The Consultative Committee for Space Data Systems

CCSDS

Harmonization Exemplified

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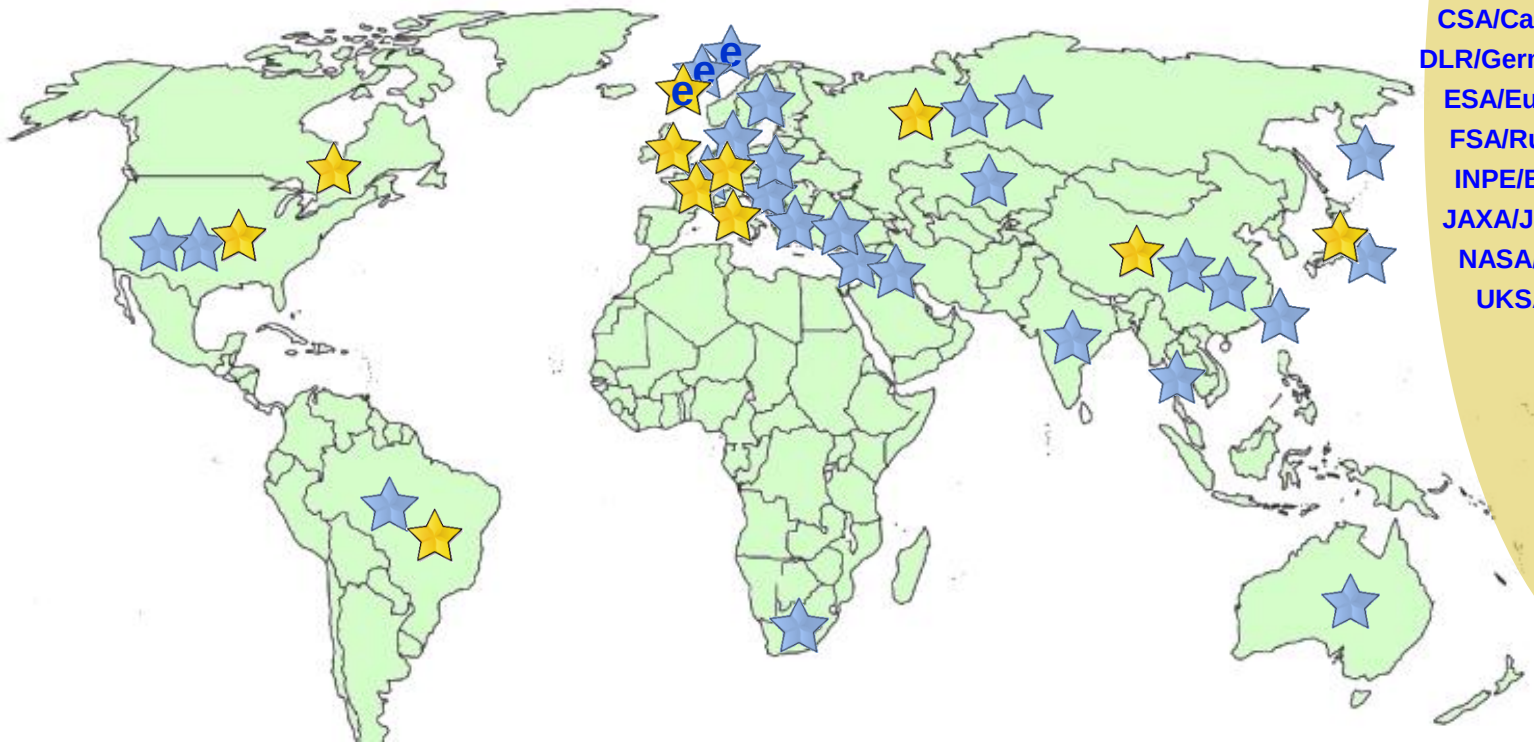
CCSDS – Harmonizing What?

- 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, harmonization of ***communications and data systems*** brings the most benefit to multi-agency interoperability.
- CCSDS Started in 1982 developing at the lower layers of the protocol stack. The CCSDS scope has grown to cover standards throughout the ISO communications stack, plus other Data Systems areas (architecture, archive, security, XML exchange formats, etc.

CCSDS – Harmonizing with whom?

CCSDS – An Agency-Led International Committee

- Currently 11 Member agencies
- Currently 28 Observer Agencies
- Agencies represent 26 nations
- Currently 141 Commercial Associates
- Also functions as an ISO Committee
  - TC20/SC13 - Space Data & Info Transfer Systems



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

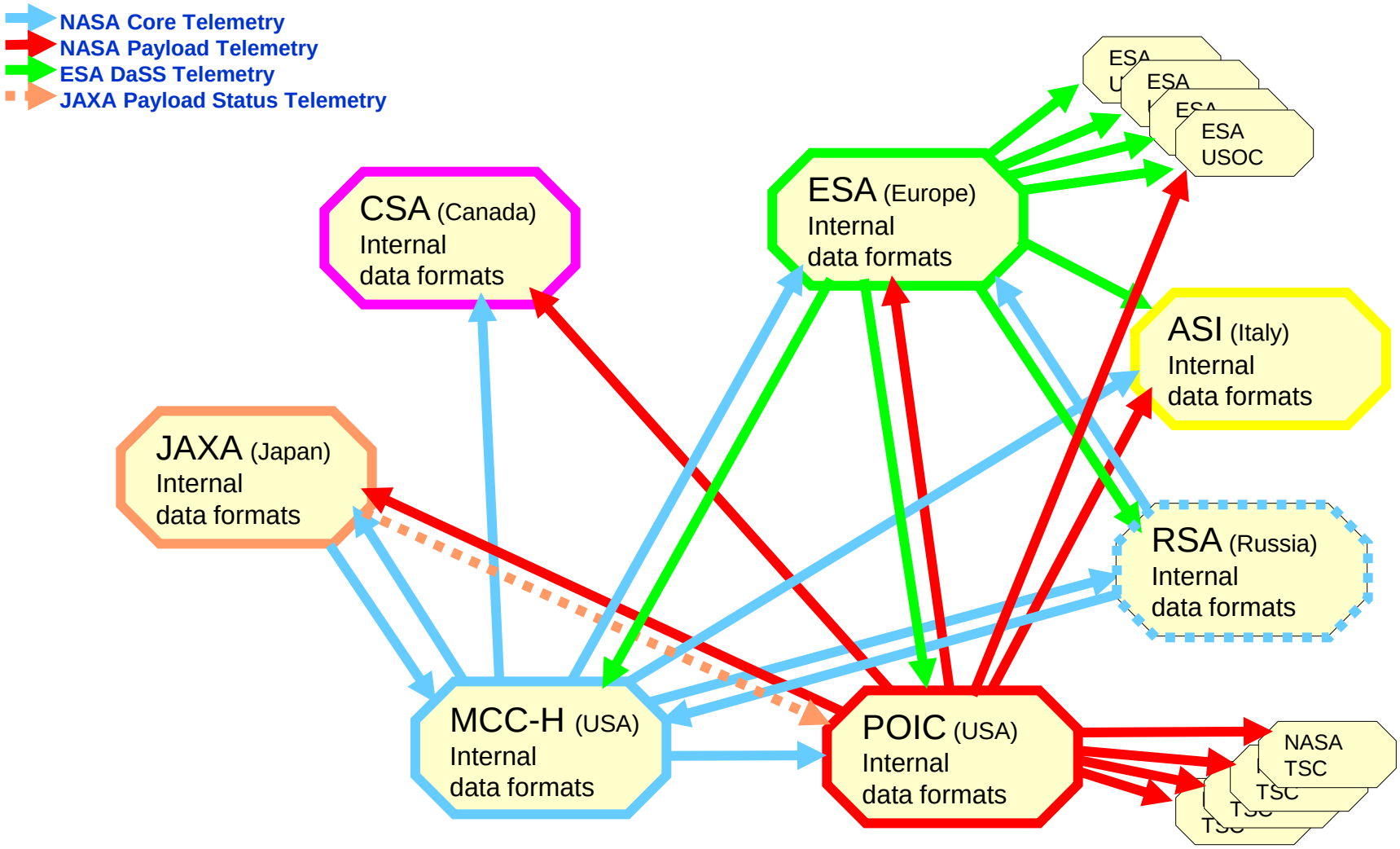
ASA/Austria
BFSPO/Belgium
CAS/China
CAST/China
CLTC/China
CSIR/South Africa
CSIRO/Australia
DCTA/Brazil
DNSC/Denmark
EUMETSAT/Europe
EUTELSAT/Europe
GISTDA/Thailand
HNSC/Greece
IKI/Russia
ISRO/India
KARI/Korea
KFKI/Hungary
MOC/Israel
NCST/USA
NICT/Japan
NOAA/USA
NSARK/Kazakhstan
NSPO/Taipei
SSC/Sweden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

CCSDS – Harmonizing Why?

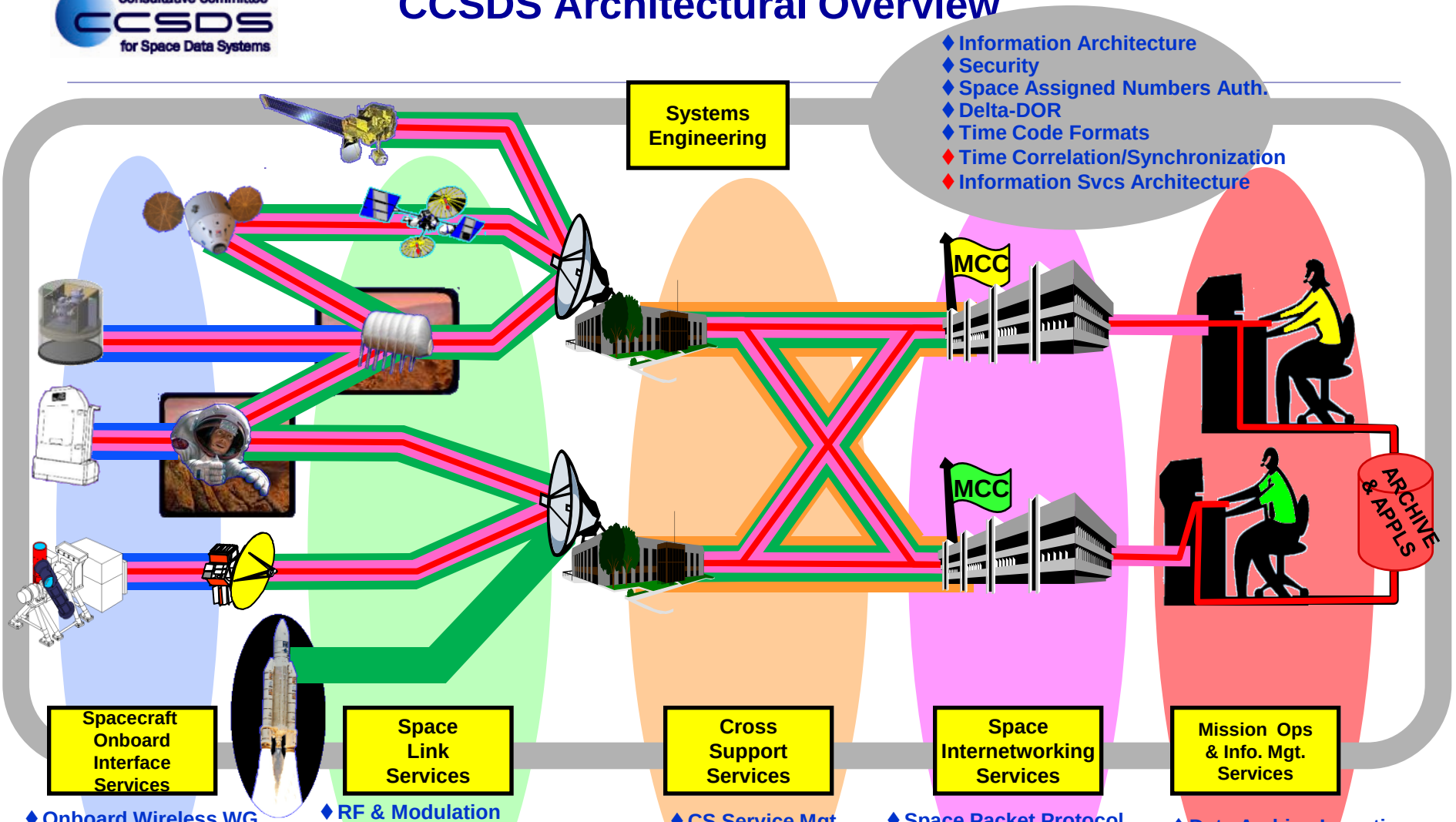
- Historically, internationally collaborative missions have tight schedules right at program start.
  - Standards prepared in advance are more methodically developed for long-term benefits.
- Spaceflight is expensive. Interoperability allows cross-agency cost sharing in joint programs.
- Even if a mission is not a joint program, missions should comply with standards to enable contingency (rescue) operations. Examples:
  - 1995 - NASA DSN “rescue” of UK’s STRV vehicle
  - 2008 - NASA DSN “rescue” of ESA’s XMM-Newton mission

CCSDS – Harmonizing Why?

Int'l Space Station example – Telemetry formats



CCSDS Architectural Overview



- ♦ Onboard Wireless WG
- ♦ Application Support Services
- ♦ Onboard Plug-n-Play

- ♦ 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

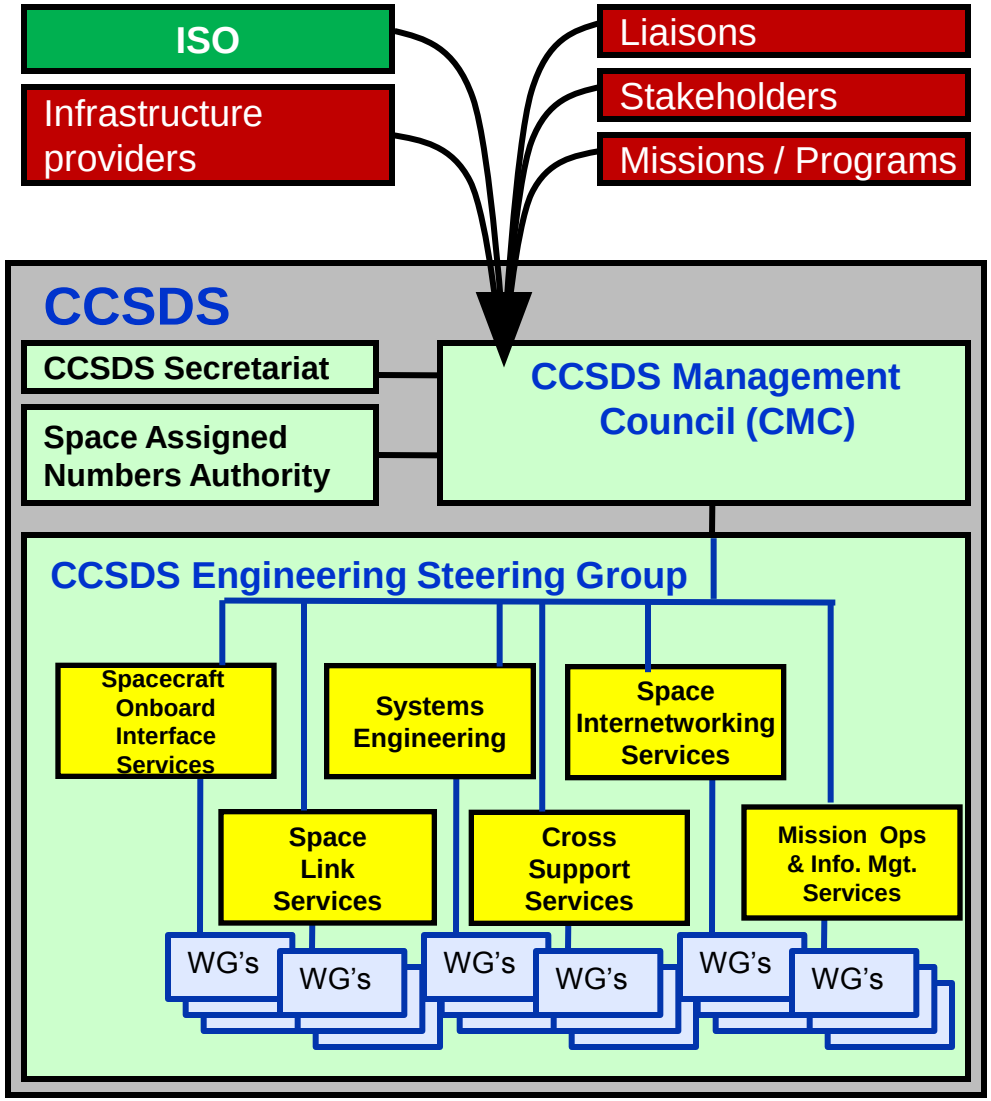
- ♦ CS Service Mgt
- ♦ CS Transfer Svcs
- ♦ Cross Support Architecture
- ♦ Reference Arch.

- ♦ Space Packet Protocol
- ♦ Asynch Messaging
- ♦ IP-over-CCSDS Links
- ♦ Motion Imagery & Apps
- ♦ Delay Tolerant Networking
- ♦ Voice

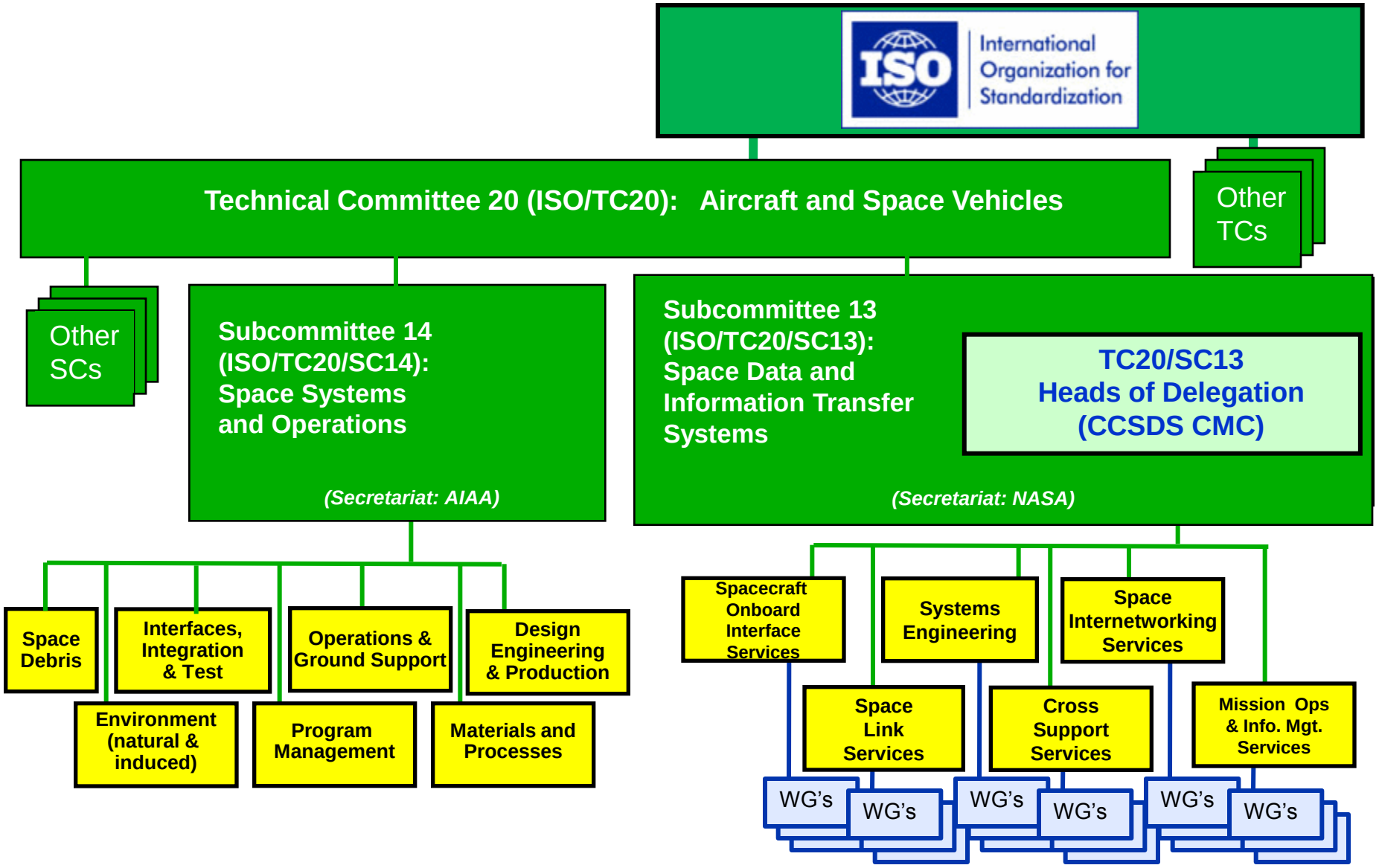
- ♦ Data Archive Ingestion
- ♦ Navigation
- ♦ Info. Pack. & Registries
- ♦ Spacecraft Monitor & Control
- ♦ Digital Repository Audit/Certification

Thirty-three working groups (some in formative stages♦)

CCSDS Structure and Organization

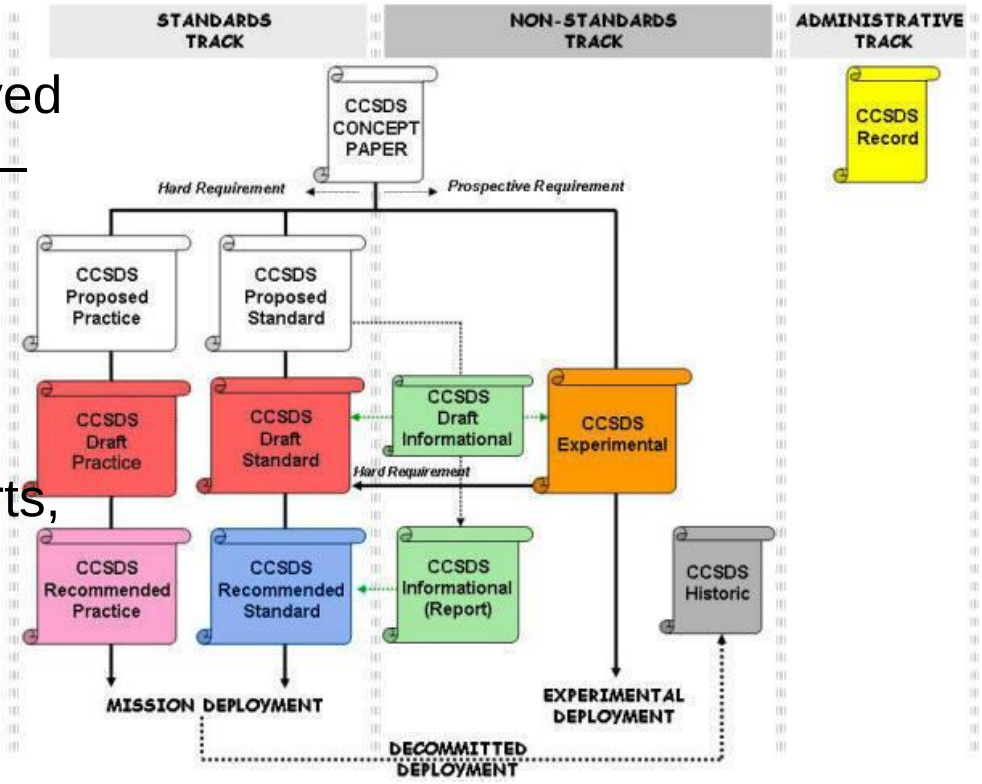


CCSDS Relationships with ISO

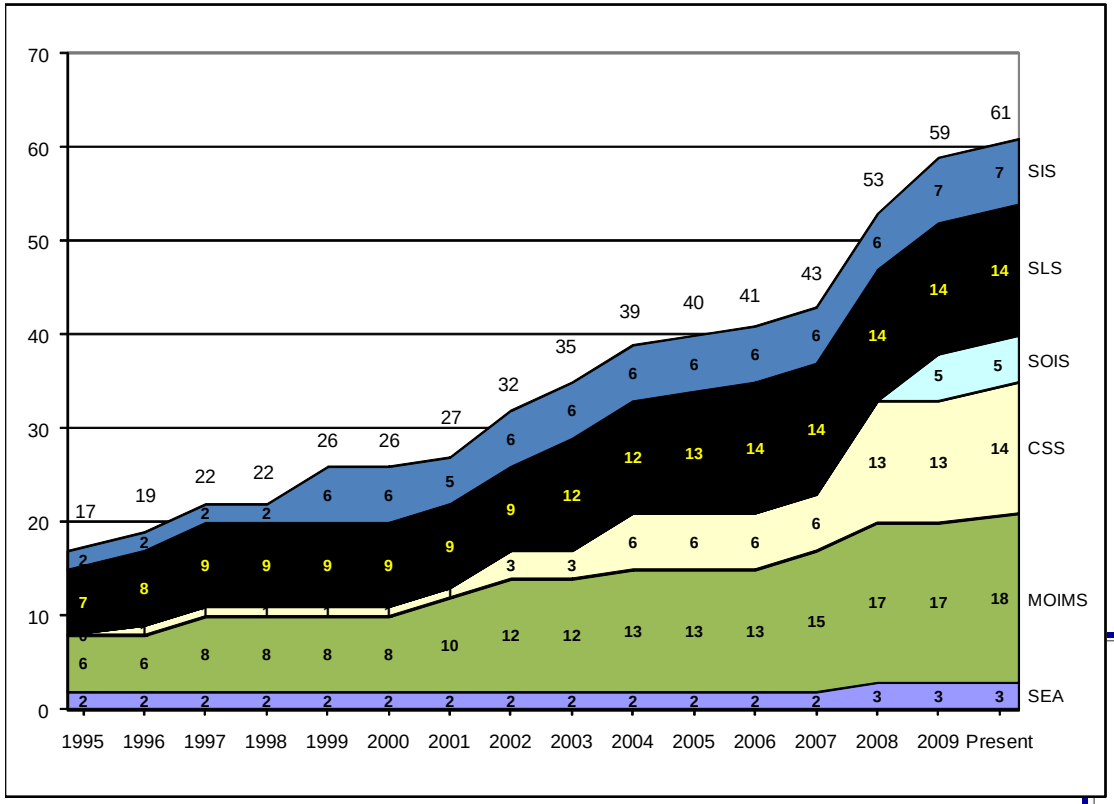


CCSDS Process – Colors of Books

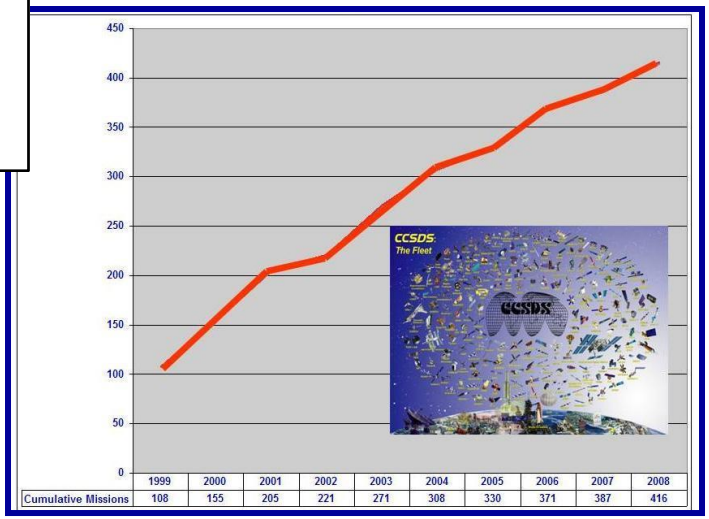
- Blue Books: Recommended Standards – Verified for Interoperable Implementations (with options specified)
- Magenta Books: Recommended Practices – Normative, but not for directly implementable for interoperability
- Red Books: Drafts of Blue or Magenta books not yet approved
- Orange Books: Experimental – New Technology or Single-Agency
- Green Books: Informational, concepts, etc.
- Yellow Books: Technical reports, Procedures, etc.
- Silver Books: Historical (deprecated)



CCSDS Overview



61 Standards and Practices Currently Active



514 missions have used some CCSDS standards

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

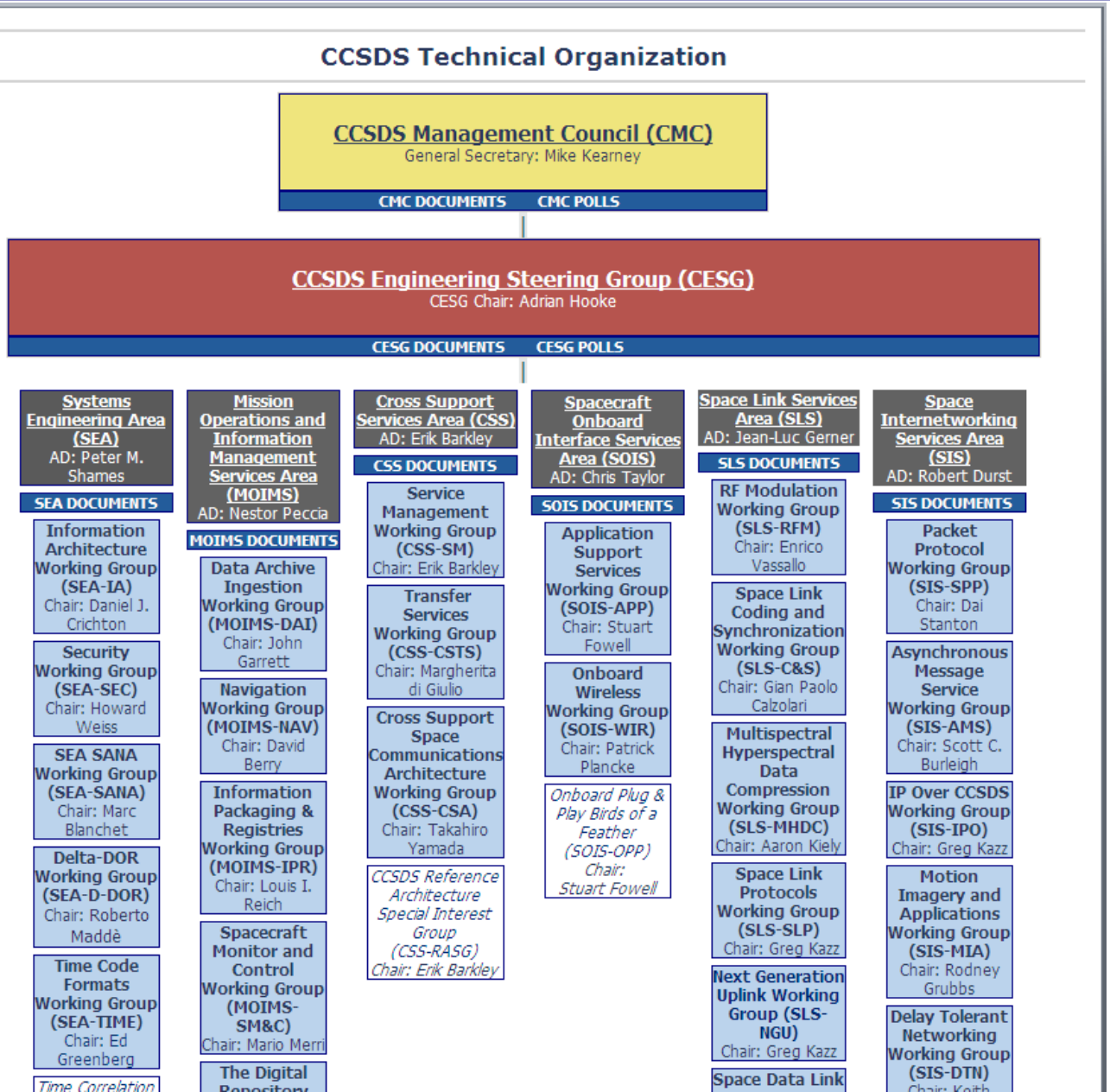
Access to CCSDS Technical WG info: www.ccsds.org > CWE

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.

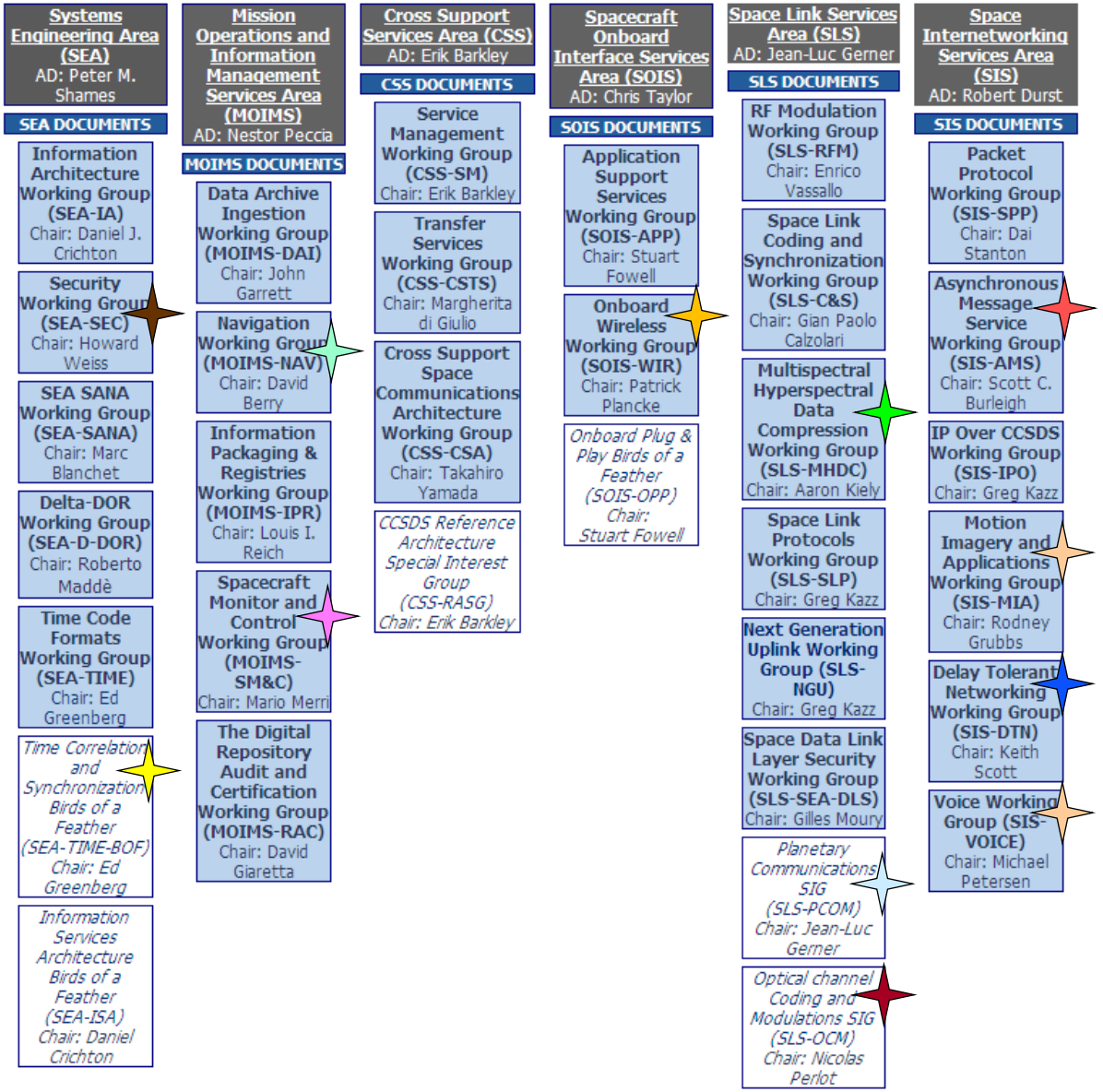
To access more information please click on the CMC, CESG, Area, WG, or BOF name.

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



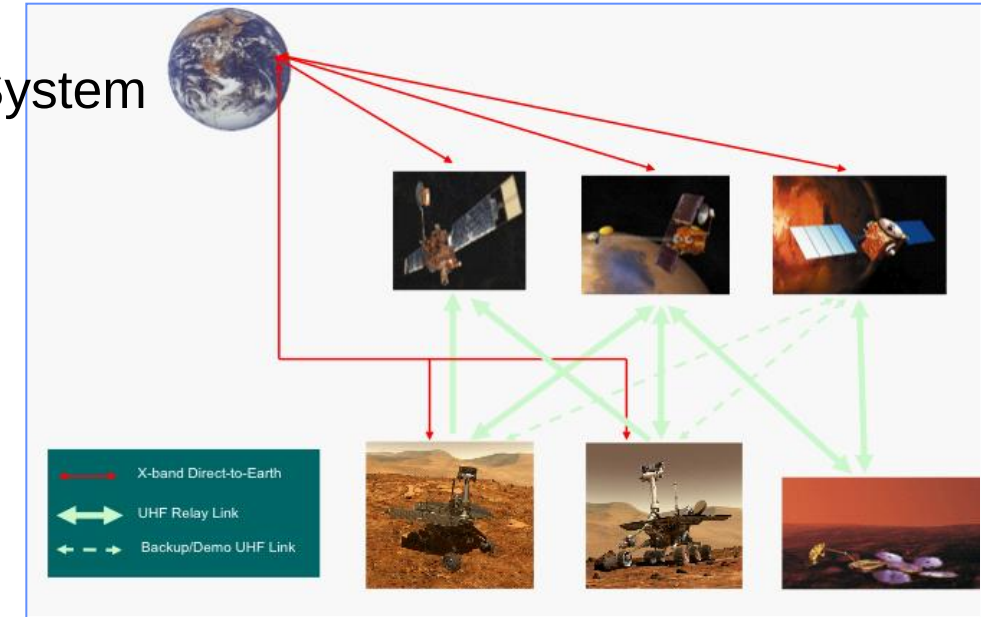
Sampling of Technical Topics

- Topics to be discussed:
  - DTN WG
  - AMS WG
  - Multi/Hyperspectral Data Compression
  - Onboard Wireless
  - Spacecraft Monitor & Control
  - Navigation WG
  - Security WG
- New work items briefly mentioned
  - Optical Coding and Modulation SIG
  - Planetary Comm BOF
  - Time Correl/Sync BOF
  - Voice/Video WGs

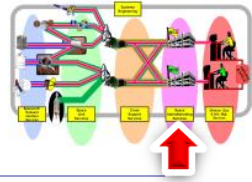


Delay/Disruption Tolerant Networking

- 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
  - Current green book almost finalized. Establishes Rationale, Develops Scenarios, explores candidate technologies
  - In work: DTN Bundle Protocol (BP) specification and Licklider Transport Protocol (LTP) Blue Books.
- Future work – Complete Solar System Internet (SSI) infrastructure with
  - Network Management
  - Naming/Numbering conventions
  - Contact Graph Routing
  - File Delivery Protocol (CFDP)

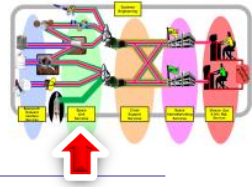


Asynchronous Message Service (AMS)



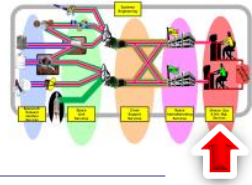
- The AMS Working Group is standardizing messaging middleware for flight mission communications.
  - AMS provides “message bus” functionality for flight missions, including both publish/subscribe and client/server interaction models.
  - Unlike JMS or DDS, AMS is *a wire protocol rather than a service 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: Loosely-coupled, simplified interfaces
  - Overall reduction in system complexity
- Past Progress and Current Work
  - Final Red Book has passed Agency review, but more interoperability testing is needed before Blue Book is published.
- Reference implementation is available as open source, included in JPL’s “ION” software distribution at: http://www.openchannelfoundation.org/projects/ION/

Onboard Wireless Working Group



- Overview of Onboard Wireless activity
  - Provides standards-based resources to achieve interoperable wireless network communication
  - 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
  - Group will “downselect” from plethura of 802.11 standards available
  - Major benefit, ground and space: RFID for logistics tracking
- Past Progress
  - Current Green Book completing publication process
    - Examines the possibilities and advantages of the application of *wireless communications technology* to space missions
- Current / Future Work
  - 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

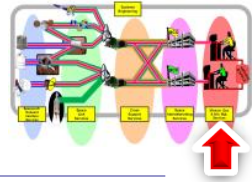
Spacecraft Monitor and Control



- Emphasis is on standardizing common functions that are in every mission, at the ***application level***
- Capitalizes on industry approach of a Service Oriented Architecture
- SOA paradigm: Define providers and consumers of service
  - Information transferred between the two contains semantics
- Result: Plug-in architecture.
  - Components plug into services
  - Provides application portability as well as interoperability
- Initial focus of effort: Ground MCCs.
  - Eventually will include flight systems that provide services

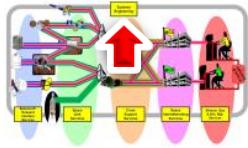
- See following presentation by Mario Merri, CCSDS SM&C WG Chair

Navigation WG



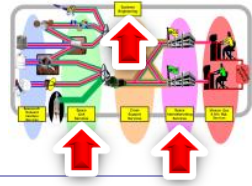
- The Navigation Working Group is chartered to develop standards covering spacecraft orbits, attitudes, and tracking
- Past Progress and Current Work
  - Orbit Data Messages (version 2.0 published 11/2009)
    - Three standard message formats for exchanging orbit descriptions
      - Orbit Parameter Message (OPM) is a state vector (position and velocity at epoch; must be propagated)
      - Orbit Mean Elements Message (OMM) is an orbit state (mean Keplerian elements; must be propagated)
      - Orbit Ephemeris Message (OEM) is an ephemeris (position and velocity at multiple epochs; must be interpolated)
  - 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
      - Attitude Parameter Message (APM) is an attitude state at epoch, must be propagated
      - Attitude Ephemeris Message (AEM) a series of attitude states at multiple epochs, allows modelling of any number of torques, must be interpolated
  - Navigation Green Book (version 3.0 published 05/2010)
    - Contains technical background related to the Nav WG Recommendations
  - Nav Data Messages XML Spec Blue Book (pub late 2010)
    - Contains XML representations of all above Nav WG standards
- Future work – Conjunction Data Message
  - See upcoming presentation by Dr. Finkleman

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
- On-going work:
  - Encryption and authentication algorithm standard
  - Key management guide and standard
  - Mission planner's security guide
  - Network layer security profile
  - Information security glossary

Other New Work Areas



- Optical Coding and Modulation BOF
  - 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
- Planetary Communications BOF
  - Will address comm on planetary surfaces
    - Lunar/Mars, Robotic/Human, Orbiters/Rovers/Habitats, etc.
  - Currently surveying agencies for mission plans and needs
- Time Correlation and Synchronization BOF
  - Exotic technical problem - establishing time on distant spacecraft
  - Applies spacecraft-to-spacecraft, space-to-MOC, etc.
- 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
- More participation in these freshly-forming topics is encouraged.

Concluding Information

- Recent Membership News
  - Thailand, Turkey, Kazakhstan admitted as observer agencies
  - Nigeria and Egypt expressing interest

- Next Tech WG meeting: May 16-20, 2011
  - At DIN (German Standards Institute), Berlin
  - Hosted by DLR (German Space Agency)
  - Visit www.ccsds.org for info
  - Management meeting the following week includes joint meeting with ISO TC20 SC14 *Space Systems and Operations*

Concluding Information

- **Take-home message: Still much work to be done**
  - This is an ongoing process; as technology changes, new standards must emerge
  - New technologies will enable new mission concepts, sometimes unanticipated benefits.
  - CCSDS rapidly standardizes new technologies. New and Standard – the best of both worlds.
- **For Earth Orbital missions, communications standards will bring improved performance and partnerships**
  - LEO missions are numerous – hence will benefit the most from standardization
  - New technology (Internetworked SensorWebs, etc.) will automate spacecraft fleet responsiveness
  - Partnering between agencies allows sharing of the mission workload and faster reactions to anomalies
- **For Deep Space missions, when mankind reaches other planetary surfaces, we can't afford to not have standardization.**
  - It's too far away to have the inefficiencies of incompatible systems.
  - It's too far away to ***not*** use the help of other agencies on that new planet.