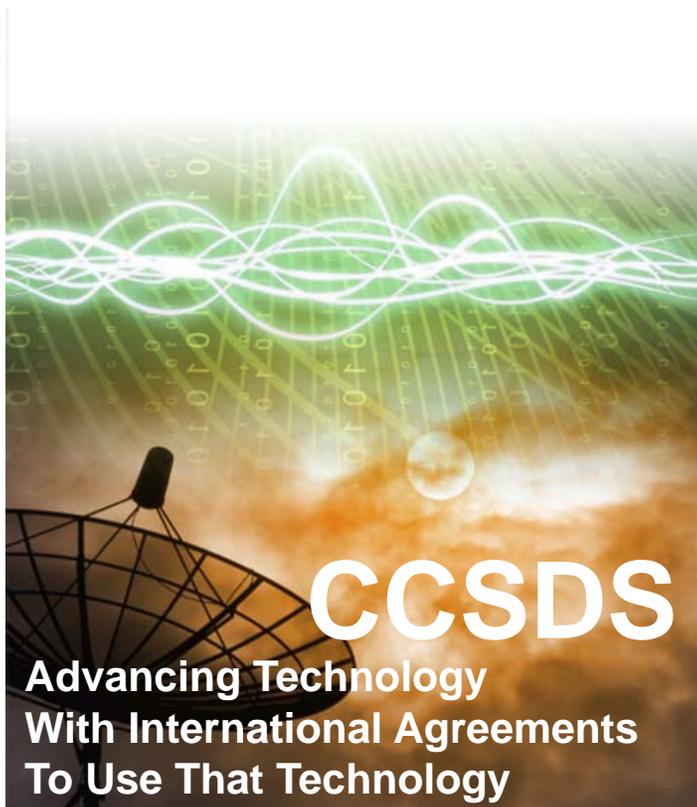


CCSDS Overview

The Consultative Committee for Space Data Systems
August 2014



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
- ✦ Focus on WGs of interest to ALTEC
- ✦ CCSDS Online Resources
- ✦ Summary

The Essential Message

- ✦ This work must be done before new programs begin.
- ✦ By the time new programs have firm requirements, their path is set, and they will not wait for development of new standards.
- ✦ They only adopt standards that are available at their program start.
- ✦ Right now, it is critically important to prepare for upcoming international missions that are not yet formulated.

New missions have new communications needs;

New technology is changing the game rapidly;

Therefore, a responsive standardization program is
more important than ever.

CCSDS – Scope and Origins

- ✦ CCSDS = The Consultative Committee for Space Data Systems
- ✦ **Communications and data systems** standards.
- ✦ Since 1982 starting at the lower layers of the protocol stack.
- ✦ Now:
 - ✧ Throughout the entire ISO communications stack
 - ✧ Plus other Data Systems areas (architecture, archive, security, XML exchange formats, etc.
 - ✧ **End to end** data/comm architecture for any mission





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.”

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.

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

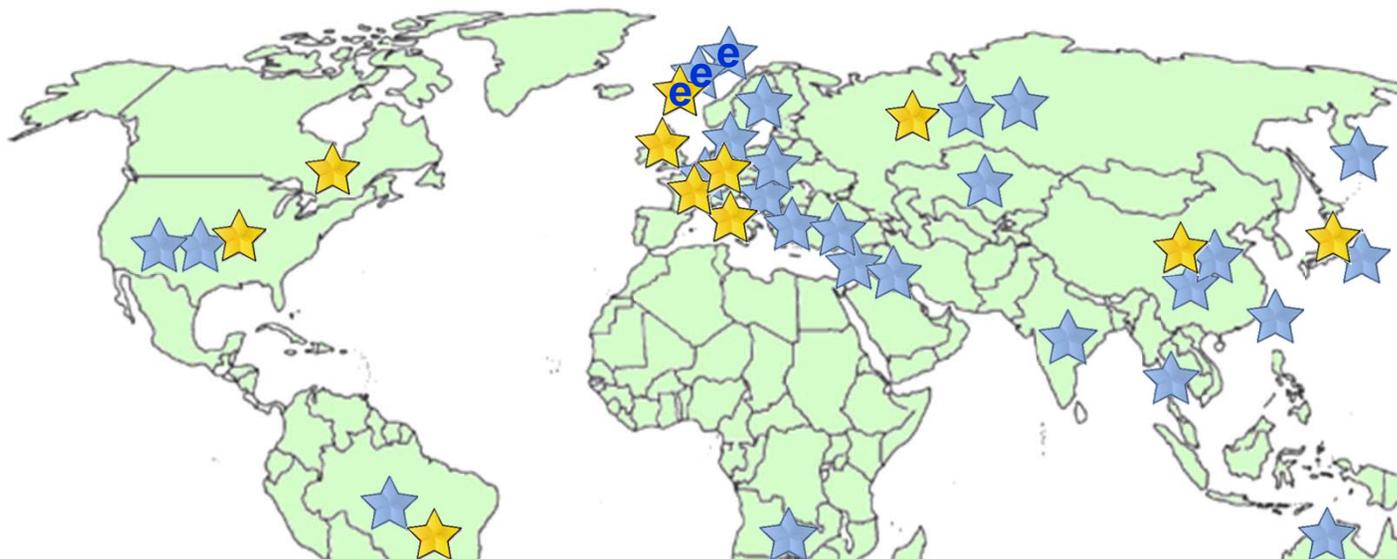
CCSDS Overview - Participation

★ CCSDS – An Agency-Led International Committee

- ✧ Currently 11 Member agencies
- ✧ Currently 29 Observer Agencies
- ✧ Agencies represent 27 nations (and 3 European orgs)
- ✧ Currently 108 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

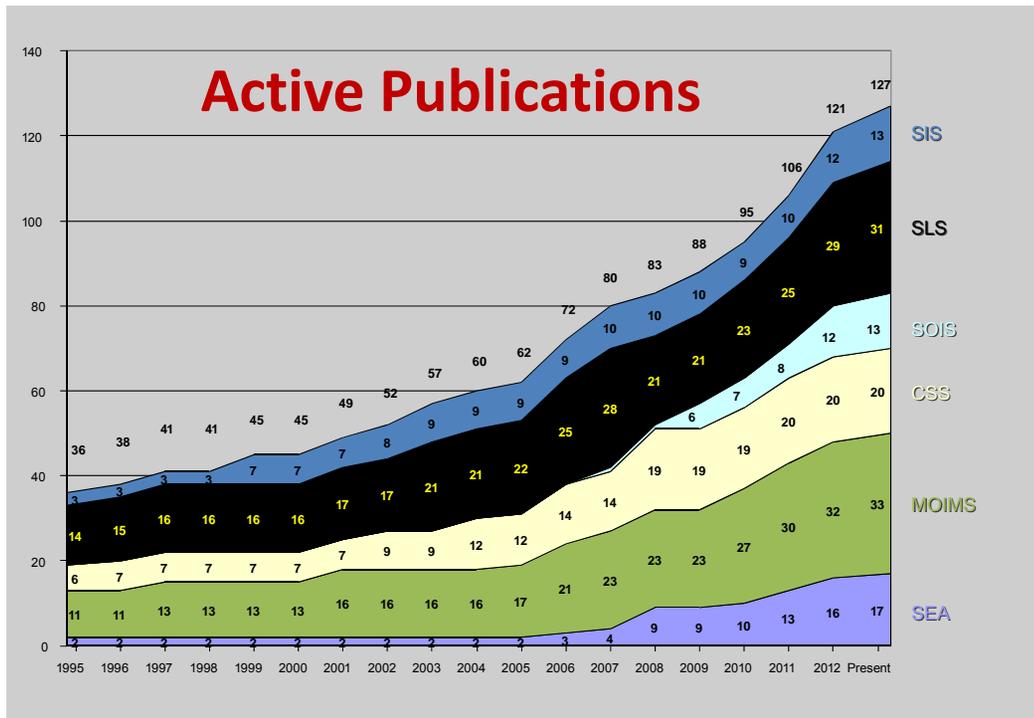


★
OBSERVER
AGENCIES

★
MEMBER
AGENCIES

- ASA/Austria
- BFSP0/Belgium
- CAS/China
- CAST/China
- CLTC/China
- CSIRO/Australia
- DCTA/Brazil
- ASI/Italy
- DNSSC/Denmark
- CNES/France
- EUMETSAT/Europe
- CNSA/China
- EUTELSAT/Europe
- CSA/Canada
- GISTDA/Thailand
- DLR/Germany
- HNSC/Greece
- IKI/Russia
- ESA/Europe
- ISRO/India
- FSA/Russia
- KARI/Korea
- INPE/Brazil
- KFKI/Hungary
- JAXA/Japan
- MOC/Israel
- NASA/USA
- NCST/USA
- UKSA/UK
- NICT/Japan
- NOAA/USA
- NSARK/Kazakhstan
- NSPO/Taiwan
- SANSA/South Africa
- SSC/Sweden
- SSO/Switzerland
- SUPARCO/Pakistan
- TsNIIMash/Russia
- TUBITAK/Turkey
- USGS/USA

CCSDS Overview



Currently Active Publications: 135

Normative (Blue & Magenta): 85
Informative (Green): 52

Downloadable for free from
www.ccsds.org

All major pubs since 1982: ~285
(Some were historical mission needs or superseded technology)

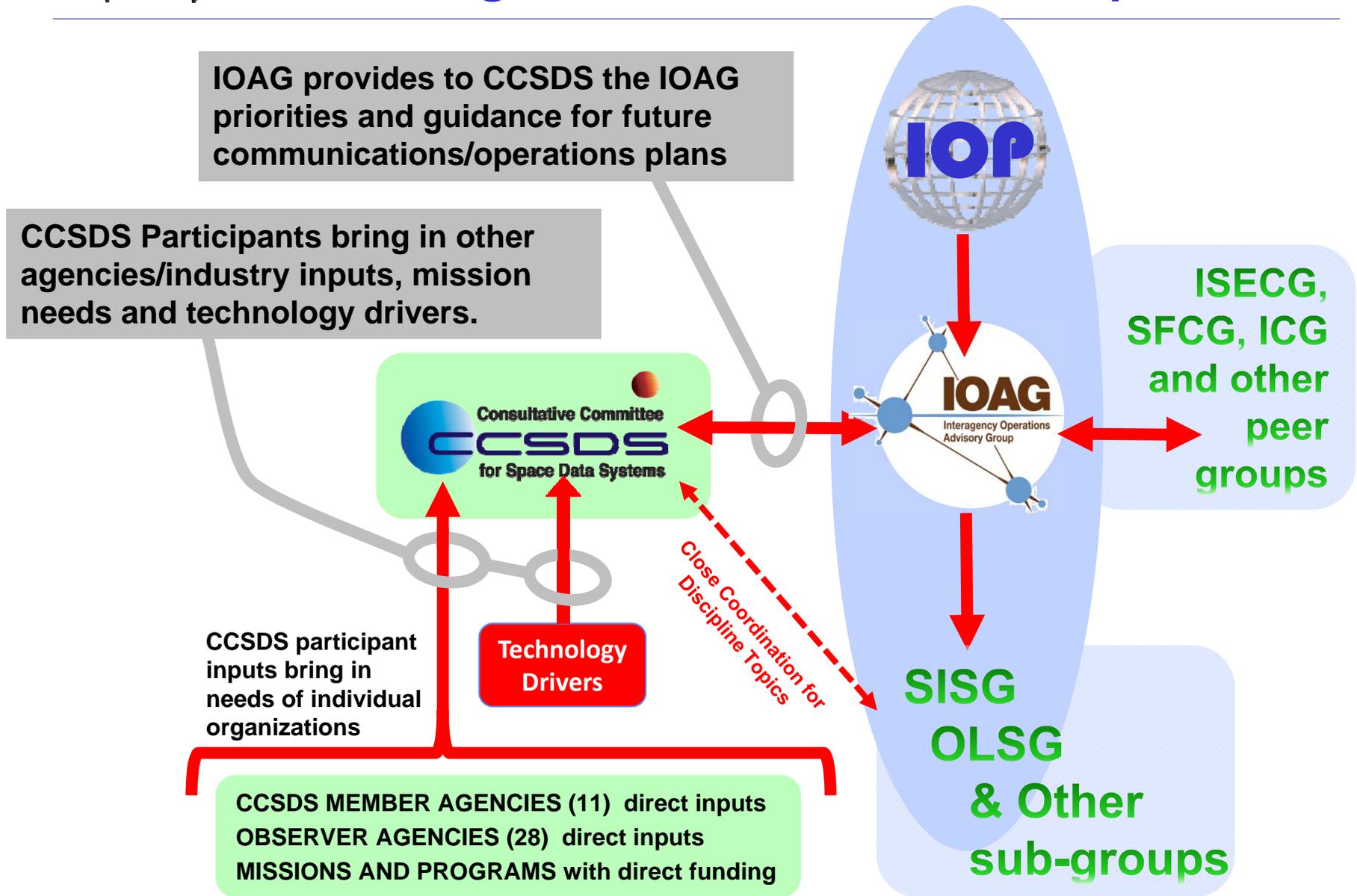
718 space missions have adopted and used various CCSDS standards



Cumulative Missions	99	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	108	155	205	221	271	308	330	371	387	416	435	461	544	596	627	718

CCSDS Overview

Organizational Interrelationships



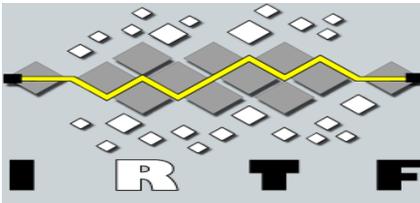
Some Organizational Interrelationships



OMG: Object Management Group

Industry standards for exchange of application information among vendor products

CCSDS/OMG have some common standards and periodic joint meetings

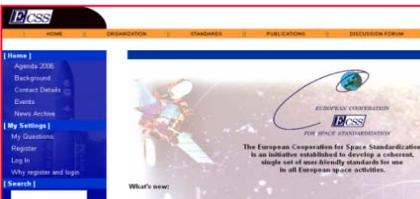


IETF: Internet Engineering Task Force

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

End-to-End Architecture

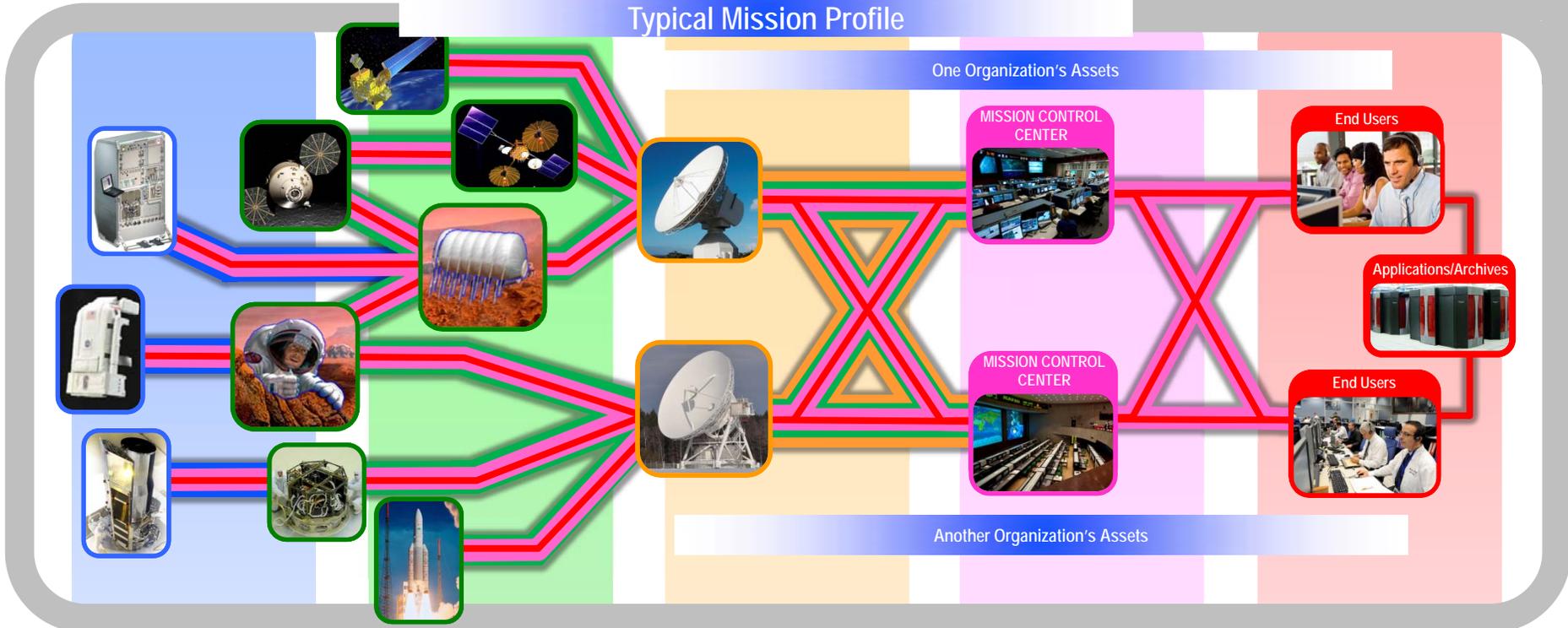
Six Technical Areas, Twenty-Six Teams

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

Systems Engineering

- ◆ Security
- ◆ 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
- ◆ Optical Coding and Mod

Cross Support Services

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

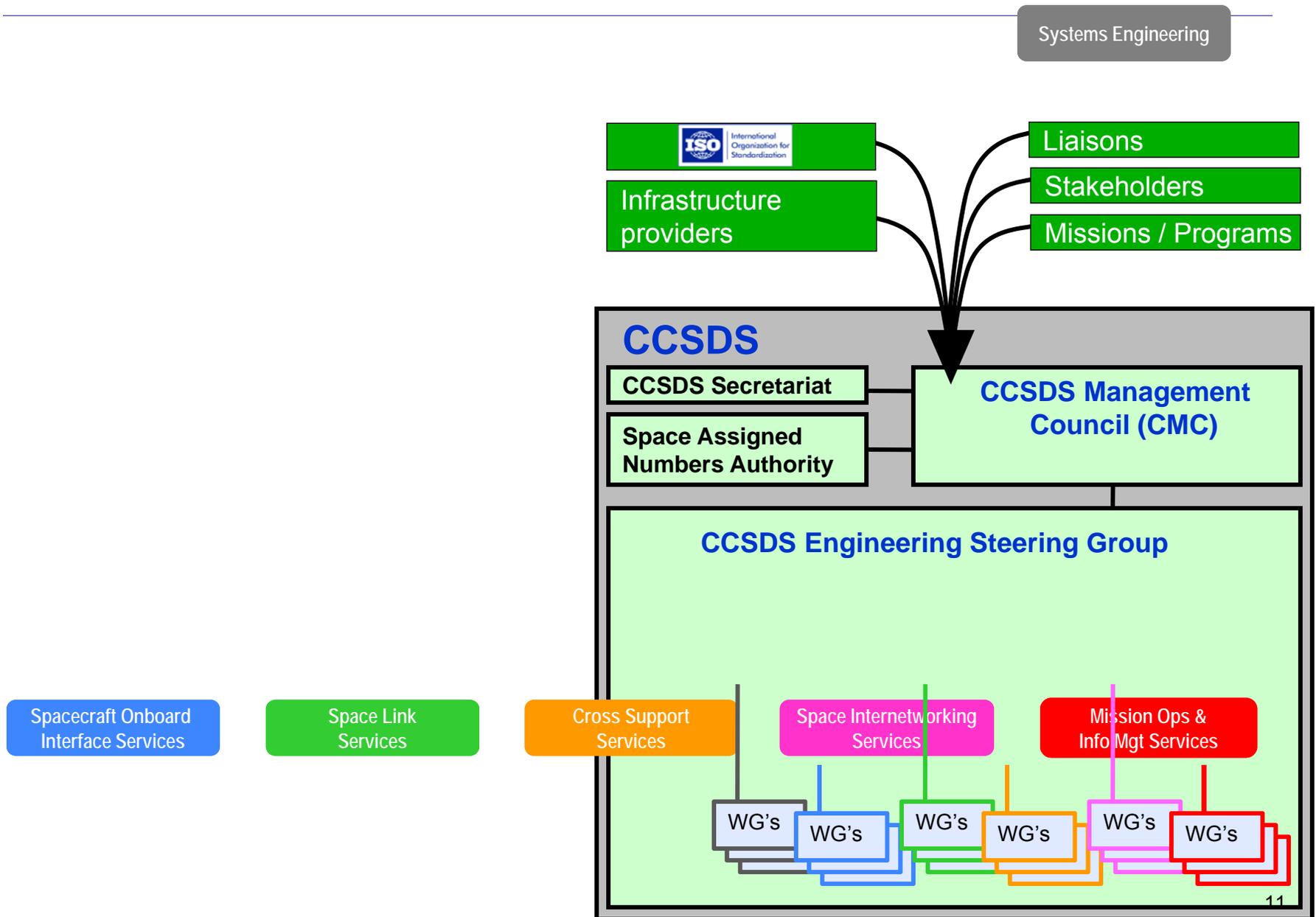
Space Internetworking Services

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

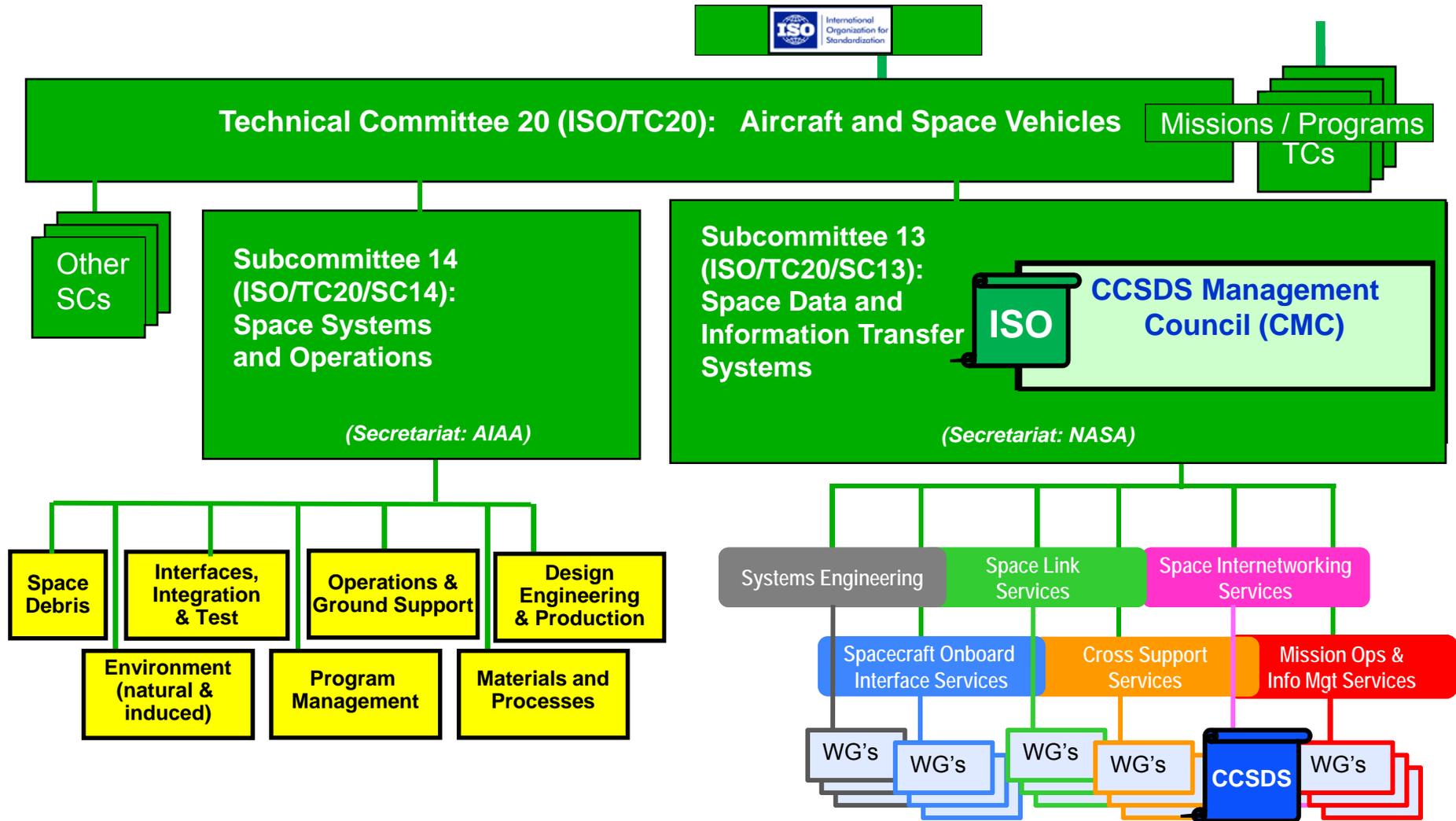
Mission Ops & Info Mgt Services

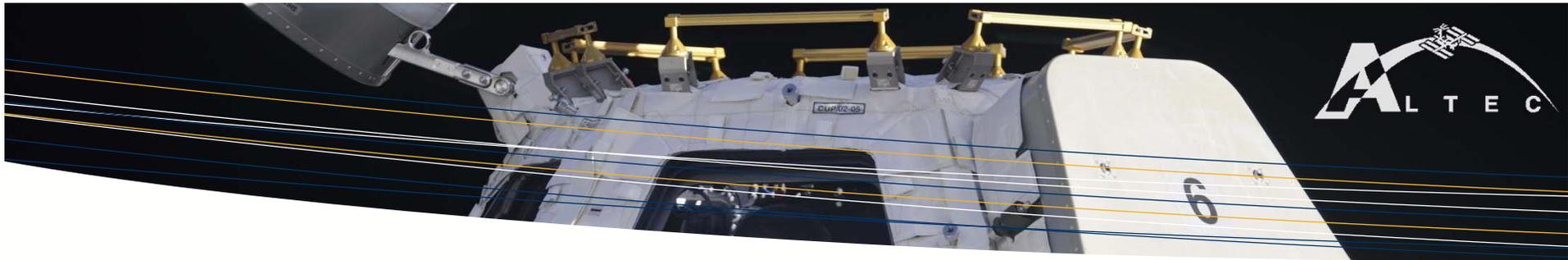
- ◆ Data Archive Ingestion
- ◆ Navigation
- ◆ Spacecraft Monitor & Control
- ◆ Digital Repository Audit/Certification
- ◆ Telerobotics

CCSDS Structure and Organization

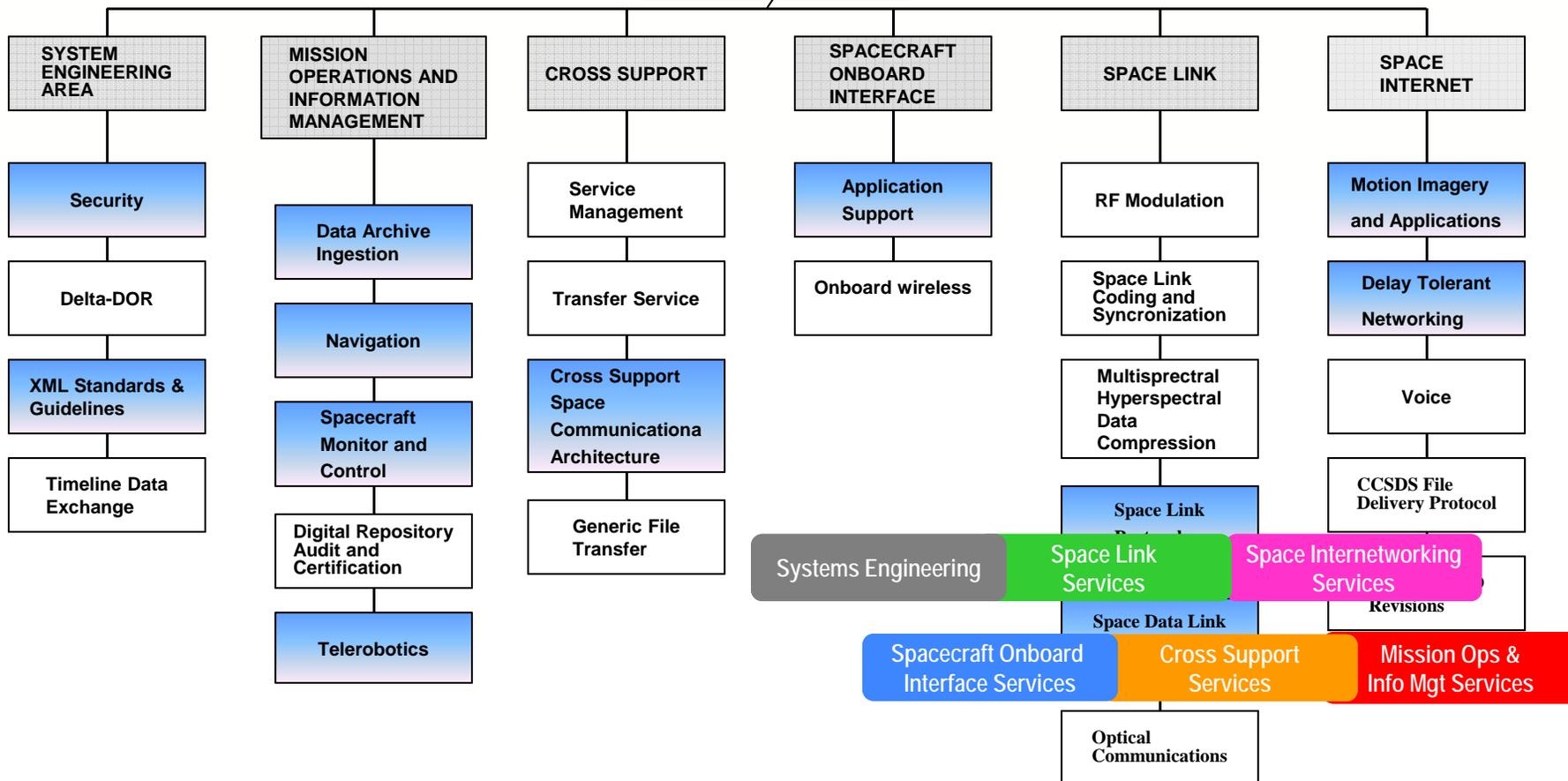


CCSDS Relationships with ISO





CCSDS



Security Working Group

✦ The CCSDS Security Working Group:

- ✧ Security is a KEY mission concern. This group addresses CCSDS agreements for secure uplink commanding (authentication, integrity, confidentiality) , secure downlink telemetry (confidentiality, integrity), and science data privacy (confidentiality, authentication, integrity).

Systems Engineering

Provides security advice and guidance to CCSDS working group for security factors and practices in other CCSDS standards.

✦ Documents developed and ready for application (10 total):

- ✧ Green Book on use of security in CCSDS
- ✧ Security Architecture for Space Data Systems
- ✧ CCSDS Encryption Algorithms and authentication algorithms
- ✧ System interconnection guide
- ✧ Mission planner's security guide

✦ On-going work: Key management guide and standard, Threat guide, Network layer security profile

✦ Key Objectives for upcoming Meetings

- ✧ Review key management document progress
- ✧ Discuss Network Layer Security testing progress
- ✧ Discuss & review changes to Threat Green Book revision

- ✦ CCSDS has many WGs issuing XML specifications within their standards
- ✦ Divergence on how it is represented causes confusion to implementers
- ✦ XSG SIG plans to unify those representation to prevent that divergence.

- ✦ DAI WG:
 - ✧ Develops standardized methods for acquiring, ingesting, preserving, and accessing information in archives with an emphasis on long term preservation approaches.
 - ✧ Works closely with Repository Audit and Certification (RAC) WG
- ✦ Recent Documents completed
 - ✧ Reference Model for an Open Archival Information System (OAIS)
 - ◆ World-wide the most widely recognized and cited digital archiving standard
 - ◆ Most popular CCSDS Document
 - ✧ Producer-Archive Ingest Methodology Abstract Standard (PAIMAS)
 - ◆ Checklist of phases and steps to ingest data into an archive
 - ✧ Producer-Archive Ingest Specification (PAIS)
 - ◆ Formats used to model and then perform transfers between Producers and Archives
 - ❖ Most recently completed CCSDS standard, ISO equivalent is in balloting, a tutorial to aid users in applying standard is in progress
- ✦ Documents in development
 - ✧ Information Curation Process
 - ◆ Intends to detail information preservation issues from initial mission planning, through data generation, information development and eventual archiving
 - ◆ Building off of work by EU Earth Observation communities Long-Term Digital Preservation project

- ✦ 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, Δ DOR, 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)

- ✦ 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
 - ✧ Promises plug-n-play service interfaces, migration of apps onboard
- ✦ 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, Mon/Ctrl (TLM/CMD) in agency review
 - ✧ Alerts (alarm limits, etc.) currently in review cycle
 - ✧ Working on several language bindings and transport bindings
- ✦ New Development: IOAG formed MOSSG subcommittee to review CCSDS MO Services approaches and create an IOAG Service Catalog
 - ✧ MOSSG = Mission Ops Systems Strategy Group

- ✦ Objectives: For the space telerobotics technology development and operations community, develop a specification for the compatibility layer that permits operators and robotic agents to freely exchange information, enabling the operators to communicate with heterogeneous robots in a uniform fashion.
- ✦ Only green (informative) book is in work right now, but work plan is blue (normative) protocol specifications.

- ✦ Developing “big picture” description to guide CCSDS architecture for communications cross-support.
- ✦ Identifies how many of the CCSDS standards fit together
- ✦ Products:
 - ✧ **Completed:** Cross Support Architecture Concept and Rationale, Green (informative) Book
 - ✧ **In Agency Review Now:** Space Cross Support Communications Architecture Requirements Document
 - ◆ Magenta (normative) Book — Recommended Practice

- ✦ Developing standardized layered service interfaces for onboard avionics to promote interoperability
 - ✧ Supports and references lower layer link services, but currently only points to those external standards (SpaceWire, 1553, etc.)
 - ✧ More specifically now, to harmonize the Interface Control Document (ICD) among space components (hardware & software components)
- ✦ Current objectives
 - ✧ Standardize XML schema for Electronic Data Sheets (EDS)
 - ◆ Required for development of universal components to enable interoperability and ease of integration of components across different vendor suppliers
 - ✧ Development of Dictionary of Terms (DOT) book
 - ◆ Required to define common terms for SOIS EDS components
- ✦ Recent developments: Some proposals for bringing onboard link (bus) standards into CCSDS for standardization
 - ✧ RapidIO

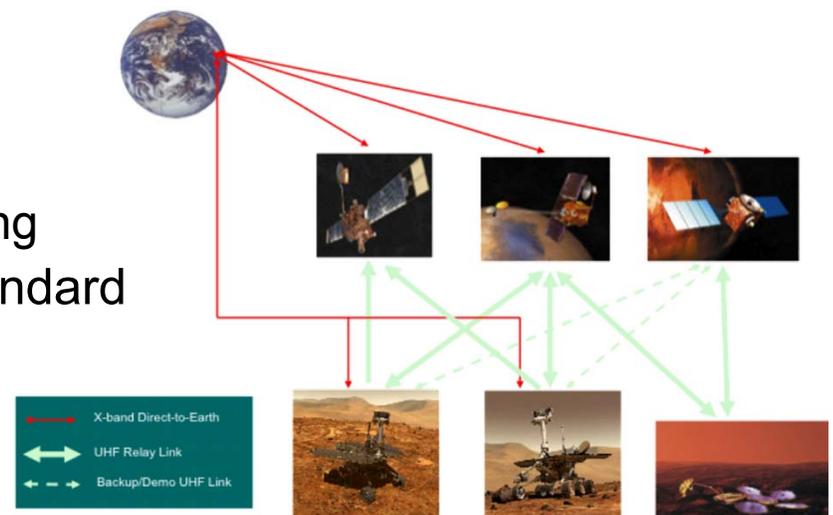
- ✦ Objective: Adapt or develop link layer protocols for space including near earth, deep space, proximity environments.
- ✦ **New effort**: Advanced space link protocol that will combine and surpass the functions of TM, TC and ProX-1
 - ✧ “Fix” traditional CCSDS protocols for higher capacities (optical comm), Cislunar environment, etc.
 - ◆ Next Generation Space Link Protocol
 - ◆ Unified Space Link Protocol
- ✦ Next meeting: Get consensus on the Unified SLP green book draft.

- ✦ Objective: develop a recommendation for a security protocol operating at the data link layer of CCSDS spacelinks. This security protocol should provide authentication and/or encryption both for uplink and downlink, and it should be independent from any specific cryptographic algorithm
- ✦ Work Plan:
 - ✧ Develop a CCSDS Link Layer Security standard protocol (Blue Book) to work with existing CCSDS link layer (TM, TC, AOS) as well as future link layer protocols (Unified SLP).
 - ✧ In support of that, Green (informative) and Yellow (test) Books will also be developed.
- ✦ Next meeting: work on key management, security control directives, extended procedures

- ✦ Objective: Interoperability between cooperating agencies' digital video systems.
 - ✧ Historical problems with NDSC, PALS, SECAM, etc.
 - ✧ Huge variety of new digital video standards. Need to down-select to the subset supporting space operations.
- ✦ Supporting Green book (informative) is published
- ✦ Working on Blue (normative) book
 - ✧ Will generally point to external standards with commercial implementations, not develop new formats
- ✦ Plans for next meeting focus on completing last review of blue book and developing test report.

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
 - ✧ SSI Architecture Document and Rationale Green books are published.
 - ✧ DTN Bundle Protocol (BP) specification and Licklider Transmission Protocol (LTP) Blue Books to be completed soon
- ✦ Future work – Complete Solar System Internet (SSI) infrastructure with
 - ✧ Network Management
 - ✧ Contact Graph Routing
 - ✧ File Delivery Protocol (CFDP) refactoring
- ✦ Breaking News: IETF making DTN a standard for the terrestrial internet



Other New Work Areas

- ✦ Planning Systems (BOF at London meeting)
 - ✧ Seeking to develop standardized interfaces for exchange of Mission Operations Planning Data, for both robotic and human spaceflight programs.
- ✦ Onboard Wireless WG
 - ✧ Wireless onboard comm reduces launch weight.

Online Resources

www.CCSDS.org

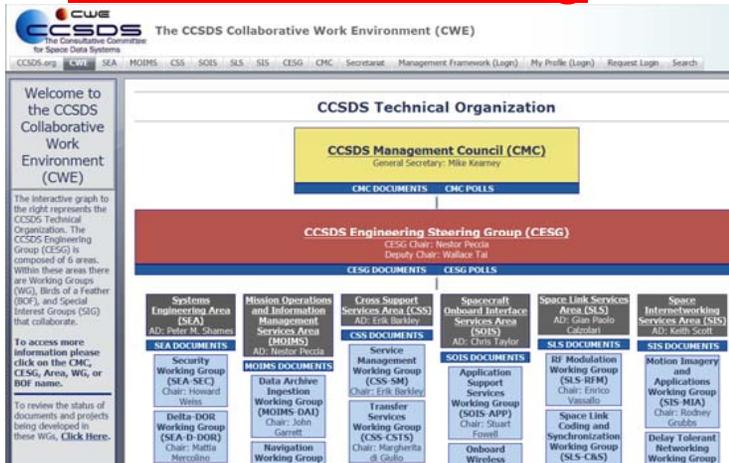


The screenshot shows the CCSDS.org homepage. At the top, there is a navigation menu with links for About, Publications, Review Documents, Meetings, Press Room, Participation, Implementations, and Search. Below the menu is a header section with the CCSDS logo and the text 'The Consultative Committee for Space Data Systems - The Official Web Site'. A large 'Welcome to CCSDS.org' message is displayed, followed by a paragraph about the organization's history and mission. To the right, there are 'Quick Links' for 'Sign In here...' and 'CWE'. Below the main text, there are several sections: 'Headlines' with recent news items, 'Events' with upcoming meetings and conferences, 'Number Assignments' for space, SANA, and spacecraft ID, and 'Related Organizations' including IOAG and ISO TC20/SC13. A 'BLOG' link is also visible at the bottom right.

Public Website

- ✦ Overview info (About tab)
- ✦ Access to published standards (Publications tab)
- ✦ Comment on documents in review
- ✦ Meeting info & logistics
- ✦ Commercial implementations
- ✦ Missions that have adopted CCSDS
- ✦ New Work Items Announcements
- ✦ General Announcements (Blog)

CWE.CCSDS.org



The screenshot shows the CCSDS Collaborative Work Environment (CWE) website. The header includes the CCSDS logo and the text 'The CCSDS Collaborative Work Environment (CWE)'. Below the header is a navigation menu with links for CMC, SEA, MOIMS, CSS, SOIS, SLS, SIS, CSEG, CMC, Secretariat, Management Framework (Login), My Profile (Login), Request Login, and Search. The main content area is titled 'CCSDS Technical Organization' and features a hierarchical organizational chart. At the top is the 'CCSDS Management Council (CMC)' with General Secretary Mike Kinney. Below it is the 'CCSDS Engineering Steering Group (CESG)' with Chair Rainer Preuss and Deputy Chair Wallace Tai. The chart is divided into several areas: Systems Engineering Area (SEA), Mission Operations and Information Management Services Area (MOIMS), Cross Support Services Area (CSS), Spacecraft Onboard Interface Services Area (SOIS), Space Link Services Area (SLS), and Space Internetworking Services Area (SIS). Each area has a list of working groups and their chairs. For example, the SEA includes the Security Working Group (SEA-SEC) and the Delta-DOR Working Group (SEA-D-DOR). The MOIMS area includes the Data Archive Ingestion Working Group (MOIMS-DAI) and the Navigation Working Group. The CSS area includes the Service Management Working Group (CSS-SM) and the Transfer Services Working Group (CSS-CSIS). The SOIS area includes the Application Support Services Working Group (SOIS-APP) and the Onboard Working Group (SOIS-CBS). The SLS area includes the RF Modulation Working Group (SLS-RFM) and the Space Link Coding and Synchronization Working Group (SLS-CBS). The SIS area includes the Motion Imagery and Applications Working Group (SIS-MA) and the Delay Tolerant Networking Working Group.

Collaborative Work Environment

- ✦ Development environment for developing new standards
- ✦ Access to Areas' and WGs' materials (some private areas require ID/PW)
- ✦ Contact info for ADs and WG leads
- ✦ Access to schedule/status of current standards development projects

CCSDS Summary

- ✦ Final message: There is 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 both earth-orbital and deep space missions. Including 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.

Backup/Alternative Charts

Future Mission Drivers

PAST

PRESENT

DRIVERS FOR THE

FUTURE



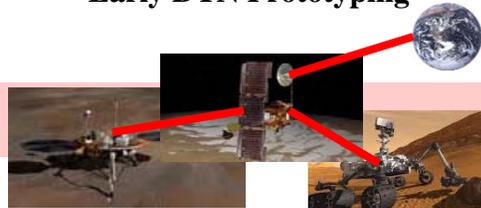
**Shuttle/SpaceLab
CCSDS packets**



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



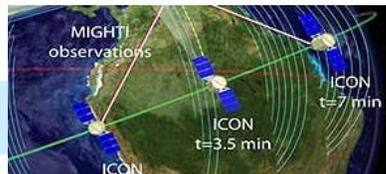
**Brief Recon Flyby,
Short-Lived Probes
Direct-to-Earth links**



**Missions designed for orbital relays,
Longer duration**



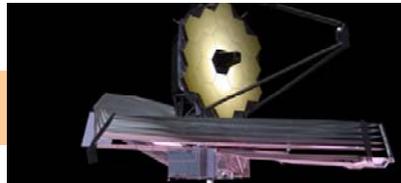
**Single-Spacecraft
Survey/Sensors**



**Spacecraft Constellations
and formation flying**



**Single-Spacecraft
Observatories in LEO**



**Greater Distances
Higher bandwidth**

In Situ Exploration

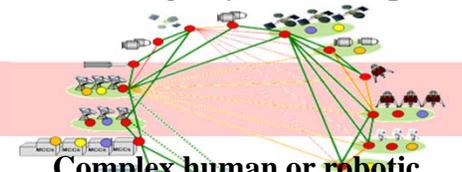
- Human Expeditions
- Long Duration, High Reliability
- Mobile comm protocols
- Voice, Video, Medical handling
- Onboard Autonomy
- Highly integrated ops



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

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**

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**

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**

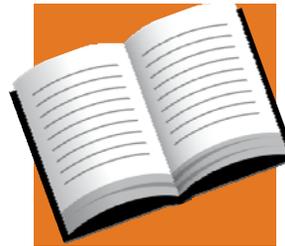
Field Guide to CCSDS Book Colors



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 architecture, 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.