



## CCSDS Navigation Working Group

David Berry

18-Oct-2021

# 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 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). [Note: Currently no SIGs or BOFs]
- Each WG, SIG or BOF is associated with an Area
- Navigation 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:
  - ASI
  - CNES
  - DLR
  - ESA
  - ETRI
  - JAXA
  - NASA (JPL, GSFC, JSC)
  - UKSA
  - ISO TC20/SC14 (CCSDS “sister organization”)
  - Agencies that previously named representatives to the Nav WG, but have not recently participated: RFSA
- Other agencies that participate in CCSDS, but have not been involved in Navigation WG: CSA, INPE, CNSA
- Commercial and/or military support is sponsored by an agency

- Current Work Items
  - [Attitude Data Messages \(ADM\)](#) (V.2 in progress)
  - [Conjunction Data Message \(CDM\)](#) (V.2 in progress)
  - [Orbit Data Messages \(ODM\) V.2](#) (V.3 in Agency Rvw)
  - [Tracking Data Message \(TDM\) V.2](#) (V.3 in progress)
- Completed Work Items
  - [Navigation Data Messages Overview V.2](#) (V.3 starting soon)
  - [Navigation Data - Definitions & Conventions V.4](#)
  - [Navigation Data Messages/XML Spec](#) (V.3 starting soon)
  - [Pointing Request Message \(PRM\)](#) (published Feb 2018)
  - [Re-Entry Data Message \(RDM\)](#) (published Oct 2019)
- “On Hold” Work Items
  - Navigation Events Message (NEM, White Book in progress)
  - 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 Messages – XML Spec (NDM/XML): David
- Navigation Events Message (NEM): Alain, Frank
- Orbit Data Messages (ODM): Dan
- Tracking Data Message (TDM): Cheryl
- Navigation Data Messages Overview: Patrick



## Progress Since Spring 2021 Meetings

- ADM: Completed Version P1.11 internal review, Version P1.12 nearly complete, XML section and schemas complete
- CDM: Resolution of Version P1.0.1 review comments largely completed, P1.0.2 in progress
- NDM/XML: V.2 published; CESG poll for corrigenda to RDM, TDM V.2, CDM approved, CMC poll in progress; new project for V.3 approved (for compatibility with ODM and ADM updates)
- NDMO: new project for V.3 approved
- NEM: No significant progress
- ODM: Version P2.42 provided to Secretariat for document processing, CESG/CMC Agency Review polls completed, Agency Review commenced.
- PRM: Corrigenda material published
- TDM: No significant progress
- SANA: All registries required for ODM Agency Review established
- 4 Working Group telecons
- Action Items: 21 of 39 completed (53.8%), 17 outstanding (43.6%), 1 cancelled (2.6%)

## Fall 2021 "Virtual" Meeting Objectives

- Confirmed Agenda
  - ADM: Discussion of Pink Book P1.12 changes, initial prototyping plan discussions, SANA requirements?
  - ODM: Discussion of prototyping status, Agency Review details, and any early RIDs
  - CDM: Completed discussion of Pink Book 1.0.1 review comments, P1.0.2 plans
  - NDM/XML: Discussion of NDM/XML V.3 new project
- Time Permitting
  - Fragmentation Data Message (FDM): Current status of this potential new project... is it time?
- No Discussion (Time Constraints)
  - Tracking Data Message (?), Navigation Events Message, Navigation Data Messages Overview (?)

## Fall 2021 Current WG Participating Members

1. David Berry
2. Vitali Braun
3. Frank Dreger
4. Cheryl Gramling
5. Julie Halverson
6. Hideaki Hinagawa
7. Ralph Kahle
8. Alain Lamy
9. Jose Miguel Lozano
10. Dan Oltrogge
11. Vincent Schaeffer
12. Brian Swinburne
13. Elena Vellutini
14. Patrick Zimmerman

- Web Sites
  - [www.ccsds.org](http://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](mailto:moims-nav@mailman.ccsds.org) (general traffic)
  - [moims-nav-exec@mailman.ccsds.org](mailto:moims-nav-exec@mailman.ccsds.org) (WG internal)
  - **Do NOT use one that has "bounces" in the name**

# Q&A

- ???
- ???
- ???
- ???
- ???
- ???
- ???
- ???
- ???
- ???
- ???



Backup Slides

- 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 (4.0) was published 11/2019
- Next Steps: None at this time

- 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
- Green Book 2.0 published 04/2020
- Next Steps: Commence new V.3 project to report recent progress



- 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
- Work started ~2003, became Blue Book 05/2008 (ISO Standard 13541:2010), currently being revised as result of 5 Year Review; Attitude Comprehensive Message (ACM), new message analogous to ODM's "Orbit Comprehensive Message", being added; XML added
- Infusion Status: in daily use at NASA/GSFC, ESA, Orekit
- Current issue is Pink Book 1.11
- Next Steps: Complete V.2 revisions, do Agency Review

- 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, NASA/JPL, others?
- Current issue: Pink Book 1.0.1
- 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 White Book 1.0, 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 2.0, ADM 1.0, CDM 1.0, RDM 1.0, TDM 2.0
- Work started 05/2004, became Blue Book 12/2010 (ISO Standard 17107:2011), V.2 published 05/2021, **new V.3 project recently approved**
- Was first “approved” registry in the SANA Registry
- Other Desirable Work: Agency infusion
- Current issue is Blue Book 2.0
- Next Steps: Corrigenda for CDM, RDM, TDM due to support for qualified data elements; Version 3 that removes instructions for ODM/XML (and ADM/XML?) since the instructions will be in the ODM (and ADM?)

## 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
- Infusion Status: Orbit Data Messages widely used in ops
- Current issue is Pink Book 2.1 (Agency Review)
- Next Steps: Complete Agency Review, RIDs, Prototypes

## 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 S/C, onboard instrument, various constraints and rates, applicable epochs, other 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
- Agency infusion: ESA, also being used by MOIMS/Mission Planning WG
- Next Steps: 5 Year Review Fall 2022

## 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, Blue Book November 2019
- Agency infusion: ESA, DLR
- Next Steps: Continued Agency infusion

## 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, Blue Book 2 published 06/2020, **currently being revised based on expanded requirements**
- Infusion Status: in progress or complete at ESA, DLR NASA/JPL, JHU/APL, ISRO, others?
- Current issue is Blue Book V.2
- Next Steps: Continued agency infusion, initiate TDM version 3 (first Pink Book)