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
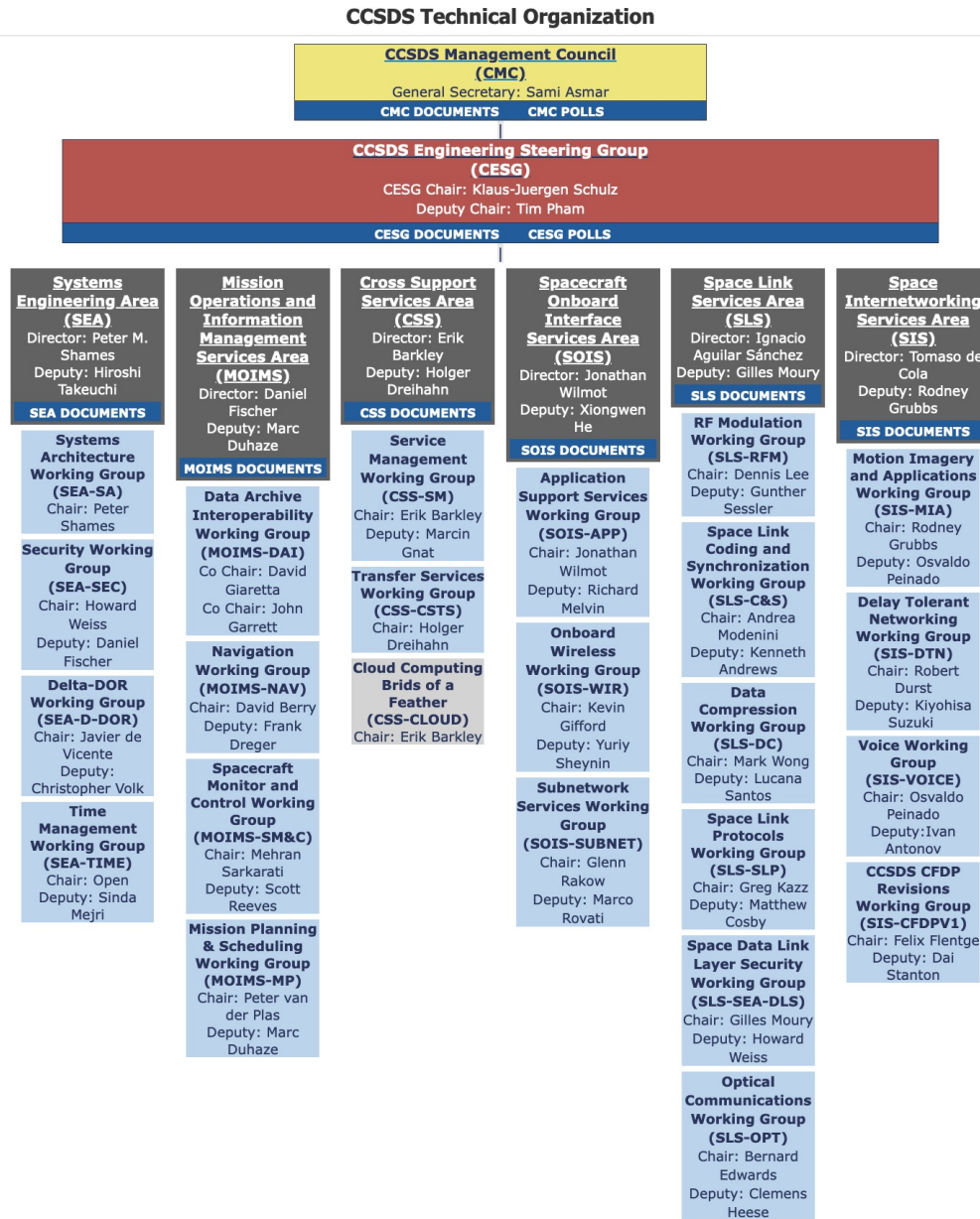
- Set priorities for current meetings

- Are there any new attendees? If so, let's go around the room and introduced ourselves...

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). [Note: Currently 1 BOF, no SIGs]

- 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

CCSDS Organization Chart

CCSDS Technical Organization

CCSDS Management Council (CMC)
General Secretary: Sami Asmar
CMC DOCUMENTS   CMC POLLS

CCSDS Engineering Steering Group (CESG)
CESG Chair: Klaus-Juergen Schulz
Deputy Chair: Tim Pham
CESG DOCUMENTS   CESG POLLS

Systems Engineering Area (SEA)
Director: Peter M. Shames
Deputy: Hiroshi Takeuchi
SEA DOCUMENTS

- **Systems Architecture Working Group (SEA-SA)**
  Chair: Peter Shames
- **Security Working Group (SEA-SEC)**
  Chair: Howard Weiss
  Deputy: Daniel Fischer
- **Delta-DOR Working Group (SEA-D-DOR)**
  Chair: Javier de Vicente
  Deputy: Christopher Volk
- **Time Management Working Group (SEA-TIME)**
  Chair: Open
  Deputy: Sinda Mejri

Mission Operations and Information Management Services Area (MOIMS)
Director: Daniel Fischer
Deputy: Marc Duhaze
MOIMS DOCUMENTS

- **Data Archive Interoperability Working Group (MOIMS-DAI)**
  Co Chair: David Giaretta
  Co Chair: John Garrett
- **Navigation Working Group (MOIMS-NAV)**
  Chair: David Berry
  Deputy: Frank Dreger
- **Spacecraft Monitor and Control Working Group (MOIMS-SM&C)**
  Chair: Mehran Sarkarati
  Deputy: Scott Reeves
- **Mission Planning & Scheduling Working Group (MOIMS-MP)**
  Chair: Peter van der Plas
  Deputy: Marc Duhaze

Cross Support Services Area (CSS)
Director: Erik Barkley
Deputy: Holger Dreihahn
CSS DOCUMENTS

- **Service Management Working Group (CSS-SM)**
  Chair: Erik Barkley
  Deputy: Marcin Gnat
- **Transfer Services Working Group (CSS-CSTS)**
  Chair: Holger Dreihahn
- **Cloud Computing Brids of a Feather (CSS-CLOUD)**
  Chair: Erik Barkley

Spacecraft Onboard Interface Services Area (SOIS)
Director: Jonathan Wilmot
Deputy: Xiongwen He
SOIS DOCUMENTS

- **Application Support Services Working Group (SOIS-APP)**
  Chair: Jonathan Wilmot
  Deputy: Richard Melvin
- **Onboard Wireless Working Group (SOIS-WIR)**
  Chair: Kevin Gifford
  Deputy: Yuriy Sheynin
- **Subnetwork Services Working Group (SOIS-SUBNET)**
  Chair: Glenn Rakow
  Deputy: Marco Rovati

Space Link Services Area (SLS)
Director: Ignacio Aguilar Sánchez
Deputy: Gilles Moury
SLS DOCUMENTS

- **RF Modulation Working Group (SLS-RFM)**
  Chair: Dennis Lee
  Deputy: Gunther Sessler
- **Space Link Coding and Synchronization Working Group (SLS-C&S)**
  Chair: Andrea Modenini
  Deputy: Kenneth Andrews
- **Data Compression Working Group (SLS-DC)**
  Chair: Mark Wong
  Deputy: Lucana Santos
- **Space Link Protocols Working Group (SLS-SLP)**
  Chair: Greg Kazz
  Deputy: Matthew Cosby
- **Space Data Link Layer Security Working Group (SLS-SEA-DLS)**
  Chair: Gilles Moury
  Deputy: Howard Weiss
- **Optical Communications Working Group (SLS-OPT)**
  Chair: Bernard Edwards
  Deputy: Clemens Heese

Space Internetworking Services Area (SIS)
Director: Tomaso de Cola
Deputy: Rodney Grubbs
SIS DOCUMENTS

- **Motion Imagery and Applications Working Group (SIS-MIA)**
  Chair: Rodney Grubbs
  Deputy: Osvaldo Peinado
- **Delay Tolerant Networking Working Group (SIS-DTN)**
  Chair: Robert Durst
  Deputy: Kiyohisa Suzuki
- **Voice Working Group (SIS-VOICE)**
  Chair: Osvaldo Peinado
  Deputy: Ivan Antonov
- **CCSDS CFDP Revisions Working Group (SIS-CFDPV1)**
  Chair: Felix Flentge
  Deputy: Dai Stanton

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 months minimum)
- When Agency Review is passed, prototyping is complete, test reports filed, "Approval to Publish", 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, "OK to use")
- Green Books are non-normative technical reports
- Other colors in CCSDS spectrum:
  - Yellow=Record, Orange=Experimental, Magenta=Best Practice

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)
  - UKSA
  - ISO TC20/SC14   (CCSDS "sister organization")
  - CCSDS-related organizations that previously named representatives to the Nav WG, but have not recently participated: ASI, RFSA, ETRI
- 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

Nav WG Documents ("Color Coded")

- Current Work Items
  - Attitude Data Messages (ADM)   (V.2 in approval poll)
  - Conjunction Data Message (CDM)   (V.2 in progress)
  - Tracking Data Message (TDM) V.2   (V.3 in progress)
  - Navigation Data Messages/XML V.3 (V.4 in progress)
  - Navigation Events Message (NEM)   (White Book, just beginning)
  - Launch Data Message (LDM)   (White Book, just beginning)

- Completed Work Items
  - Navigation Data Messages Overview V.3 (published Mar 2023)
  - Navigation Data Definitions & Conventions V.4 (pub Nov 2019)
  - Orbit Data Messages (ODM) V.3   (published Apr 2023)
  - Pointing Request Message (PRM)   (published Feb 2018)
  - Re-Entry Data Message (RDM)   (published Oct 2019)

- "On Hold" Work Items
  - Several "Draft" Projects and future ideas (FDM, NFM)

Lead & Co-Editors for Works In Progress

- Attitude Data Messages (ADM): Alain, Julie
- Conjunction Data Message (CDM): Brian, Dan
- Tracking Data Message (TDM): Juan, Cheryl
- Nav Data Msgs XML Spec (NDM/XML): David, Jose Miguel
- Navigation Events Message (NEM): Alain, Frank

Progress Since Spring 2023 Meetings

- ADM: Completed V.2 test plan, prototypes, testing, test report, "Approval to Publish" polls in progress

- CDM: Completed preparation of Pink Book draft P1.0.5 and P1.0.6, initiated internal review (nearly complete)

- NDM/XML V.4: Completed schema updates for ADM V.2 and posted to SANA, initiated Pink Book 3.0.1 (nearly complete)

- NEM: No significant progress (ADM priority)

- PRM: Corrigendum published

- TDM: Continued development of P-2.0.2

- SANA: Completed "external registry" NDM-XML Schema Archive

- 4 Working Group telecons

- 26 of 47 Action Items completed (55.3%), 0 cancelled, 21 remain open (44.7)%. Of the 21 open, 4 have progress, 6 are dependent on other actions/events that are not complete

- NOTE: Progress was good, but artificially low at least in part due to budget issues with the NASA Standards Program at JPL

Fall 2023 Meeting Objectives

- Current Items
  - ADM: Report current status, prepare for "Approval to Publish"
  - CDM: Continued discussion of recent drafts and issues, prepare for "Approval for Agency Review", initiate test plan
  - TDM: Continued discussion of recent drafts and issues
  - NDM/XML: Discussion of NDM/XML V.4, V.5, issues & schedule
  - PRM: "Reconfirm" the document
  - LDM: First draft?
  - SANA Registry: Discussion of current developments, upcoming registry changes

- Future Items

  - Initiate revision of Navigation Data Definitions & Conventions
  - Discuss preliminary ideas for future projects
  - Navigation Events Message... is it time to get serious?
  - Fragmentation Data Message... potential new project... is it time?
  - Navigation Functional Message... potential new project... is it time?
  - LunaNet... does Nav WG have related projects?

Current WG Members

1. David Berry - Chair (NASA/JPL)
2. Frank Dreger - Deputy Chair (ESA/ESOC)
3. Vitali Braun (ESA)
4. Juan Crenshaw (NASA/GSFC)
5. Cheryl Gramling (NASA/GSFC)
6. Julie Halverson (NASA/GSFC)
7. Hideaki Hinagawa (JAXA)
8. Ralph Kahle (DLR)
9. Alain Lamy (CNES)
10. Jose Miguel Lozano (ESA/GMV)
11. Dan Oltrogge (NASA/Comspoc, ISO TC20/SC14)
12. Brian Swinburne (UKSA/Airbus)
13. Elena Vellutini (ASI – not registered Fall 2023)
14. Patrick Zimmerman (NASA/JSC)

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 communication)
  - moims-nav-exec@mailman.ccsds.org (WG internal)
  - Do NOT use the 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 WG)
- Work started <u>early</u> in the history of the Navigation WG (pre-2000)

- Current issue: 4.0 published 11/2019
- Next Steps: 5.0 revision to be proposed

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"; Area Director suggested just having 2 different Green Books (a simpler approach)
- Non-normative document
- Has a different development process (all internal WG)
- Initiated at Berlin meetings Spring 2011

- Current Issue: 3.0 published 03/2023
- Next Steps: None at this time

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
- Work started ~2003, became Blue Book 05/2008 (ISO Standard 13541:2010), currently revised as result of 5 Year Review; Attitude Comprehensive Message (ACM), analogous to ODM's "OCM" added; XML format added
- Infusion Status: in use at NASA/GSFC, ESA, Orekit
- Current issue: Pink Book 1.2
- Next Steps: Publish Blue Book 2 document

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 (record?), ISO/DIS 19389, currently in revision
- Infusion Status: USSF 18th Space Command, NASA/CARA, SDC, CNES, NASA/JPL, others?
- Current issue: Pink Book 1.0.6
- Next Steps: Complete V.2 revisions; 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)
- Current issue: N/A
- Next Steps: Complete White Book 1.0 draft

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, CDM, ODM, RDM, and TDM
- Currently compatible with ODM 3.0, 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, V.3 published May 2023
- Fun Fact: was first "approved" registry in SANA Registry
- Other Desirable Work: Agency infusion

- Current issue: Pink Book 3.0.1 (removes instructions for ADM/XML since the instructions are now in the ADM)
- Note: Schemas and docs are now slightly out of phase
- Next Steps: Complete addressing schema version/name issue, complete V.4 publication, initiate V.5 for CDM

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 Mean Elements Message (OMM) is an orbit state
  - Mean Keplerian elements; must propagate
- Orbit Ephemeris Message (OEM) is an ephemeris
  - Position/velocity at multiple epochs; must interpolate
- Orbit Comprehensive Message (OCM) is a comprehensive message designed to contain much more detailed orbit info
- Work started ???, became Blue Book V.1 09/2004 (ISO Standard # 22644 01/2006), Blue Book V.2 11/2009 (ISO Standard #26900:2012), Blue Book V.3 05/2023
- Infusion Status: OEM, OMM, OPM widely used in ops

- Current issue: Blue Book 3.0
- Next Steps: Promote adoption of OCM

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/MP WG
- Current issue: Blue Book 1.0 published 02/2018
- Next Steps: Reconfirm document

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 11/2019
- Agency infusion: ESA, DLR

- Current issue: Blue Book 1.0 published 11/2019
- Next Steps: 5 Year review Spring 2024

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: Pink Book V.2.0.1
- Next Steps: Draft P-2.0.2, continue addition of new material