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 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
- 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
- "Silver Book" is historic, no longer normative
- Blue Books undergo 5 year reconfirmation review
- Revised Blue Books enter a draft stage colored "Pink"

Nav 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)
  - RFSA
  - ISO TC20/SC14   (CCSDS "sister organization")
  - Agencies that have 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
    - Tracking Data Message (TDM) (5 yr revision ongoing)
    - Attitude Data Messages (ADM) (5 yr revision ongoing)
    - Orbit Data Messages (ODM)   (5 yr revision ongoing)
    - Nav Data Messages/XML Spec (5 yr revision pending)
    - Navigation Data - Definitions and Conventions
    - Navigation Data Messages Overview (White Book)
    - Pointing Request Message (PRM, White Book)
    - Navigation H/W Message (NHM, White Book)
    - Spacecraft Maneuver Message (SMM, White Book)
- Completed Work Items
    - Conjunction Data Message (CDM)
- "On Hold" Work Items
    - Events Message (EVM, Concept Paper)
    - Spacecraft Perturbations Message (SPM, White Book)
    - Several "Draft" Projects and future ideas

Progress Since Spring 2015 Meetings

- PRM: White Book 2.6 had CESG Poll, was conditionally approved, now working to resolve conditions
- NHM: White Book 13/14 just completed, just distributed
- ODM: Pink Book 2.30, 2.31 distributed and reviewed
- Navigation Data Messages Overview Green Book: in CESG Poll (ending 20-Nov-2015)
- Navigation Data – Definitions and Conventions Green Book: Version 4 project approved, project entered
- Action Items: 23 of 33 completed (70%... last time 40%), 7 outstanding, 3 cancelled
- NOTE
  - Spring 2014 to Fall 2014: 224 days
  - Fall 2014 to Spring 2015: 133 days
  - Spring 2015 to Fall 2015: 226 days
  - Fall 2015 to Spring 2016: 143 days

Fall 2015 Meeting Objectives

- Complete resolution of outstanding conditions placed on Agency Review of PRM White Book
- Initiate preparations of NHM White Book Agency Review
- Continue discussion of ODM Pink Book
- Continue discussion of TDM Pink Book
- Continue discussion of ADM Pink Book
- Continue discussion of SMM White Book
- Initiate discussion of NDM/XML Blue Book revisions
- "Complete" the "Good Citizens of Nav WG" Guideline
- Complete Boot Camp for new/potential document editors
- Complete joint meetings with SM WG and SM&C WG
- Continue support discussions with SANA Steering Group
- Initiate discussion of Green Book Version 4 update
- Initiate discussion of future standardization topics

Fall 2015 Registered Participants

1. David Berry
2. Frank Dreger
3. Tim Flohrer
4. Dale Force
5. Joe Hashmall
6. Reinhard Kiehling
7. Alain Lamy
8. Alexandru Mancas
9. Dmitry Marareskul
10. Fran Martinez
11. Dan Oltrogge
12. Juan Carlos Raymond
13. Karen Richon
14. 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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- ???
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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
- Most recent edition (3.0) was published 05/2010
- Green Book 4.0 project recently approved; update not yet started
- Next steps: Complete first version of 4.0 draft

- 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
- CESG Poll currently in progress
- Publication imminent
- Next steps: Complete CESG Poll, publish document

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
- 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?

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 control centers for operations
- 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
- First White Book forthcoming
- NOTE: Interest in this document by Service Management WG and CCSDS System Engineering Area (SEA)
- Next steps: On hold while SEA effort progresses

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.12
- 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)
- First "approved" registry in the SANA Registry
- Other Desirable Work: Agency infusion
- Next Steps: 5 Year Review, "qualified" vs. "unqualified" schemas, namespace revision, oemType changes

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 WB14
- Next steps: Complete White Book drafting; Agency Review

Orbit Data Messages (ODM) (ODM)

- 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 Hybrid Message (OHM) is 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 is Agency Review draft
- Next steps: complete Agency Review, initiate prototyping

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: Complete White Book drafting (or eliminate?)

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
- 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?)

Tracking Data Message (TDM) (TDM)

- Standard message format for exchanging tracking data
- TDM supports widely used tracking data types:
  - Ground-based 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 1.0.2; 1.0.3 in progress
- Next Steps: Complete 5 Year Revisions (hopefully before Spring 2016 Meetings), initiate Agency Review