CCSDS Navigation Working Group

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Purpose

- Introduce the CCSDS Navigation Working Group and its technical program 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 https://cwe.ccsds.org/default.aspx
- CCSDS consists of 6 general “Areas”
- Areas are partitioned into 23 smaller groups called “Working Groups” (WG), “Special Interest Groups” (SIG), or “Birds of a Feather Groups” (BOF). Currently no SIGs or BOFs.
- 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 (In Brief)

- A "Concept Paper" suggests a need for standardization
- A Working Group is chartered to develop Recommendation
- Working Group develops material (an iterative process)
- Recommendation documents go through stages: Proposed (White), Draft (Red), Final (Blue), Revised Draft (Pink)
- White Books are internal to the Working Group
- When a 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 standard process entered at advanced stage(DIS/FDIS)
- Blue Books have 5 year review (reconfirm/retire/revise)
- Blue Books being revised enter a draft stage colored Pink
- Retired books are Silver (historic, no longer normative)
- Green Books are non-normative technical reports
- Other colors in CCSDS spectrum (Yellow, Orange, Magenta)

Navigation WG Participating Membership

- The CCSDS Navigation Working Group has had regular participation from the following space agency/organizations:
  - CNES
  - DLR
  - ESA
  - ETRI
  - JAXA
  - NASA (JPL, GSFC, JSC)
  - Roscosmos State Corporation for Space Activities
  - UKSA
  - ISO TC20/SC14 (CCSDS "sister organization")
  - 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 and/or military support is sponsored by an agency

Nav WG Documents ("Color Coded")

- Current Work Items
  - Attitude Data Messages (ADM) (V.2 in progress)
  - Conjunction Data Message (CDM) (V.2 in progress)
  - Navigation Data Messages/XML Spec (V.2 in progress)
  - Orbit Data Messages (ODM) (V.3 in progress)
  - Tracking Data Message (TDM) (V.2 in progress, V.3 starting)
  - Navigation Data - Definitions & Conventions (V.4 in progress)
  - Navigation Data Messages Overview (V.2 in progress)
  - Re-Entry Data Message (RDM) (nearly Blue)
  - Navigation Events Message (NEM, White Book in progress)
- Completed Work Items
  - Pointing Request Message (PRM) (published Feb 2018)
- "On Hold" Work Items
  - Several "Draft" Projects and future ideas (FDM, LDM)

Lead & Co-Editors for Works In Progress

- Attitude Data Messages (ADM): Alain, Julie
- Conjunction Data Message (CDM): Brian, Dan
- Navigation Data - Definitions & Conventions: Cheryl
- Navigation Data Messages Overview: Patrick
- Navigation Data Messages – XML Spec (NDM/XML): David
- Navigation Events Message: Alain, Fran
- Orbit Data Messages (ODM): Dan
- Re-Entry Data Message (RDM): Alexandru
- Tracking Data Message (TDM) Version 2: David
- Tracking Data Message (TDM) Version 3: Cheryl

Progress Since Spring 2019 Meetings

- ADM: Version P1.8 completed internal review
- CDM: Meeting with producers/customers/stakeholders
- Navigation Data – Definitions & Conventions Green Book: Submitted to Secretariat, completed CESG Poll
- Navigation Data Messages Overview: Submitted to Secretariat, ready for CESG Poll
- NDM/XML: Version 1 Schemas Revision C created
- NEM: No significant progress
- ODM: Version P2.39 nearing completion
- RDM: Submitted to Secretariat, completed CESG Poll
- TDM: P1.3 and P1.4 (SANA updates) distributed; Prototyping continues
- SANA: 7 of 8 original registries in place; those required for RDM "Approved"
- Action Items: 37 of 62 completed (60%... last time 54%), 23 outstanding (37%), 2 cancelled (3%)

Fall 2019 Meeting Objectives

- ADM: Continue discussion of Pink Book, new ACM material
- CDM: Continue discussions of potential changes
- Navigation Data Messages Overview: Wait for CESG Poll
- Navigation Data – Definitions & Conventions: Resolve CESG Poll conditions
- NDM/XML: Continue discussion of Pink Book
- NEM: Continue discussion of infrastructure
- ODM: Continue discussion of any outstanding issues, prepare for prototyping
- RDM: Resolve CESG Poll conditions; celebrate completion
- TDM V.2: Continue discussion of prototyping Test Plan/Rpt
- TDM V.3: Continue discussion of desired new features
- SANA: Meet w/SANA Operator representative, continue discussion of material migration to SANA

Fall 2019 Participants

1. David Berry
2. Frank Dreger
3. Tim Flohrer
4. Cheryl Gramling
5. Julie Halverson
6. Hideaki Hinagawa
7. Ralph Kahle
8. Alain Lamy
9. Stijn Lemmens
10. Alexandru Mancas
11. Fran Martinez
12. Klaus Merz
13. Dan Oltrogge (via telecon)
14. Vincent Schaefer
15. Brian Swinburne
16. 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
    - All draft documents available, archived drafts too
    - 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)
  - Do NOT use one that has "bounces" in the name

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)
- 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; most recent draft completed CESG Poll (with conditions) 10/2019
- Next steps: Resolve CESG Poll conditions, complete CMC Poll, Publish version 4.0!!!

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)
- Initiated at Berlin meetings Spring 2011
- Published 12/2015
- Green Book 2.0 project in progress; current issue ready for CESG Poll
- Next steps: Complete CESG Poll, CMC Poll, publish Version 2.0 update

Attitude Data Messages (ADM) (ADM)

- Three 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
- Attitude Comprehensive Message (ACM), new message analogous to ODM's "Orbit Comprehensive Message"
- Work started ~2003, became Blue Book 05/2008 (ISO Standard 13541:2010), currently being revised as result of 5 Year Review, ACM to be added
- Current issue is Pink Book 1.8
- Infusion Status: in daily use at NASA/GSFC, ESA
- Next Steps: Complete V.2 revisions, do Agency Review

Conjunction Data Message (CDM) (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 provides 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
- First White Book January 2011, became Blue Book June 2013 (CCSDS record?), ISO/DIS 19389
- Infusion Status: CSpOC, NASA/CARA, SDC, CNES, others?
- Next Steps: Complete V.2 revisions, do Agency Review

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
- Deliverables: 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: Complete first White Book, XML infrastructure

Navigation Data Messages/XML Spec (NDM/XML) (NDM/XML)

- Directive to put Navigation WG Recommendations into XML format came from CMC ~2002
- 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, RDM 1.0, TDM 1.0
- Work started 05/2004, became Blue Book 12/2010 (ISO Standard 17107:2011), currently being revised as result of 5 Year Review
- Was first "approved" registry in the SANA Registry
- Other Desirable Work: Agency infusion
- Next Steps: Complete Version 2 revisions ("qualified" vs. "unqualified" schemas, namespace revision, oemType changes, consolidation of "common" schemas), do Agency Review

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 2.38 (P2.39 imminent)
- 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 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, approved for development in Spring 2010
- First White Book Spring 2011, Blue Book 02/2018
- Next steps: Agency infusion (being used by MOIMS/Mission Planning WG)

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 01/2016
- Approved for development/added to Charter 06/2016
- First White Book 08/2016, Agency Review complete 07/2018, completed CESG Poll (with conditions) 10/2018
- Next Steps: Resolve CESG Poll conditions, complete CMC Poll, Publish!!!

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, phase, optical
  - 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 P1.4, Agency Review complete
- Next Steps: Complete prototype testing, complete CESG/CMC Polls, initiate TDM version 3