CCSDS: Advancing with Technology

By Mike Kearney

Considering the origins of the Consultative Committee for Space Data Systems (CCSDS), it should be no surprise that the committee's standards are often linked to technology advancements. CCSDS grew out of late 1970s work by the National Aeronautics and Space Administration (NASA) Jet Propulsion Labs' Adrian Hooke and his colleagues, pioneering packet telemetry approaches.

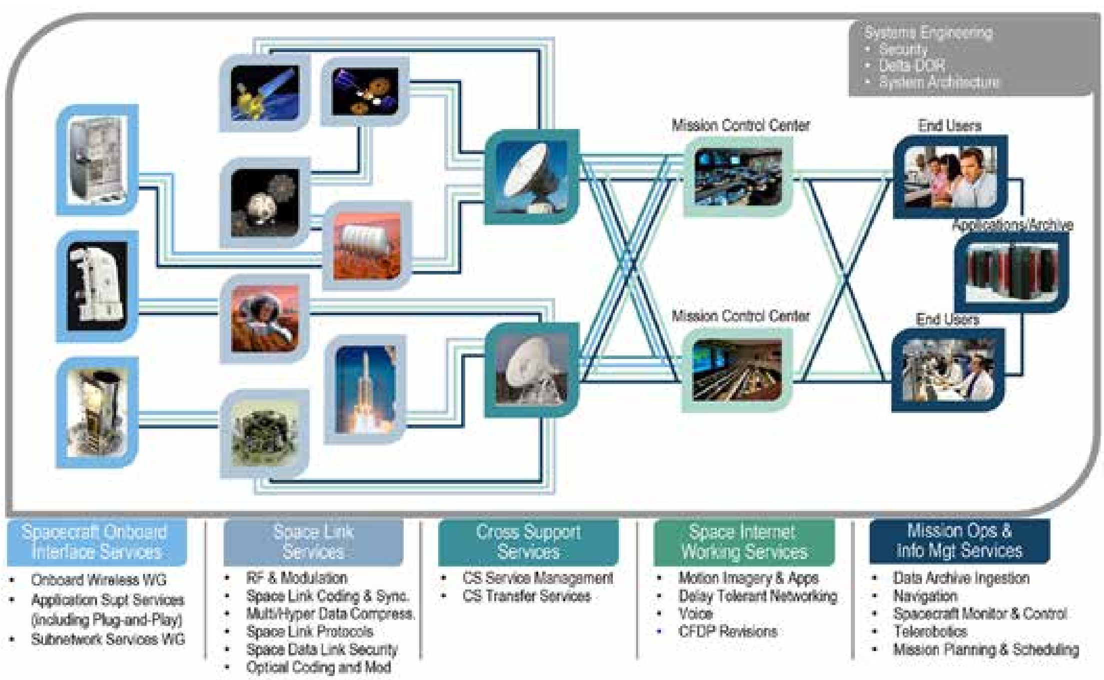
In the early 1980s, Mr. Hooke used his contacts in the European Space Agency (ESA) to organize a NASA-ESA bilateral activity to use the technology for international space cooperation. This quickly grew into the fully international CCSDS. As Mr. Hooke provided leadership of the CCSDS over the next three decades, CCSDS addressed such breaking communications technologies as advanced coding and sysncronization methods, data compression methods, space internet-working, and optical communications. While the organization does not per se have a charter to develop advanced technologies, it quickly recognizes when emerging technologies are important to international interoperability, and it advances them directly toward standardization.

The civil space standards overview in this issue provides the overall landscape that CCSDS fits into, and the business case for participating in standards development. This article provides specifics for CCSDS and some sound bytes on the development work where CCSDS is standardizing important technologies in the communications and data domain.

CCSDS has two roles in the standards domain: besides publishing its standards under CCSDS cover, most of its normative standards are also forwarded to the International Standards Organization (ISO) for approval where the CCSDS organization is recognized as ISO TC20/SC13 (the sister organization to SC14). This dual-certification (CCSDS and ISO) improves acceptance in the international arena. SC13 standards are the same content with an ISO cover, but while CCSDS distributes its standards for free, ISO standards must be purchased for a fee.

As of this writing, CCSDS has 160 published and currently active documents, and it is currently working on 86 approved document projects. These projects span virtually all technical areas associated with any spaceflight mission, as illustrated in the CCSDS architecture overview in Figure 1.

Figure 1. The CCSDS End-to-End Architecture



Note: Technical areas are color coded, and the working group titles are listed for each area.
Source: CCSDS, used with permission.

A Sampling of Exciting Ongoing Development Efforts

Some representative topics are being developed in CCSDS that should be of interest to all organizations with a future stake in spaceflight missions. If you are in one of those organizations and have a technical background in that area, consider contacting the CCSDS working group chair in these teams (see links) and signing up to participate. Participation can be electronic (e-mail discussions and document reviews) or in person at CCSDS meetings. Of course, in this international civil space arena, all the responsibilities for export and International Traffic in Arms Regulations compliance apply to the participants.

In the Space Link Protocols Working Group, a new space link protocol is being developed to eventually supplant the long-standing CCSDS TM/TC/AOS (Telemetry, Telecommand, and Advanced Orbital Systems) protocols. It is the Unified Space Link Protocol. The Informative (Green) book is due in 2017 and the Normative (Blue) book is due in 2018. This is a very foundational and important effort for future spacecraft command and control.

In the Delay Tolerant Networking (DTN) Working Group, internet protocols are being adapted for the demands of spaceflight, including disruption and delay tolerance. DTN provides a dramatic improvement in bandwidth and latency for disrupted environments. While the solution to "Delay" issues draws the attention of deep space missions, DTN also greatly improves LEO mission resilience and efficiency by automating the recovery from communications gaps. This effort is in response to agreement by 14 civil space agencies in the Interagency Operations Advisory Group that envision a "Solar System Internet" for future space communications architectures. NASA has fully engaged this initiative by implementing DTN on the International Space Station; this is already showing real on-orbit benefits. Currently, the working group has completed the basic protocols and network management and is now working on routing and security for the DTN environment. This is done in close coordination with the Internet Engineering Task Force to maintain compatibility with the terrestrial Internet. DTN capabilities will have a dramatic impact on missions in the long-range future.

The Space Data Link Security Working Group is standardizing security features at the link layer for CCSDS protocols. The Informative (Green) book is due in 2017 and the Normative (Blue) book is due in 2018.

The Spacecraft Onboard Interface Services area's Application Support Services Working Group has developed innovative standards for onboard electronic data sheets to streamline configuration and control of onboard spacecraft data systems. This is an XML-based method to fully describe access protocols and virtualization of common onboard sensor/actuator devices and onboard software components, including the standardization of classes. Both the Informative (Green) and the Normative Recommended Practice (Magenta) books are due in 2017, while the Normative Recommended Standard (Blue) book is due in 2018.

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The Onboard Wireless Working Group (WWG) efforts are for (1) asset tracking and management; (2) intra-vehicle communications; and (3) assembly, integration, and test (AIT) activities. Asset tracking is basically RFID-based logistics control, for example, for onboard habitats or flight support ground systems. Intra-vehicle communications supports not only WiFi-based communications for habitats and spacesuits, but also payload-to-launch-vehicle WiFi that will help reduce launch weight and improve rapid payload integration. The AIT focus is to improve launch facility ground support equipment configuration and connectivity for test scenarios. Because of efficiency improvements and rapid configuration in all these scenarios, this work has dramatic implications for both launch and on orbit systems. The WWG has completed several RFID books, and it is working on its final Normative (Blue) book for RFID; it has started work on the wireless network communications Informative (Green) book.

The Optical Communications Working Group is establishing practices and standards so missions can use the much greater bandwidth and performance by using laser-based space communications systems. Because optical communications systems are susceptible to weather interference at the ground stations, missions will need to have alternative ground station support from other agencies, hence driving the need for interoperability. There are some difficult issues with standardization choices, so this group recently resolved to issue some experimental specifications first, currently scheduled for 2019. Besides those documents on physical layer functions and coding/synchronization, they are also developing agreements on atmospheric/weather practices and processes. Figure 2 depicts NASA's Laser Communications Relay Demonstration, which will perform optical communications in the gigabit range.

Figure 2. NASA's Laser Communications Relay Demonstration

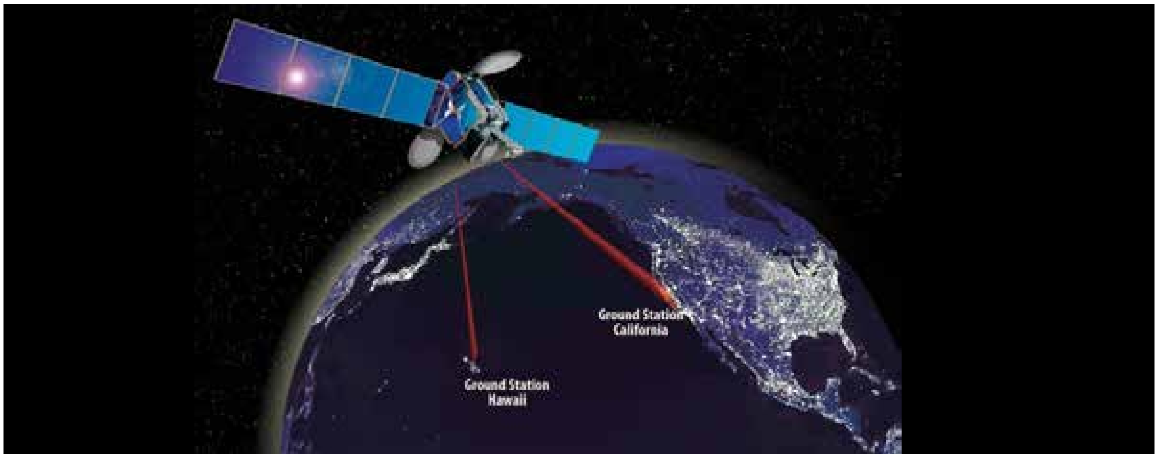

Image courtesy of NASA.

Digital preservation is an application that is often mistakenly not considered until the mission is over. It needs to start with a standard process adopted early in the development cycle. The CCSDS Data Archive Ingest (DAI) Working Group has developed the Open Archival Information System (OAIS) as a process to guide that practice, and it has been overwhelmingly adopted even in organizations outside of the space industry. The OAIS document is currently in its 5-year review and the DAI working group is soliciting comments. Moving from processes to protocols, the DAI working group has a notional plan for a future architecture for interoperable interfaces for archives, and participants with an interest in having their mission's data accessible in the truly long term are welcome to engage.

There are many other topics at work in CCSDS as well, and all 86 (as of this writing) current standards documents that are in development are described in the list of projects on the CCSDS Management Framework. Clicking on the working group name will take you to its charter, and clicking on the document name will take you to its description and schedule.

Conclusions

In the field of data and communications, CCSDS is a great resource for organizations with a stake in the future of spaceflight to identify the technologies that are on the horizon for standardization and to get involved in influencing the ways that technology can be effectively used. Standardization of technology features such as interoperable interfaces will drive industry trends and the accessibility of that technology. Your future missions will use some of these standards, and your opportunity to shape them is happening now.

OTHER RESOURCES

The CCSDS website at www.ccsds.org is your starting point for more resources like the links in this article. It includes prototype software implementations, lists of vendors for CCSDS-compliant systems, and contacts for each working group and agency. Besides a workshop course from the Space Infrastructure Foundation, there is also a training class on CCSDS protocols that is often available at the Ground Systems Architecture Workshop held in the Los Angeles area in March.

About the Author

Mike Kearney is a volunteer educator with the Space Infrastructure Foundation, the basis for his contribution to this publication. Based in Huntsville, AL, he is also an employee of the Aerospace Corporation and a consultant with Seabrook Solutions, LLC. He retired from NASA in 2015 after a 34-year career, primarily in ground systems development and operations. During Mr. Kearney's last 8 years with NASA, he served as chairman and general secretary of the international CCSDS committee and secretary of ISO's Technical Committee 20 Subcommittee 13.