CCSDS Navigation Working Group

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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 23 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 occurs
- 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)
- Blue Books have 5 year review (reconfirm/retire/revise)
- Revised Blue Books enter a draft stage colored “Pink”
- Retired books are “Silver” (historic, no longer normative)
- “Green Books” are non-normative technical reports

Navigation WG Participating Membership

- The CCSDS Navigation Working Group has had regular participation from the following space agency/organizations:
  - CNES
  - DLR
  - ESA
  - JAXA
  - NASA (JPL, GSFC, JSC, GRC)
  - ISO TC20/SC14 (CCSDS "sister organization")
  - RFSA
  - Agencies that previously 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
  - Attitude Data Messages (ADM) (Version 2 revisions ongoing)
  - Orbit Data Messages (ODM) (Version 3 revisions ongoing)
  - Tracking Data Message (TDM) (Version 2 revisions ongoing)
  - Nav Data Messages/XML Spec (Version 2 revisions ongoing)
  - Navigation Data - Definitions and Conventions (Ver 4 revisions)
  - Pointing Request Message (PRM)
  - Navigation H/W Message (NHM, White Book) ????
  - Re-Entry Data Message (RDM, White Book)
  - Events Message (EVM, Brand New Project, "virtual" White Book)
- Completed Work Items
  - Conjunction Data Message (CDM)
  - Navigation Data Messages Overview
- "On Hold" Work Items
  - Several "Draft" Projects and future ideas (FDM, LDM)
- Recently Deleted Work Items
  - Spacecraft Maneuver Message (SMM, White Book)
  - Spacecraft Perturbations Message (SPM, White Book)

Lead Editors

- Attitude Data Messages (ADM): Alain, Julie
- Conjunction Data Message (CDM): N/A
- Events Message (Events Data Message?): Alain
- Navigation Data - Definitions & Conventions: Dale
- Navigation Data Messages Overview: Dale?
- Navigation Data Messages – XML Spec (NDM/XML): David
- Navigation Hardware Message (NHM): Julie
- Orbit Data Messages (ODM): Dan
- Pointing Requests Message (PRM): Fran
- Re-Entry Data Message (RDM): Alexandru
- Tracking Data Message (TDM) Version 2: David
- Tracking Data Message (TDM) Version 3: Cheryl

Progress Since Spring 2017 Meetings

- ADM: Version P1.5 published
- EVM: Project approved
- Navigation Data – Definitions and Conventions Green Book: Intro format chosen
- NDM/XML Spec: schema revisions uploaded to SANA
- NHM: On hold
- ODM: Review of Version P2.36 completed
- PRM: Resolution to publish issued, ESOC concerns addressed
- RDM: White Books 4, 5, 6 published
- TDM: Version P1.0.5 published
- SANA: Proposed material for time systems, reference frames, element sets, and navigation definitions/info were developed
- Action Items: 29 of 40 completed (72.5%... last time 78%), 11 outstanding (27.5%), 0 cancelled (0%)
- NOTE
  - Spring to Fall Duration (days, 2014-2016): 224, 226, 190, 176
  - Fall to Spring Duration (days, 2014-2017): 133, 143, 199

Fall 2017 Meeting Objectives

- Continue discussion of ODM Pink Book
- Continue/expand discussion of material on SANA
- Continue discussion of RDM White Book, Request Agency Review (AR)
- Continue discussion of TDM Pink Book, Request AR
- Complete decision on future direction for NHM
- Continue discussion of Green Book Version 4 update, resolve Glossary content question; Request CESG Approval to Publish
- Continue discussion of ADM Pink Book
- Initiate discussion of EVM requirements (and rename)
- Continue progress toward "Navigation Data Message"
- NOT Objectives:
  - Boot Camp (time conflict on Thursday AM)
  - SANA Steering Group (time conflict, Thursday PM)

Spring 2017 Registered Participants

1. Kyohei Akiyama
2. David Berry
3. Dale Force
4. Cheryl Gramling
5. Ralph Kahle
6. Alain Lamy
7. Alexandru Mancas
8. Dmitry Marareskul
9. Fran Martinez
10. Dan Oltrogge
11. Julie Halverson
12. Patrick Zimmerman

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 (pre-2000)
- Most recent edition (3.0) was published 05/2010
- Current issue is draft 3.4
- Green Book 4.0 project in progress; four drafts of updates have been distributed
- Next steps: Complete version 4.0 update

Navigation Data Messages Overview

- 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
- Published 12/2015
- 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
- Current issue is Pink Book 1.5
- Infusion Status: in daily use at NASA/GSFC, ESA
- Other Desirable Work: further agency infusion
- Next Steps: Complete version 2 revisions (including "ACM"?), 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
- Project approved August 2017
- Deliverable: Blue Book based on the “Events Message” Concept Paper
- NOTE: Interest in this document by CSS/SM WG and CCSDS System Engineering Area (SEA)
- Next steps: Define requirements, define events, first White Book

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, RDM W.4
- 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), currently being revised as result of 5 Year Review (but progress is slow)
- Was first "approved" registry in the SANA Registry
- Other Desirable Work: Agency infusion
- Next Steps: Version 2 revisions ("qualified" vs. "unqualified" schemas, namespace revision, oemType changes, removal of material moved to other messages)

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: Determine if the NHM can be a viable standard

Orbit Data Messages (ODM) (ODM)

- Four standard message formats for exchanging orbit descriptions
- 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
- Current issue is Pink Book 2.36
- Infusion Status: Orbit Data Messages are used in daily ops
- Next Steps: Complete Version 3 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: Publish document!

Re-Entry Data Message (RDM)

- The Re-entry Data Message (RDM) specifies a standard message format to be used in the exchange of spacecraft (re-)entry information between Space Surveillance and Tracking (SST) data providers, satellite owners/operators and other parties.
- These messages can be used to inform spacecraft owners/operators of predicted re-entries or warn civil protection agencies about potential ground impacts.
- Concept Paper January 2016
- Approved for development/added to Charter in June 2016
- Deliverable: Blue Book and schema based on the “Re-Entry Data Message” Concept Paper
- First White Book August 2016, current version is WB6
- Next Steps: Complete White Book, conduct Agency Review

Tracking Data Message (TDM) (TDM)

- Standard message format for exchanging tracking data
- TDM supports widely used tracking data types:
  - 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 being revised as result of 5 Year Review
- Infusion Status: in progress or complete at ESA, NASA/JPL, JHU/APL, ISRO, DLR
- Current issue is Pink Book 1.0.5
- Next Steps: Complete Version 2 revisions, initiate Agency Review, publish document, re-open content discussions for TDM V3