CCSDS Navigation Working Group

David Berry

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Purpose

- Introduce the technical program of the CCSDS Navigation Working Group to new members
- Highlight progress since prior meetings
- Set priorities for current meetings

Agenda

- CCSDS Overview
- Navigation Working Group Overview
- Navigation Working Group Documents
- Q&A

CCSDS & the Navigation Working Group

- CCSDS is an organization which acts as the "principal technical engine of ISO TC20/SC13"

- Develops international standards related to space data

- Organization chart at http://public.ccsds.org/sites/cwe/default.aspx

- CCSDS consists of 6 general "Areas"

- Areas are partitioned into approximately 25 smaller groups called "Working Groups" (WG), "Special Interest Groups" (SIG) and "Birds of a Feather Groups" (BOF)

- Each WG, SIG or BOF is associated with an Area

- NAV WG is part of CCSDS Mission Operations and Information Management Services Area (MOIMS)

- Charter is to produce CCSDS Recommendations related to the formatting and exchange of flight dynamics data

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"), Revised Draft ("Pink")
- 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
- ISO standards process entered at advanced stage (DIS/FDIS)
- "Green Books" are non-normative technical reports
- "Silver Book" is historic, no longer normative
- Blue Books undergo 5 year reconfirmation review
- Revised Blue Books enter a draft stage colored "Pink"

- The CCSDS Navigation Working Group has had regular participation from the following space agency/organizations:
    - CNES
    - DLR
    - ESA
    - JAXA
    - NASA (JPL, GSFC, JSC, GRC)
    - RFSA
    - ISO TC20/SC14   (CCSDS "sister organization")
    - Agencies that have named representatives to the Nav WG, but have not recently participated: ASI
- Other agencies that participate in CCSDS, but are not involved in Navigation WG: UKSA, CSA, INPE, CNSA
- Commercial/military support are sponsored by an agency

Nav WG Documents ("Color Coded")

- Current Work Items
    - Tracking Data Message (TDM) (5 yr revision ongoing)
    - Attitude Data Messages (ADM) (5 yr revision ongoing)
    - Orbit Data Messages (ODM)   (5 yr revision ongoing)
    - Nav Data Messages/XML Spec (5 yr revision pending)
    - Navigation Data - Definitions and Conventions (revision in progress)
    - Navigation Data Messages Overview
    - Pointing Request Message (PRM)
    - Navigation H/W Message (NHM, White Book)
    - Spacecraft Maneuver Message (SMM, White Book)
- Completed Work Items
    - Conjunction Data Message (CDM)
- "On Hold" Work Items
    - Events Message (EVM, Concept Paper)
    - Spacecraft Perturbations Message (SPM, White Book)
    - Several "Draft" Projects and future ideas (RDM, FDM, LDM)

Progress Since Fall 2015 Meetings

- PRM: Red Book was released for Agency Review, Agency Review was completed
- NHM: White Book 15 was distributed, review ongoing
- ODM: Pink Book 2.32 was distributed, review ongoing
- TDM: Pink Book 1.0.3 was distributed, review ongoing
- Navigation Data Messages Overview Green Book: published!
- Navigation Data – Definitions and Conventions Green Book: Draft 3.1.1 distributed, review initiated
- Action Items: 16 of 26 completed (62%... last time 70%), 10 outstanding, 0 cancelled
- NOTE
  - Spring 2014 to Fall 2014: 224 days
  - Fall 2014 to Spring 2015: 133 days
  - Spring 2015 to Fall 2015: 226 days
  - Fall 2015 to Spring 2016: 143 days
  - Spring 2016 to Fall 2016: 206 days

Spring 2016 Meeting Objectives

- Complete disposition of RIDs from Agency Review of PRM Red Book, initiate discussion of prototyping
- Continue discussion of ODM Pink Book
- Continue discussion of TDM Pink Book
- Continue discussion of Green Book Version 4 update
- Continue discussion of ADM Pink Book
- Find new Lead Editor for NHM
- Continue discussion of future standardization topics
- Complete Boot Camp for new/potential document editors
- Complete joint meetings with CSS/SM WG and CSS/CSTS WG
- Continue support of discussions with SANA Steering Group and XML SIG

1. Kyohei Akiyama
2. David Berry
3. Dale Force
4. Cheryl Gramling
5. Alain Lamy
6. Byoung-Sun Lee
7. Dmitry Marareskul
8. Fran Martinez
9. Dan Oltrogge
10. Juan Carlos Raymond
11. Patrick Zimmerman

- For various reasons, several participants from Fall 2015 are not able to participate in Spring 2016

Useful Web Sites/Contacts

- Web Sites
  - www.ccsds.org – general web site of the CCSDS
  - http://cwe.ccsds.org/moims/default.aspx , then choose the "MOIMS-NAV" tab on the far left menu
    - Select 'Marketing Materials' from the menu for various papers and presentations on the use of CCSDS Nav WG standards
- E-mail Address
  - moims-nav@mailman.ccsds.org (general traffic)
  - moims-nav-exec@mailman.ccsds.org (WG internal)

Q&A

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Backup Slides

Navigation Data - Definitions & Conventions

- Contains technical material related to the Navigation Working Group Recommendations
- Non-normative document
- Has a different development process (all internal to the working group, with CESG approval)
- Work started early in the history of the Navigation WG
- Most recent edition (3.0) was published 05/2010
- Green Book 4.0 project recently approved; first draft of update has been distributed
- Next steps: Complete version 4.0 update

- Contains high level overview of and use cases for Navigation Working Group Recommendations
- Originally intended to be "Volume 2 of existing Navigation Green Book"; AD suggested just having 2 different Green Books (a simpler approach)
- Non-normative document
- Has a different development process (all internal to the WG, with CESG approval)
- Initiated at Berlin meetings Spring 2011
- CESG Poll currently in progress
- Published December 2015
- Next steps: Revise upon publication of PRM

Attitude Data Messages (ADM) (ADM)

- 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
- Work started ~2003, became Blue Book 05/2008 (ISO Standard 13541:2010), currently being revised as result of 5 Year Review
- Infusion Status: in daily use at NASA/GSFC, ESA
- Other Desirable Work: further agency infusion
- Next Steps: Complete 5 Year Revisions, initiate Agency Review

Conjunction Data Message (CDM)

- Standard message formats 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
- Also, to provide information for satellite operators to use to make decisions regarding whether and how to maneuver in order to avoid space collisions
- Added to Charter/approved for development in Fall 2010
- Deliverable: Blue Book and schema based on the "Conjunction Assessment Message" Concept Paper
- First White Book January 2011, became Blue Book June 2013, ISO/DIS 19389
- Infusion Status: JSpOC, NASA/CARA, SDC, others?
- Next Steps: 5 Year Review in 2018

Events Message (EVM)

- Standard message formats for exchanging information regarding predicted orbital events
- Orbital events describe when and possibly how some situations occur (generally related to a satellite) and constitute a major data type used in operations centers
- Proposed at Colorado Springs Spring 2009, Concept Paper Fall 2010, added to Nav WG Charter Spring 2011
- Work item in Charter approved December 2011
- Deliverable: Blue Book based on the "Events Message" Concept Paper
- First White Book forthcoming
- NOTE: Interest in this document by CSS/SM WG and CCSDS System Engineering Area (SEA)
- Next steps: On hold while CSS/SM effort progresses

Navigation Data Messages/XML Spec (NDM/XML)

- Describes an integrated XML schema set for encoding the ADM, ODM, and TDM
- Compatible with ODM 1.0, ODM 2.0, ADM 1.0, CDM 1.0, TDM 1.0
- Draft schemas compatible with NHM W.14
- Directive to put Navigation WG Recommendations into XML format came from CMC ~2002
- Work started 05/2004, became Blue Book 12/2010 (ISO Standard 17107:2011)
- First "approved" registry in the SANA Registry
- Other Desirable Work: Agency infusion
- Next Steps: 5 Year Revisions ("qualified" vs. "unqualified" schemas, namespace revision, oemType changes)

Navigation Hardware Message (NHM)

- Standard message formats for exchange of navigation hardware data
- Data includes attitude & navigation sensor data, actuator data, and data produced by the onboard GN&C system
- This data is required to produce history or prediction of the spacecraft attitude (orientation) and/or orbit trajectory (position and velocity)
- The transmission of these messages from the telemetry unpacking entity to the navigators is a key element factored into spacecraft navigation solutions
- Proposed at Berlin Fall 2008, Concept Paper Spring 2010
- Added to Charter Spring 2010, and approved for development early in Fall 2010
- First White Book Spring 2011, current issue is WB15
- Next steps: Assign new Lead Editor, complete White Book drafting; Agency Review

Orbit Data Messages (ODM) (ODM)

- Three standard message formats for exchanging orbit descriptions (currently adding 4th)
- Orbit Parameter Message (OPM) is a state vector
  - Position/velocity at epoch; must propagate
- Orbit Ephemeris Message (OEM) is an ephemeris
  - Position/velocity at multiple epochs; must interpolate
- Orbit Mean Elements Message (OMM) is an orbit state
  - Mean Keplerian elements; must propagate
- Orbit Comprehensive Message (OCM) is a comprehensive message designed to contain much more detailed info
- Work started ???, became CCSDS Blue Book V.1 09/2004 (ISO Standard # 22644 01/2006), CCSDS Blue Book V.2 11/2009 (ISO Standard #26900:2012), currently in revision
- Infusion Status: Orbit Data Messages are used in daily ops
- Next Steps: Complete 5 Year revisions, Agency Review

Pointing Request Message (PRM)

- Standard message formats for transmission of pointing requests in formal language
- Reduces "common language" pointing request errors
- The requested pointing could be a pointing of a spacecraft instrument or of an onboard-antenna, within the future attitude sequence of the specified spacecraft
- PRM identifies spacecraft, onboard instrument, various constraints and rates, applicable epochs, and other descriptive metadata
- Proposed at Berlin Fall 2008, Concept Paper Fall 2009
- Added to Charter Fall 2009, and approved for development in Spring 2010
- First White Book Spring 2011, current issue Red Book
- Next steps: complete Agency Review RID dispositioning, initiate prototyping

Spacecraft Maneuver Message (SMM)

- Standard message formats for exchanging information regarding maneuver summary information
- Data exchange involves both predicted and reconstructed information related to intentional changes to the spacecraft orbit and attitude using spacecraft actuators (initial focus on thrusters, other actuators later)
- Current design covers 3 messages, one each for maneuver planning, design, and analysis
- Proposed at Berlin Fall 2008, Concept Paper Fall 2010, added to Nav WG Charter in Spring 2011
- Work item in Charter approved December 2011
- Deliverable: Blue Book based on the "Spacecraft Maneuver Message" Concept Paper
- First White Book April 2012, current issue stalled
- Next steps: Complete White Book drafting (or eliminate?)

Spacecraft Perturbations Message (SPM)

- Standard message formats for exchanging information regarding forces/torques that perturb spacecraft orbit/attitude
- SPM identifies the spacecraft, perturbing source, the magnitudes of the perturbations at epoch, and other descriptive metadata
- Can be used to provide predicted or measured values
- Proposed at Berlin Fall 2008, Concept Paper Spring 2009, Initial White Book draft Fall 2009
- De-emphasized of late to due emphasis on NDM/XML, CDM, and potential document overlap issues in Nav WG (potential overlaps with SMM, NHM, and EVM)
- Next steps: "On hold"... re-evaluate need after publication of NHM (and SMM?)

Tracking Data Message (TDM) (TDM)

- Standard message format for exchanging tracking data
- TDM supports widely used tracking data types:
  - Ground-based radiometrics: Doppler, range, angle, Delta-DOR
  - Ancillary information (e.g., meteorological, media delays, clock bias/drift)
- Work started 10/2003, became Blue Book 11/2007, Corrigenda published 09/2010, ISO 13526:2010, currently in revision
- Infusion Status: in progress or complete at ESA, NASA/JPL, JHU/APL, ISRO, DLR
- Current issue is Pink Book 1.0.3
- Next Steps: Complete 5 Year Revisions (hopefully before Fall 2016 Meetings), initiate Agency Review