



PNT Standards:

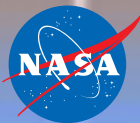
What is being done?

What needs to be done?

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Consultative Committee for Space Data Systems



CCSDS web site: www.ccsds.org

CCSDS & the Navigation Working Group

- CCSDS is closely affiliated with ISO TC20/SC13 (Aircraft & Space Vehicles / Space data & information transfer systems)
- Formed in 1982 by world's major space agencies to provide a forum for discussion of common problems in the development and operation of space data systems
- Composed of 11 member agencies, 28 observer agencies, and over 140 industrial associates
- Creates recommendations for data and information-systems standards to promote interoperability and cross support
- Org chart: <http://public.ccsds.org/sites/cwe/default.aspx>
- 6 general “Areas” partitioned into over 25 smaller groups
- Navigation WG charter is to produce recommendations related to the formatting and exchange of flight dynamics data
- Navigation WG has had regular participation from CNES, DLR, ESA, JAXA, NASA (JPL, GSFC, JSC), ISO TC20/SC14

CCSDS Standards Development Process

- A “Concept Paper” suggests a need for standardization
- Working Group chartered to develop Recommendation
- Working Group develops material (iterative process)
- Recommendation documents go through several stages: Proposed (“White”), Draft (“Red”), Final (“Blue”)
- White Books are internal to the Working Group
- When White Book matures, promotion to Red Book
- Formal Agency Review process commences (2-3 months)
- When Agency Review is passed, prototyping is complete and test reports filed, promotion to Blue Book occurs
- Entire process can take 4 to 5 years or longer
- ISO standards process entered at advanced stage (DIS/FDIS)
- Blue Books have 5 year reconfirmation review, may be retired
- Retired Blue Books are called “Silver”, no longer normative

Navigation Working Group Technical Program

“Color Coded”

- Published Standards
 - [Orbit Data Messages \(ODM\)](#) (5 year revision commencing)
 - [Tracking Data Message \(TDM\)](#) (5 year revision ongoing)
 - [Attitude Data Messages \(ADM\)](#) (5 year revision ongoing)
 - [Conjunction Data Message \(CDM\)](#)
 - [Navigation Data Messages / XML Specification](#)
- Standards in Progress
 - Pointing Request Message (PRM, White Book)
 - Navigation Hardware Message (NHM, White Book)
 - Spacecraft Maneuver Message (SMM, White Book)
- Standards “In Planning”
 - Events Message (EVM, Concept Paper)
 - Spacecraft Perturbations Message (SPM, Concept Paper)
 - Spacecraft Re-Entry Message (SREM, 5 Year Plan Item)

Orbit Data Messages (ODM)

CCSDS 502.0-B-2, ISO 26900:2012

- Three standard message formats for exchanging orbit descriptions
- Orbit Parameter Message (OPM) is a state vector
 - Position/velocity at epoch; must propagate
- Orbit Mean Elements Message (OMM) is an orbit state
 - Mean Keplerian elements; must propagate
- Orbit Ephemeris Message (OEM) is an ephemeris
 - Position/velocity at multiple epochs; must interpolate
- Infusion Status: Orbit Data Messages are used in daily operations in several space agencies (NASA (DSN, CARA), ESA, ISRO), JSpOC, and the Space Data Center (SDC)
- Next Steps: A number of revisions based on the 5 Year Review are being evaluated

Tracking Data Message (TDM)

CCSDS 503.0-B-1, ISO 13526:2010

- Standard message format for exchanging tracking data
- Message format for exchanging tracking data (uplink/downlink frequencies, range, angles, Δ DOR, ancillary information (e.g., meteorological, ionosphere/troposphere delays, clock bias, clock drift))
- Infusion Status: in progress or complete at ESA, NASA/JPL, JHU/APL, ISRO, DLR
- Next Steps: A number of revisions based on the 5 Year Review are being evaluated

Attitude Data Messages (ADM)

CCSDS 504.0-B-1, ISO 13541:2010

- Two standard message formats for exchanging spacecraft attitude descriptions
- Attitude Parameter Message (APM) is an attitude state at epoch, must be propagated
- Attitude Ephemeris Message (AEM) specifies a series of attitude states at multiple epochs, allows modelling of any number of torques, must be interpolated
- Infusion Status: ESA data distribution system, NASA/GSFC MMS, JWST
- Next Steps: A number of revisions based on the 5 Year Review are in progress

Conjunction Data Message (CDM)

CCSDS 508.0-B-1, ISO 19389:2014

- Format for transmission of conjunction assessment data that will warn spacecraft operators of pending close approaches between their spacecraft and another spacecraft or on-orbit debris
- Provides information for satellite operators to use to make decisions regarding whether and how to maneuver in order to avoid in-space collisions
- Infusion Status: JSpOC has fully implemented the CDM; it is their primary means on notifying an operator of a conjunction assessment. CDMs are read by the NASA/CARA (Conjunction Assessment Risk Analysis) process. Also used at CNES and the SDC.

Navigation Data Messages/XML Specification

CCSDS 505.0-B-1, ISO 17107:2011

- Describes an integrated XML schema set for encoding the ODM, TDM, CDM, and ADM
- No different flight dynamics related information... simply re-formats the messages defined in the underlying standards
- Next Steps: A number of XML schema revisions based on the upcoming 5 Year Review are contemplated (“qualified” vs. “unqualified” schemas, namespace revision)

CCSDS Navigation WG Standards In Progress

- Pointing Requests Message (PRM) CCSDS 509.0-W-xx
 - Message formats for formally representing pointing requests for spacecraft instruments, onboard antennas, etc.
 - ESA prototype in use on ROSETTA mission
- Navigation Hardware Message (NHM) CCSDS 510.0-W-xx
 - Message formats for exchange of navigation hardware data including attitude and navigation sensor data, actuator data, and data produced by the onboard GN&C system
 - Data is required to produce history or prediction of spacecraft attitude and/or position/velocity
- Spacecraft Maneuver Message (SMM) CCSDS 511.0-W-xx
 - Message formats for exchanging predicted/reconstructed maneuver info
 - Intentional changes to orbit/attitude using spacecraft actuators
 - Current plan covers 3 messages (1 each for planning, design, and analysis) to be produced over 2 Blue Book issues
- Publication date for all planned for 2017 (perhaps optimistic!)

CCSDS Navigation WG Standards “In Planning”

- The following projects are on the “to do list” for the CCSDS Navigation Working Group
- List is in “relative reality” order (as of 01/2015)
- Events Message (EVM): formats for exchanging information regarding predicted orbital events that describe when and how some satellite related phenomena (e.g., occultation, eclipse)
- Spacecraft Perturbation Message (SPM): formats for exchanging information regarding forces/torques that perturb spacecraft orbit/attitude (predicted or measured)
- Satellite Re-Entry Message (SREM): formats for exchanging information regarding satellites re-entering Earth atmosphere

Other Developers of Space Standards

ISO TC20/SC14: Aircraft & space vehicles/Space systems & operations

- ISO/PRF 16164: Disposal of satellites operating in or crossing Low Earth Orbit
- ISO/DIS 16679.2: Relative motion analysis elements after LV/ SC Separation
- ISO 18197: Space based services requirements for centimetre class positioning
- ISO 23339:2010: Unmanned spacecraft -- Estimating the mass of remaining usable propellant
- ISO 24113:2011: Space debris mitigation requirements
- ISO 26872:2010: Disposal of satellites operating at geosynchronous altitude
- ISO 27852:2011: Estimation of orbit lifetime
- ISO 27875:2010: Space systems -- Re-entry risk mgmt for unmanned spacecraft and launch vehicle orbital stages

Other Developers of Space Standards

ECSS: European Cooperation for Space Standardization

- Initiated to harmonize requirements from existing Standards for space projects, and to provide a single, coherent set of standards for use in all European space system development and operation
- Goal: develop a common set of consistent standards for hardware, software, information and activities to be applied in space projects, so that life cycle costs are minimized, while quality, functional integrity, reliability and compatibility are improved
- ECSS-E-ST-60-30C: Satellite attitude and orbit control system (AOCS) requirements
- ECSS-E-ST-10-09C - Reference coordinate system

Other Developers of Space Standards

AIAA – American Institute of Aeronautics and Astronautics

- AIAA is accredited by the American National Standards Institute and manages a wide range of national aerospace standards publications and activities
- Several active Committees on Standards whose members volunteer their time and expertise
- AIAA also provides Secretariat services for ISO TC20/SC14 and ISO TC20/SC13 and assists CCSDS in development of data- and information-system standards
- ANSI/AIAA S-131-2010: Standard: Astrodynamics - Propagation Specifications, Technical Definitions, and Recommended Practices

Benefits/Drawbacks

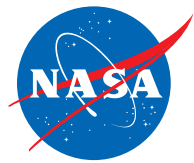
- Benefits of International Standards
 - International Standards bring technological, economic and societal benefits
 - They help to harmonize technical specifications of products and services making operations more efficient and breaking down barriers to international trade/cooperation
 - Important tools to reduce risks and costs, and improve both quality and communication between parties during the preparation and execution of space programs, especially where there is an expectation of interoperability
- Drawbacks
 - It can take a long time to develop an international standard due to built-in process issues, insufficient funding, time between face-to-face meetings, necessity for consensus
 - Working on standards not seen as “sexy”, and requires much patience, so frequent turnover in participants

Perils of Standards Development...

Credit: <http://xkcd.com/927/> "Standards"

HOW STANDARDS PROLIFERATE:
(SEE: A/C CHARGERS, CHARACTER ENCODINGS, INSTANT MESSAGING, ETC)





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