CCSDS Navigation Working Group

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09-Apr-2018
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
- CCSDS consists of 6 general “Areas”
- Areas are partitioned into 23 smaller groups called “Working Groups” (WG). Also, “Special Interest Groups” (SIG) & “Birds of a Feather Groups” (BOF) (but none now)
- 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
  - UKSA
- 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: 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)**
  - Re-Entry Data Message (RDM, White Book=>Red Book)
  - Navigation Events Message (NEM, "virtual" White Book)
- **Completed Work Items**
  - **Pointing Request Message (PRM)**
  - **Conjunction Data Message (CDM)** (5 Year Review this mtg)
  - **Navigation Data Messages Overview** (update upcoming soon)
- **“On Hold” Work Items**
  - Several “Draft” Projects and future ideas (FDM, LDM)
- **Recently Deleted Work Items**
  - Navigation Hardware Message
Lead Editors

- Attitude Data Messages (ADM): Alain, Julie
- Conjunction Data Message (CDM): N/A
- Navigation Events Message: Alain
- Navigation Data - Definitions & Conventions: Dale
- Navigation Data Messages Overview: David
- Navigation Data Messages – XML Spec (NDM/XML): David
- 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 Fall 2017 Meetings

- ADM: Version P1.6 published
- Navigation Data – Definitions and Conventions Green Book: Version 3.5 published
- Navigation Data Messages Overview: Update approved
- ODM: Version P2.37 published
- PRM: Blue Book published
- RDM: White Book 7 published, Secretariat Document processing, CESG Poll for Agency Review
- TDM: Version P1.0.6 published, Secretariat Document processing, CESG Poll for Agency Review
- SANA: Material for time systems, reference frames, element sets, orbit centers, navigation definitions/info refined, meeting with SANA Operator, "mockup" of SANA registry produced
- CDM: Progress towards deleting "CDM Originator" registry
- Action Items: 24 of 42 completed (57%... last time 72.5%), 18 outstanding (43%), 0 cancelled (0%)

**NOTE**
- Spring to Fall Duration (days, 2014-2017): 224, 226, 190, 176
- Fall to Spring Duration (days, 2014-2018): 133, 143, 199, 151
Spring 2018 Meeting Objectives

• Continue discussion of ODM Pink Book
• Continue discussion of material on SANA, meet w/SANA Operator
• Initiate discussion of RDM Test Plan
• Initiate discussion of TDM Test Plan
• Continue discussion of Green Book Version 4 update, Request CESG Approval to Publish(?)
• Continue discussion of ADM Pink Book, new ACM material
• Continue discussion of NEM requirements
• Continue progress toward "Navigation Data Message KVN"
• Initiate/Complete CDM 5 Year Review
• Initiate new project for Navigation Data Message Overview
• Other Possible Objectives:
  • Boot Camp (however, time conflict Friday AM)
  • SANA Steering Group (however, time conflict Friday PM)
Spring 2018 Registered Participants

1. David Berry
2. Frank Dreger
3. Cheryl Gramling
4. Julie Halverson
5. Alain Lamy
6. Alexandru Mancas
7. Fran Martinez
8. Dan Oltrogge
9. Brian Swinburne
10. Patrick Zimmerman
Useful Web Sites/Contacts

- Web Sites
  - [www.ccsds.org](http://www.ccsds.org) – general web site of the CCSDS
  - [http://cwe.ccsds.org/moims/default.aspx](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](mailto:moims-nav@mailman.ccsds.org) (general traffic)
  - [moims-nav-exec@mailman.ccsds.org](mailto:moims-nav-exec@mailman.ccsds.org) (WG internal)
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
- Green Book 4.0 project in progress; current issue is draft 3.5
- 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 (project essentially approved... CMC Poll closed 04/04/2018 with unanimous vote to "Adopt")
Attitude Data Messages (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 1.6
- 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

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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.
- Infusion Status: JSpOC, NASA/CARA, SDC, CNES, others?
Navigation Events Message (NEM)

- 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, SANA Registry of Events
- 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) (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 schema compatible with RDM W.6
- 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)
Orbit Data Messages (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
- Current issue is Pink Book 2.37
- 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, Blue Book 02/2018
- Next steps: Agency infusion
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, final version is WB7
Next Steps: conduct Agency Review, prototyping
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)
- Infusion Status: in progress or complete at ESA, NASA/JPL, JHU/APL, ISRO, DLR
- Current issue is Pink Book 1.0.6, submitted to Secretariat
- Next Steps: Complete Version 2 revisions, initiate Agency Review, publish document, re-open content discussions for TDM V3