

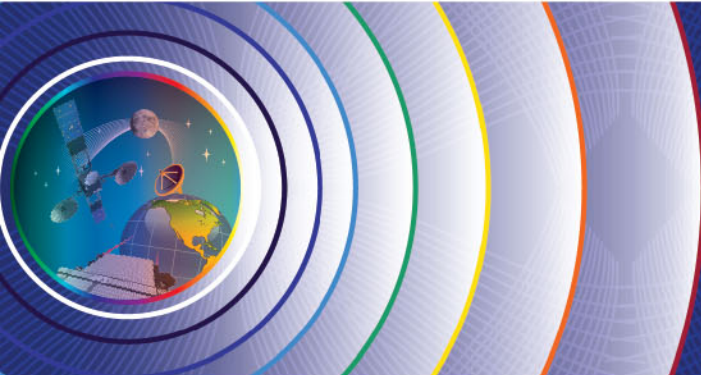
SPACE SPECS :
The CubeSat Revolution

Monday, March 18, 2019
13:00 - 17:00

Hyatt Regency Town Center
Reston, VA, USA (Washington, DC area)



National Aeronautics and
Space Administration



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Standards for the Space Enterprise

The standards are here today and you really don't want to reinvent the wheel



Not that long ago . . .



- Started in 1999 by California Polytechnic State University, San Luis Obispo and Stanford University's Space Systems Development Lab, the CubeSat form-factor standard was designed to increase access to space for university students.

That beginning has revolutionized our access to space.

- Today, CubeSats are being designed by hobbyists, clubs, high schools, NASA and the DoD, and by universities and other organizations around the world.
- The small size has challenged system developers to think creatively, to miniaturize components, develop more efficient ops concepts, and develop new mission designs which take into account the inherent spatial and temporal potential of low-cost constellations of inexpensive satellites.
- Today, standards from the OMG, CCSDS, and others are making the development of CubeSat missions easier and easier and able to meet ever increasing sets of system capabilities.

Simple Survey on Standards and CubeSats:



Responses from simply asking about standards and CubeSats:

- What, why wouldn't they be using standards??!!
- What do you mean? CubeSat is itself a standard.
- I need standards for my CubeSat so I can use the available open source software.
- We follow the standards so I can have my CubeSat dispensed from the Space Station.
- We need the standards the same way the big missions need the standards.
- Well, which standards are you talking about – there are so many for CubeSats.

What we used to hear . . .

- Yuck!
- But my mission is special
- I am in a hurry, I can't do standards

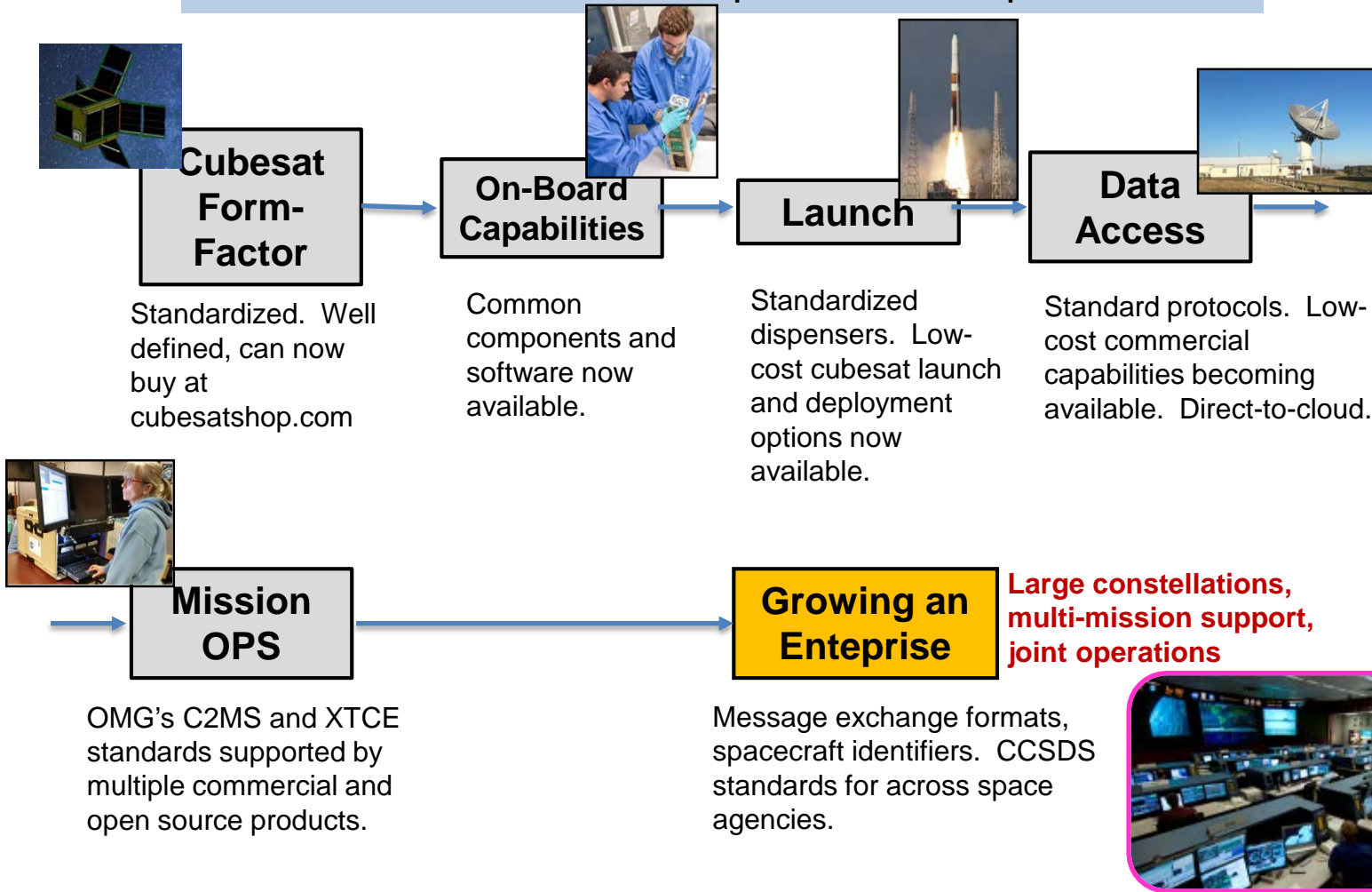


Lunar IceCube. NASA GSFC, JPL Morehead State University, Vermont Tech and Busek Company.

Look How Far We Have Come!



WOW! The industry is evolving rapidly – supported by standards and a now-proven marketplace.



Data Standards for Space Systems



NASA uses standards from many organizations. Specific to space data system standards, the two leading world-wide organizations are the OMG and CCSDS.



Founded in 1989, OMG is driven by vendors, end-users, academic institutions and government agencies covering a broad range of technical areas. Hundreds of member organizations. The Space Domain Task Force was created to clarify space, satellite and ground systems requirements, with a goal to provide a transparent, space-standards development environment that is open to all participants.

Key standards include:

XTCE – XML Telemetry and Command Exchange format to describe a mission's tlm and cmd lists.

C2MS – Command and Control Message Specifications. Formats for the exchange of key interface information for integrating ground system software components.

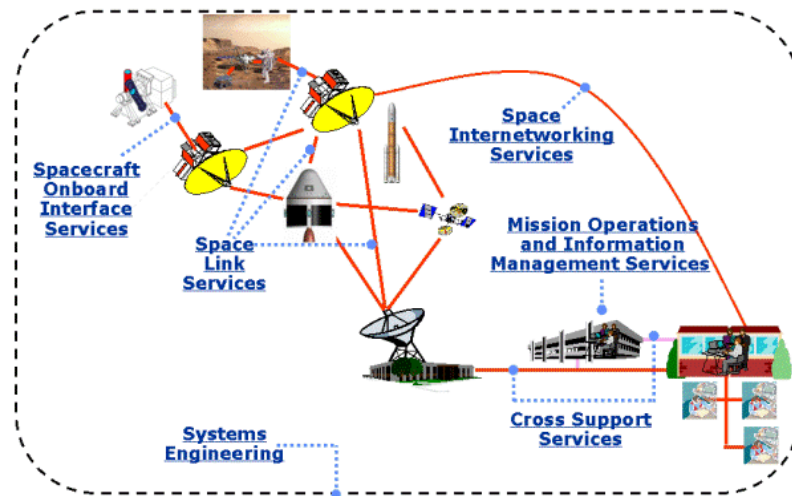
GEMS – Ground Equipment Monitoring Service to allow simplified integration and operations of ground equipment.

SOLM – Spacecraft Operations Language Metamodel to represent spacecraft operations procedures.



Consultative Committee for Space Data Systems

Founded in 1982, now has members from 27 nations. Original focus was on space-ground communications and protocols, but has expanded into data compression, navigation data formats, mission operations interoperability services and more. CCSDS standards have been used on over 900 space missions.



CCSDS Overview

End-to-End Architecture



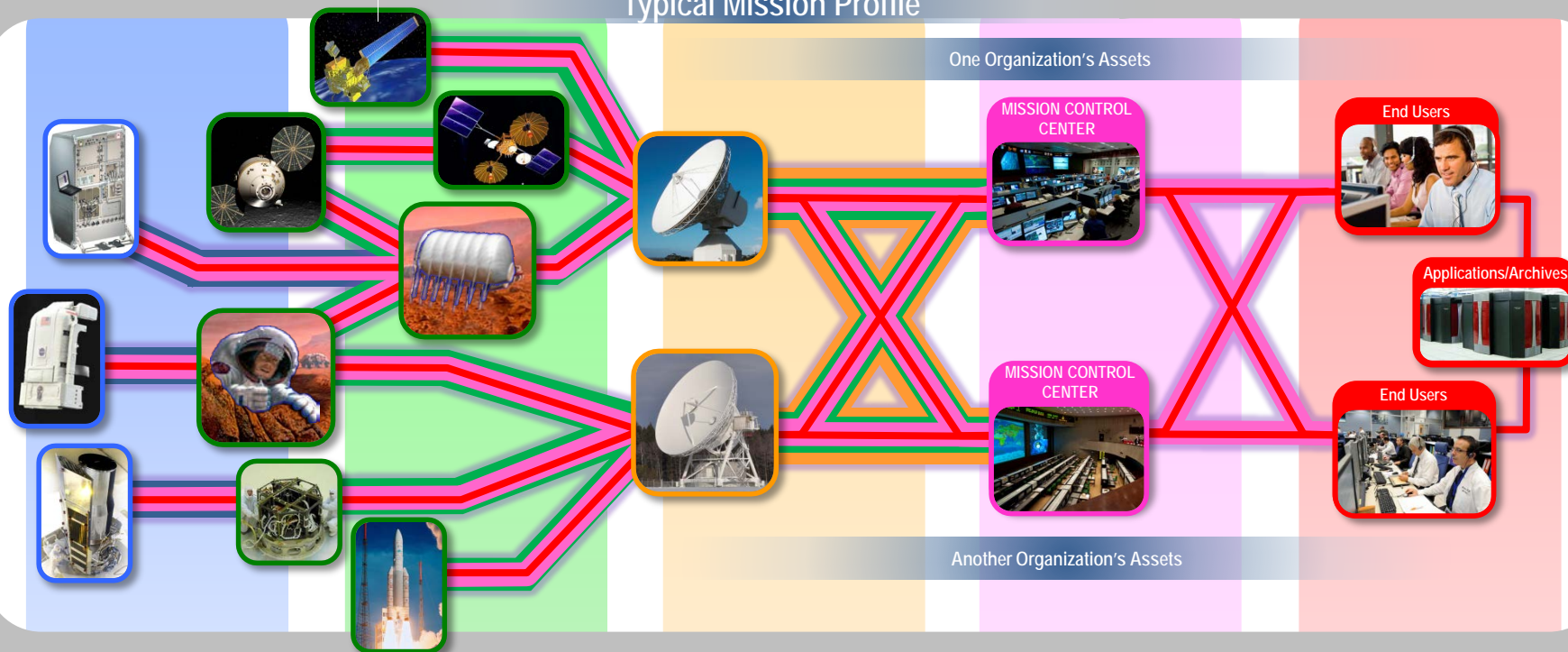
Six Technical Areas, Twenty-Six Teams

- ◆ 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

- ◆ Spacecraft Monitor & Control
- ◆ Navigation
- ◆ Planning and Scheduling
- ◆ Data Archive Ingestion

Moving to an Enterprise



- What happens when we start moving to dozens or hundreds (or even thousands) of small satellites?
- How do I move away from the approach of having teams of human operators assigned to each satellite?

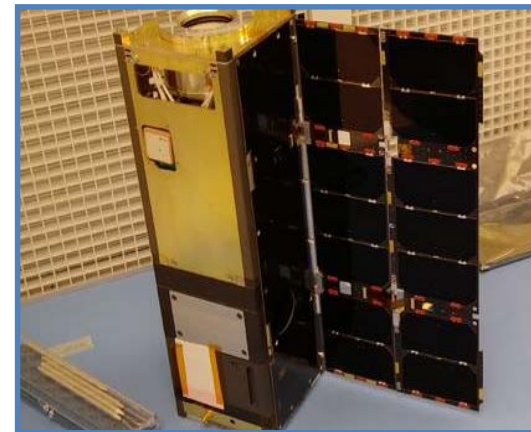
[this can be a huge topic; insert 50 detailed charts here if talk is longer than just a few minutes]

- Short answer notes:
 - Common, well-defined interfaces become even more crucial as we move toward larger enterprise systems.
 - Both CCSDS and the OMG standards address key protocols and message/file formats
 - More data will be exchanged between more organizations using more applications
 - Commercial and open source software products must be multi-satellite aware - many already are
 - New operations concepts must be developed
 - Keep an eye on the commercial sector – they are leading the innovation effort
 - Machine learning and data analytics will begin to play a significant role
 - Many routine functions should no longer require humans sitting on a console
 - New architectures will continue to evolve
 - Open architectures, data sharing, mixed vendor systems
 - Direct-to-cloud ground-station-as-a service
 - Cloud hosting of more and more functions

What Other Standards Do we Need?



- **The answer is up to the community. Let us know.**
- The OMG SDTF has already identified new initiatives
 - CubeSat reference model
 - Standardized vocabulary and ontology
 - Simple display page exchange
 - C2MS expansion
- CCSDS is also addressing specific areas
 - 20+ active working groups
 - How to handle spacecraft identification
 - Standards for planning and scheduling requests and schedule exchanges
 - Mission Operations Service specifications
- Other areas for consideration
 - Licensing – does the government know how to handle thousands of requests?
 - IEEE parts certification for CubeSats



CeREs. NASA GSFC and Southwest Research Institute.

Final Chart - Terminology



reinvent the wheel

informal

to waste time trying to do something that has already been done successfully by someone else

Merriam Webster

Ex: **Building CubeSat missions without standards would be like reinventing the wheel.**

commodity com·mod·i·ty (kə-mŏd'ī-tē)*n. pl. com·mod·i·ties*

1 : an economic good: such as

a : a product of agriculture or mining agricultural commodities like grain and corn

b : an article of commerce especially when delivered for shipment

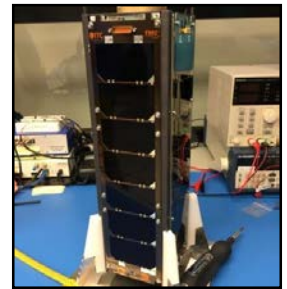
c : a mass-produced unspecialized product commodity; ex. memory chips

2a : something useful or valued: such as patience also : thing, entity

b : convenience, advantage ... the many commodities incidental to the life of a public office

Merriam Webster

Ex: **By following standards, CubeSat structures, launch dispensers, products that support CubeSat fabrication and operations, and services for launch and data access are quickly becoming available as trusted commodities. Users can focus more of their effort on the true mission of their endeavor.**



STF-1. NASA GSFC and West Virginia University.