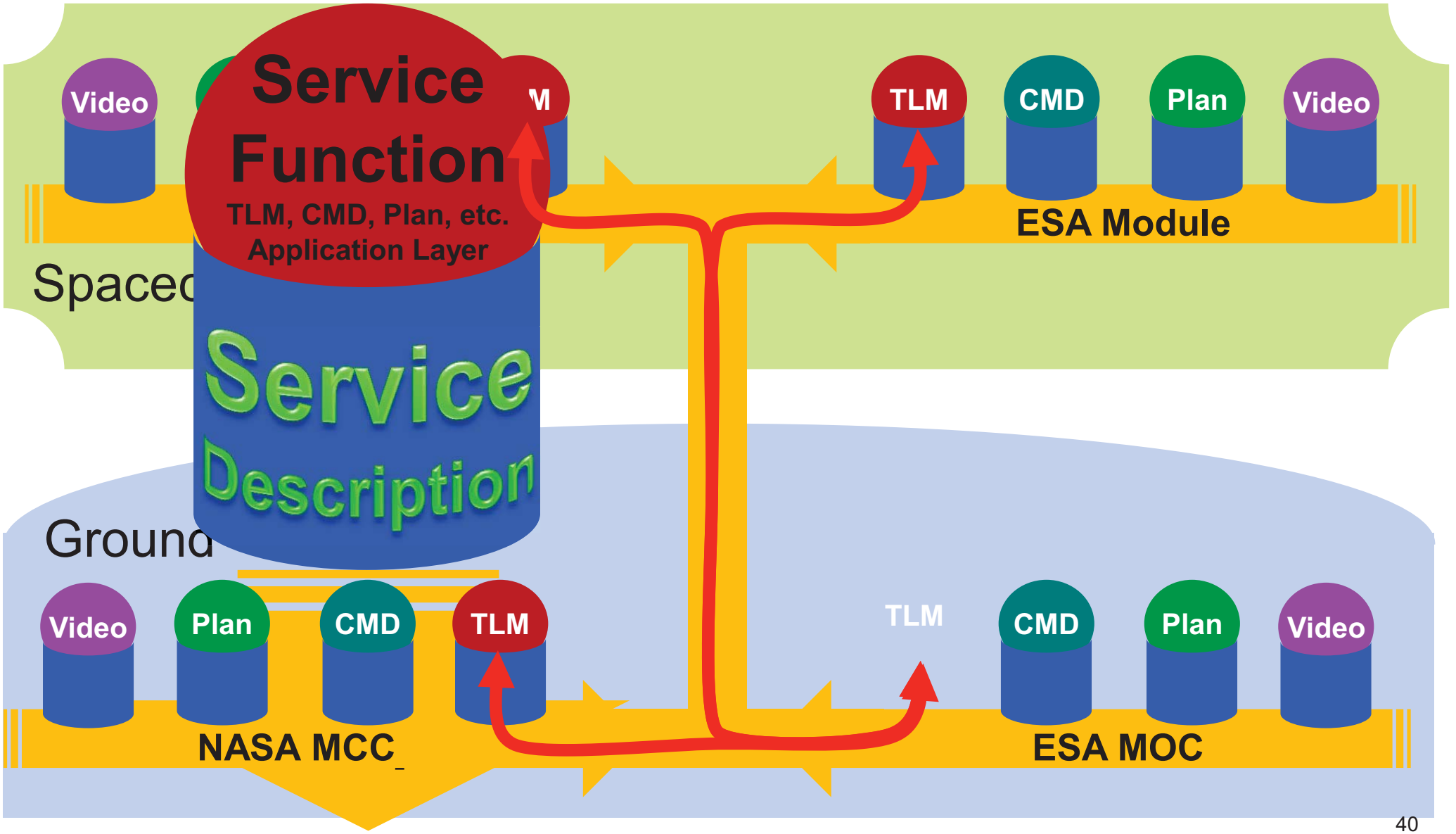
How CCSDS MO Services Work

Service Oriented Architecture
→widely used in other industries

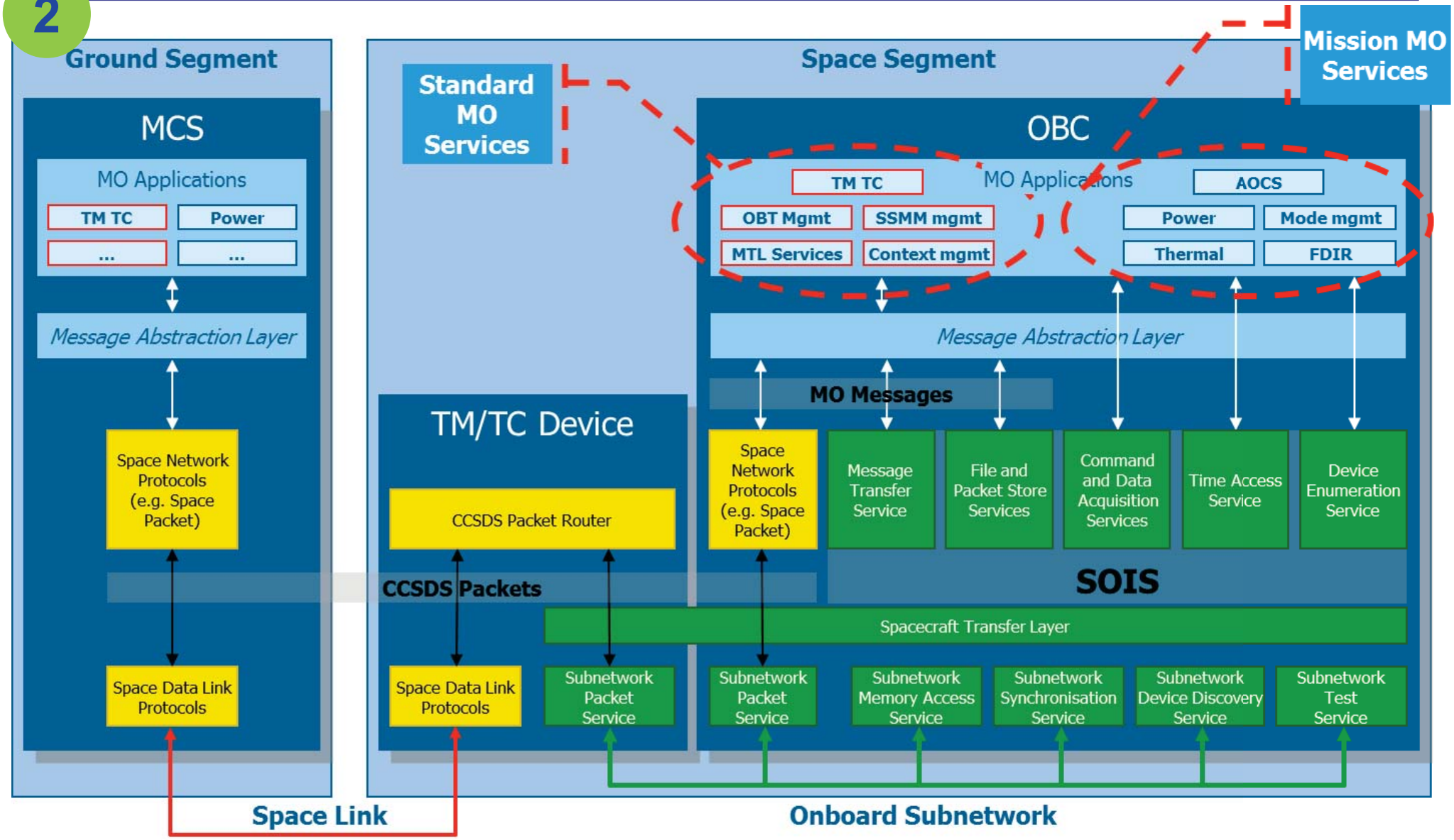


How CCSDS MO Services Work

Cross-support is based on *operational configuration and on security*
→ *NOT* on a new software development project.



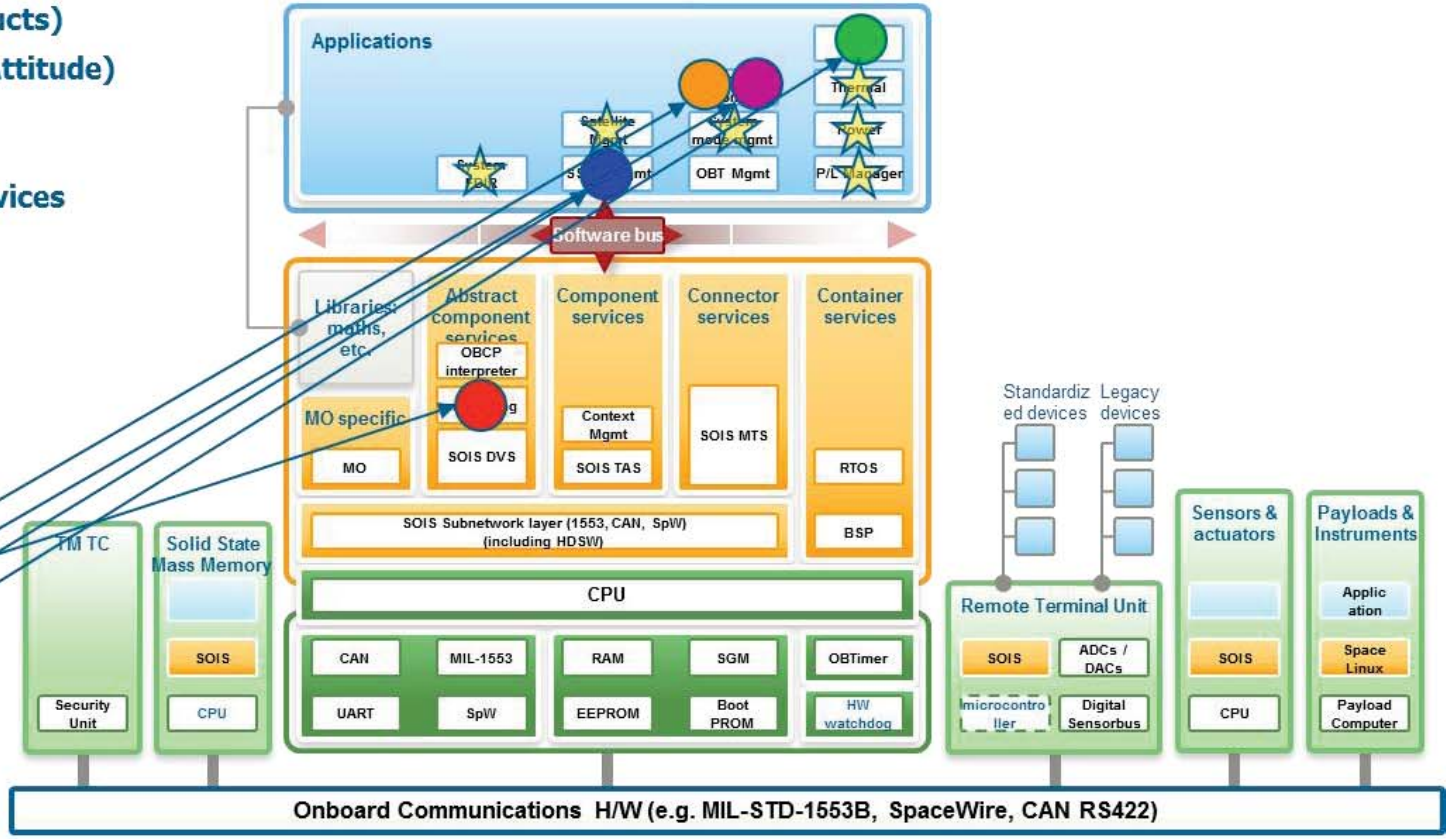
Future architecture



Distributable Mission Operations Functions

2

- M&C (Status, Control)
- Automation (Procedures, Timelines)
- Planning (Tasks, Goals)
- Mission Data (Products)
- Navigation (Orbit, Attitude)
- On-board Software
- Mission specific services



Navigation WG

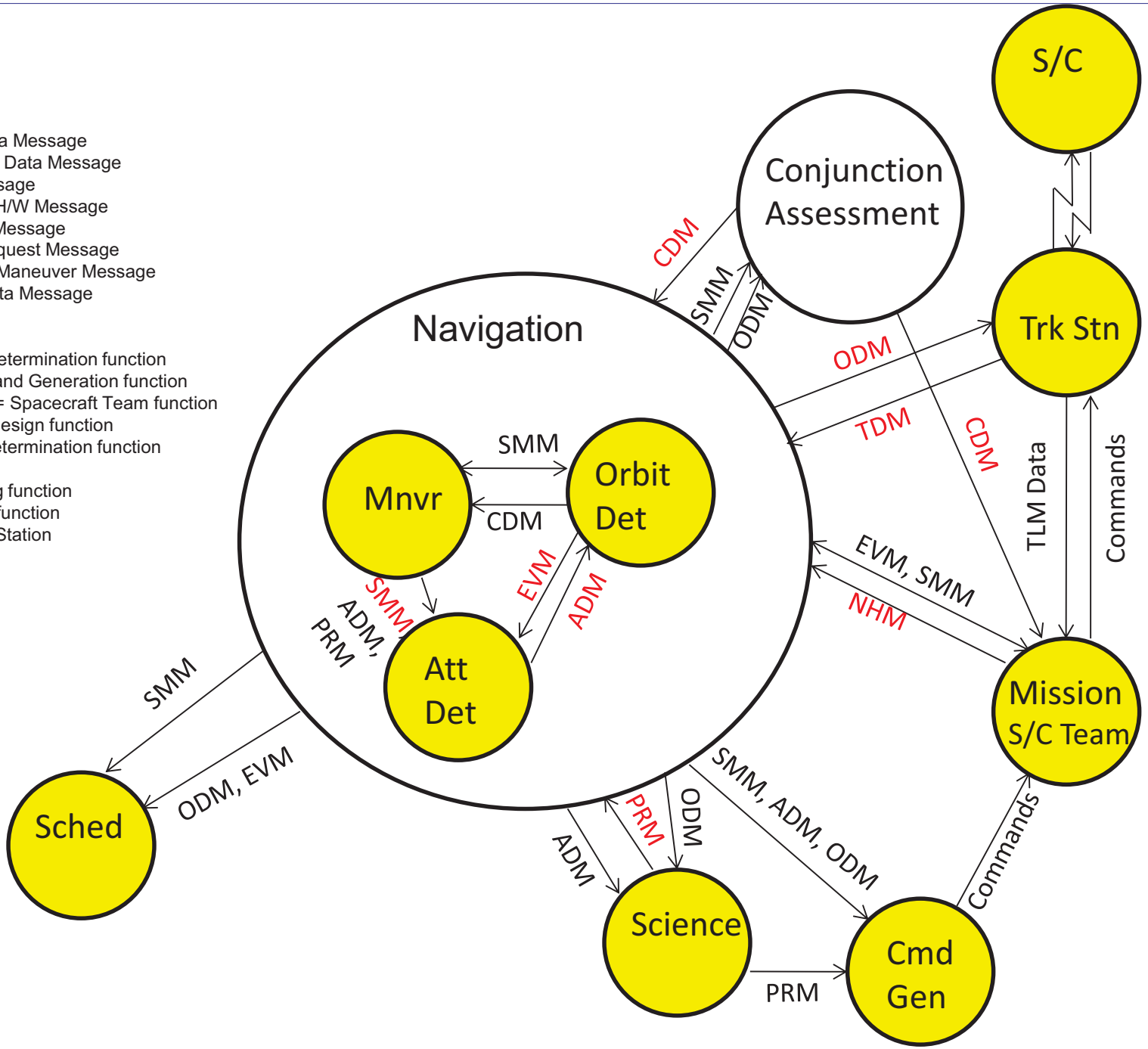
- The CCSDS Navigation Working Group is chartered to develop standards covering exchange of spaceflight dynamics related data
- Past Progress and Current Work
  - Orbit Data Messages (version 2.0 published 11/2009)
    - Three standard message formats for exchanging orbit descriptions
  - Tracking Data Message (version 1.0 published 11/2007)
    - Message format for exchanging tracking data; supports widely used tracking data types: Doppler, range, angle, ΔDOR, ancillary information
  - Attitude Data Messages (version 1.0 published 05/2008)
    - Two message formats for exchanging spacecraft attitude descriptions
  - Navigation Green Book (version 3.0 published 05/2010)
    - Contains technical background related to the Nav WG Recommendations
  - Nav Data Messages XML Specification (version 1.0 published 12/2010)
    - Contains XML representations of all above Nav WG standards
  - Conjunction Data Message (pub June 2013)
    - Standard message format for informing spacecraft operators of object conjunctions in space (spacecraft/spacecraft, spacecraft/debris, debris/debris)
- Future work
  - Pointing Requests Message – communicating complex on-orbit cross-support pointing requests (e.g., inertial, limb, terminator, velocity, nadir, track)
  - Navigation Hardware Message – exchanging onboard navigation H/W data between space agencies (e.g., thrusters, accelerometers, star trackers, etc.)
  - Spacecraft Maneuver Message – exchanging information regarding spacecraft maneuvers (requirements, design, reconstructed performance)

The Navigation Roadmap

3

Messages
ADM = Attitude Data Message
CDM = Conjunction Data Message
EVM = Events Message
NHM = Navigation H/W Message
ODM = Orbit Data Message
PRM = Pointing Request Message
SMM = Spacecraft Maneuver Message
TDM = Tracking Data Message

Functions
Att Det = Attitude Determination function
Cmd Gen = Command Generation function
Mission S/C Team = Spacecraft Team function
Mnvr = Maneuver Design function
Orbit Det = Orbit Determination function
S/C = Spacecraft
Sched = Scheduling function
Science = Science function
Trk Stn = Tracking Station

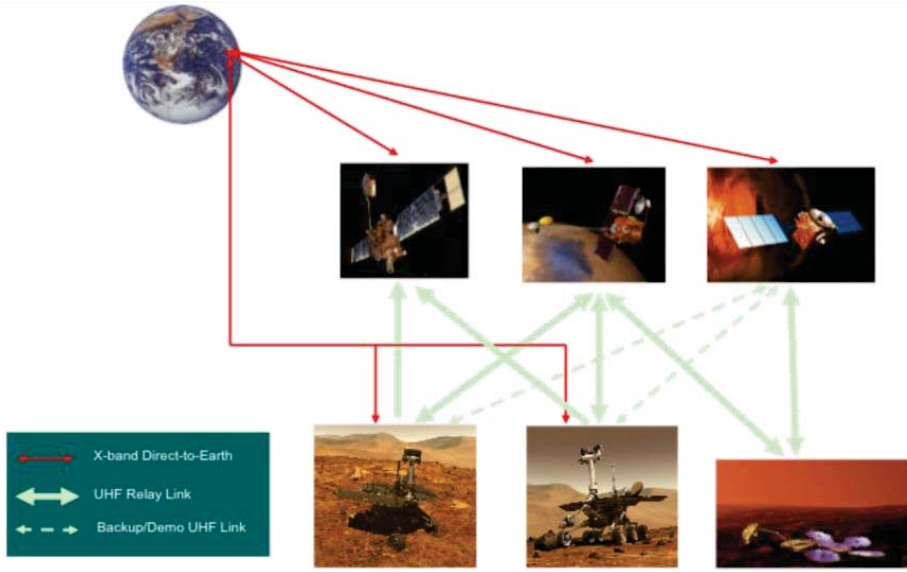


Other New Work Areas

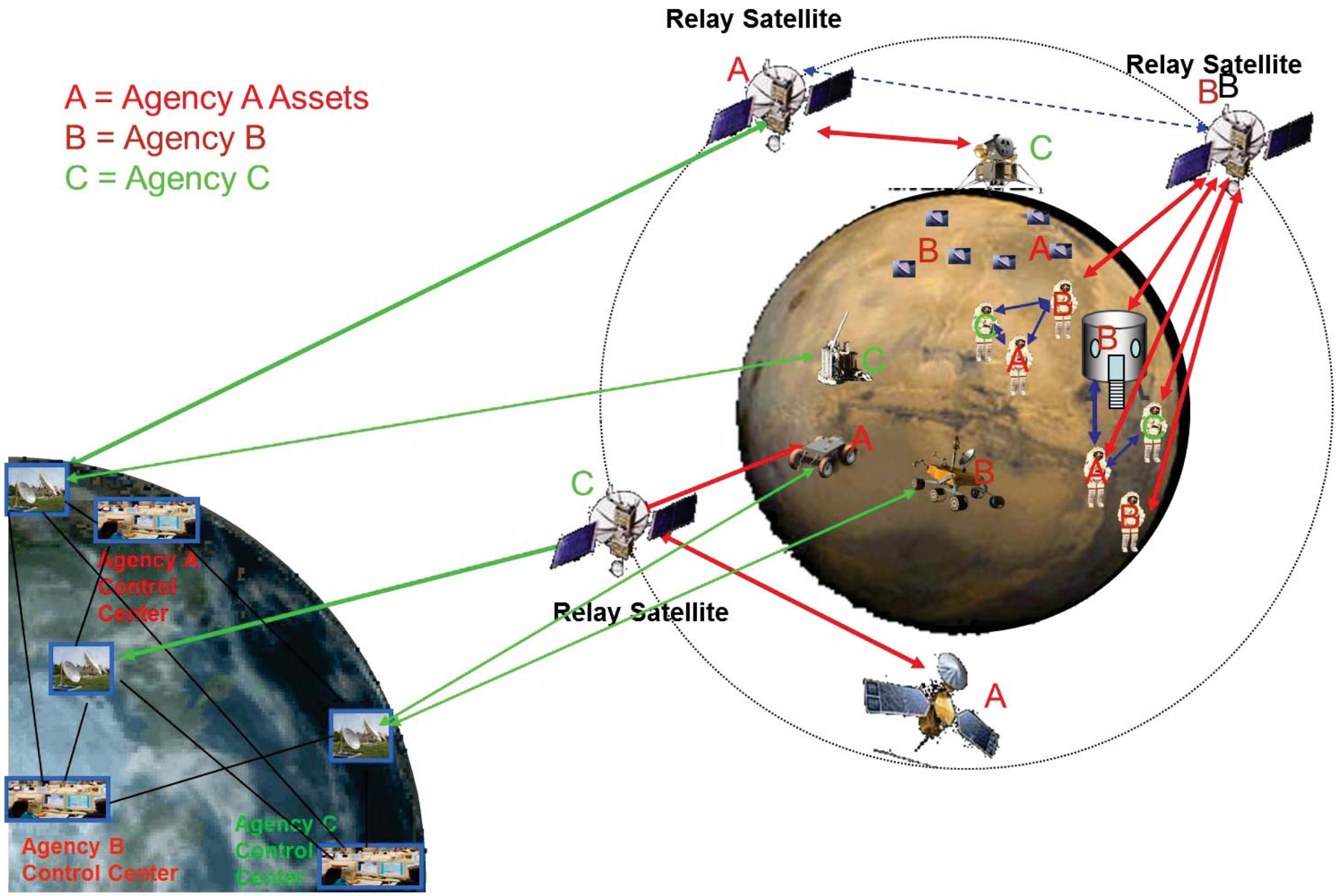
- Optical Coding and Modulation SIG (Special Interest Group)
  - Considering whether it is time for an Optical Comm standard
  - Would support Mars-Earth, LEO-GEO, LEO DTE scenarios
  - Interesting work in optical coding and modulation for interoperability

Delay/Disruption Tolerant Networking (DTN)

- The DTN Working Group is laying the foundation for the Solar System Internet (SSI)
  - Provides automated routing in space (like terrestrial Internet), but compared to current IP technology:
    - Adds Delay/Disruption tolerance for deep space environment
    - Delivers more data, faster in disrupted near-earth environment
- Past Progress and Current Work
  - Green book establishes rationale, develops scenarios, explores candidate technologies
  - Due to be approved/published this year: SSI Architecture Document, DTN Bundle Protocol (BP) specification and Licklider Transmission Protocol (LTP) Blue Books.
- Future work – Complete Solar System Internet (SSI) infrastructure with
  - Network Management
  - Contact Graph Routing
  - File Delivery Protocol (CFDP)



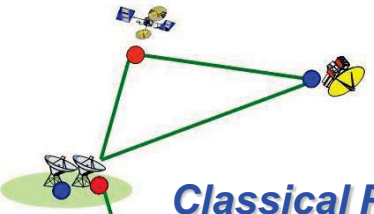
Future Vision: Integrated Operations



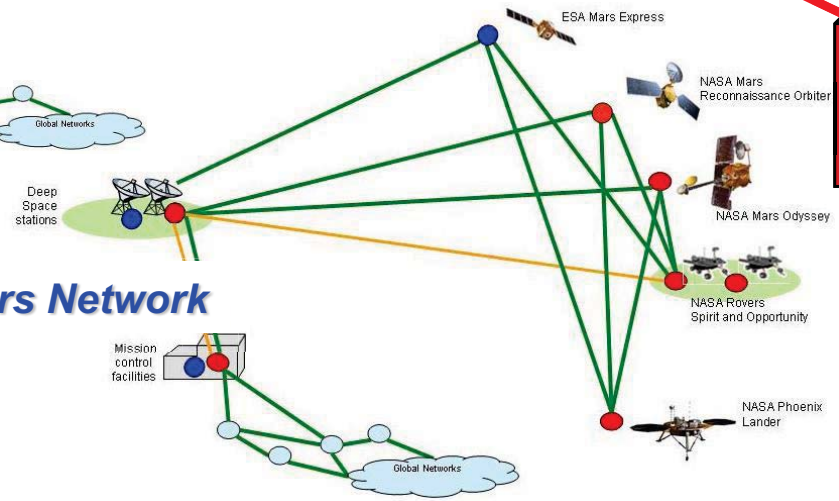
Consultative Committee for Space Data Systems

A clear way forward to a networked architecture

Space Internetworking Services 6.



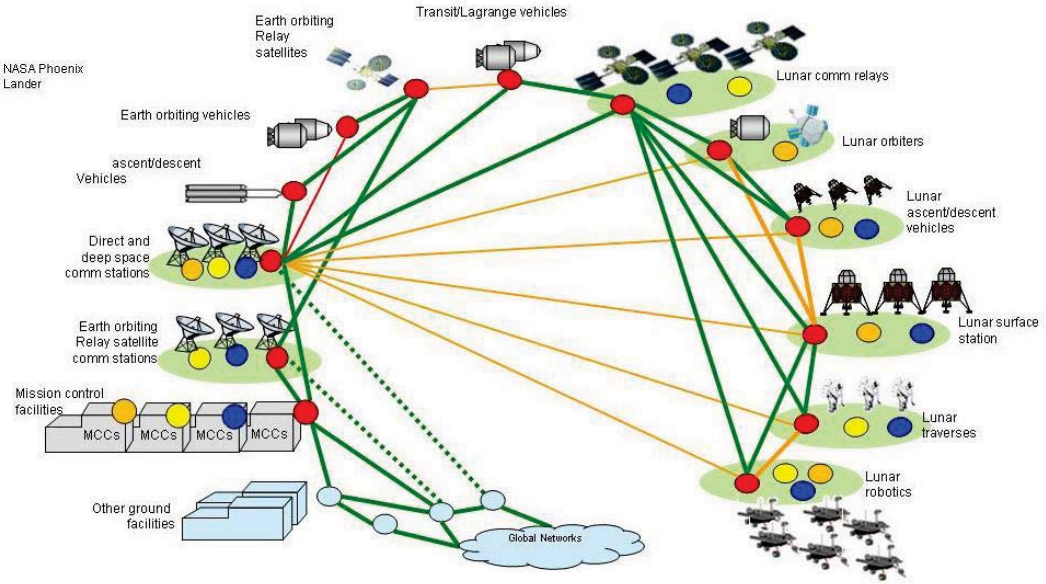
Classical Point-to-Point



Current Mars Network

(DTN)
IP
DTN
Space Packet

CCSDS
Space Link Protocols

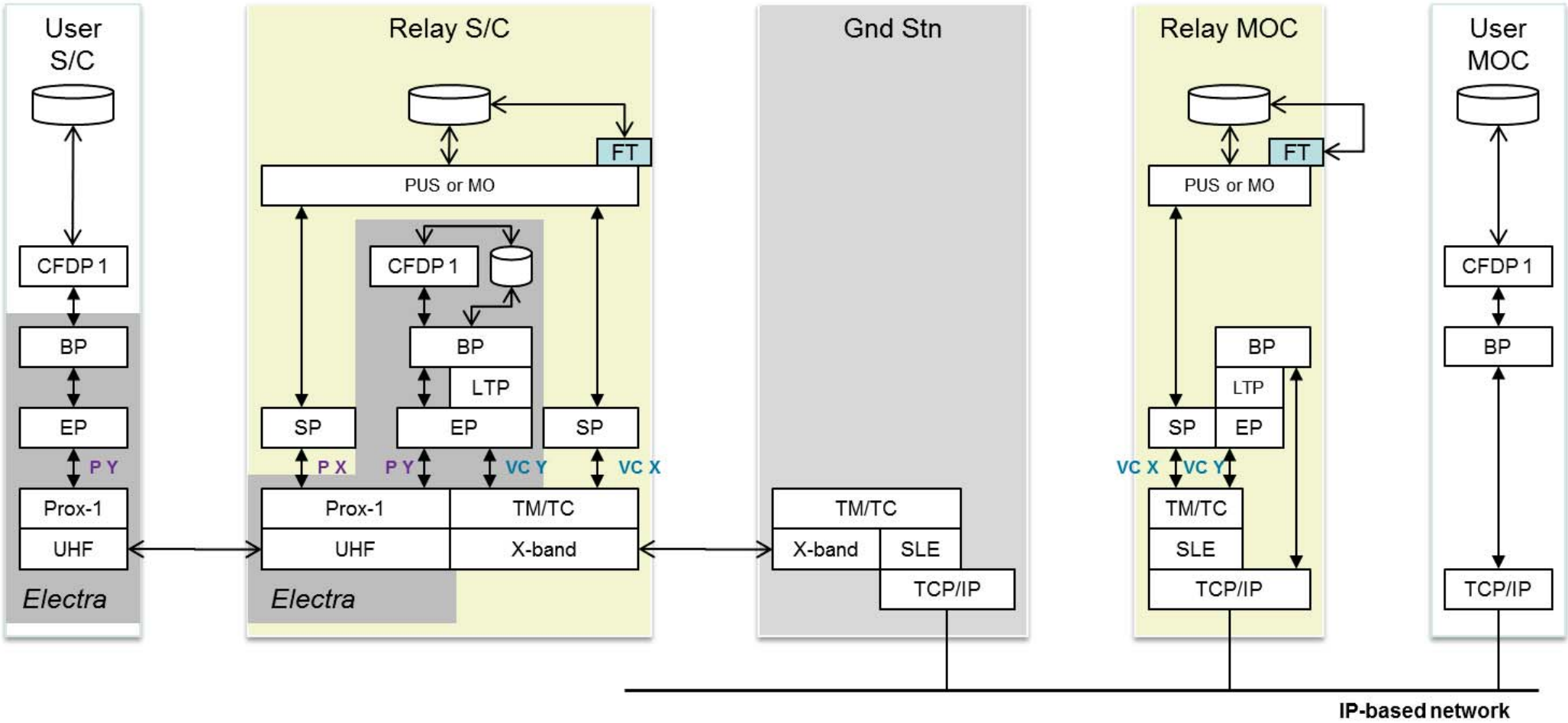


Potential Lunar Network

- ✓ Increasing reliance on international cooperation
- ✓ Smooth, backwards-compatible *evolution* to future space internetworking
- ✓ *Increasing reliance on data relays and the need to transition towards a networked architecture*

Space System Internetworking Evolution Options

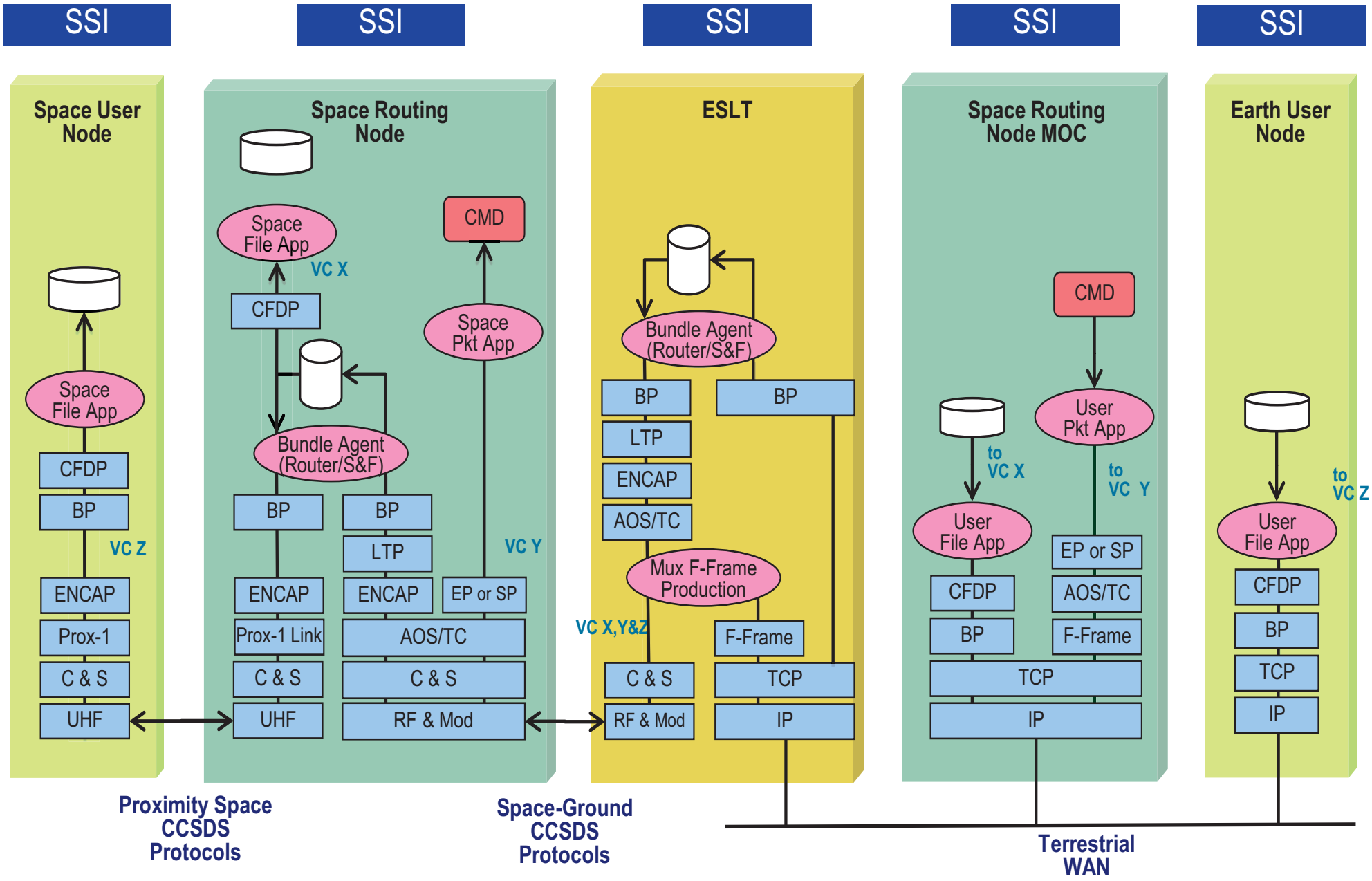
DTN operating at Agency A
Agency B operations are based on DTN end-to-end, including class-1 CFDP over DTN
A DTN node is added at the Orbiter MOC;
Interface between MOCs is streaming, not file-based, for DTN-enabled user



Consultative Committee for Space Data Systems

SSI End-to-End Forward All DTN

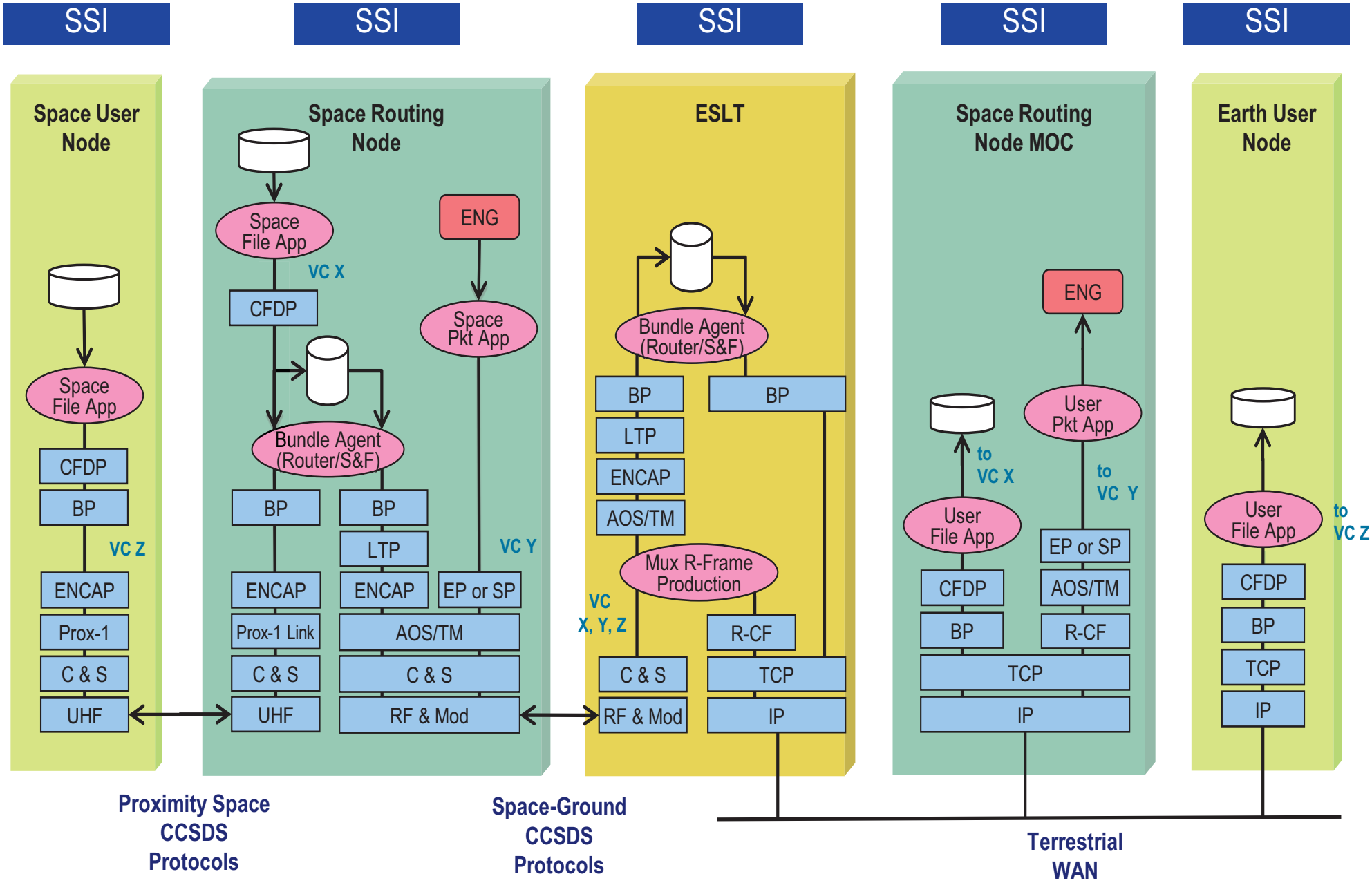
Space Internetworking Services 6.



Consultative Committee for Space Data Systems

SSI End-to-End Return All DTN

Space Internetworking Services 6.



Asynchronous Message Service (AMS)

- The AMS Working Group ***FINISHED AND CLOSED***
- Completed standardizing messaging middleware for flight mission communications.
  - AMS provides "message bus" functionality for flight missions, including both publish/subscribe and client/server interaction models.
  - Unlike JMS or DDS, AMS is *a wire protocol rather than a service spec*
    - Conformant implementations are interoperable, no gateways needed.
  - Unlike AMQP, AMS is *peer-to-peer, not reliant on a message broker*
    - High performance, fault tolerant.
  - Unlike RTPS, AMS is *designed to run efficiently over space links*
    - Uses a built-in delay-tolerant and disruption-tolerant multicast tree.
- Overall benefit: Flight-system capable, loosely-coupled, simplified interfaces
  - Overall reduction in interface complexity
- Completed publication of Blue Book, and closed Working Group
- Reference implementation is available as open source, included in JPL's "ION" software distribution at: http://www.openchannelfoundation.org/projects/ION/

Other New Work Areas

- Voice and Video WGs
  - Classic problem of Voice/Video degradation from analog/digital conversions during cross support
  - Digital video adds more complexity
  - Plan to establish “profiles” of cross-supported commercial standards
  - Addressing both ground systems (between MCC’s) and flight systems interoperability

Other New Work Areas

- Telerobotics WG
  - Seeking to develop standardized protocols for operating space-borne robotic systems
- Planning Systems (Future BOF)
  - Seeking to develop standardized interfaces for exchange of Mission Operations Planning Data, for both robotic and human spaceflight programs.

CCSDS Summary

- Take-home message: Still much work to be done
  - Enabling interoperability between international agencies for future missions – both Earth-Orbital and Exploration
  - Long-range vision – automated routing and delay tolerant networking for deep space crosslinks between spacecraft and surface systems
  - Near-term need – evolutionary approach to sustain cross-support agreements with other agencies.
- Organizations with a stake in the future of Space Missions and the expertise to contribute to CCSDS should become engaged.

Consultative Committee
CCSDS
for Space Data Systems

Other Opportunities for NSPO
to participate in international activities

SpaceOps

- SpaceOps Committee organizes the SpaceOps Conferences every two years
  - Also other publication and outreach functions
- Valuable forum for exchanging info on the most important phase of a spaceflight mission: Operations!
- The next SpaceOps Conferences:
  - Pasadena California (JPL), May 2014
  - Daejeon Korea (KARI) May 2016
- Also, participation in the committee may be of interest to NSPO
  - Committee meets about twice per year
- www.SpaceOps.org.

Space Generation Advisory Council

- SGAC is a non-profit organization that represents 18-35 year olds in international space policy at the United Nations, at agencies, in industry, and in academia
  - Founded as a result of the 1999 UNISPACE III conference
  - SGAC has had permanent observer status in the UN COPUOS since 2001 and has been a member of the UN Economic and Social Council since 2003
  - Is headquartered in Vienna, Austria and is hosted by the European Space Policy Institute
  - SGAC has a volunteer network of more than 4,000 members in over 100 countries
- Conferences
  - Space Generation Congress (SGC)
  - Space Generation Fusion Forum
- Year-round Projects
- Pragmatic Policy Suggestions
  - Reports to United Nations COPUOS committee
  - Recommendations from Space Generation Congresses
- Scholarships
- Special Projects
  - ISECG-NASA Videos, IAA Study Groups, European Space Expo, etc.

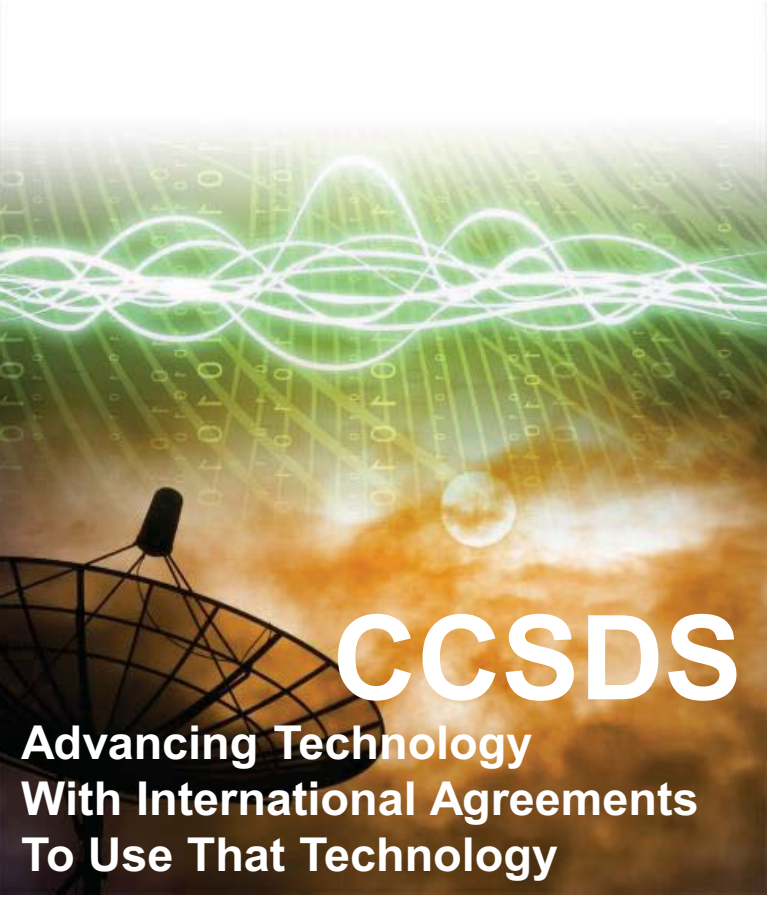
IOAG Catalog

- The IOAG maintains a listing of communications ground stations that are available for international cross-support.
- NSPO sites are not currently included
- If NSPO has antenna sites that might be available to other agencies or organizations, to cross-support other programs, NSPO should submit the appropriate technical info to the IOAG.
- This allows mission planners in other agencies to know what is available.
- It may also be of interest to NSPO planners to see what comm resources are available to support your missions.
- Of course, cross-support with other agencies is achieved only through other negotiations for bilateral support.
- If NSPO is interested, contact Angel Oria at angel.oria-1@nasa.gov,
- Also CC the IOAG chairman Michael Schmidt (Michael.Schmidt@esa.int) and IOAG secretariat, Stephanie Wan (Stephanie.Wan@nasa.gov).

Consultative Committee for Space Data Systems

CCSDS SLE and CSS

Space Link Extension
Cross Support Services



Mike Kearney
CCSDS Chair & General Secretary
NASA MSFC EO-01
256-544-2029
Mike.Kearney@nasa.gov

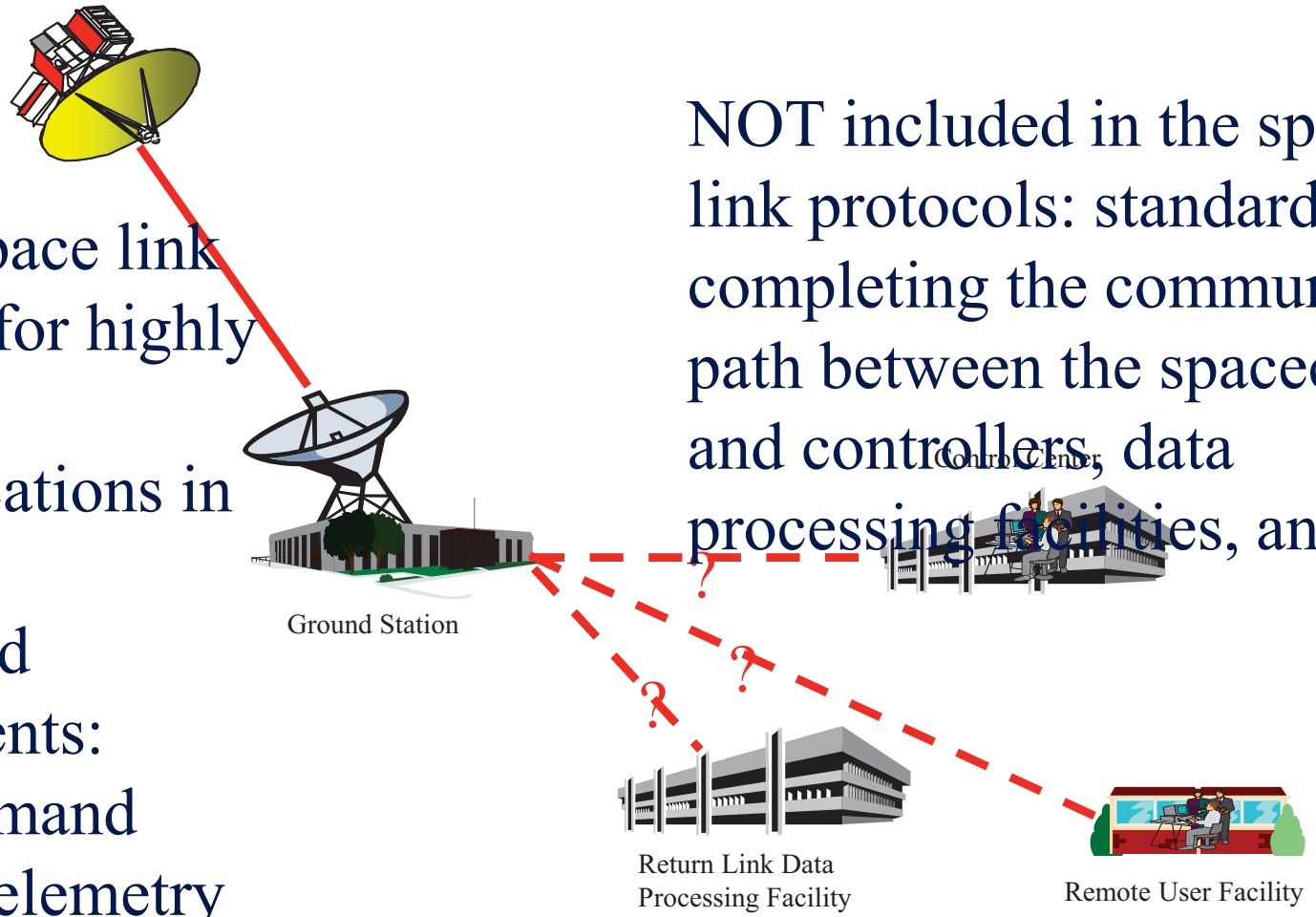
Erik Barkley
Cross Support Services Area Director
NASA JPL 3970
Erik.J.Barkley@jpl.nasa.gov

Agenda

- Space Link Extension (SLE)
- Transition from SLE to CSTS
- Cross Support Transfer Services (CSTS)
- Cross Support Service Management (CSSM)
- Cross Support Area Projects
- Conclusions

The Situation circa 1990
(State of CCSDS Standardization of S/C Communications)

CCSDS space link Protocols for highly efficient communications in resource-constrained environments:
- Telecommand
- Packet Telemetry
- Advanced Orbiting



NOT included in the space link protocols: standards for completing the communication path between the spacecraft and controllers, data processing facilities, and users

The Situation Circa 1990:
Agency Specific Solutions

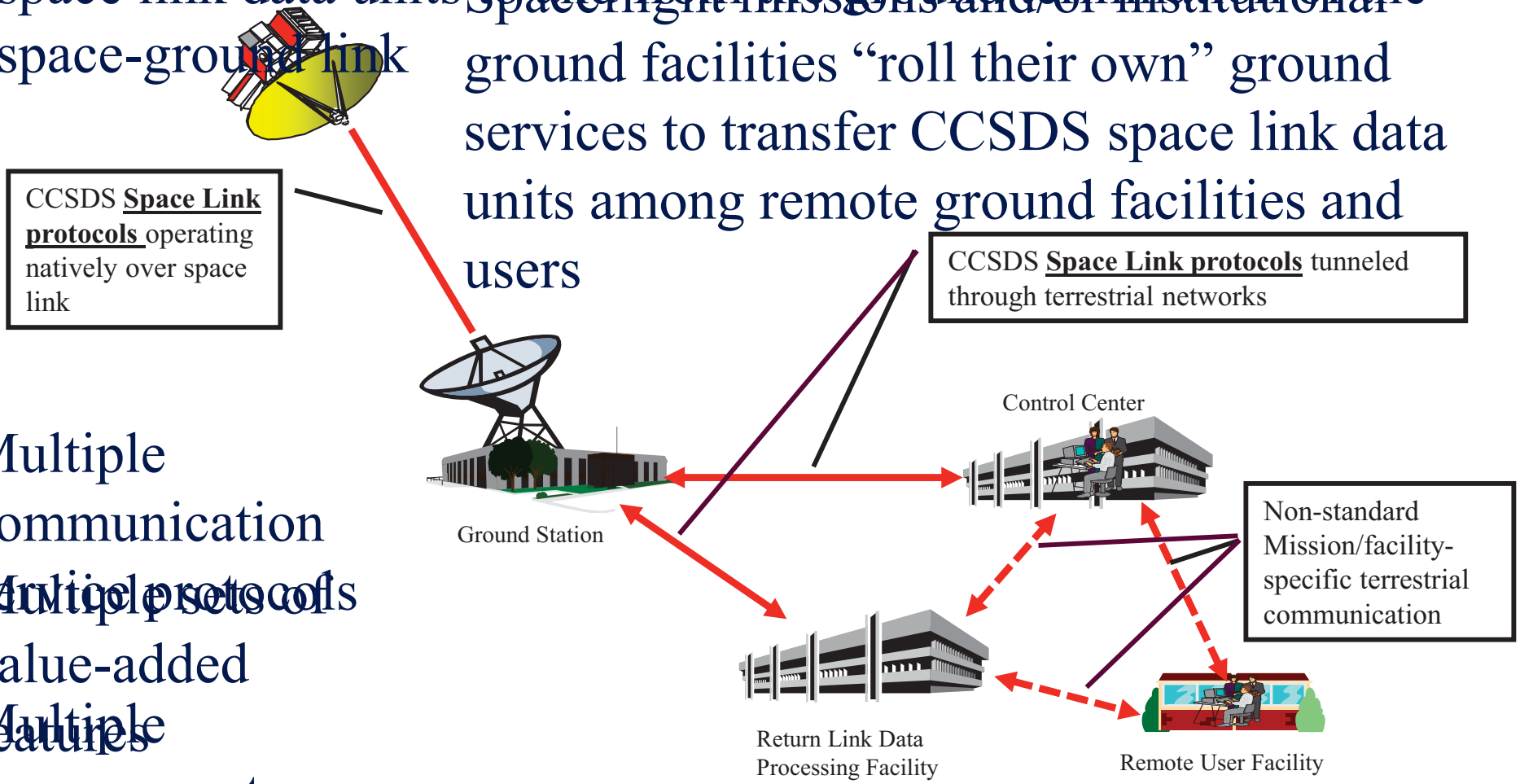
Spaceflight missions "roll their own" ground services to transfer CCSDS space link data units to and from the ground termination of the space-ground link

Spaceflight missions and/or institutional ground facilities "roll their own" ground services to transfer CCSDS space link data units among remote ground facilities and users

Multiple communication services

Multiple sets of value-added features

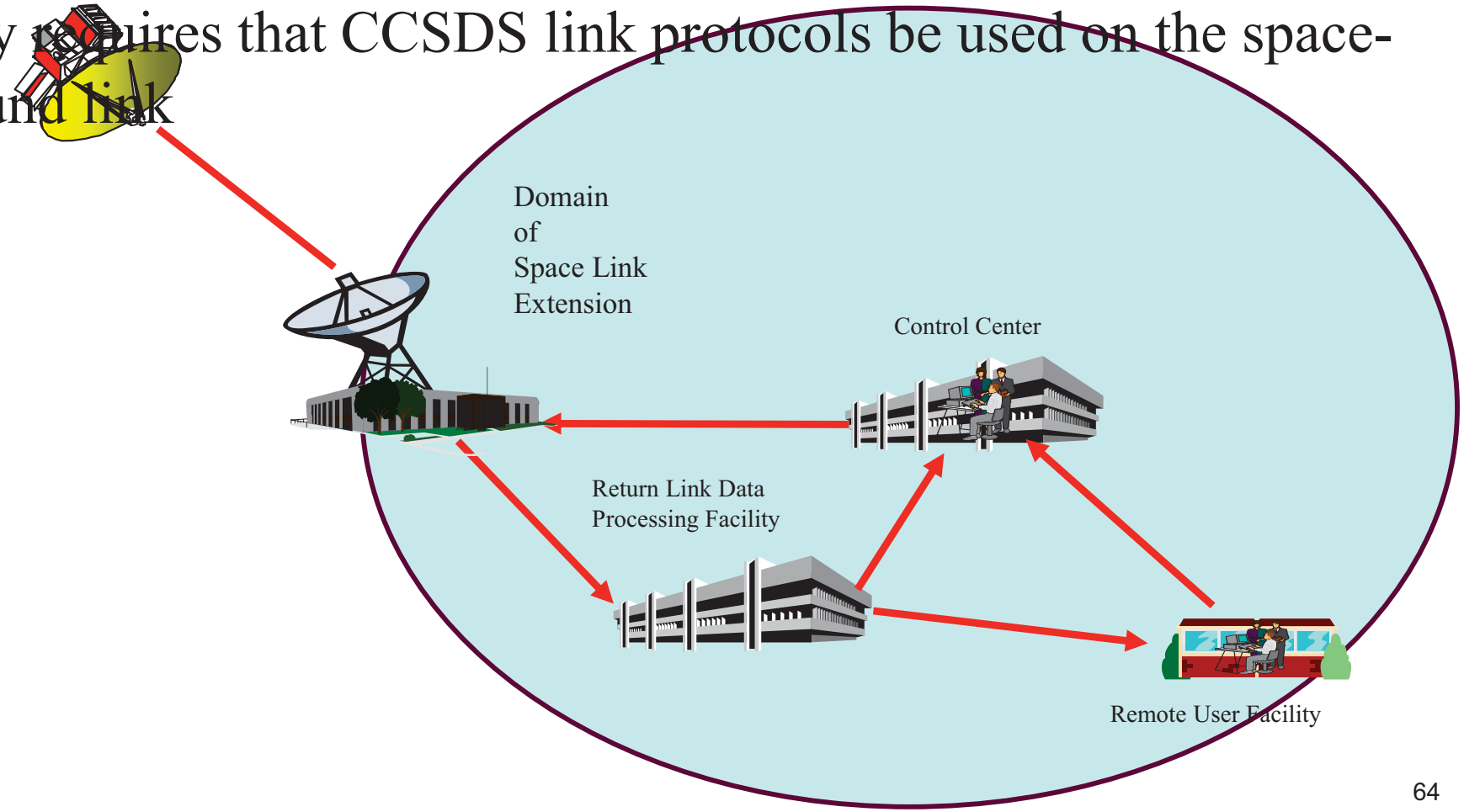
Multiple management capabilities and



The Situation from 2001 to present
Space Link Extension

Standard services for exchanging CCSDS space link data units between ground termination of the space link and remote users

- Standardizing terrestrial links as well as space links
- Evolution of mission-unique/provider-unique services
- Only requires that CCSDS link protocols be used on the space-ground link

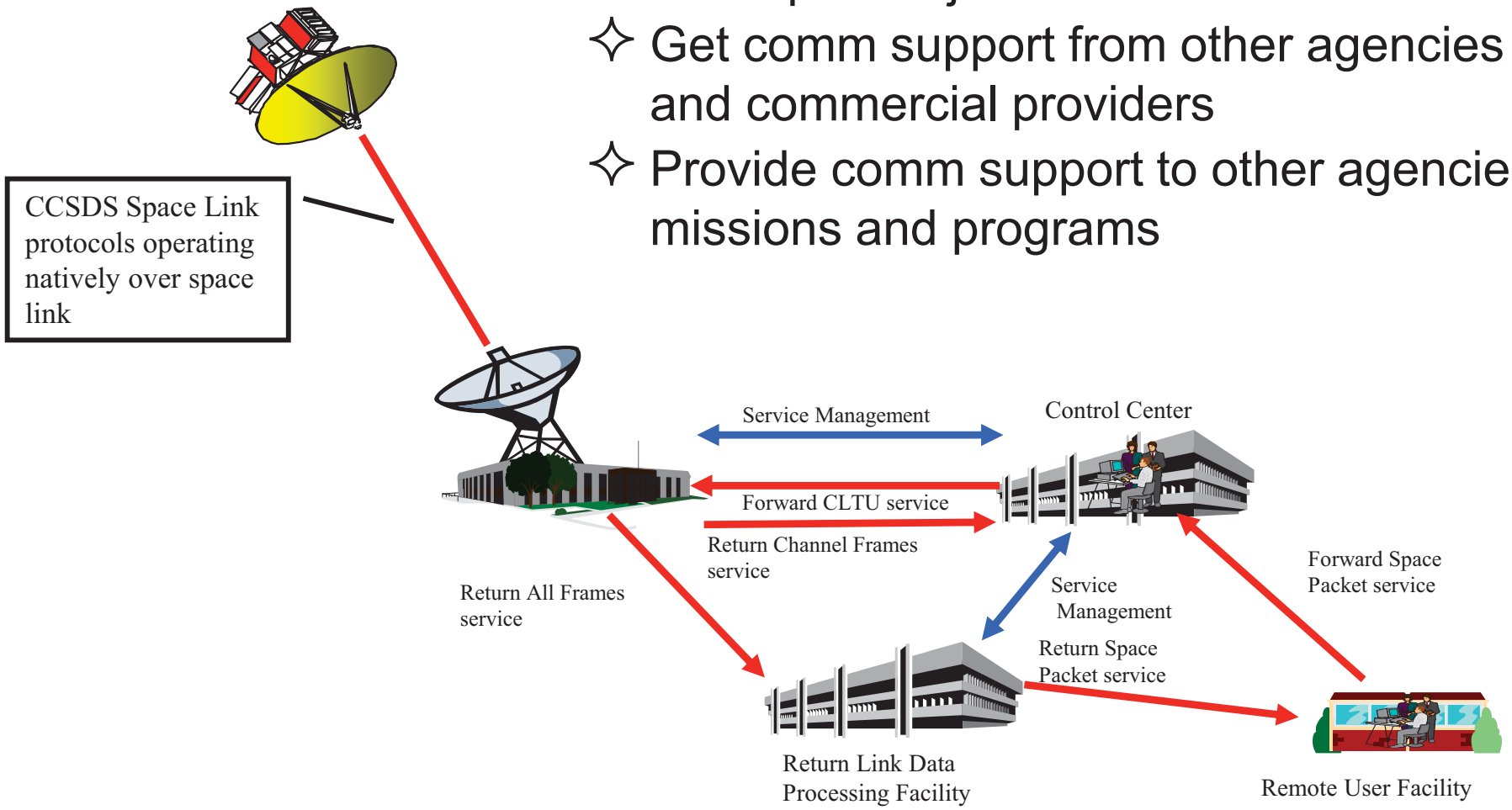


Standardized Capabilities of SLE Services

- Service association establishment, configuration, and termination
- Access control and authentication
- Transfer of CCSDS space link data units with ancillary data, e.g.:
  - Ground receipt time for return link data
  - Radiation time window for forward link data
- Offline storage and retrieval
- Space link data status information
- Transfer service status and accounting information
- Production status information
- Reliable transmission to multiple service users
- (Limited) Service management – some mechanisms for control of executing transfer services

Space Link Extension
One Example Configuration

- This makes it very cost-effective to:
  - Participate in joint missions
  - Get comm support from other agencies and commercial providers
  - Provide comm support to other agencies' missions and programs



Benefits of SLE Services

- SLE services address more than just data transfer
  - Connections management, service configuration, status and accounting reports
- SLE services are designed to operate over commercially-available packet network infrastructure
- Common data and management interface simplifies operation of spaceflight missions across multiple space-ground network service providers
- Services are scalable - only those services that are required by a user mission or service provider need be implemented
- Standardized services increase market for space-ground network services providers
- Expanded global market for COTS SLE products: increased number of vendors and/or lower costs for products
- Reduced costs and technical and schedule risks
- SLE places no additional requirements on spacecraft that already use CCSDS space link protocols

Space Link Extension Transfer Services

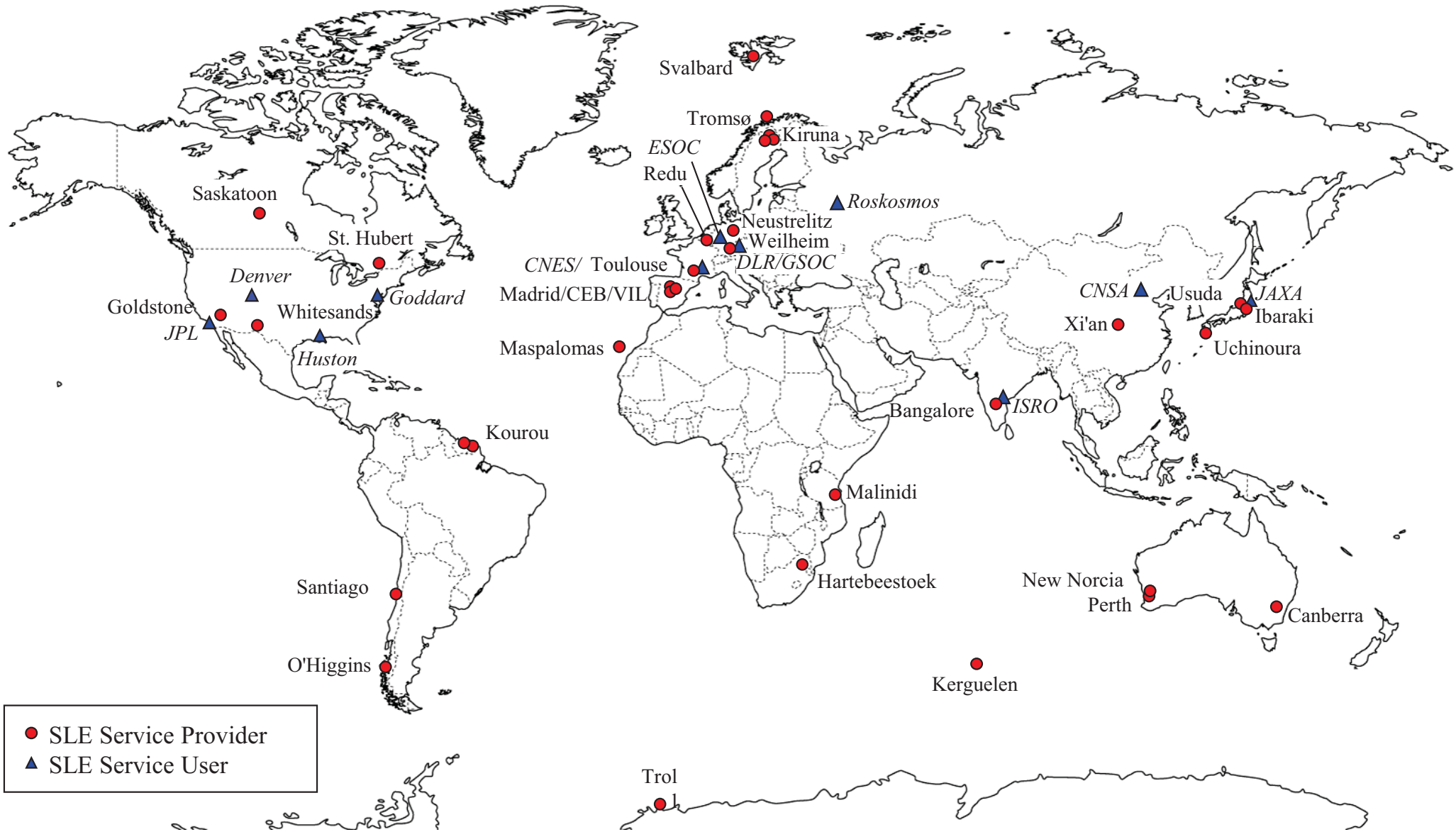
- Seventeen (17) SLE transfer services
  as identified in SLE Reference Model
  - Ten (10) forward (uplink) services
    - » Forward CLTU (Command Link Transmission Unit)
    - » Forward TC (Telecommand) Frame
    - » Forward TC-VCA (Virtual Channel Access)
    - » Forward Space Packet
    - » Forward proto-VCDU (Virtual Channel Data Unit)
    - » Forward Insert
    - » Forward C/VCDU ((Coded)/VCDU)
    - » Forward VCA
    - » Forward Bitstream
  - Seven (7) return (downlink) services
    - » Return All Frames
    - » Return Insert
    - » Return Channel Frames
    - » Return FSH (Frame Secondary Header)
    - » Return OCF (Operations Control Field)
    - » Return Bitstream
    - » Return Space Packet

Notes:

- **Not all of these are published Standards;** ***see CCSDS website for published SLE standards***
- ***A next generation framework for data transfer standards is in progress (more on next slides)***
- ***This list may be revised as new***

Consultative Committee for Space Data Systems

SLE Success Story (2002 to 2009)



This is all great, but….

- Seventeen (17) SLE transfer services →17 separate recommendations, prototyping, sets of agency reviews, maintenance issues, etc
  - Recommendations tended to be duplicative in terms of substantial technical content
  - CCSDS should be able to do something better…
- CCSDS decided to take a new approach that factors all of the common technical stuff into a re-usable framework and re-use framework to meet agency needs for inter-operation, data transfer, including data that does not necessarily have a spacelink component
  - E.g, what about ground station service production monitor data?

Transition from SLE to CSTS

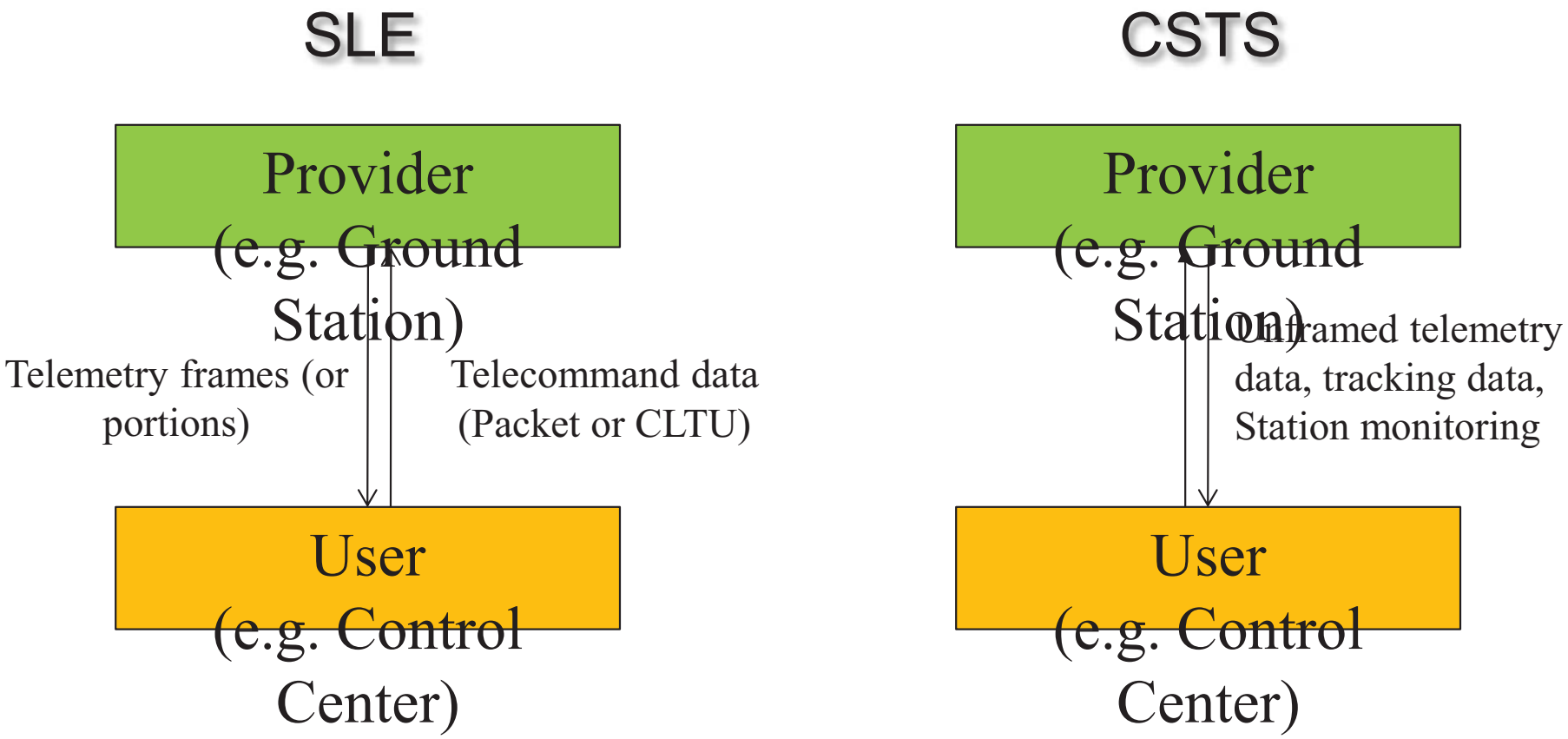
- The Cross Support Transfer Services (CSTS) are designed to pick up where SLE left off:
  - Creating new services (not duplicating SLE services) which are needed for future missions
  - Doing that in a new way – with a simpler architecture around a reusable framework.
  - Unfortunately, the new way (reusable framework) makes CSS not compatible/interoperable with SLE.
  - The CCSDS agencies have decided to leave SLE capabilties in place while adding CSTS capabilities for new functions
- As a result, agencies are expected to implement both SLE and CSTS, depending on the capabilities they need to interface with at their and others' comm sites.
  - First implementing SLE as the core mechanism
  - Then implementing CSTS as the supplemental mechanism for new needs
- Similarly CSSM will add new management services that supplement what is currently done with SLE… management of ground station and antenna site functions remotely from the user facility (MCC, etc.).

Cross Support Transfer Services (CSTS)

Overview

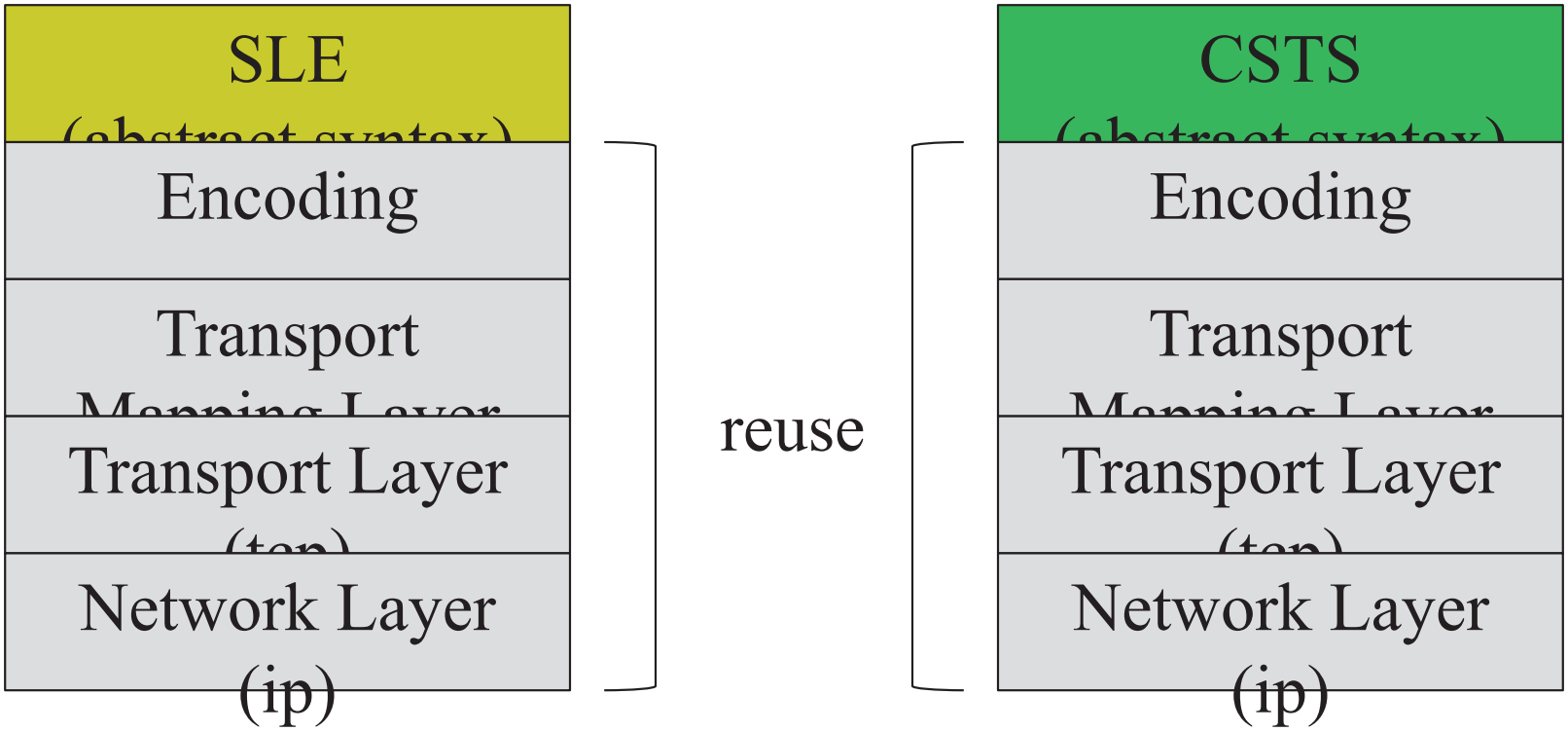
CSTS builds on SLE success (1)

CSTS builds on SLE success by supporting additional types of data.



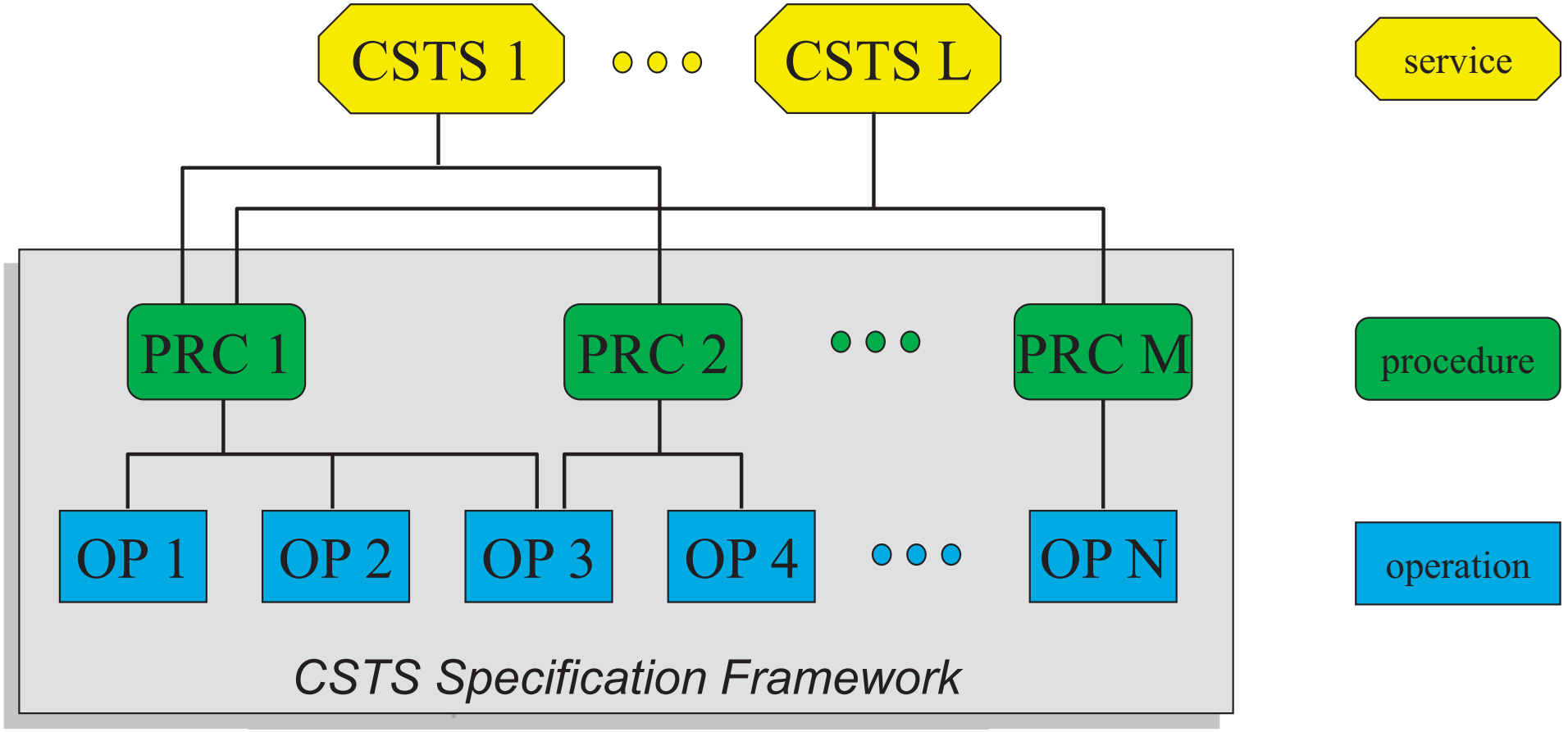
CSTS builds on SLE success (2)

CSTS reuses all the protocol layers underneath SLE, as well as the abstract syntax concept for its protocol messages.



CSTS adds new services efficiently

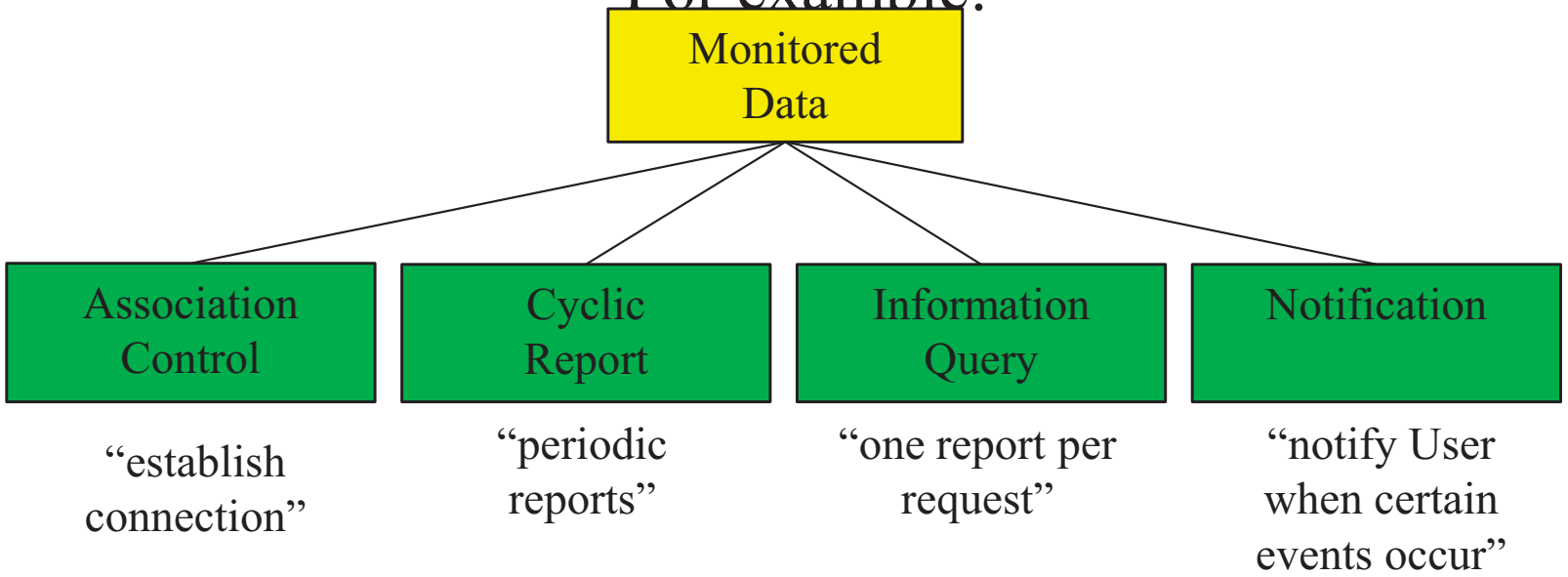
The CSTS Framework provides a reusable foundation that allows services to be defined and implemented efficiently.



CSTS Services use the Framework

Each service uses only those Framework procedures that are needed to get the job done.

For example:

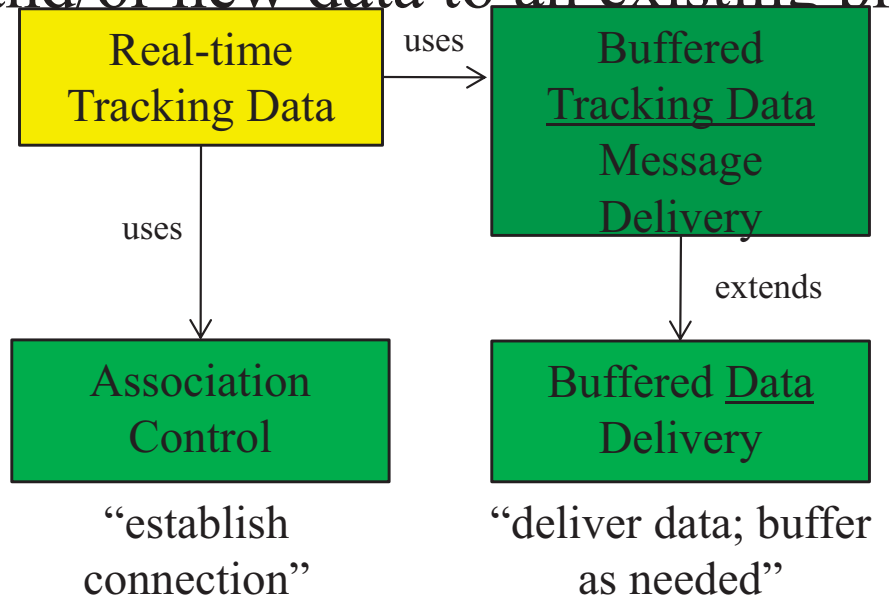


Service

Framework Procedures

A CSTS service may extend the Framework

If a service needs capabilities that are not supplied by the Framework, it may extend the Framework – it can create a new procedure that adds new behavior and/or new data to an existing procedure.



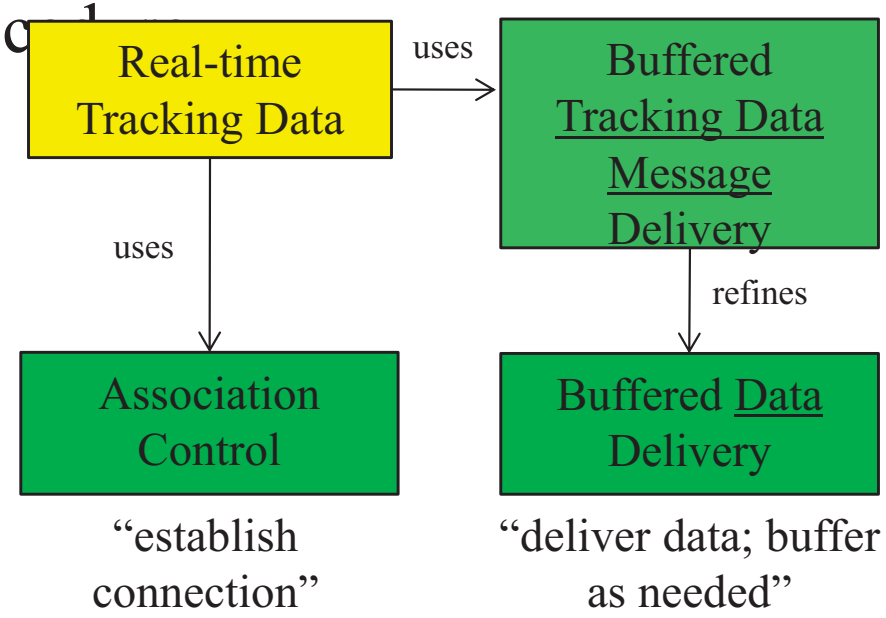
Service + new procedure

Framework Procedures

The new procedure adds one capability to the existing procedure - it delivers one *context* message prior to a stream of *Tracking Data* messages.

A CSTS service may refine the Framework

If a service needs more precise capabilities than the abstract capabilities provided by the Framework, it may refine the Framework -- for example, a new procedure narrows the possibilities provided by an existing proc

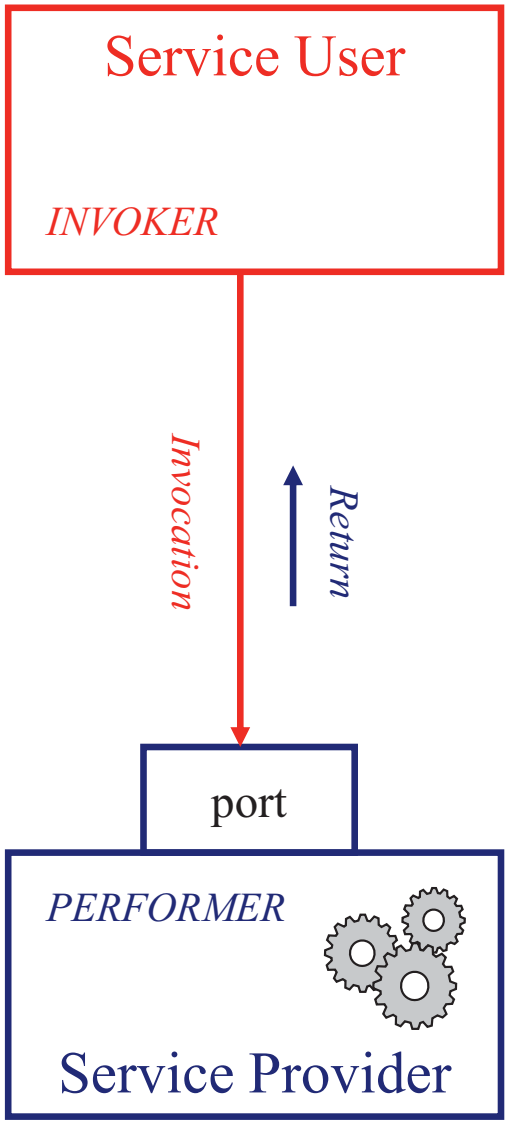


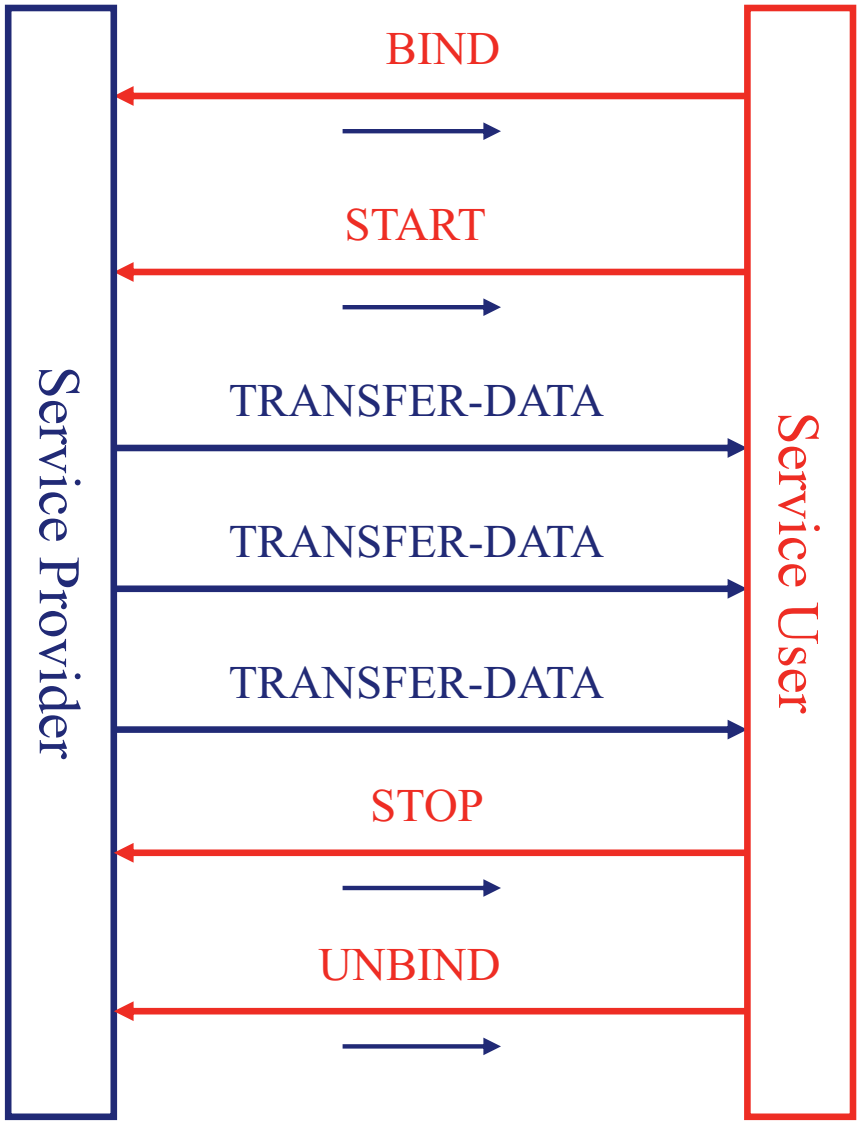
Service + derived procedure

Framework Procedures

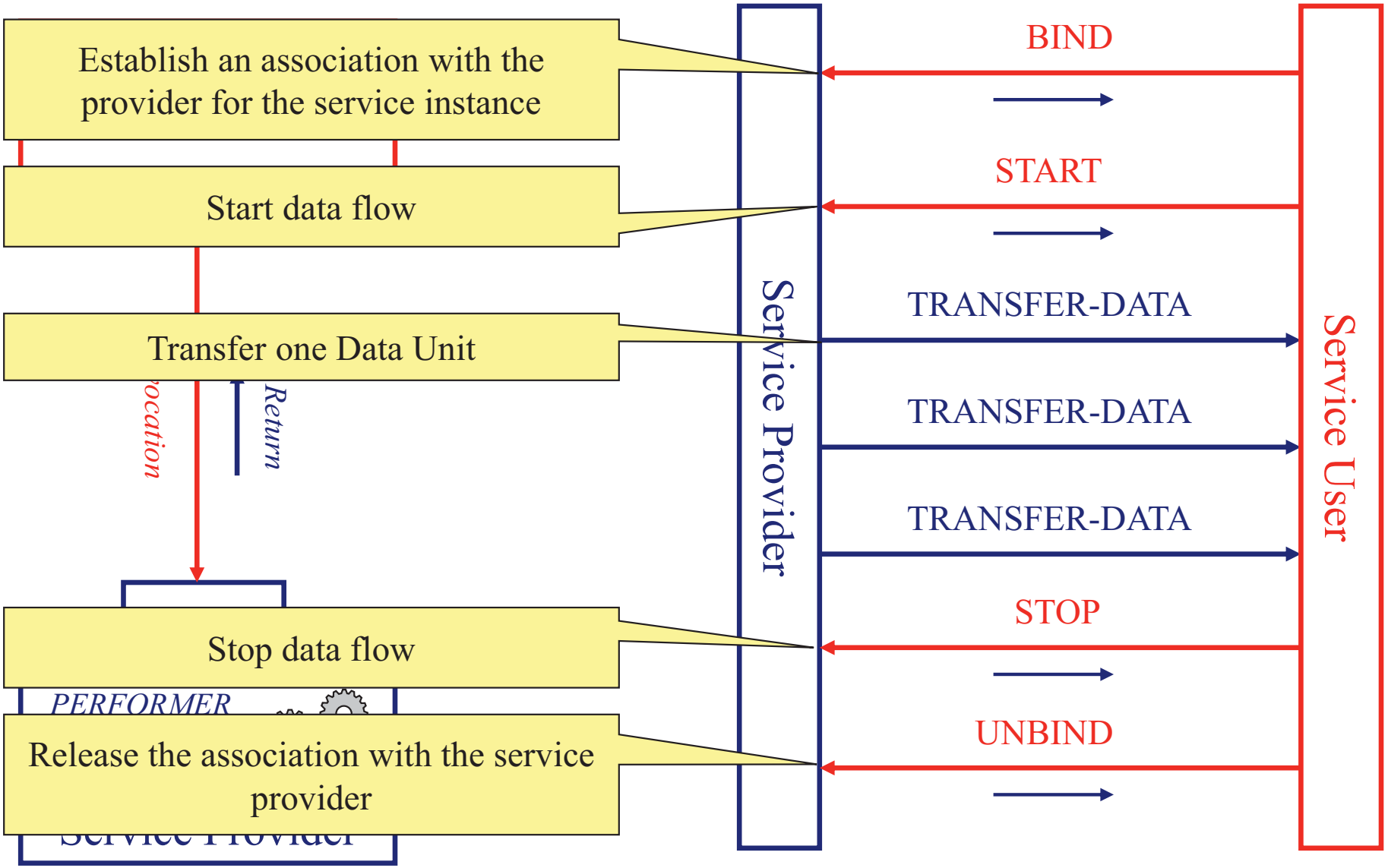
The Buffered-Data-Delivery procedure does not specify the format of the data to be delivered; the new procedure specifies that the data will match the standard Tracking Data Message format.

CSTS Lower-layer Building Block – Operations

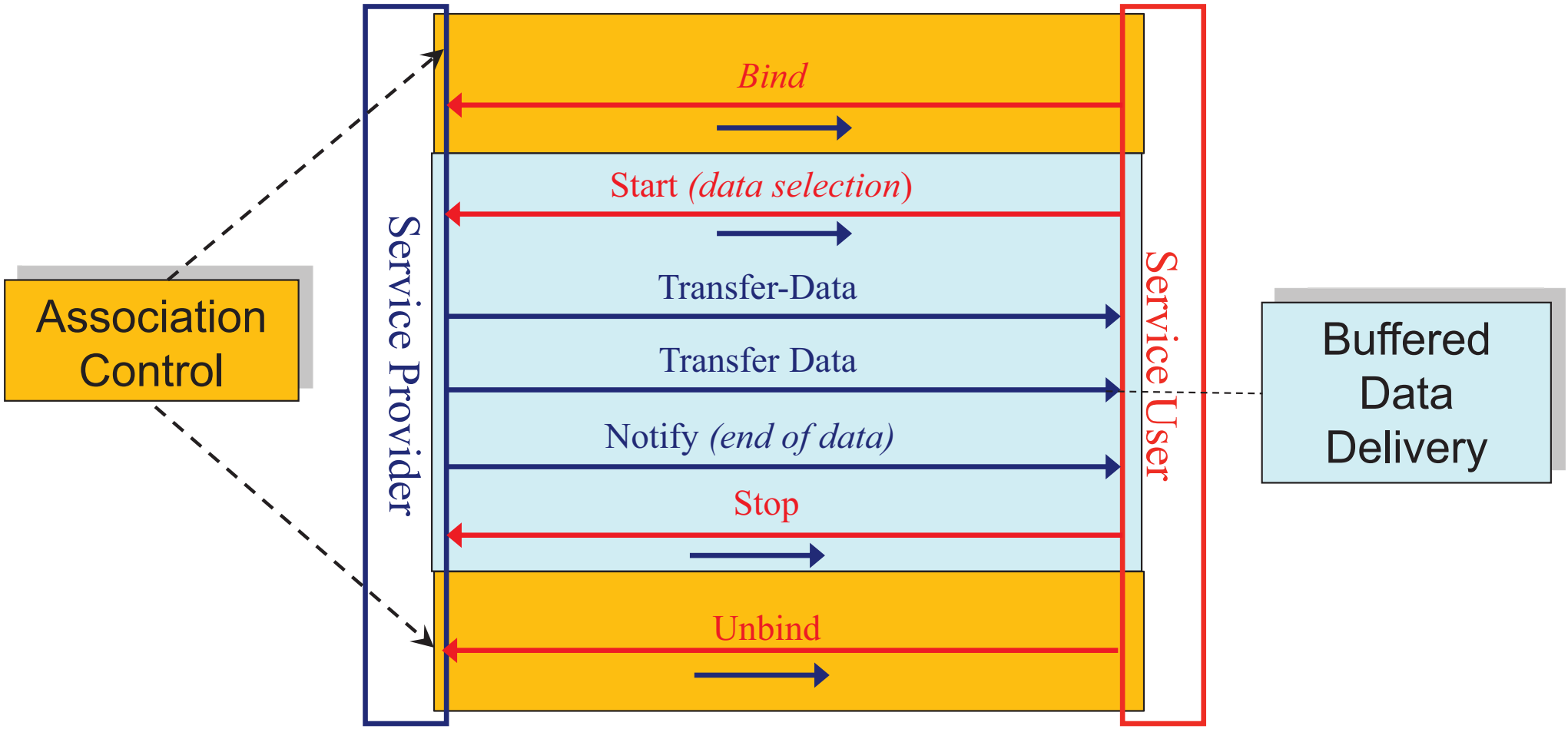




CSTS Lower-layer Building Block – Operations

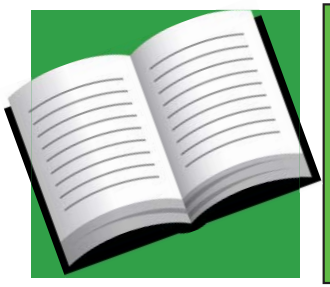


CSTS Higher-layer Building Block - Procedures



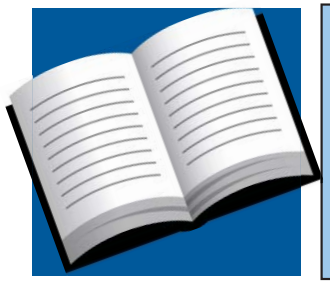
Note: The Buffered Data Delivery procedure includes mechanisms for buffering and releasing of data units.

CCSDS CSTS Major Documents



GREEN BOOK – Informative Report
Cross Support Transfer Service
Specification Framework Concepts

MAGENTA BOOK – Recommended Practice
Guidelines for Specification of
Cross Support Transfer Services

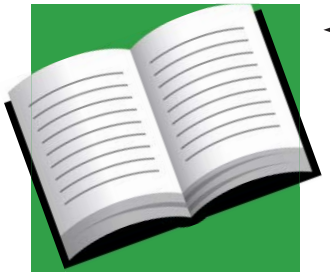


BLUE BOOK – Recommended Standard
Cross Support Transfer Service
Specification Framework

Increasing Level Of Detail and Specification

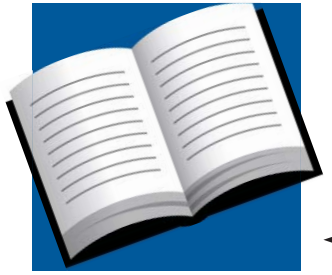
Current draft of Framework Blue Book is available in the private area of CCSDS CWE for WG participants, or it can be provided on request. HOWEVER, be careful not to implement systems to that specification until it is approved by CCSDS.

CCSDS CSTS Major Documents



- The ***Concepts report*** explains:
  - How the Framework fits into the bigger picture.
  - The approach taken within the Framework
  - Capabilities that are assumed to be provided by protocol layers below the Framework.
  - How to use the Framework to build a service.

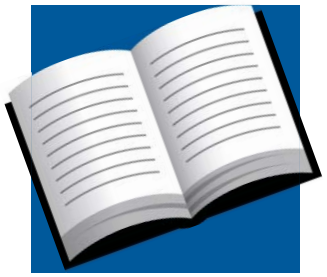
- The ***Guidelines specification*** is intended to guide people who want to create new services. This specification attempts to ensure that:
  - Services make maximum use of the reusable Framework.
  - When a service extends the Framework, that it does so in the most efficient way that is practical.
  - Service specifications follow a consistent outline.
  - Services are consistent in how they use Service Management to configure themselves.



- The ***Framework specification*** defines the procedures and operations that make up the Framework. This includes specifying the format of all CSTS protocol messages.

CSTS - Reading the Framework specification

- For managers and others interested in the bigger picture, sections 1 and 2 are recommended.
- For implementers and others interested in the detailed rules to be followed, sections 3 and 4 are recommended.
- Note that the formal definition of protocol message formats is found in Annex C.



CSTS Conclusions

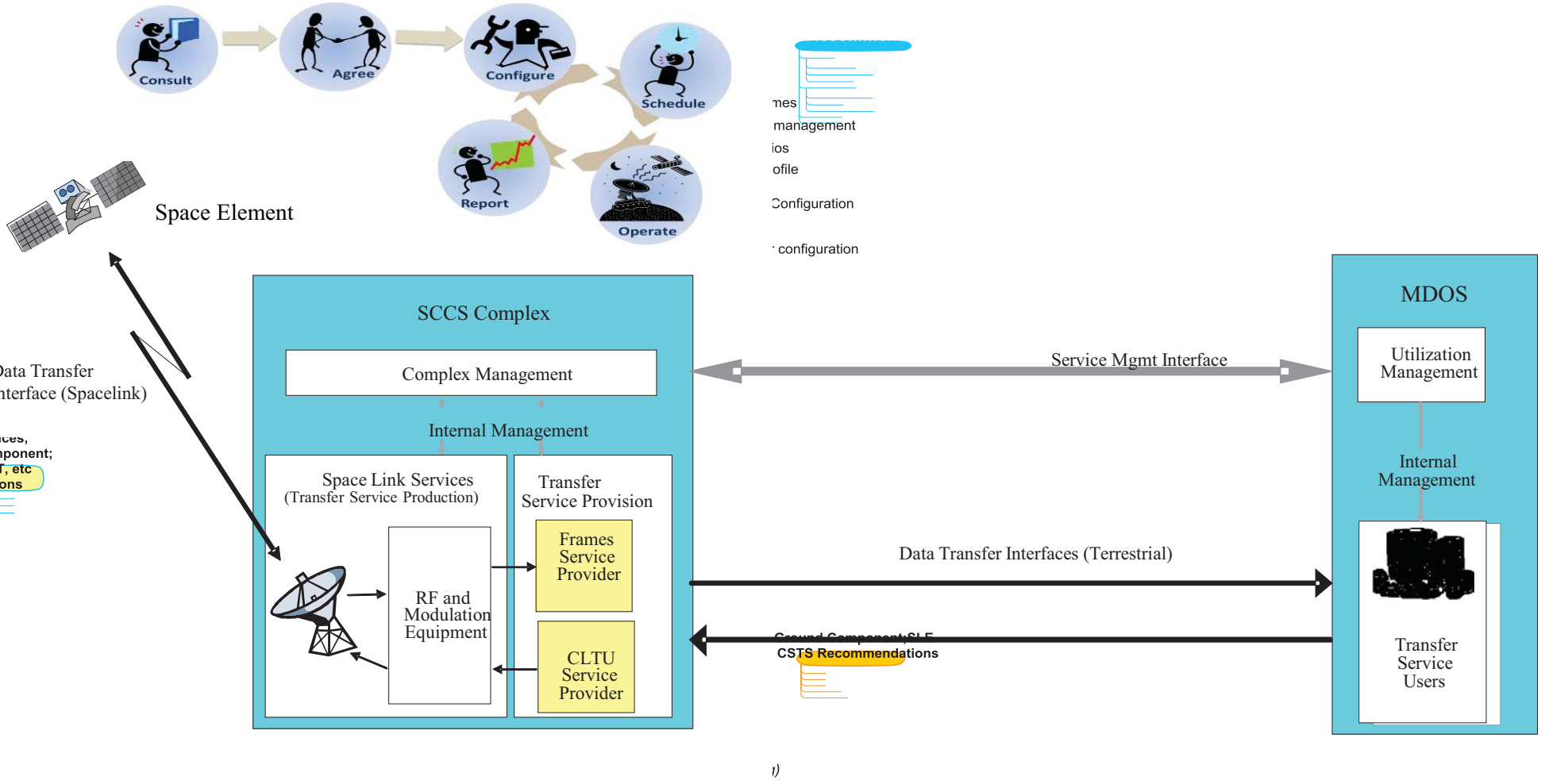
- The CSTS Framework builds on proven SLE concepts, and much of the source code developed for SLE can be reused for CSTS.
- The CSTS Framework provides an efficient path to defining and implementing new services – it enables savings in time and cost.
  - The Framework specification provides building blocks that can be used to build new services.
  - These building blocks can easily be extended and/or refined as necessary.
- While it is possible to transition the existing SLE services to the CSTS approach, there are no plans to do so at this time.

…But it all needs to be managed…

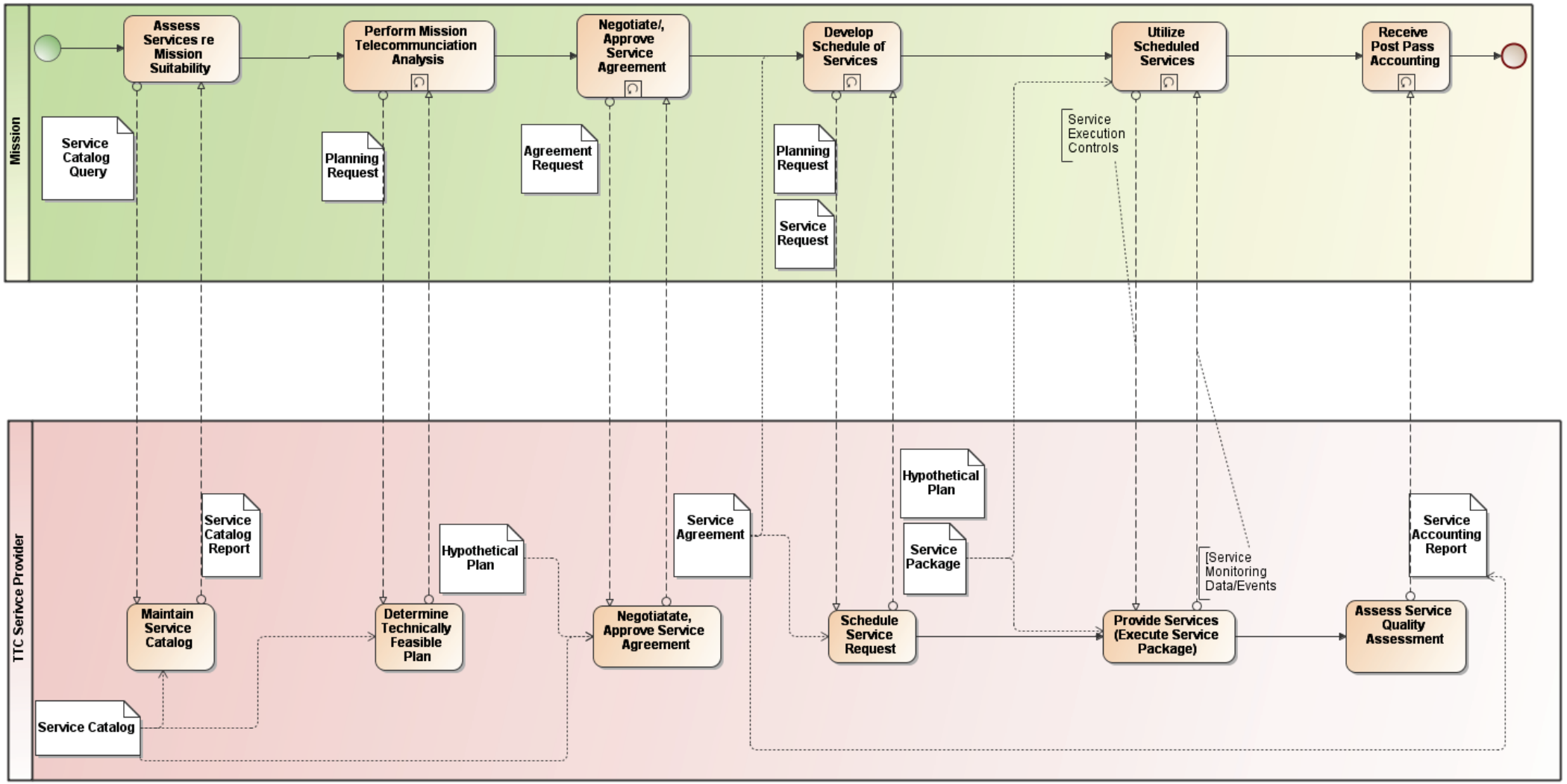
- Real-world spacecraft tracking requires planning and coordination of many different types of information ranging from spacecraft telecommunications capabilities, to trajectory data, to real-time service execution control to accounting for services rendered.
- Define an approach that factors all of the common technical stuff into a re-usable framework and re-use framework to meet agency needs for inter-operation, data transfer, including data that does not necessarily have a spacelink component
  - E.g, what about ground station service production monitor data?
- The CCSDS Cross Support Service Management (CSSM) project was created to answer that need.

Cross Support Service Management (CSSM) A Brief Overview

- Objective
  - Define management service standards for cross support management of Telemetry, Command, Ranging and future CCSDS inter-agency services



The CCSDS Service Management Lifecycle



Current CCSDS Service Management Projects

- **Service Catalog** – definition of how to state characteristics of TTC Services offered; telemtry services supported at S, X bands up to 50 Mbps, with LDPB coding
- **Planning Information** – definition of planning information such as predicted communication geometry
- **Schedule of Services** – definition of data format for publication of network schedules
- **Configuration/Service** Agreement information – definition of space link, terrestrial data transfer (i.e. SLE and CSTS), and levels of services to be provided (for example number of spacecraft contacts for a given period of time)
- **Service request/service package** – definition of a request for TTC network services and response for such a request
- **Event Sequence** – Definition of how spacecraft, especially those in deep space, may change the configuration such that the ground systems can respond properly when it is impossible to convey the changes in real time (i.e. preplanning required because of long light time delays)
- **Service Accounting** – definition of accounting for services and qualities of services rendered; e.g, 1.2 million telemetry frames returned; 99% successful decoding

Cross Support Services Area
Current CSS Projects

- CSTS and CSSM Project Status
  - Red cells indicate important support is needed
  - NSPO participation in these WGs is welcome

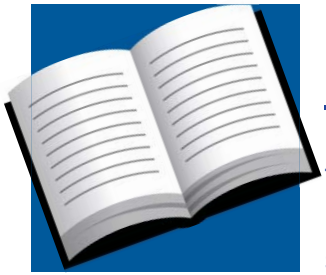
Project	Working Group	Doc type	Book Editor	Prototype 1	Prototype 2	Contributors
Cross-Support Specification Framework	CSTS WG	Blue	ESA	ESA	NASA	CNES, DLR, ESA, NASA
Cross-Support-Transfer Services Specification Framework Concept	CSTS WG	Green	DLR	N/A	N/A	CNES, DLR, ESA, NASA
Guidelines for Specification of Cross Support Transfer Services	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
Monitored Data - Cross Support Transfer Services	CSTS WG	Blue	NASA	CNES	NASA	CNES, DLR, ESA, NASA
SLE API for Return All Frames Service. Magenta Book: M-1 Update	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
SLE API for Return Channel Frames Service: M-1 Update	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
SLE API for Return Operational Control Fields: M-1 Update	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
SLE API for the Forward CLTU Service. Magenta Book: M-1 Update	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
SLE API for the Forward Space Packet Service: M-1 Update	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
SLE API for Transfer Services—Core Specification: M-1 Update	CSTS WG	Magenta	DLR	N/A	N/A	CNES, DLR, ESA, NASA
Tracking Data Cross support Transfer Service	CSTS WG	Blue	NASA			CNES, DLR, ESA, NASA
CSSM Service Agreement and Service Config Profile Data Formats	CSSM WG	Blue				
CSSM Simple Schedule Format Specification	CSSM WG	Blue	ESA	DLR	NASA	CNES, DLR, ESA, NASA
CSSM Event Sequence Data Format	CSSM WG	Blue				
CSSM Planning Data Formats	CSSM WG	Blue	ESA	NASA	ESA	DLR, ESA, JAXA, NASA
CSSM Service Accounting	CSSM WG	Blue				
CSSM Service Catalog	CSSM WG	Blue				
CSSM Service Request and Service Package Data Formats	CSSM WG	Blue				
Extensible Space Comm CSSM -- Concept	CSSM WG	Green	NASA	N/A	N/A	ESA, NASA

Conclusions

- NSPO would benefit from:
  - Adopting existing SLE standards
  - Helping to develop new CSS Area Standards (CS Transport Services and CS Service Management)
- Because…
  - After initial investment, these solutions are long-term more cost effective
  - Provides ability for NSPO to use other agencies' comm assets
  - Provides ability for NSPO to provide services to other agencies from NSPO comm assets
  - SLE software code is partly reusable for CSTS projects
  - NSPO participation in CCSDS can make CSTS and CSSM better aligned with NSPO needs

Backup Material

Field Guide to CCSDS Book Colors



BLUE BOOKS

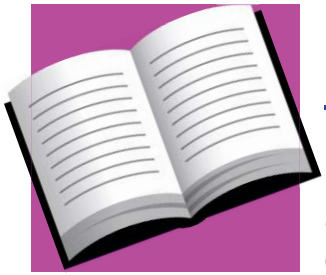
Recommended Standards

Normative and sufficiently detailed (and pre-tested) so they can be used to directly and independently implement interoperable systems (given that options are specified).

ORANGE BOOKS

Experimental

Normative, but may be very new technology that does not **yet** have consensus of enough agencies to standardize.



MAGENTA BOOKS

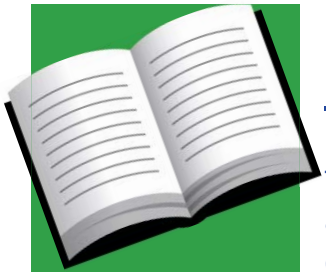
Recommended Practices

Normative, but at a level that is not directly implementable for interoperability. These are Reference Architectures, APIs, operational practices, etc.

YELLOW BOOKS

Administrative

CCSDS Procedures, Proceedings, Test reports, etc.



GREEN BOOKS

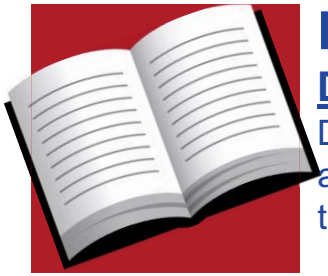
Informative Documents

Not normative. These may be foundational for Blue/Magenta books, describing their applicability, overall archtecture, ops concept, etc.

SILVER BOOKS

Historical

Deprecated and retired documents that are kept available to support existing or legacy implementations. Implication is that other agencies may not cross-support.



RED BOOKS

Draft Standards/Practices

Drafts of future Blue/Magenta books that are in agency review. Use caution with these… they can change before release.

PINK BOOKS/SHEETS

Draft Revisions For Review

Draft Revisions to Blue or Magenta books that are circulated for agency review. Pink Books are reissues of the full book, Pink Sheets are change pages only.

Consultative Committee for Space Data Systems

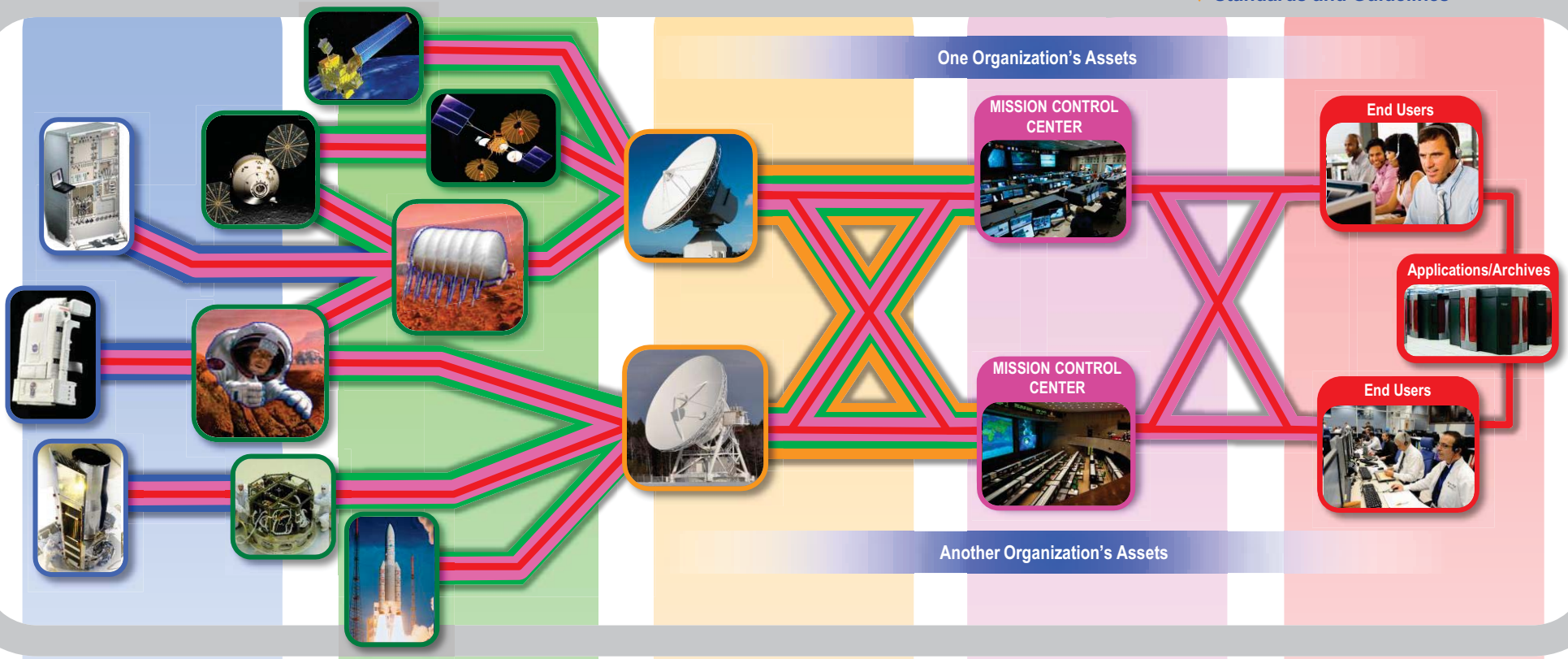
CCSDS Overview
End-to-End Architecture

Six Areas
Twenty-Eight working groups

- Working Group (producing standards)
- Birds-Of-a-Feather stage (pre-approval)
- Special Interest Group (integration forum)

Systems Engineering

- Security
- Space Assigned Numbers Auth.
- Delta-DOR
- Timeline Data Exchange
- Standards and Guidelines



Spacecraft Onboard Interface Services

- Onboard Wireless WG
- Application Supt Services (incl. Plug-n-Play)

Space Link Services

- RF & Modulation
- Space Link Coding & Sync.
- Multi/Hyper Data Compress.
- Space Link Protocols
- Next Generation Uplink
- Space Data Link Security
- Planetary Communications
- Optical Coding and Mod

Cross Support Services

- CS Service Management
- CS Transfer Services
- Cross Supt Service Arch.

Space Internetworking Services

- Asynchonous Messaging
- Motion Imagery & Apps
- Delay Tolerant Networking
- Voice
- CFDP over Encap

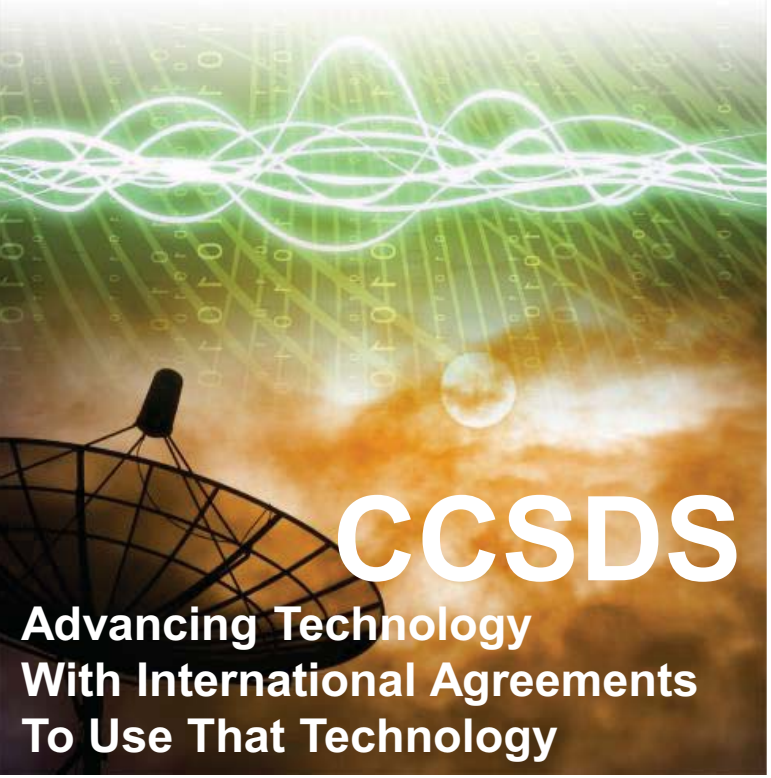
Mission Ops & Info Mgt Services

- Data Archive Ingestion
- Navigation
- Spacecraft Monitor & Control
- Digital Repository Audit/Certification
- Telerobotics

Consultative Committee for Space Data Systems

Debris Avoidance and the CCSDS Navigation Working Group

Presentation to NSPO in Taiwan
November 2013



Mike Kearney
CCSDS Chair & General Secretary
NASA MSFC EO-01
256-544-2029
Mike.Kearney@nasa.gov

Navigation WG Products

- The CCSDS Navigation Working Group is chartered to develop standards covering exchange of spaceflight dynamics related data
- Past Progress and Current Work
  - Orbit Data Messages (version 2.0 published 11/2009)
    - Three standard message formats for exchanging orbit descriptions
  - Tracking Data Message (version 1.0 published 11/2007)
    - Message format for exchanging tracking data; supports widely used tracking data types: Doppler, range, angle, ΔDOR, ancillary information
  - Attitude Data Messages (version 1.0 published 05/2008)
    - Two message formats for exchanging spacecraft attitude descriptions
  - Navigation Green Book (version 3.0 published 05/2010)
    - Contains technical background related to the Nav WG Recommendations
  - Nav Data Messages XML Specification (version 1.0 published 12/2010)
    - Contains XML representations of all above Nav WG standards
  - Conjunction Data Message (pub June 2013)
    - Standard message format for informing spacecraft operators of object conjunctions in space (spacecraft/spacecraft, spacecraft/debris, debris/debris)
- Future work
  - Pointing Requests Message – communicating complex on-orbit cross-support pointing requests (e.g., inertial, limb, terminator, velocity, nadir, track)
  - Navigation Hardware Message – exchanging onboard navigation H/W data between space agencies (e.g., thrusters, accelerometers, star trackers, etc.)
  - Spacecraft Maneuver Message – exchanging information regarding spacecraft maneuvers (requirements, design, reconstructed performance)

Navigation WG - Scope

- The CCSDS Conjunction Data Message provides a warning of a predicted spacecraft conjunction
  - It does not specify how to make such a prediction nor what to do in the event of a warning
  - This is consistent with the approach taken for all of the CCSDS flight dynamics related standards
- The NAV WG standardized the format in which a trajectory designed/determined by one party could be exchanged with another party.
- It also standardized a format for exchanging the tracking data that could be input to an orbit determination process.
- It also standardized the format in which attitude state(s) designed/determined by one party could be exchanged with another party.
- The NAV WG did NOT standardize:
  - the process of orbit determination or designing a trajectory
  - the process of attitude determination or design
  - the process of analyzing spacecraft conjunctions, but we did standardize the format in which a conjunction warning analyzed by one party could be conveyed to the affected satellite operator(s).
  - what one might do in the event that they received a conjunction warning.
    - There are too many variables, and some implied liabilities to making recommendations in this area.

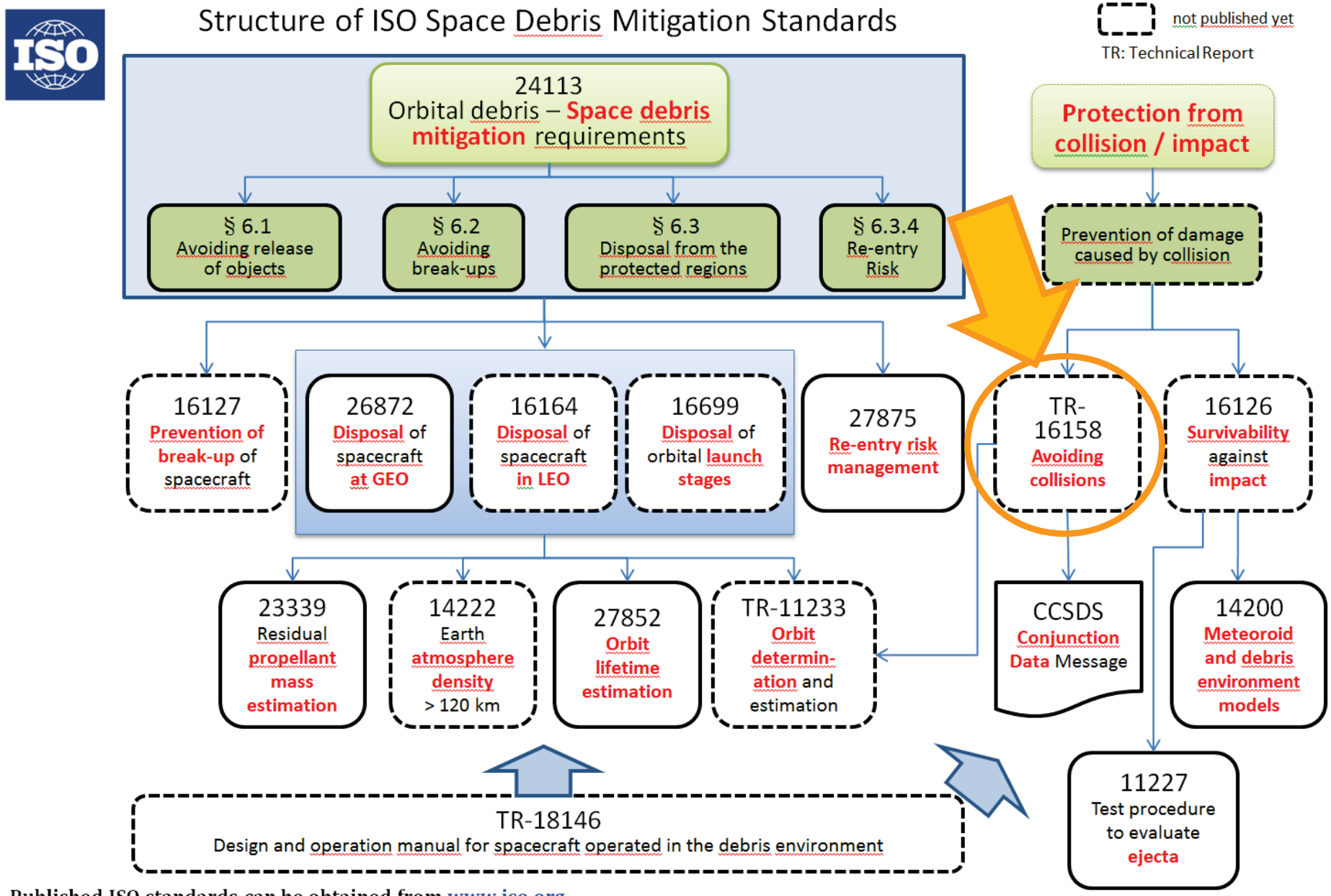
Recommendations on Navigation Ops Research

- US StratCom (Strategic Command) has hosted technical workshops on Navigation and Collision Avoidance topics in the US, Europe and Japan.
  - NSPO has not attended as far as they know
  - Recommend participating in future events
  - (Contact info?)
- Recommendation: Request the Conjunction Summary Message from JSPOC.
  - Available via www.space-track.org (login required)
  - Send email to Ms. Diana McKissock (diana.mckissock.1@us.af.mil)
  - Include a list of satellites that NSPO operates, and a list of e-mail addresses for people in their organization who are authorized to have access to that data.
- Operational Information from NASA GSFC is publically available:
  - *NASA Robotic* Conjunction Assessment *Process* - AIAA Info
  - Addresses safety volumes, etc.

Potential ISO resources for Collision Avoidance

- CCSDS only works on data exchange for navigation
- CCSDS functions as ISO TC20/SC13
- Our “Sister” organization is ISO TC20/SC14.
  - They develop spaceflight standards for processes, algorithms, procedures, etc.
- ISO TC20/SC14/WG3 has over the past few years initiated attempts to develop international standards in some of these areas, but later changed the document types to "Technical Report" (the equivalent of a CCSDS Green Book).
  - This is TR-16158, “Avoiding Collisions”
- The complete ISO document tree on Debris avoidance is on the next chart.

ISO TC20/WG14 Documents on Debris Mitigation

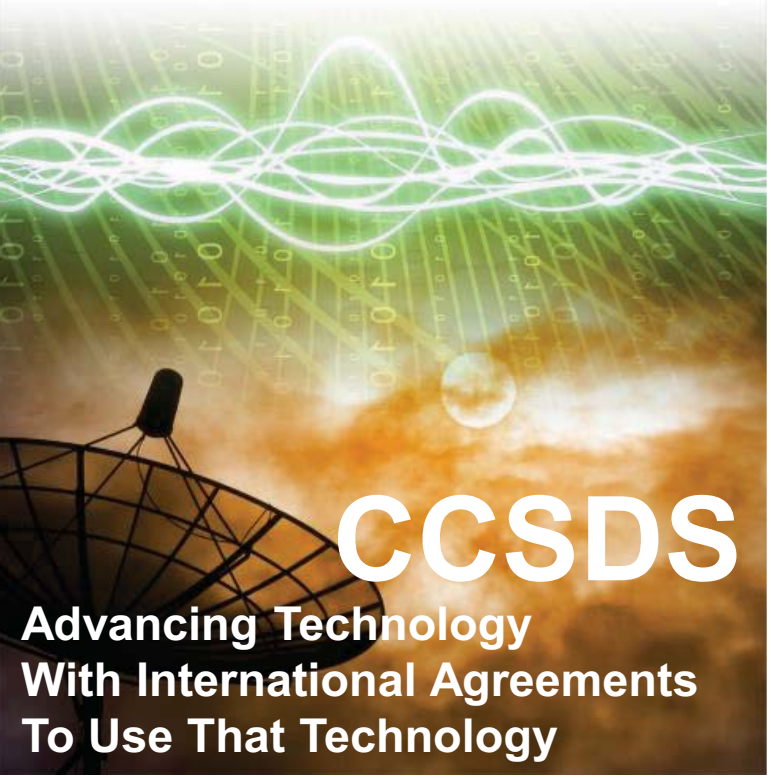


Published ISO standards can be obtained from www.iso.org

Consultative Committee for Space Data Systems

CCSDS Applied To Remote Sensing Programs

Presentation to NSPO in Taiwan
November 2013



Mike Kearney
CCSDS Chair & General Secretary
NASA MSFC EO-01
256-544-2029
Mike.Kearney@nasa.gov

Agenda

- CCSDS Background
- CCSDS Architecture
- CCSDS Areas of Interest to Remote Sensing Programs
- Summary

CCSDS – Scope and Origins

- CCSDS = The Consultative Committee for Space Data Systems
- The primary goal of CCSDS is ***interoperability*** between communications and data systems of space agencies' vehicles, facilities, missions and programs.
- Of all of the technologies used in spaceflight, standardization of ***communications and data systems*** brings the most benefit to multi-agency interoperability.
- CCSDS Started in 1982 developing standards at the lower layers of the protocol stack. The CCSDS scope has grown to cover standards throughout the entire ISO communications stack, plus other Data Systems areas (architecture, archive, security, XML exchange formats, etc.

Consultative Committee for Space Data Systems

Future Mission Drivers

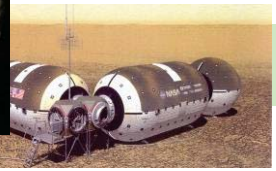
PAST → PRESENT → DRIVERS FOR THE FUTURE

Shuttle/SpaceLab
CCSDS packets

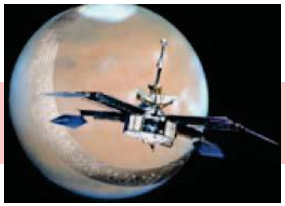
International Space Station
Adv. Orbital Sys (AOS)
Early DTN Prototyping

In Situ Exploration

- Human Expeditions
- Long Duration, High Reliability
- Mobile comm protocols
- Voice, Video, Medical handling
- Onboard Autonomy
- Highly integrated ops



Asteroid/Surface Exploration
Autonomy, High bandwidth
Multi-Agency Mission Ops

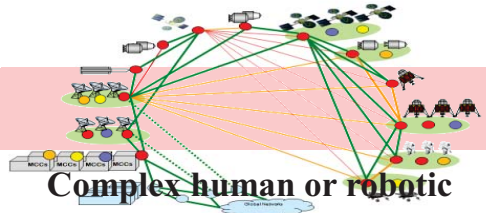


Brief Recon Flyby,
Short-Lived Probes
Direct-to-Earth links

Missions designed for orbital relays,
Longer duration

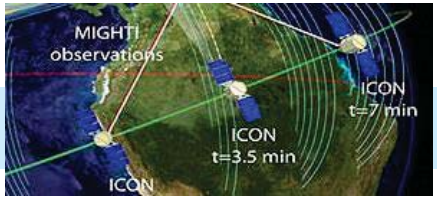
Complex Deep Space Missions

- Human ***or*** robotic exploration
- Longer Duration
- Mobile comm protocols
- Fully automated routing
- Network-Managed DTN
- Optical Communications



Complex human or robotic
Scenarios for remote surface missions
Fully automated Space Internetworking

Single-Spacecraft
Survey/Sensors



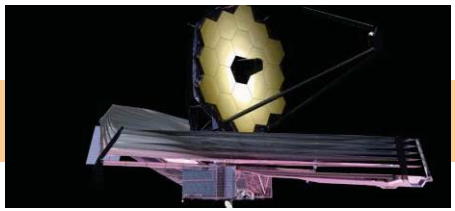
Spacecraft Constellations
and formation flying

Orbital Remote Sensing

- Long Duration, high bandwidth
- High Spatial, Spectral, & Temporal Resolution
- Low Latency Comm
- Complex link topologies
- *SensorWebs for synchronized remote sensing*

Multi-Discipline and
Multi-Resource SensorWebs

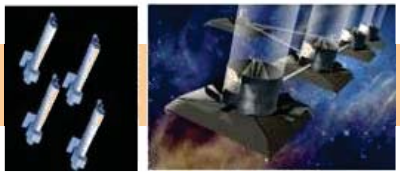
Single-Spacecraft
Observatories in LEO



Greater Distances
Higher bandwidth

Next Generation Observatories

- More Capability
- Multiple Spacecraft drive network needs
- Even Greater Capacities require new coding schemes
- Located Even Farther from Earth



Next Generation
Observatory Complexes

Consultative Committee for Space Data Systems

CCSDS Overview
End-to-End Architecture

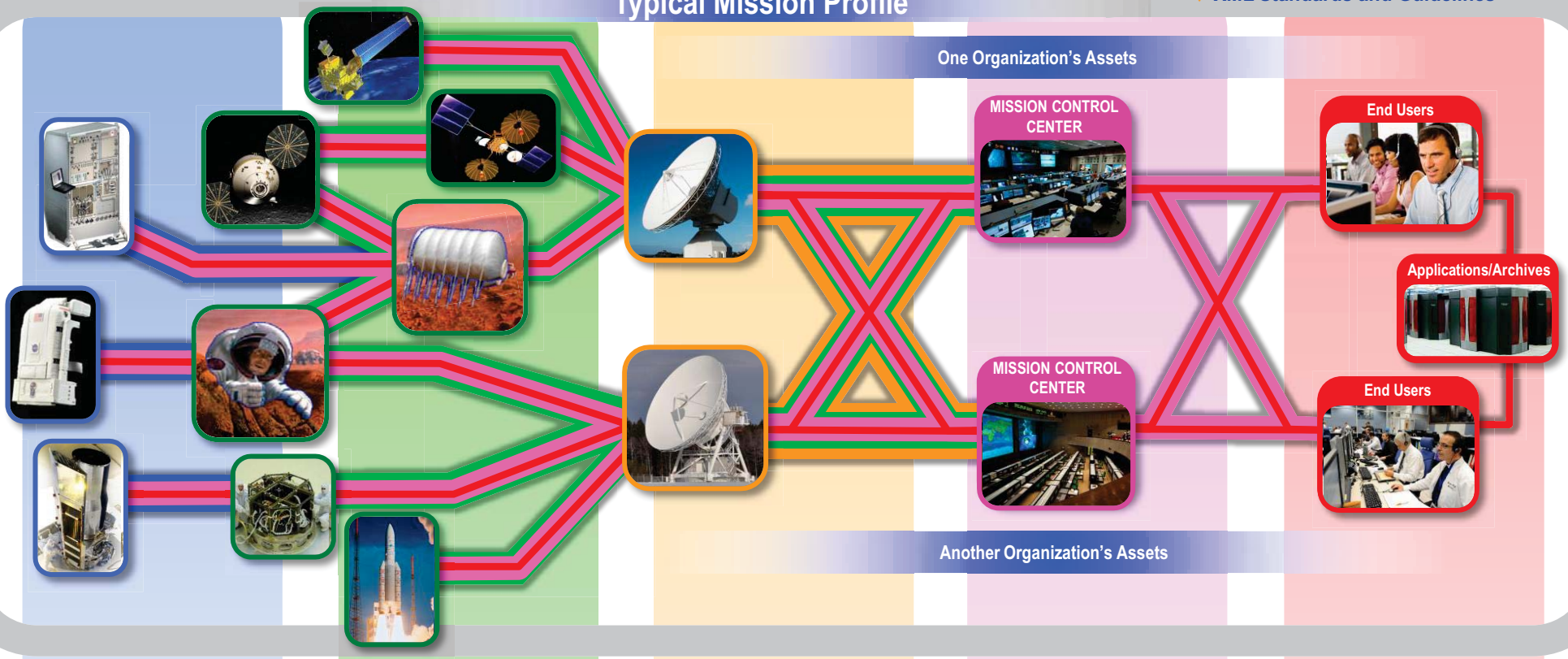
Six Technical Areas, Twenty-Nine Teams

- Working Group (producing standards)
- Birds-Of-a-Feather stage (pre-approval)
- Special Interest Group (integration forum)

Systems Engineering

- Security
- Space Assigned Numbers Auth.
- Delta-DOR
- Timeline Data Exchange
- XML Standards and Guidelines

Typical Mission Profile



Spacecraft Onboard Interface Services

- Onboard Wireless WG
- Application Supt Services (incl. Plug-n-Play)

Space Link Services

- RF & Modulation
- Space Link Coding & Sync.
- Multi/Hyper Data Compress.
- Space Link Protocols
- Next Generation Uplink
- Space Data Link Security
- Planetary Communications
- Optical Coding and Mod

Cross Support Services

- CS Service Management
- CS Transfer Services
- Cross Supt Service Arch.
- Generic Gnd-to-Gnd File Transfer

Space Internetworking Services

- Motion Imagery & Apps
- Delay Tolerant Networking
- Voice
- CFDP over Encap
- CFDP Revisions

Mission Ops & Info Mgt Services

- Data Archive Ingestion
- Navigation
- Spacecraft Monitor & Control
- Digital Repository Audit/Certification
- Telerobotics

CCSDS Areas of Potential Interest for Remote Sensing Programs

✦ Sys Eng

Security Techniques for All Missions: Encryption, Key Management, Threats, etc.

✦ SOIS

Spacecraft Design Benefits

Plug-n-Play for Spacecraft Data Busses, Electronic Data Sheets

✦ Space Link Svcs

RF & Mod techniques for more bandwidth efficiencies

Space-adapted Image Compression, Link level security, Optical (laser) comm for both cross-links and space-ground links

✦ CSS

Capabilities to use Comm Assets (antennas) from other agencies and network providers, both transport and automated management

✦ SIS - Space Internet

CFDP = proven onboard file management for remote sensing. Will be even better when rehosted on DTN (Delay Tolerant Networking). Voice helps ground comm. Video (?)

✦ MOIMS

Navigation – Avoid Collisions; Data Archives; SM&C = Service Oriented Architecture approach to MCCs and migration of apps to onboard spacecraft.

Spacecraft Onboard Interface Services
- Application Supt Services (incl. Plug-n-Play)

Space Link Services
- RF & Modulation
- Space Link Coding & Sync.
- Multi/Hyper Data Compress.
- Space Link Protocols
- Space Data Link Security
- Optical Coding and Mod

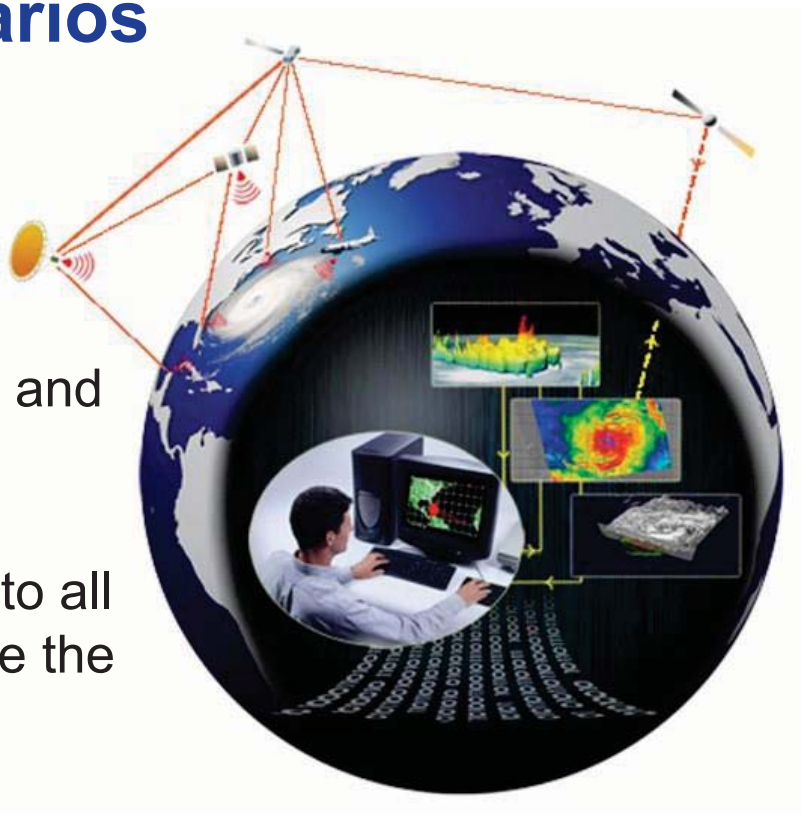
Cross Support Services
- CS Service Management
- CS Transfer Services
- Generic Gnd-to-Gnd File Transfer

Space Internetworking Services
- Motion Imagery & Apps
- Delay Tolerant Networking
- Voice
- CFDP over Encap
- CFDP Revisions

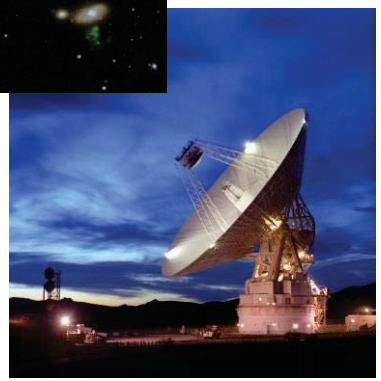
Mission Ops & Info Mgt Services
- Science Data Ingestion
- Navigation
- Spacecraft Monitor & Control

Systems Engineering
- Security

Important Scenarios



- Future SensorWeb Scenario:
  - Multiple Earth-Observing Satellites utilize automated network communications.
  - Built on foundation of CCSDS DTN, AMS, and Space Internetworking standards.
  - Major event (earthquake, volcano) occurs
  - First observation sends automated signal to all satellites, and they simultaneously observe the event
- Contingency Scenarios
  - Even if your mission does not initially have requirements for international interfaces, you need CCSDS compatibility for emergency support.
  - We have had two scenarios (XMM-Newton and STRS) where a disabled satellite was rescued with assistance from another agency, because of CCSDS compatibility.



CCSDS Summary

- As a minimum, Remote Sensing programs should work for maximum CCSDS compatibility with existing, published standards.
  - Go to www.ccsds.org, click on “Publications”.
- Even better, your programs should have their experts become engaged in the development of new CCSDS standards.
  - To insure future CCSDS standards meet your needs.
  - Contribute by telecon and electronic reviews, or even attend meetings.
  - Go to www.ccsds.org, click on “CWE”.