CCSDS 502.0-P3.0/ISO 26900 Orbit Data Message (ODM) Status

11 May 2021

12 May 2021 status

- **Have now concluded technical review and deliberations.**
- Received and aggregated ODM v2.41 proofreading review comments.
- Incorporated/disposed of v2.41 comments -> v2.42
- Continuing to prepare for OCM Testing (COMSPOC + OREKIT)
  - OREKIT team is ready for testing of both KVN and XML
  - COMSPOC team has been focused on ODM disposition of comments
- Very next steps:
  - Dialogue with SANA 14 May regarding XML schemas and assoc. rollout
  - Completing schemas and posting to support upcoming Agency Review
  - Agency Review (beginning ~ July)
  - Testing by COMSPOC and OreKit

Transitioned to new standardized CCSDS NAV WG Annex Structure

- Have now remapped to newly-adopted annex structure

Annex	ODM V.3	CDM V.2
A	Implementation Conformance Statement (ICS) Pro Forma (Normative) (A)	Implementation Conformance Statement (ICS) Proforma (Normative) (A)
B	Values for Selected Keywords (Normative) (B)	
C	Security, SANA, and Patent Considerations (Informative) (M)	Security, SANA, and Patent Considerations (Informative) (B)
D	Abbreviations and Acronyms (Informative) (I)	Abbreviations and Acronyms (Informative) (C)
E	Rationale for This Standard (Informative) (J)	Rationale and Requirements for Conjunction Data Messages (Informative) (D)
F	Technical Material and Conventions (Informative) (C)	Conjunction Information Description (Informative) (E)
G	Examples (Informative) (D)	
H	Informative References (Informative) (N)	Informative References (Informative) (F)
I	Items for an Interface Control Document (ICD) (Informative) (K)	
J	Changes Versus Previous Version (Informative) (L)	

A few recent technical changes: Covariance matrix enhancements

- Two enhancements requested to support Cislunar group rqmts.

6.2.6.11.3.1 LTM: Lower Triangular Matrix beginning with element [1,1], followed by [2,1], [2,2], [3,1], [3,2] and so on, until all $\sum_{i=1}^{N} i$ of the LTM entries have been provided as shown and ordered in Figure 6-1.

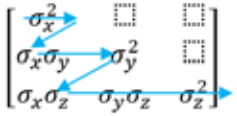


Figure 6-1: LTM covariance element ordering following time tag.

6.2.6.11.3.2 UTM: Upper Triangular Matrix beginning with element [1,1], followed by [1,2], [1,3], [2,2], [2,3] and so on, until all $\sum_{i=1}^{N} i$ of the UTM entries have been provided as shown and ordered in **Figure 6-2**.

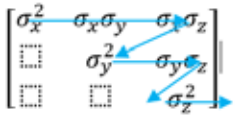


Figure 6-2: UTM covariance element ordering following time tag.

6.2.6.11.3.3 FULL: The full, symmetric covariance matrix, beginning with element [1,1], followed by [1,2], [1,3], [2,1], [2,2], [2,3], [3,1], [3,2] [3,3] and so on, until all covariance entries (there are N^2 entries in total) have been provided as shown and ordered in **Figure 6-3**.

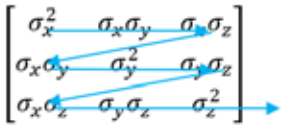


Figure 6-3: Full covariance element ordering following time tag.

6.2.6.11.3.4 LTMWCC: Lower Triangular Matrix conflated with cross-correlation terms, where correlation is obtained by dividing the covariance of the two variables by the product of their standard deviations. This combined matrix shall be provided beginning with covariance element [1,1], followed by correlation$_{xy}$, correlation$_{xz}$, covariance [2,1], [2,2], correlation$_{yz}$, and covariance [3,1], [3,2] [3,3] and so on, until all covariance entries (there are N^2 entries in total) have been provided as shown and ordered in **Figure 6-4**.

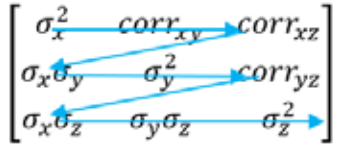


Figure 6-4: LTM covariance/correlation element ordering following time tag.

6.2.6.11.3.5 UTMWCC: Upper Triangular Matrix conflated with cross-correlation terms, provided beginning with covariance element [1,1], followed by [1,2] and [1,3], then correlation$_{xy}$, covariance [2,2], and [2,3], then correlation$_{xz}$, correlation$_{yz}$, and covariance [3,3] and so on, until all covariance entries (there are N^2 entries in total) have been provided as shown and ordered in **Figure 6-5**.

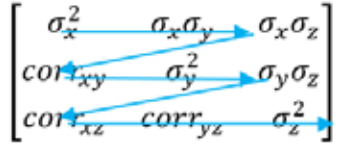


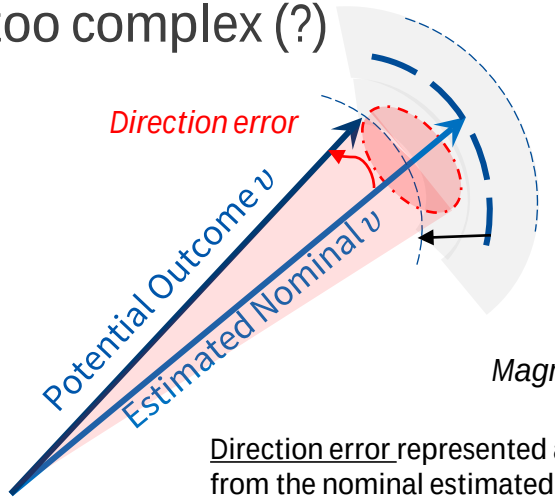
Figure 6-5: UTM covariance/correlation element ordering following time tag.

Recent technical changes: Maneuver direction uncertainty

- Conical Gaussian angular uncertainty added
- "Maneuver block: the maneuver direction uncertainty may need to be defined as an ellipse vs a circle because the error may be larger in one direction vs another. "
  - This would then require an orientation parameter – may be too complex (?)

ACC_X	Acceleration component A_X in the selected maneuver frame.	km/s**2	0.000734092785
ACC_Y	Acceleration component A_Y in the selected maneuver frame.	km/s**2	0.000189779834
ACC_Z	Acceleration component A_Z in the selected maneuver frame.	km/s**2	0.0000794872502
ACC_INTERP	Acceleration vector Euler axis/angle interpolation mode between current and next acceleration line.	n/a	OFF ON
ACC_MAG_SIGMA	One-sigma percent error on acceleration magnitude.	%	1.0
ACC_DIR_SIGMA	One-sigma angular off-nominal acceleration vector direction.	deg	5.0
DV_X	Velocity increment ΔV_X in the selected maneuver reference frame. The actual ΔV should be impulsively applied at a time of <time tag> + ½ (MAN_DURA).	km/s	0.025
DV_Y	Velocity increment ΔV_Y in the selected maneuver reference frame. The actual ΔV should be impulsively applied at a time of <time tag> + ½ (MAN_DURA).	km/s	0.0015
DV_Z	Velocity increment ΔV_Z in the selected maneuver reference frame. The actual ΔV should be impulsively applied at a time of <time tag> + ½ (MAN_DURA).	km/s	0.00029
DV_MAG_SIGMA	One-sigma percent error on ΔV magnitude.	%	2.0
DV_DIR_SIGMA	One-sigma angular off-nominal ΔV vector direction.	deg	5.0

(THR_DIR_SIGMA similarly defined)



Direction error represented as a cone offset by *x*° half-angle from the nominal estimated direction; 1s probability the maneuver occurred within the region defined by the cone. Magnitude error represented as a 1s uncertainty from the nominal estimated maneuver magnitude.

- Decision: Go with conical for now and await agency review and consider (internally) further.

Newly-requested enhancements (10 May 2021)

- EPOCH REV or ORBIT NUMBER at start of Orbit Time History
- Added Orbit Revolution Number

ORB_REVNUM	The integer orbit revolution number associated with first orbit state in this orbit state time history block. NOTE – The first ascending node crossing following launch or deployment corresponds to an orbit revolution number of one “1”.		0	1500 30007	

- Decision:
  - Definition matches those for DLR Earth missions. NASA/JSC defines launch to be orbit rev #1, and first ascending node to be start of orbit rev #2.
  - How would we count orbits in e.g., L2 ?

Newly-requested enhancements (10 May 2021)

- Energy Dissipation Rate (EDR in W/KG); consensus is that it is useful
- Added SEDR:

SEDR	The Specific Energy Dissipation Rate, which is the amount of energy being removed from the object's orbit by atmospheric drag. This value is an average calculated during the OD. (See Annex ANNEX F, Section F7 for definition.)	W/kg		4.54570E-05	O

- Decision: Accepted.

Newly-requested enhancements (10 May 2021)

- LEAP – need to identify if a leap second has occurred, when it occurred, and how many seconds were leapt. While some of this can be inferred by TAIMUTC_AT_TZERO, it may be useful to explicitly state the leap has or has not been incorporated into the Orbit Time History and Covariance Time History, and the time it was applied.
- Conflicting opinions on how to proceed
- Decision: Added the following:
  - NEXT_LEAP_EPOCH = <DATE>
  - NEXT_LEAP_TAIMUTC = 38

Member agencies

- Comparing the list of Member Agencies with the list on the web, there are different names for UK and Russian agencies.
- The list of observers also seems to have name changes, names that are not more in the web, and new names in the web that are missing in the document.
- Does editor take care of this?
- Decision: Correct – editor will address this.

SANA Registries not used for REF_FRAME or TIMING SYSTEM

- References to annex B4 have been partially removed from the document but not totally.
- In table 3-2 they have been replaced by a reference to this new section.
- Does is make sense to have SANA reference for everything but the reference frames?
- In addition, there are several differences between SANA and sec 3.2.3.2. If we follow SANA, for example, any ODM user producing TOD should change to use TOD_EARTH which could generate a lot of problems if we want to keep backward compatibility in OPM.
- E. g. ,rather than TOD_EARTH and TOD_MOON, it would make more sense TOD and TOD_MOON.
- Decision: Accept current implementation.

Spacecraft Parameters comment

- With the new comment added to Spacecraft parameters, to be CCSDS compliant, a GEO operator providing OPMs with maneuvers shall also provide DRAG_AREA and DRAG_COEFF.
- Decision: Changed “conditional” to only apply to mass parameter, and inserted NOTE to recommend supplying SRP and drag params in the appropriate regimes.

J2000 not listed in OPM, OMM, OEM

- The example J2000 is not listed in 3.2.3.2 in the list of accepted values.
- Decision: Good as implemented, after fixing examples for OPM, OMM and OEM.

Constraint on number of significant digits

- Equivalent section from ADM end with “The number of digits shall be 16 or fewer”.
- Decision: Reintroduce this text.

XML-related

- The reference to xsd does not seem in line with the last NDMXML approach. It seems we are not taking account the two options: qualified vs unqualified.
- The namespaces explanation account for the qualified vs unqualified option.
- The URLs for the ODM schemas lead to “404 page not found”. version 3.0 is not yet there and v2.0 is in a different place (also in the example in 8.3.8 and on page 8-16)
- Same as for ADM: This may have been long closed or it may open one of Pandora’s boxes – we do not need to have this discussion, but: why do we enforce in many cases an order for XML elements (by means of xsd:sequence in the schemas)? The order matters for KVN, but not so obviously for XML.
- Decisions:
  - Will discuss XML schema versioning issues with SANA folks on Friday
  - XML ordering is enforced from the standpoint of allowing XML-to-KVN compatibility.

Timing-relevant items

- I don’t understand why there could be both absolute and relative times (that may not be exactly consistent)
- TIME_SYSTEM keyword: The reason for a refer-back to Table 3-3 are not obvious.
- Decisions:
  - We previously decided not to mix absolute and relative times within a data block, per OCM requirement 6.2.1.5:
    - “Within an OCM data block, all time-tags must adhere to either relative time, or absolute time, for the entirety of that data block. Relative and absolute time shall not be used within the same data block.”
  - TIME_SYSTEM callback to Table 3-3 is to enforce backwards compatibility for OPM, OMM and OEM.

Group will review only the few technical enhancements (and associated proofreading)

- Will distribute the (e.g.) 10 changed pages for group review
- Final review comments/inputs due 26 May


CSSI