

**MINUTES OF NAVIGATION WORKING GROUP SPRING 2019 WORKSHOP 12-May-2019**  
**David S. Berry / Chair**

The CCSDS Spring 2019 Meetings were conducted at the NASA Ames Research Conference Center in Mountain View, California, USA, during the week of 06-May-2019 through 09-May-2019. NASA hosted the meetings. This is a summary of the activities of the Navigation Working Group (WG) during the week. The Navigation WG is an element of the Mission Operations and Information Management Services (MOIMS) Area in the CCSDS organization.

**ON-SITE PARTICIPANTS**

Brigitte Behal (CNES), Julien Bernard (Viagenie/SANA), David Berry (NASA/JPL), Frank Dreger (ESA/ESOC), Cheryl Gramling (NASA/GSFC), Julie Halverson (NASA/GSFC), Byoung Sun Lee (ETRI), Alain Lamy (CNES), Alexandru Mancas (ESA/ESOC), Francisco Martinez (GMV/ESA/ESOC), Mario Merri (ESA/ESOC), Dan Oltrogge (NASA (AGI, SDC, ISO TC20/SC14)), Angela Peura (CCSDS Secretariat), Patrick Zimmerman (NASA/JSC).

**TELECON PARTICIPANTS**

Brian Swinburne (Airbus/UKSA)

**AGENDA**

The final agenda for the WG meetings is available on the Navigation WG CWE at: <https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Meeting%20Materials/2019/Spring/navwg-agenda-spring-201905-final.pdf> . In the meeting proceedings below, the detailed agenda for each meeting day is included in the minutes to provide context.

**CURRENT ACTION ITEMS**

The following action items were produced during the meetings. They are also available on the CWE at <https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Meeting%20Materials/2019/Spring/navwg-action-items-201905.pdf> . The action items and due dates below reflect the status as of the end of the meetings; the list on the web page will be updated periodically between now and the next meeting series and will thus reflect relative completion progress and any new action items added after the face-to-face meetings. The list also includes any items from prior meetings that had not yet been completed.

**New Action/Outstanding Action Items**

##	Action Item	Actionee	Due Date (Original)	Due Date (Current)
4	Request CESA Poll for Navigation Data Messages Overview V.2	David	09-May-2019	09-May-2019
35	Proofreading of NDMO G1.0.5.	David	13-May-2019	13-May-2019
30	Create Divide & conquer proofreading assignments for RDM R1.5.	David	15-May-2019	15-May-2019
39	Create Divide & conquer review assignments for	David	15-May-2019	15-May-2019

##	Action Item	Actionee	Due Date (Original)	Due Date (Current)
	ADM P1.8			
42	Create Divide & conquer proofreading assignments for Navigation Data D&C 3.6	David	15-May-2019	15-May-2019
36	Produce NDMO G1.0.6 with proofreading updates	Patrick	16-May-2019	16-May-2019
38	Craft sentence for Navigation Data D&C Green Book Section 4.7 (antenna mounts)	Alexandru	16-May-2019	16-May-2019
90	Submit Orbit-Relative Reference Frames data for SANA Registry	David	26-Nov-2018	17-May-2019
34	Submit NDMO G1.0.6 to Mario	David	20-May-2019	20-May-2019
37	Review/verify 5.3.3, 5.3.6 in Navigation Data D&C V3.6	Alain/Julie	23-May-2019	23-May-2019
31	Divide & conquer proofreading of RDM R1.5.	All (as assigned)	29-May-2019	29-May-2019
1	Submit SANA Glossary revisions to SANA	Cheryl	28-Feb-2019	31-May-2019
5	Request CESG Poll for Re-Entry Data Message	David	09-May-2019	31-May-2019
28	Proofread Navigation D&C Green Book 3.6	All (as assigned)	27-Jun-2018	31-May-2019
58	Produce ODM P2.39	Dan	15-Feb-2019	31-May-2019
68	Produce NDM/XML P1.0.2	David	20-Dec-2018	31-May-2019
91	Submit Spacecraft Body Reference Frames data for SANA Registry	David	03-Dec-2018	31-May-2019
29	Research GDOP formulation that applies broadly	Cheryl	05-Jun-2019	05-Jun-2019
78	Combine events lists and distribute to WG	Alain	15-Dec-2018	05-Jun-2019
32	Produce RDM R1.6 (with no Annex B for covariance reference frames)	Alexandru	07-Jun-2019	07-Jun-2019
33	Add "ICRF" and "ITRF" to SANA values for reference frame (denotes "latest" version)	David	15-Jun-2019	15-Jun-2019
40	Review ADM P1.8	All (as assigned)	15-Jun-2019	15-Jun-2019
43	Produce Navigation Data D&C 3.7	Cheryl	15-Jun-2019	15-Jun-2019
44	Create draft "Atmosphere Models" registry material	Dan	15-Jun-2019	15-Jun-2019
45	Create draft "Gravity Models" registry material	Dan	15-Jun-2019	15-Jun-2019
46	Create draft "Orbit Types" registry material	Dan	15-Jun-2019	15-Jun-2019
47	Create draft "Orbit Averaging" registry material	Dan	15-Jun-2019	15-Jun-2019
92	Submit Revised Orbit Centers Registry data for SANA Registry	David	17-Dec-2018	15-Jun-2019
98	Produce Navigation Events Message initial draft	Alain	31-Jan-2018	15-Jun-2019
6	Request CESG Poll for Navigation D&C Green Book V.4	David	13-Apr-2018	16-Jun-2019
26	XML Section for ODM (update)	David	08-May-2018	30-Jun-2019
59	Produce ODM V3 Test Plan/Report Draft	Dan	15-Mar-2019	30-Jun-2019
73	Advise WG when CSS/SMWG "Planning Information Format" document reaches Agency	David	31-Dec-2018	30-Jun-2019

##	Action Item	Actionee	Due Date (Original)	Due Date (Current)
	Review and "Abstract Event Definition"			
74	Prepare Navigation references for SANA Registry	David	31-Oct-2018	30-Jun-2019
93	Submit Corrigenda to SANA Registry Data	David	07-Jan-2019	30-Jun-2019
96	SANA implementation of Nav References	David	31-Jan-2019	31-Jul-2019
41	Produce ADM P1.9	Alain/Julie	07-Sep-2019	07-Sep-2019
64	Produce CDM P1.0.1	Brian / Dan	30-Sep-2019	30-Sep-2019
80	Add "Re-Entry Data Message Originator" role to "Organizations Registry" upon RDM publication	David	30-Sep-2019	30-Sep-2019
81	Add RDM Terms to CCSDS Glossary	David	30-Sep-2019	30-Sep-2019
83	Navigation Data Messages KVN Structural Requirements	Alain, Cheryl, Dan, David, Julie	30-Sep-2017	30-Sep-2019
48	Add Darmstadt agenda item for NDM/KVN discussion	David	01-Oct-2019	01-Oct-2019
7	Schedule joint meeting with MP&S for Fall 2019	David	01-Sep-2019	01-Sep-2019
8	Next available number	N/A	31-Dec-2035	31-Dec-2035

### **COMPLETED Action Items**

##	Action Item	Actionee	Status	Completion Date

### **CANCELLED Action Items**

##	Action Item	Actionee	Reason

## **WORKSHOP PROCEEDINGS**

### **DAY 1, MONDAY 06-May-2019**

0815 0845 Registration  
0845 1015 CCSDS Opening Plenary  
1015 1120 MOIMS Opening Plenary  
1120 1215 Admin: Agenda, Intro to Nav WG, Guidelines, Prev Action Items  
1215 1330 Lunch  
1330 1730 Orbit Data Msg V.3 (P2.38 draft, Prototyping Plan, Project Schedule)

### **0845 1015 CCSDS Opening Plenary**

The CCSDS Spring 2019 Meeting series started with a CCSDS Opening Plenary attended by all participating CCSDS members. Steve Townes (new CCSDS General Secretary) provided a brief welcome to the meetings. Margherita di Giulio (CESG Chair) chaired the meeting and provided a few opening remarks.

Information on the traditional set of various logistical matters and items of general interest was provided by Michael Blackwood of the CCSDS Secretariat (e.g., wireless access, details of start/stop times, break times, lunch, security, future meeting schedule, etc.).

We had one guest speaker: Philip Liebrecht (NASA Space Communications and Navigation) spoke regarding NASA's plans for lunar exploration in the next 5 years (lunar astronauts, lunar gateway, lunar relay, through the recently announced 2024 "Boots on the Moon" initiative). Phil stated emphatically that international standards are the key to the work of the future. The NASA lunar vision for a sustainable program with commercial and international partners requires international standards due to the focus on partnering.

There were some important announcements made in this meeting, as follows:

1. The CCSDS is planning the following upcoming meetings:

- a) Fall 2019 hosted by ESA/ESOC at Darmstadt, Germany (4-day, Darmstadtium), 21-24 October, 2019
- b) Spring 2020 hosted by NASA at Marshall Space Flight Center, Huntsville, Alabama, USA, dates TBD
- c) Fall 2020 hosted by CNES at Toulouse, France, Mercure Hotel & Novotel Hotel, 26-30 October, 2020
- d) Spring 2021 hosted by NASA at TBD, USA, dates TBD
- e) Fall 2021 hosted by ESA at TBD, dates TBD
- f) Spring 2022 hosted by NASA at TBD, dates TBD

2. The "Boot Camp" session will be on Thursday from 0845-1230, Room B152-108. It was pointed out that those who are editing CCSDS documents must attend the Boot Camp (at least once).

3. The number of missions that have used CCSDS standards in some respect is now up to 1,133.

4. Margherita gave some updates from the perspective of the CESC (Margherita's presentation is available on the Navigation Working Group CWE at [https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Meeting%20Materials/2019/Spring/S19-Opening-Plenary\\_FINAL.pdf](https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Meeting%20Materials/2019/Spring/S19-Opening-Plenary_FINAL.pdf)):

- There have been 14 CMC polls, 6 Agency Reviews, and 10 new projects approved since October 2018 (Fall Meetings)
- The allocation of Chairs, Deputy Chairs, Lead Editors, prototype 1, and prototype 2 across the member agencies was shown.
- The CESC meeting on Friday 10-May-2019 will discuss topics such as conversion of the Time BOF to a working group; the boundary between MO Services and SOIS Electronic Data Sheets; documents due for reconfirmation, retirement, or revision; the Technical Editor document queue; and a Unified RID template.
- The CCSDS/IOAG relationship is documented in IOAG Service Catalogs #1, #2, and the ICPA, which links ICPS projects to relevant CCSDS projects.

5. The number of people registered for the meetings is 195.

6. There are 160 currently active CCSDS documents (99 normative, 61 informative).

After these announcements and opening proceedings, the final portion of the General Plenary involved the Directors of the six CCSDS Areas presenting the detailed plans for the week for their respective areas.

## **1015 1120 MOIMS Opening Plenary**

The overall CCSDS Plenary was followed immediately by the MOIMS Opening Plenary meeting, which was chaired by Area Director Mario Merri. Mario gave an overview of the status of the MOIMS working groups, as follows:

- DAI (Data Archive Ingest) has good momentum, active WG with Long Term Data Preservation (LTDP) and archive architecture in discussion. Regularly scheduled teleconferences.
- Navigation has high momentum; it is a very active WG with a lot of ongoing work.
- SM&C (Spacecraft Monitor & Control): Focusing on Mission Operations (MO) services. A good momentum, very active WG with an ambitious work plan. Very strong potential for the WG in context of the Lunar Operations Platform Gateway. Issues: (1) Services vs. Formats, (2) MO Services on Board.
- MP&S (Mission Planning & Scheduling): High momentum, very active. This is the youngest WG in MOIMS. A Green Book has been finished, and they are working on a Blue Book. Marc Duhaze (CNES) is the new Deputy Chair.
- Telerobotics: No momentum. The WG is basically on hold. The Blue Book project has been demoted to a draft project. Mario is reluctant to disband the WG; he still believes in it..

Mario reported on a meeting conducted 03/04-April-2019 at ESTEC regarding the Lunar Gateway. He presented some slides from that presentation, which focused on interoperability, a ground segment focus, and a pitch for MO Services. He also remarked that we should also consider space-to-space standardization. He asserted that the MOIMS Area could instantly provide expert support to the Gateway. As a refresh of the Gateway topic, a diagram of telemetry exchanges was presented; this covered lunar orbiting, Earth<=>Moon, lunar outposts, rovers, astronauts, cubesats, and international partners. It showed the large number of point-to-point telemetry exchanges that could presumably be reduced via standardization.

Mario concluded by requesting that WG Chairs keep Mario and Brigitte involved and let them know if there are any meetings they should attend. Mario announced that the MOIMS Dinner would be held on the evening of Wednesday 08-May-2019 at 1900 hours.

## **1120 1215 Admin: Agenda, Intro to Nav WG, Guidelines, Prev Action Items**

The Navigation WG meeting was started immediately after the close of the MOIMS Opening Plenary. In attendance this day were David Berry, Frank Dreger, Cheryl Gramling, Julie Halverson, Alain Lamy, Byoung Sun Lee, Alexandru Mancas, Fran Martinez, Dan Oltrogge, Patrick Zimmerman.

We launched into a review of the agenda for the week. Given that we had no new members with us in the pre-lunch session, the presentation of the "Introduction to the Navigation WG" material focused on progress since the last meeting series and priorities for this meeting series; details of the publications were not discussed. Since there were no new attendees, we also did not review the Working Group Guidelines.

We reviewed outstanding Action Items from the Berlin meetings. Five items had been closed between the 03-Apr-2019 telecon and the first day of the Spring Meetings: Alain had distributed ADM P1.8, Patrick had distributed the Navigation Data Messages Overview G1.0.4, Cheryl had distributed the Navigation

Data - Definitions and Conventions Green Book 3.6, David had submitted the Orbital Covariance Matrix Types material to the SANA Registry, and the review of ODM P2.38 was concluded. There were also several action items that were scheduled to be updated during the meeting week.

Dan raised a question as to whether or not the Launch Data Message could be addressed at this time. David explained that, as the champion, Dan is the logical person to be Lead Editor, but the ODM work is a priority. Additionally, the Working Group needs to complete some in progress projects before proposing new work.

Review of the action items from Berlin showed that as of the start of the meetings, 27 of 50 were completed (54%), 22 remained outstanding (44%), and 1 had been cancelled (2%). Several of the outstanding action items had been added during the period between the Fall and Spring meetings. Overall, the percentage of action items completed was quite good.

### **1330 1730 Orbit Data Msg V.3 (P2.38 draft, Prototype Plan, Project Schedule)**

Dan started his presentation by indicating that the ODM P2.38 had 103 pages of combined CRM comments (approximately 600 comments). Many of these were minor typos, missing parentheses, etc., which are easily dispositioned. A number of other issues (listed below) required discussion by the group. Dan had started a P2.39 draft prior to the meetings, and made corrections to the text as decisions were made during the discussion. (Note that some of the topics/decisions below were made during subsequent sessions which also discussed ODM P2.38.)

- XML and relevance of Fran's comments: Fran's comments may not apply given the proliferation of text through the various documents.
- GDOP/OD Confidence: add GDOP, remove OD Confidence
- Maneuver Elements of Information implementation: reduce complexity by requiring order fixed as in table
- Child deployments: The deployment appears in the "parent" OCM one time only; after deployment each "child" object needs its own OCM
- Interpolation boundary: Duplicate timetag originally allowed; Dan to consider removing for the time being (?)
- Apparent/absolute magnitude: Apparent magnitude appears in TDM, absolute removed. Dan to ponder issue with respect to OCM.
- Upper/Lower Case: For keywords, there is no discussion; they must be upper case. For COMMENTS, upper/lower mixed case is OK. For free text that cannot be used in a decision statement upper/lower is OK (but this puts a burden on the implementer and receiver if they have different opinions about decision statements).
- Length of day: 86400 SI seconds (for the foreseeable future).
- \*\_CENTER: May include spacecraft and ground stations, but they won't be added to the Orbit Centers SANA Registry.

Dan's ODM status presentation is available on the CWE at [https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Orbit%20Data%20Messages%20\(ODM\)/20190506\\_ODM\\_2.38\\_Review.pdf](https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Orbit%20Data%20Messages%20(ODM)/20190506_ODM_2.38_Review.pdf).

### **DAY 2, TUESDAY 07-MAY-2019**

0845 1015 Orbit Data Msg V.3 (P2.38 draft, Prototyping Plan, Project Schedule)  
1015 1150 Re-Entry Data Message (Prototyping Plan & Report, schedule); FDM

1150 1235 Orbit Data Msg V.3 (P2.38 draft, Prototyping Plan, Project Schedule)  
1235 1335 Lunch  
1335 1425 Navigation Data Messages Overview  
1425 1505 AIAA Space Traffic Management  
1505 1625 Navigation Data Definitions & Conventions Green Book  
1625 1710 Tracking Data Message V3 Discussion  
1710 1730 Free (Building 3 closes)

In attendance this day were David Berry, Frank Dreger, Cheryl Gramling, Julie Halverson, Alain Lamy, Byoung Sun Lee, Alexandru Mancas, Fran Martinez, Dan Oltrogge, Patrick Zimmerman.

### **0845 1015 Orbit Data Msg V.3 (P2.38 draft, Prototyping Plan, Project Schedule)**

As we had not completed discussion of the ODM, and it is a priority working group project, we continued discussion of the ODM P2.38 CRM.

- MASS, WET\_MASS, DRY\_MASS discussion. Conclusion: Keywords will be MASS, DRY\_MASS. Note that RDM has WET\_MASS, DRY\_MASS, so the conclusion is consistent.
- Relative vs. Absolute Time. Conclusion: Elimination of "DT=" and "T=".
- Duty Cycle issues. Duty cycle "NONE" will be converted to "CONTINUOUS". There was much discussion of phase angle based duty cycles to be resolved by Dan and Cheryl.

The ODM discussion was not yet completed, but Dan had a telecon so we switched topics.

### **1015 1150 Re-Entry Data Message (Prototyping Plan & Report, schedule); FDM**

Alexandru provided the RDM current status; the Agency Review is complete, and the required prototyping is complete. He explained that there were 3 independent prototypes of the message. During the prototyping phase, there were multiple editorial changes in the Red Book, fixing typos, etc. Both ESA and DLR used their existing re-entry prediction systems in the prototyping. In short, the prototyping and the standards document upon which it is based are very technically mature.

Alexandru indicated that there was still a normative Annex B which contains only 3 lines of relative reference frames; the WG indicated that Alexandru should assume that the SANA Registry including relative reference frames will be available by the time the RDM is published, and that Annex B should be removed from a Red Book R1.6 to complete the RDM conversion to use of SANA. David indicated that he would ensure that the required registry is online when needed.

At the end of the RDM presentation, we had allowed time for Alexandru to do an updated presentation on the Fragmentation Data Message (FDM) concept; the RDM and FDM had been proposed concurrently at the Darmstadt 2015 Fall Meetings, but the WG had indicated a prioritization should occur. The RDM was chosen. Since the RDM is nearing publication, it is a good time to re-introduce the FDM concept. The Concept Paper produced previously is available on the CWE, but there are new events that can be added to the report, e.g., a recent ASAT test (the perpetrator of which Alexandru indicated he was not at liberty to identify, regardless of the fact that the event was widely publicized). Fragments of this event are still in orbit. Alexandru took an action item to revise the FDM Concept Paper.

Alexandru's RDM status presentation is available on the CWE at [https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Re-Entry%20Data%20Message%20\(RDM\)/RDM-presentation-201905.pdf](https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Re-Entry%20Data%20Message%20(RDM)/RDM-presentation-201905.pdf).

The link to Alexandru's FDM presentation is <https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Concept%20Papers/FDM-presentation-201905.pdf>

### **1150 1235 Orbit Data Msg V.3 (P2.38 draft, Prototyping Plan, Project Schedule)**

We continued discussion of the ODM P2.38. Topics included:

- Discussion of total thrust vs. componentized thrust: No change for now.
- Annex B chained references: These were moved to Section 1.7
- "ICRF" value generic (as opposed to ICRF1-2-3): We agreed to add "ICRF" to the Celestial Body Reference Frames SANA registry, with the convention that the undifferentiated value was meant to indicate the latest version (likewise for ITRF).
- International designator / OBJECT\_ID: There was much discussion on this topic. The older standards recommend the international designator format for the OBJECT\_ID. We agreed not to "fix" this in prior messages, but it will need to be addressed in the future modular message discussion.

### **1335 1425 Navigation Data Messages Overview**

Patrick reported that V1.0.3 had been published 11-Jan-2019 and contained 27 primarily editorial comments from V1.0.2. A V1.0.4 revision was published 30-Apr-2019. Remaining work: the document is potentially complete and ready for polling. David indicated that we would need a proofreading cycle, but stated his intent to request the Green Book polling by CESG and CMC in the MOIMS Plenary report.

### **1425 1505 AIAA Space Traffic Management**

Given that we had a few minutes prior to the next scheduled topic, Dan requested time to discuss a "drop in topic". This was based on an American Institute of Aeronautics & Astronautics (AIAA) white paper a few years ago that generated a lot of interest, wherein the AIAA decided to generate tasks related to STM. One of 3 tasks was to look not just in CCSDS, not just in ISO, but look at what's out there for space standards, specifically in the area of Space Traffic Management (STM). Dan indicated that he is the chair of the AIAA/STM working group. They are performing a mapping of mandates, guidelines, and practices to their originating bodies. Discussion is consensus based, as is customary in many standards organizations. This topic was not decisional; Dan offered it as information for the participants in the Navigation WG.

### **1505 1625 Navigation Data Definitions & Conventions Green Book**

Cheryl led the discussion of the Navigation Data: Definitions and Conventions Green Book. She pointed out that she had inherited Green Book from Dale. She had provided a CRM with comments on Version 3.5 and Version 3.5.5. A version 3.6 that reflects these changes and various cleanup items has been published. For example, the whole attitude section (5.3.3) was revised and made consistent with reference texts. Also, definitions of the terms "definitive", "predictive", "absolute", "relative" with respect to state were added. We also discussed the upcoming glossary migration to SANA. During discussion, a few additional topics came up:

- Units: Table 3-2 will be revised to address issues with the fundamental SI units, combinations of SI units, and alternate units
- Alexandru raised some antenna mount questions; he acquired an action item to address the topic.

We continue to intend that the Version 3.6 Green Book will become the last "reviewed draft" of the Book prior to submitting it to the Secretariat for the obligatory pre-publication polls. A proofreading "divide & conquer" action item for version 3.6 will be assigned to all, with special assignments for Alain and Julie in the attitude sections and Alexandru as noted above.



A potential future for this Green Book is that we may eventually be able to migrate all of the material to the SANA Registry. With the CCSDS Glossary and some expansion of the CCSDS Normative Annex Registries, a high percentage of the material currently in the Green Book could potentially be hosted on the SANA. This cannot be done at this time, as we need to publish Version 4 of the Green Book, but it is possible that there might never be a Green Book version 5.

### **1625 1710 Tracking Data Message V3 Discussion**

Cheryl led group discussion of her compilation of initial ideas for the TDM V.3. She indicated that there was no new material relative to Berlin, but it was good to do a refresh. There were some questions regarding adding material to TDM that is well standardized already (e.g., SLR, GPS). The Europeans are interested in having a single standard source for tracking measurement data. The topic of attitude sensor data (previously excluded from the ACM) came up, as well as the potential inclusion of new data types and data types previously excluded from the TDM. Given that that TDM Version 2 has not yet been published, and Cheryl is still completing the Green Book Version 4, serious work on the TDM Version 3 won't begin immediately, but we are positioning.

### **DAY 3, WEDNESDAY 08-May-2019**

0845 1000 Orbit Data Msg V.3 (Prototyping Plan, Project Schedule)  
1000 1015 Navigation Data Messages XML Spec update + Project Schedule  
1015 1210 Annex Migration=>SANA Status  
1210 1330 Lunch  
1330 1510 Attitude Data Message V2 + Project Schedule  
1510 1640 Tracking Data Message V2 (Prototyping Plan & Report, Project Schedule)  
1640 1730 Free  
1900 ???? MOIMS Area Dinner

In attendance this day were Brigitte Behal, Julien Bernard, David Berry, Frank Dreger, Cheryl Gramling, Julie Halverson, Alain Lamy, Byoung Sun Lee, Alexandru Mancas, Francisco Martinez, Mario Merri, Dan Oltrogge, Patrick Zimmerman.

### **0845 1000 Orbit Data Msg V.3 (P2.38 draft, Prototyping Plan, Project Schedule)**

We started off the day with a few outstanding items on the ODM that had not been discussed earlier in the week. Specifically, we had not updated the ODM project schedule and had not addressed one of the keyword issues (the proliferation of \*\_EPOCH\_TZERO keywords that appeared in the OCM P2.38). The schedule was updated with the thought that the P2.39 would be the "second" draft with respect to the CWE schedule, indicating Dan's confidence that the material will be very mature in P2.39. Based on this discussion, it was agreed to: revert DEF\_EPOCH\_TZERO to EPOCH\_TZERO; retain STM\_EPOCH\_TZERO and MAN\_EPOCH\_TZERO; remove ORB\_TZERO, COV\_TZERO; all times in the OCM will be in the same TIME\_SYSTEM. The prototyping plan will be addressed in the Fall 2019 Meetings.

### **1000 1015 Navigation Data Messages XML Spec update + Project Schedule**

The ODM discussion took a bit longer than allocated, so there was only a short period of time remaining prior to the arrival of Julien Bernard from the SANA Registry. Consequently, not much was accomplished. David explained to Fran about his review comments of the NDM/XML P1.0.1 and the reason why the changes may not be accepted. Specifically, the text in the NDM/XML is now being

reproduced in the various standards documents. The same language already appears in the CDM, RDM, TDM, ADM, and ODM. We could fix documents in revision fairly easily, but others not so easily. David searched the WG guidelines document for a relevant guideline he thought was there. It can be summarized quickly: Is it wrong? Fix. Unclear? Clarify. Otherwise, leave alone unless it is being replaced by new functionality. Fran indicated that he understood, and noted that his suggestions were just that, suggestions. David indicated that some of the suggestions may be included if they met the proposed guideline. David took an action item to update the guidelines document as well.

### **1015 1210 Annex Migration=>SANA Status**

We were joined by Julien Bernard of the SANA Operator (Viagenie) to continue discussion of the proposed migration of material from Navigation WG normative annexes into SANA registries. This was a very productive session.

We discussed the References structure in the SANA. They cannot accommodate the prototype structure the WG suggested, but can support links. Since the SANA will not function as a repository for substantiating documents, David indicated that we can keep approved reference documents on the MOIMS-NAV CWE. We will need to get approval from some authors to post a copy of the material instead of a link. Dan noted that it would be useful to "future proof" the registries.

Julien was informed that we had decided to add the word "Orbital" on the front of the "Covariance Matrix Types" registry name given that the Attitude Comprehensive Message (ACM) will have different covariance matrix formulations. David stated that the material in the Orbital Covariance Matrix Types beta registry looks good.

Other notes:

- Julian noted that we cannot in general sort by OID.
- The SANA team is working on a representation that reflects the hierarchy of registries.
- The Nav WG will be sending them more data, e.g., we will be sending them Glossary data soon.
- Julien noted that the SANA can now support images (some of the relative reference frames are illustrated and will benefit from this new feature).
- Julien noted that the Nav WG is using the SANA Registry most aggressively of all working groups.

On the topic of terminology (glossary, etc.): Dan stated that the ISO TC20/SC14 is a disaster. The Ukrainian delegation managing terminology for TC20, which has improved the situation. Definitions of terms appear in various documents; and may be inconsistent even in the same working group. Julien explained that Tom Gannett has access to the SANA Glossary. He added that the SANA may work on a way that others can update their own entries. Mario suggested that editors look for terms in documents that are under review/revision. We hypothesized that the terms in the SANA Glossary are not consistent, but could become so with some effort.

We concluded by indicating to Julien that the Nav WG will soon be sending material on 4 new areas to SANA: atmospheric models, gravity models, orbit types, and orbit averaging types, as well as Glossary material and the final navigation registries that appeared in the original Navigation WG registry "mock up".

### **1330 1510 Attitude Data Message V2 + Project Schedule**

We started with the obligatory sacrifice to the technology gods... we had moved to a new conference room and could NOT get the projector to work. This took quite a while to resolve; it was ultimately

solved by bringing a portable projector into the room. Alain gave a presentation on ADM changes; he stated that he had received 150 comments on the ADM P1.6. Alain pointed out that XML had been added to the ADM; David said the XML section would need to be updated to handle the ACM. The ADM P1.8 does not yet take advantage of the new SANA registries. A "MESSAGE\_ID" keyword was added, consistent with the WG direction.

Julie discussed the ACM, which is new in P1.8, via a few examples. In principle she is trying to keep it as similar as possible to the OCM. Julie stated that ACM angular measurements are in radians; per statements in the ADM V.1 Blue Book "radians are outside the nominal standard." This is a technical issue that will need to be resolved, but it does not seem to be a particularly contentious issue. Sections in the ACM include: Attitude State Time History, Space Object Physical Characteristics, Attitude State Covariance Time History, Maneuver Specification, Attitude Determination Data, and User-Defined Parameters.

The group discussed and decided to have the WG review ADM P1.8 because the prior ADM P1.7 had not been reviewed. The project schedule did not require an update because it was not yet out of date.

The link to Alain's ADM presentation is [https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Attitude%20Data%20Messages%20\(ADM\)/ADM1.8\\_changes-2019-05-08.pdf](https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Attitude%20Data%20Messages%20(ADM)/ADM1.8_changes-2019-05-08.pdf).

The link to Julie's ACM presentation is [https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Attitude%20Data%20Messages%20\(ADM\)/ACM\\_update\\_2019-05-08.pdf](https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Attitude%20Data%20Messages%20(ADM)/ACM_update_2019-05-08.pdf)

### **1510 1640 Tracking Data Message V2 (Prototyping Plan & Report, Project Schedule)**

David showed the status of the "TDM Blue Book Approach Plan" he had prepared and the latest Test Plan/Report. After discussion the group agreed that "DATA\_TYPES" keyword didn't need to be tested. Alexandru suggested producing it on output of a TDM. Cheryl indicated that the DOPPLER\_COUNT test is having a few "non-Doppler-count" issues, but she anticipates good results. Fran is researching with Frank Budnik the PHASE\_CT questions raised by David. The CWE schedule for the TDM V2 was updated. There was a significant slip due to there not having been much work since the Fall 2018 Meetings.

The approach plan is available on the CWE [https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Tracking%20Data%20Message%20\(TDM\)/TDM-blue-book-approach-plan.pdf](https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Tracking%20Data%20Message%20(TDM)/TDM-blue-book-approach-plan.pdf)).

### **DAY 4, THURSDAY 09-MAY-2019**

0845 1030 Navigation Events Message White Book + Project Schedule  
1030 1230 Conjunction Data Message V2 Initial Discussions  
1230 1330 Lunch  
1330 1600 Prep Closing Report, Action Items, Five Year Plan, Set Next Telecon  
1600 1730 MOIMS Closing Plenary

In attendance this day were David Berry, Frank Dreger, Cheryl Gramling, Julie Halverson, Alain Lamy, Byoung Sun Lee, Alexandru Mancas, Fran Martinez, Dan Oltrogge, Brian Swinburne (telecon), Patrick Zimmerman.

## **0845 1030 Navigation Events Message White Book + Project Schedule**

Alain explained that there was not yet a Navigation Events Message (NEM) White Book. He explained that this was largely due to the fact that the intended contents are not yet completely clear. For example, should the events be listed in the book? or in a SANA registry? After a question related to the NEM requirements, Alain went over the working version of the NEM requirements. Then showed a number of examples in KVN format that constitute use cases that can be used to guide the development of the message.

The group stated a preference for events to be defined on SANA, however, Dan pointed out that there could be lots of email traffic requesting addition of events to the SANA. It may be desirable to defer to System Engineering as the arbiter as to whether or not an event is added given their overarching role in the CCSDS. Some issues to address:

- Should we accommodate several objects in the same file?
- How should we standardize events? This generated a fair amount of discussion.
- Are possibilities in XML greater than KVN?
- Do we want to allow a difference in capabilities between XML and KVN?
- Should we support only a single time scale? or multiple time scales? (Discussion here tended towards a single time scale.)
- The introduction of relative time causes an issue with respect to the definition of second.

Alain indicated he would try to define a White Book Version 1 in one month. His presentation on NEM status and issues is available at [https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Navigation%20Events%20Message%20\(NEM\)/NEM\\_2019\\_05\\_09.pdf](https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Navigation%20Events%20Message%20(NEM)/NEM_2019_05_09.pdf) . The presentation on NEM Requirements is available at [https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Navigation%20Events%20Message%20\(NEM\)/NEM\\_requirements\\_2019-05-09.pdf](https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Draft%20Documents/Navigation%20Events%20Message%20(NEM)/NEM_requirements_2019-05-09.pdf) .

## **1030 1230 Conjunction Data Message V2 Initial Discussions**

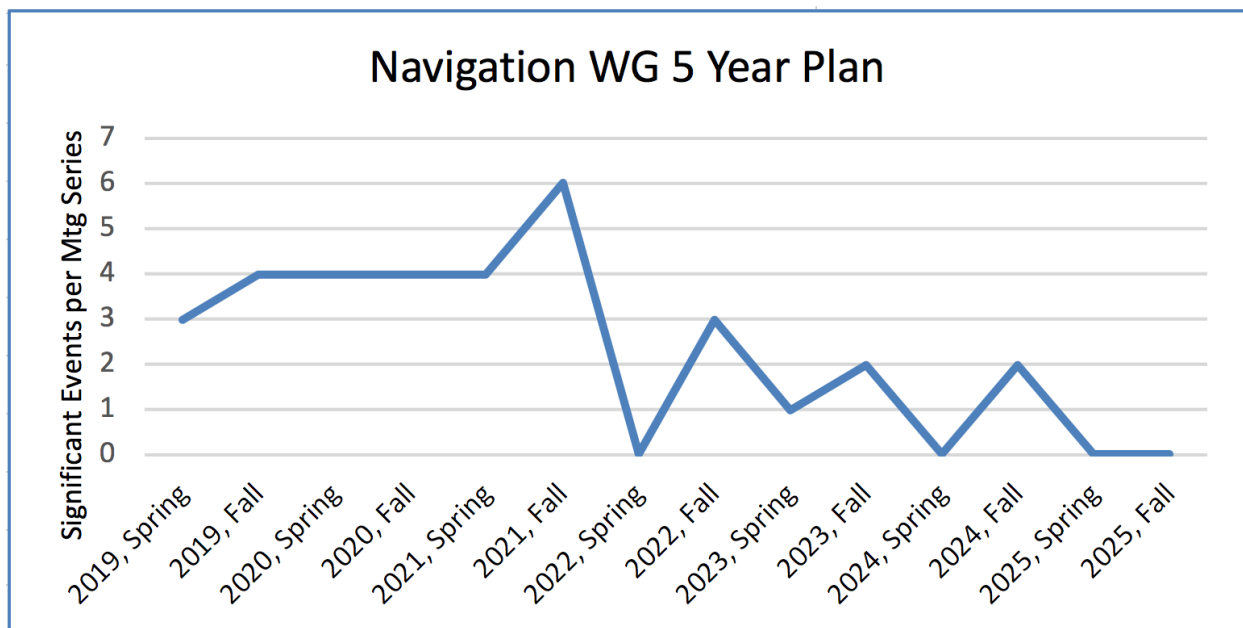
Brian joined us via telecon for this discussion. Brian and Dan have done some coordination. We reviewed and discussed a CRM that contained prospective modifications to the CDM. Dan mentioned that he had sent requests to the Space Data Association members regarding potential modifications to the CDM. The document has not yet been modified, so there is no Pink Book to review yet. Brian and Dan have focused on collecting and reviewing comments. Some items included:

- Make the CDM more consistent with the ODM
- Include a measure of covariance confidence/realism
- Add a unique identifier for a specific conjunction (since the characteristics may change as time passes); CSpOC seems to have done something like this in a COMMENT in the CDM Header.
- In discussion of RCS and AREA\_PC, Alexandru indicated that he would like to consult with colleagues
- Regarding the CDM covariance matrix, which is only available in the RTN frame. David indicated that this was what the JSpOC wanted in the CDM during the initial development. Dan indicated a desire to speak with the 18th Space Command regarding RTN limitations and the desire to make the CDM consistent with other alternative formulations. He noted that CSpOC is getting more capability so this might be possible.

### 1330 1600 Prep Closing Report, Action Items, Five Year Plan, Set Next Telecons

David reviewed the draft Final Report with the remaining members of the WG (a few members had had to leave early due to travel plans). We worked through the draft Final Report, making modifications as applicable. David showed the list of potential action items that had arisen through the week; these had been augmented by the action items still open from Fall 2018. For some action items David had already assigned target dates if they came up in the course of earlier discussion; for other items we set target dates in this session.

We then worked through and updated the Working Group's 5 Year Plan. The final result can be viewed in the following plot of significant events per meeting. The full plan is on the CWE at <https://cwe.ccsds.org/moims/docs/MOIMS-NAV/Meeting%20Materials/2019/Spring/navwg-5-year-plan-201905.pdf>.



As a last item, David showed a proposed plan of WG telecons between the Spring 2019 Meetings and Fall 2019 Meetings (to be found at the end of these minutes); in principle this plan was adopted, though things like this are usually subject to some changes. This was the final closing matter, and the Navigation WG meeting was concluded. Those still in attendance were thanked for a productive meeting week, we bid each other safe travels, and we started making plans for the next meetings in Darmstadt in October 2019.

All materials from the meetings (agenda, introductory presentation, action items, report, 5 Year Plan, and these minutes) are available on the CWE at the following link:

<https://cwe.ccsds.org/moims/docs/Forms/AllItems.aspx?RootFolder=%2Fmoims%2Fdocs%2FMOIMS-NAV%2FMeeting%20Materials%2F2019%2FSpring&FolderCTID=0x012000C8EEDFBFAD59894AB84FF1AF9485D0AB&View={72CC1C3E-EFA9-498B-BEA5-C88E7DEE0C54}>

Draft documents reviewed during the meetings are in their respective directories on the CCSDS CWE:

<https://cwe.ccsds.org/moims/docs/Forms/AllItems.aspx?RootFolder=%2Fmoims%2Fdocs%2FMOIMS-NAV%2FDraft%20Documents&FolderCTID=0x012000C8EEDFBFAD59894AB84FF1AF9485D0AB&>

View={72CC1C3E-EFA9-498B-BEA5-C88E7DEE0C54}#InplviewHash72cc1c3e-efa9-498b-bea5-c88e7dee0c54=FolderCTID%3D0x012000C8EEDFBFAD59894AB84FF1AF9485D0AB-RootFolder%3D%252Fmoims%252Fdocs%252FMOIMS%252DNAV%252FDraft%2520Documents-SortField%3DLinkFilename-SortDir%3DAsc

## **1600 1500 MOIMS Closing Plenary**

In attendance at this meeting were Mario Merri (MOIMS AD), Brigitte Behal (MOIMS DAD); David Berry and Frank Dreger (NAV); Dan Smith and Stefan Gärtner (SM&C); John Garrett (DAI); Marc Duhaze (MP&SS); and a few other members of the various working groups.

The reports of the Navigation, Spacecraft Monitor & Control (SM&C), Digital Archive Ingest (DAI), and Mission Planning & Scheduling (MPS) WGs were presented; the Telerobotics WG did not meet during this meeting series so there was no report. David presented for Navigation; the report is shown immediately below.

## **NAVIGATION WORKING GROUP CLOSING REPORT**

### **Achievements for this meeting cycle**

- Completed internal WG review of revisions to drafts of the Orbit Data Messages, Attitude Data Messages, Re-Entry Data Message, Navigation Data Definitions & Conventions, Navigation Data Messages Overview
- Continued discussion of Navigation Events Message in preparation for first WB
- Continued discussion of Prototyping Plans/Results for the Tracking Data Message V.2
- Continued discussion of prospective revisions to Tracking Data Message V3 (new project)
- Continued discussion of prospective revisions to the Conjunction Data Message
- Completed review and update of CWE project schedules for all documents
- Completed update of WG 5 Year Plan
- Continued discussion of structure and content of Navigation data on the SANA Registry
- Initiated discussion of prospective new project: Fragmentation Data Message

### **Working Group Status**

- Active, "High Momentum"

### **Interaction with other WGs**

- Completed joint meeting w/SANA Operator regarding plans to migrate material from document annexes to SANA (Glossary Terms, Relative Reference Frames, Attitude Control & Spacecraft System Reference Frames, Atmospheric Models, Gravity Models, Technical References, etc.)

### **Problems and Issues**

- Room size was extra large and extra cold on Days 1, 2, and half way through Day 3 (many attendees wore coats all day, facility manager consulted but was not able to remedy, we moved)
- Room could not be locked, causing lunchtime security concerns
- WiFi service was excellent, telecon worked great
- It was nice that most necessary projector adapters were supplied (HDMI, Mac, etc.); we had some troubles with equipment

### **Resolutions Agreed Upon this Meeting:**

- NAV-1: The Navigation WG thanks NASA/Ames for their hosting of this CCSDS Meeting series.
- NAV-2: Request to perform CESG Poll and CMC Poll to approve publication of the Navigation Data Messages Overview Green Book V2
- Further Resolutions Anticipated in the Next 6 Months:
- NAV-3: Request to perform CESG Poll and CMC Poll to approve publication of the Navigation Data – Definitions and Conventions Green Book V4

- NAV-4: Request to perform CESG Poll and CMC Poll to approve publication of the Re-Entry Data Message

**Navigation WG Document Status Summary**

<b>Area and WG name</b>	<b>CCSDS Ref Nr</b>	<b>Document Title</b>	<b>Status / Comments</b>	<b>Start and / or Target Publication Date</b>	
MOIMS NAV	500.0	Navigation Data—Definitions and Conventions (Update)	Excellent progress. Nearing "ready to publish" state.	Start date	09-Nov-2015
				End date	15-Oct-2019
MOIMS NAV	500.2	Navigation Data Message Overview (Update)	Excellent progress. 2 updated white books distributed. Nearing "ready to publish" state.	Start date	25-Apr-2018
				End date	15-Sep-2019
MOIMS NAV	508.1	Re-Entry Data Message	Excellent progress. Prototyping completed. Discussion of "end game" activities (final tweaks, proofread, etc.)	Start date	03-Jul-2016
				End date	30-Sep-2019
MOIMS NAV	502.0	Orbit Data Message (ODM) 5 Year Review Revision	Good progress. Continued internal draft reviews.	Start date	16-Apr-2015
				End date	18-Feb-2021
MOIMS NAV	503.0	Tracking Data Message (TDM) 5 Year Review Revision	Minimal progress. Continued prototyping discussion.	Start date	09-Oct-2013
				End date	15-May-2020
MOIMS NAV	504.0	Attitude Data Message (ADM) 5 Year Review Revision	Good progress. Continued internal draft reviews.	Start date	16-Apr-2015
				End date	30-Apr-2021
MOIMS NAV	505.0	Navigation Data Messages XML Specification 5 Year Review Revision	Minimal progress.	Start date	13-Jul-2016
				End date	31-Jul-2020
MOIMS NAV	TBD	Navigation Events Message	Good progress. Many questions related to scope remain. Productive discussion of many options.	Start date	07-Nov-2017
				End date	30-Apr-2021
MOIMS NAV	503.0	Tracking Data Message (TDM) Version 3 Revision	Good progress. Continued discussion of possible extensions and data additions.	Start date	07-Jan-2019
				End date	30-Nov-2022
MOIMS NAV	508.0	Conjunction Data Message 5 Year Revision	Acceptable progress. Continued discussion of possible extensions and data additions.	Start date	14-Jan-2019
				End date	15-Oct-2021

**Navigation WG Upcoming New Work Items**

None

### **Suggestions for Improvement**

- Project schedules in the **CWE Framework** have dates in the "American" format (mm/dd/yyyy), however, many CCSDS WG members are more comfortable with an alternate format (dd/mm/yyyy). These two formats are ambiguous for a high percentage of each year. It is suggested that the project schedules use a standard format that is not ambiguous (e.g., dd-MMM-yyyy, where "MMM" is the letter abbreviation of the month, such as 09-May-2019).
- The consensus of the Nav WG is that Opening Plenaries should be shorter. The Area Director summaries are not broadly useful, and should be moved out of the full Plenary and into the Area Plenaries.

### **DAY 5, FRIDAY 10-May-2019**

No Working Group Meetings. The CESG met on Friday.

### **NEXT TELECON(S):**

The WG established Wednesday 05-Jun-2019 at 1400 UTC as the next telecon date. A meeting invitation will be sent. Tentative agenda:

1. Approve Spring 2019 Meeting Minutes
2. SANA Registry Status
3. Action Item Update & Other Document Status

Additionally, a full schedule of monthly meetings until the Fall 2019 Meetings was proposed, as follows:

05-Jun-2019 13:00 UTC

10-Jul-2019 13:00 UTC

07-Aug-2019 13:00 UTC

11-Sep-2019 13:00 UTC

09-Oct-2019 13:00 UTC

Fall 2019 Meetings 21-Oct-2019 to 24-Oct-2019