



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 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 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)
- “Green Books” are non-normative technical reports
- 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)

- 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 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 \(ADM\)](#) (5 year revisions ongoing)
 - [Orbit Data Messages \(ODM\)](#) (5 year revisions ongoing)
 - [Tracking Data Message \(TDM\)](#) (5 year revisions ongoing)
 - [Nav Data Messages/XML Spec](#) (5 year revisions ongoing)
 - [Navigation Data - Definitions and Conventions \(in revision\)](#)
 - [Pointing Request Message \(PRM\)](#)
 - Navigation H/W Message (NHM, White Book)
 - Spacecraft Maneuver Message (SMM, White Book)
 - Re-Entry Data Message (RDM, White Book)
- Completed Work Items
 - [Conjunction Data Message \(CDM\)](#)
 - [Navigation Data Messages Overview](#)
- “On Hold” Work Items
 - Events Message (EVM, Concept Paper)
 - Spacecraft Perturbations Message (SPM, White Book)
 - Several “Draft” Projects and future ideas (FDM, LDM)

Progress Since Spring 2016 Meetings

- ADM: P1.2 published
- Navigation Data – Definitions and Conventions Green Book: Draft 3.3 distributed, review ongoing
- NHM: White Book 15 review was suspended; resolutions on future direction (cancel/keep) published for discussion
- ODM: Several Pink Book drafts were distributed (latest 2.35), review ongoing
- Nav Data Msgs XML Spec: 5 Year Revision project approved
- PRM: **Red Book** was updated based on RID dispositions, draft prototyping test plan prepared
- RDM: White Book 0 published
- TDM: Review of Pink Book 1.0.3 ongoing
- Action Items: 20 of 32 completed (63%... last time 62%), 9 outstanding, 3 cancelled
- NOTE
 - Spring to Fall Duration (days, 2014-2016): 224, 226, **190**
 - Fall to Spring Duration (days, 2014-2017): 133, 143, ???

Fall 2016 Meeting Objectives

- Complete discussion of PRM prototyping plan
- Continue discussion of ODM Pink Book
- Continue discussion of TDM Pink Book
- Determine future direction for SMM
- Determine future direction for NHM
- Continue discussion of Green Book Version 4 update
- Complete joint meetings on Events (EVM) with CSS/SM WG
- Continue discussion of ADM Pink Book
- Initiate discussion of RDM White Book
- Complete Boot Camp for new/potential document editors
- Continue support of discussions with SANA Steering Group and XML SIG

Fall 2016 Registered Participants

1. Kyohei Akiyama
 2. David Berry
 3. Frank Dreger
 4. Dale Force
 5. Cheryl Gramling
 6. Ralph Kahle
 7. Reinhard Kiehling
 8. Alain Lamy
 9. Alexandru Mancas
 10. Fran Martinez
 11. Dan Oltrogge
 12. Julie Thienel
 13. Patrick Zimmerman
- For various reasons, some participants from Spring 2016 are not able to participate in Fall 2016

- 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

- 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 recently approved; three drafts of updates have 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
- Published 12/2015
- Next steps: Revise upon publication of PRM

- 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
- NOTE: Interest in this document by CSS/SM WG and CCSDS System Engineering Area (SEA)
- Next steps: Add a project to the CWE Framework, incorporate CSS/SM Event definition, define events, first White Book

- 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)
- Was 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)

- 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 is a viable standard

- 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: initiate prototyping, publish document

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: Determine if the SMM is a viable standard

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, put on hold approximately Spring 2010
- 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?)

- 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 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, initiate Agency Review, publish document, re-open content discussions for TDM V3