

# **Recommendations on Owner/Operator Ephemeris Data Format for Department of Commerce Traffic Coordination System for Space (TraCSS)**

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## **1. Purpose**

This document provides the space situational awareness (SSA) community with information on proposed owner/operator data format for the Department of Commerce (DOC) Traffic Coordination System for Space (TraCSS). TraCSS proposes to use the format recommended by the Consultative Committee for Space Data Systems (CCSDS) orbit comprehensive message (OCM) ephemeris format as detailed in the CCSDS Orbit Data Messages (ODM) recommended standard<sup>1</sup>. The ODM specifies message formats for use in transferring spacecraft orbit information between space agencies and commercial or governmental spacecraft operators. The current issue, April 2023, includes the OCM.

In this document, DOC suggests some constraints on the fields and implementation of the OCM as necessary to meet the needs of TraCSS. Section 3 of this document provides a comprehensive description of the recommended format, including constraints. This document also describes an opportunity to learn about the content of this document through a listening session to be held by NOAA's Office of Space Commerce (OSC) and provide comments during the session or by email following the webinar as described in Section 4 in this document. DOC welcomes feedback on:

1. if there are operational considerations if the information in certain fields was not available;
2. if any of the proposed fields are considered to be not necessary;
3. if there are additional fields that should be included in the proposed list;
4. if there are issues with not including COMMENT fields;
5. thoughts on the USABLE\_START\_TIME, USABLE\_END\_TIME parameters; and

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<sup>1</sup> Orbit Data Messages, Recommended Standard (Blue Book), CCSDS 502.0-B-3. Washington, D.C. CCSDS, April 2023. Available at: <https://public.ccsds.org/Pubs/502x0b3e1.pdf>. Accessed April 28, 2024. [Note: The OCM specific section begins on Page 6-1.]

## 6. other comments.

OSC plans to leverage the information contained in the proposed format for the ingest of satellite ephemeris and maneuver plans, which will be used for analyses for the provision of SSA and space traffic coordination (STC) safety data products and services. OSC is still determining data sharing policies for such information, is interested in leveraging industry best practices for open data sharing to support spaceflight safety and STC, and thus welcomes feedback on whether certain fields are proprietary.

This document does not provide an overview of TraCSS. More information on TraCSS, including videos, is available at the TraCSS website<sup>2</sup>. For more information on standards for data exchange and TraCSS, see the document “Recommendations on Standards for Provision of Space Situational Awareness Data from Department of Commerce Traffic Coordination System for Space (TraCSS)”<sup>3</sup>. For more information on conjunction data message (CDM) recommendations, see the document “Recommendations on Conjunction Data Message Fields for Department of Commerce Traffic Coordination System for Space (TraCSS)”<sup>4</sup>.

## 2. Background

### 2.1. Consultative Committee for Space Data Systems

The Consultative Committee for Space Data Systems (CCSDS)<sup>5</sup> is a multi-national organization of international space agencies that develops open communications and data standards for space systems. The standards are available through the International Organization for Standardization (ISO) Technical Committee (TC) 20, Aircraft and Space Vehicles, Subcommittee (SC) 13, Space Data and Information Transfer Systems, and at the CCSDS website.

CCSDS has multiple working groups developing and publishing standards. The Navigation Working Group family of space data messages are most applicable for use by space launch operators, spacecraft operators, SSA service data providers, analysts,

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<sup>2</sup> Visit <https://www.space.commerce.gov/traffic-coordination-system-for-space-tracss/> for more information on TraCSS, including videos. Accessed April 28, 2024

<sup>3</sup> Visit <https://www.space.commerce.gov/video-update-on-tracss-data-standards-and-formats/> for a video overview of “Recommendations on Standards for Provision of Space Situational Awareness Data from Department of Commerce Traffic Coordination System for Space (TraCSS)” and <https://www.space.commerce.gov/wp-content/uploads/January-2024-Recommendations-TraCSS-Standards-for-Data-Exchange.pdf> for a copy of the recommendations. Accessed April 28, 2024

<sup>4</sup> Visit <https://www.space.commerce.gov/tracss-listening-session-space-data-standards-and-formats/> for a video overview of “Recommendations on Conjunction Data Message Fields for Department of Commerce Traffic Coordination System for Space (TraCSS)” and <https://www.space.commerce.gov/wp-content/uploads/Recommendation-on-TraCSS-CDM-Fields-1.pdf> for a copy of the recommendations. Accessed April 28, 2024

<sup>5</sup> Visit <https://public.ccsds.org/default.aspx> for more information on the CCSDS. Accessed April 28, 2024

and message exchange partners and are freely accessible at the CCSDS website. Many space data exchange standards already exist. These are reviewed via a periodic review cycle of no more than five years and cover a wide range of messages and formats.

## 2.2. CCSDS Orbit Data Messages

As detailed in the CCSDS ODM Recommended Standard (see reference in footnote 1), the set of orbit data messages in the recommended standard is the baseline concept for trajectory representation in data interchange applications that are supported between the member agencies of the CCSDS<sup>6</sup>. The ODM Recommended Standard establishes a common framework and provides a common basis for the interchange of orbit and orbit-relevant data. The ODM Recommended Standard is an international standard published under the auspices of CCSDS and ISO TC 20, Subcommittee 13, developed jointly and in concert with the ISO TC20/SC14. As such, this CCSDS standard is also properly labeled as ISO 26900.

The ODM Recommended Standard specifies four standard message formats for use in transferring spacecraft orbit information between space agencies and commercial or governmental spacecraft operators: The Orbit Parameter Message (OPM), the Orbit Mean-Elements Message (OMM), the Orbit Ephemeris Message (OEM), and the Orbit Comprehensive Message (OCM). Such exchanges are used for:

- pre-flight planning for tracking or navigation support;
- scheduling tracking support;
- carrying out tracking operations (sometimes called metric predicts);
- performing orbit comparisons;
- carrying out navigation operations such as orbit propagation and orbit reconstruction;
- assessing mutual physical and electromagnetic interference among satellites orbiting the same celestial body (primarily Earth, Moon, and Mars at present);
- performing orbit conjunction (collision avoidance) studies; and
- developing and executing collaborative maneuvers to mitigate interference or enhance mutual operations.

The ODM Recommended Standard includes sets of requirements and criteria that the message formats have been designed to meet. For exchanges in which these requirements do not capture the needs of the participating agencies and satellite operators, another mechanism may be selected.

The recommended Orbit Data Message format is ASCII<sup>7</sup>.

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<sup>6</sup> See [https://public.ccsds.org/participation/member\\_agencies.aspx](https://public.ccsds.org/participation/member_agencies.aspx) for a listing of member agencies participating in CCSDS and more information on the topic of membership. Accessed April 28, 2024

<sup>7</sup> Information Technology—8-Bit Single-Byte Coded Graphic Character Sets—Part 1: Latin Alphabet No. 1. International Standard, ISO/IEC 8859-1:1998. Geneva: ISO, 1998.

The CCSDS ODM document describes both ‘Keyword = Value Notation’ (KVN) as well as Extensible Markup Language (XML)<sup>8</sup> formatted messages. In the immediate future, OSC is planning to use only the existing KVN format.

As currently specified, an OPM, OMM, or OEM file is to represent orbit data for a single spacecraft, and the OCM is to represent orbit data for either a single spacecraft or single parent spacecraft of a parent/child spacecraft deployment scenario. It is possible that the architecture may support multiple spacecraft per file; this could be considered in the future.

TraCSS plans to use OCM format for owner/operator ephemeris. Following additional background on the OCM in Section 2.3 in this document, the recommendations on OCM ephemeris data format for TraCSS are presented in Section 3. Section 4 provides a description of how and what to comment on with respect to the recommendations in Section 3.

### **2.3. Orbit Comprehensive Message**

As described in the ODM Recommended Standard (see reference in footnote 1), an OCM specifies position and velocity of either a single object or an *en masse* parent/child deployment scenario stemming from a single object<sup>9</sup>. The OCM aggregates and extends OPM, OEM, and OMM content in a single comprehensive hybrid message (file) and includes the following additional capabilities:

- Optional Earth Orientation (UT1 and UTC)<sup>10</sup> at a nearby (relevant) reference epoch;
- Optional Leap second specification;
- Optional area cross-sections for drag, Solar Radiation Pressure (SRP) perturbations modeling;
- Optional spacecraft dimensions and orientation information for collision probability estimation;
- Optional orbit states (specified using one or more of Cartesian and orbit elements and reference frames) for a single or parent object at either a single epoch or as a time history (ephemeris);
- Optional covariance matrix of selectable/arbitrary order for a single or parent object at either a single epoch or as a time history (ephemeris) that reflects the uncertainty of the orbit solution or simulation used to obtain the nominal states in the orbit state(s);

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<sup>8</sup> XML Specification for Navigation Data Messages. Issue 3. Recommendation for Space Data System Standards (Blue Book), CCSDS 505.0-B-3. Washington, D.C.: CCSDS, May 2023.

<sup>9</sup> Note: a sequence of OCMs for either a single object or for multiple objects can be aggregated into a single navigation data message XML file as described in Section 8.12 and shown in annex G in the ODM Recommended Standard (see reference in footnote 1).

<sup>10</sup> Note: TraCSS will only accept UTC.

- Optional covariance content options (e.g., Cartesian 3x3, 6x6, 7x7, or any combination of order, reference frame, and orbit elements);
- Optional maneuver specification (impulsive or finite burn);
- Optional perturbations model specification; and
- Optional orbit determination data and metrics.

The OCM simultaneously emphasizes flexibility and message conciseness by offering extensive optional content while minimizing mandatory content. The OCM is well-suited for exchanges that (1) involve automated interaction (e.g., computer-to-computer communication when frequent, fast automated time interpretation and processing is required), and (2) involve regular orbit data transfer for numerous objects (e.g., 200,000) using minimal network bandwidth, disk storage, and quantity of files. The OCM allows the user, in a single message/file, to either embed high-fidelity orbit propagation into an ephemeris time history (akin to the OEM ephemeris) or specify orbital states that can be propagated with supplied perturbations model parameters (akin to OPM content), or both.

The OCM may be used for assessing mutual physical or electromagnetic interference among Earth-orbiting spacecraft, developing collaborative maneuvers, and representing the orbits of active satellites, inactive man-made objects, near-Earth debris fragments, etc. The OCM reflects the dynamic modeling of any users' approach to conservative and nonconservative phenomena.

### 3. Recommendations for Orbit Comprehensive Message

The OCM format is extremely comprehensive and flexible. It is noted that developing and testing a parser that can handle the full range of variations possible with the format would be extremely difficult. Additionally, the TraCSS program has specific needs for certain fields to enable the provision of SSA and STC safety services. Therefore, TraCSS proposes the following constraints to the CCSDS OCM specifications with the goals of:

- 1) facilitating the communication of accurate, concise ephemeris and metadata for the purpose of space traffic coordination analyses; and
- 2) limiting the impact of the constraints on other potential users of the data products

Each field from the OCM specification (Tables 6-1 through 6-7, 6-10, and 6-11 in the OCM Recommended Standard<sup>11</sup>) are assessed below in this document with one of the following categories described in Table 1.

#### Table 1. Assessment categories for OCM specifications for TraCSS.

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<sup>11</sup> Orbit Data Messages, Recommended Standard (Blue Book), CCSDS 502.0-B-3. Washington, D.C. CCSDS, April 2023. Available at: <https://public.ccsds.org/Pubs/502x0b3e1.pdf>. Accessed April 28, 2024.

Status	Abbr.	Description
KEEP	K	Keep the field with no change to the CCSDS specification for mandatory utilization within TraCSS.
IGNORE	I	The field may be present, but will not be parsed by the TraCSS system
RESTRICT	R	The field is restricted in some manner relative to the CCSDS specification
FUTURE	F	Future use of this field is envisioned, but will not be parsed or used in TraCSS 1.0

Additionally, the CCSDS “Optional” (O) specification may be promoted to “Mandatory” (M) and where possible, published standards are specified for enumerated values. In some cases, default values have been provided for “Conditional” (C) content.

TraCSS plans to ignore all COMMENT fields. A TraCSS proposal to ignore a particular data section or specification does not preclude an owner/operator from use of that field outside of TraCSS.

**Table 2. OCM file layout and ordering specification per Table 6.1 in the OCM Recommended Standard. This table describes the order and purpose of the OCM file sections.**

Section	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	Additional Information
OCM Header	M	M	K	
OCM Metadata	M	M	K	
Orbit Data	O	M	R	Each file shall contain a single Orbit Data section, unless multiple sections are used to represent pre and post maneuver trajectories in the representation of impulsive maneuvers
Physical Properties	O	M	K	
Covariance Data	O	M	R	Each file shall contain a single Orbit Data section, unless multiple sections

				are used to represent pre and post maneuver trajectories in the representation of impulsive maneuvers.  The number of Covariance Data sections must be equal to the number of Orbit Data sections, and each shall cover the same time span.
Maneuver Data	O	O	K	
Perturbations Parameters	C	C	K	
Orbit Determination	O	M	K	
User-Defined Parameters	O	O	I	

**Table 3. OCM header per Table 6.2 in the OCM Recommended Standard. This table specifies the keywords for each header item.**

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
CCSDS_OCM_VERS	M	M	R	3.*	
CLASSIFICATION	O	O	I		All TraCSS data products will be unclassified
CREATION_DATE	M	M	K		
ORIGINATOR	M	M	K		<a href="https://sanaregistry.org/r/organizations/">https://sanaregistry.org/r/organizations/</a>
MESSAGE_ID	O	M	R	UUID	Universally Unique Identifier

**Table 4. OCM metadata per Table 6.3 in the OCM Recommended Standard. This table specifies the metadata keywords.**

<b>Keyword</b>	<b>CCSDS M/O/C</b>	<b>TraCSS M/O/C</b>	<b>TraCSS Refine ment</b>	<b>TraCSS Restriction</b>	<b>Additional Information</b>
META_START	M	M	K		
OBJECT_NAME	O	O	K		
INTERNATIONAL_DESIGNATOR	O	M	K		Use UNKNOWN where an international designator is not known or available.
CATALOG_NAME	O	M	R	“DoD Satellite Catalog”	Additional catalogs may be added in the future
OBJECT_DESIGNATOR	O	M	R	DoD Satellite Catalog Number	TraCSS is reviewing approaches to assign object designators for objects that are lacking a DOD Satellite Catalogue Number
ALTERNATE_NAMES	O	O	I		
ORIGINATOR_POC	O	M	K		
ORIGINATOR_POSITION	O	M	K		
ORIGINATOR_PHONE	O	M	K		
ORIGINATOR_EMAIL	O	M	K		
ORIGINATOR_ADDRESS	O	M	K		



Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
TECH_ORG	O	M	K		
TECH_POC	O	M	K		
TECH_PHONE	O	M	K		
TECH_EMAIL	O	M	K		
TECH_ADDRESSES	O	M	K		
PREVIOUS_MESSAGE_ID	O	O	F		
NEXT_MESSAGE_ID	O	O	F		
ADM_MSG_LINK	O	O	I		
CDM_MSG_LINK	O	O	O		If present, the overall file should include an ephemeris released in response to the CDM linked within this field
PRM_MSG_LINK	O	O	I		
RDM_MSG_LINK	O	O	I		
TDM_MSG_LINK	O	O	I		
OPERATOR	O	M	R	Enumerated Value	Based on organizations registered with TraCSS

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
					Unknown and N/A are also valid values
OWNER	O	M	R	Enumerated Value	Based on owners registered with TraCSS Unknown and N/A are also valid values
COUNTRY	O	M	R	Enumerated Value	ISO3166, <a href="https://www.iso.org/iso-3166-country-codes.html">https://www.iso.org/iso-3166-country-codes.html</a> or UNKNOWN  Full text or abbreviation may be used.
CONSTELLATION	O	M	R	Enumerated Value	Based on constellations registered with TraCSS Unknown and N/A are also valid values
OBJECT_TYPE	O	M	R	Enumerated Value	<a href="https://sanaregistry.org/r/object_types/">https://sanaregistry.org/r/object_types/</a>
TIME_SYSTEM	M	M	R	UTC	
EPOCH_TZERO	M	M	K		
OPS_STATUS	O	M/O	K	Enumerated Value	<a href="https://sanaregistry.org/r/operational_status/">https://sanaregistry.org/r/operational_status/</a> This may be a comma separated list of values, for example: OPERATIONAL_MANEUVERABLE,DEGRADED_OPERATIONS  Mandatory for Owner/Operator provided data

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
ORBIT_CATEGORY	O	O	R	Enumerated Value	<a href="https://sanaregistry.org/r/orbit_categories/">https://sanaregistry.org/r/orbit_categories/</a> (Only the Earth centered options)
OCM_DATA_ELEMENTS	O	M	K		
SCLK_OFFSET_AT_EPOCH	C	C	I		The SCLK_* values are conditional upon TIME_SYSTEM being set to SCLK, which we are restricting to UTC
SCLK_SEC_PER_SI_SEC	C	C	I		The SCLK_* values are conditional upon TIME_SYSTEM being set to SCLK, which we are restricting to UTC
PREVIOUS_MESSAGE_EPOCH	O	O	F		
NEXT_MESSAGE_EPOCH	O	O	F		
START_TIME	O	M	K		This should correspond to the earliest USABLE_START_TIME value in the Orbit data blocks
STOP_TIME	O	M	K		This should correspond to the latest USABLE_STOP_TIME value in the Orbit data blocks
TIME_SPAN	O	O	I		Redundant to START_TIME, STOP_TIME

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refine ment	TraCSS Restriction	Additional Information
TAIMUTC_AT_T ZERO	O	O	I		TraCSS will specify best practices and sources for EOP data.
NEXT_LEAP_E POCH	O	O	I		TraCSS will specify best practices and sources for EOP data.
NEXT_LEAP_T AIMUTC	C	C	I		TraCSS will specify best practices and sources for EOP data.
UT1MUTC_AT_ TZERO	O	O	I		TraCSS will specify best practices and sources for EOP data.
EOP_SOURCE	O	O	I		TraCSS will specify best practices and sources for EOP data.
INTERP_METH OD_EOP	O	O	I		TraCSS will specify best practices and sources for EOP data.
CELESTIAL_SO URCE	O	O	I		TraCSS will specify best practices and sources for EOP data.
META_STOP	M	M	K		

**Table 5. OCM orbit data per Table 6.4 in the OCM Recommended Standard. This table provides an overview of the OCM trajectory state time history ('ephemeris') section.**

Notes:

- 1) Multiple orbit data sections shall only be used to represent pre and post maneuver trajectories in impulsive maneuver situations.

- a. Multiple orbit data sections must be consecutive in time such that **USABLE\_START\_TIME** of a section must equal **USABLE\_STOP\_TIME** of the previous Orbit Data section (if present)
- 2) The trajectory state time history section shall contain at least 5 records prior to the mandatory **USABLE\_START\_EPOCH** value and 5 records after the **USABLE\_STOP\_EPOCH** value to ensure accurate interpolation within the “usable” time span of the data.

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
TRAJ_START	M	M	K		
TRAJ_ID	O	M	R	Orbit Data sections shall be numbered consecutively starting with 1	
TRAJ_PREV_ID	O	O	I		
TRAJ_NEXT_ID	O	O	I		
TRAJ_BASIS	O	M	R	Enumerated Value	<p><b>OPERATIONAL:</b> The trajectory expected to be flown, including maneuvers and other considerations. This is to be used by satellite owner/operators</p> <p><b>PREDICTED:</b> The expected trajectory based on propagation of an OD solution, without insight into vehicle operations</p> <p><b>CANDIDATE:</b> A candidate trajectory for the purpose of maneuver screening, corresponds to DoD SPECIAL</p>

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
					DETERMINED: Retrospective reconstruction of a trajectory for quality control monitoring or post-event analysis
TRAJ_BASIS_ID	O	O	I		
INTERPOLATION	O	O	K		Recommendation only
INTERPOLATION_DEGREE	O	O	K		Recommendation only
PROPAGATOR	O	O	I		
CENTER_NAME	M	M	R	EARTH	
TRAJ_REF_FRAME	M	M	R	EME2000	<a href="https://sanaregistry.org/r/celestial-body-reference-frames/">https://sanaregistry.org/r/celestial-body-reference-frames/</a>
TRAJ_FRAME_EPOCH	C	C	I		Irrelevant for the chosen TRAJ_REF_FRAME
USEABLE_START_TIME	N/A	M	R		The trajectory state time history section shall contain at least 5 records prior to the USEABLE_START_EPOCH value to ensure accurate interpolation within the “usable” time span of the data
USEABLE_STOP_TIME	N/A	M	R		The trajectory state time history section shall contain at least 5 records

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
					following the USABLE_STOP_EPOCH value to ensure accurate interpolation within the “usable” time span of the data
ORB_REVNUM	O	O	I		
ORB_REVNUM_BASIS	C	C	I		
TRAJ_TYPE	M	M	R	CARTPV, CARTPVA	<a href="https://sanaregistry.org/r/orbital_elements/">https://sanaregistry.org/r/orbital_elements/</a>
ORB_AVERAGING	C	C	I		Not relevant for CARTPV, CARTPVA TRAJ_TYPE
TRAJ_UNITS	O	O	I		The SANA registry specifies the units (km, km/s, km/s^2)
<state time history data>	M	M	R		This section shall contain at least 5 records prior to the USABLE_START_EPOCH value and 5 records after the USABLE_STOP_EPOCH value to ensure accurate interpolation within the “usable” time span of the data
TRAJ_STOP	M	M	K		

**Table 6. OCM space object physical characteristics per Table 6.5 in the OCM Recommended Standard. This table gives an overview of the OCM space object physical characteristics section.**

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
PHYS_START	M	M	K		
MANUFACTURER	O	O	I		
BUS_MODEL	O	O	I		
DOCKED_WITH	O	O	F		
DRAG_CONST_AREA	O	O	K		
DRAG_COEFF_NOM	O	O	K		
DRAG_UNCERTAINTY	O	O	F		
INITIAL_WET_MASS	O	O	I		
WET_MASS	O	M/O	K		Mandatory for Owner/Operator provided data
DRY_MASS	O	O	F		
OEB_PARENT_FRAME	O	O	I		
OEB_PARENT_FRAME_EPOCH	O	O	I		



Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refine ment	TraCSS Restriction	Additional Information
OEB_Q1	O	O	I		
OEB_Q2	O	O	I		
OEB_Q3	O	O	I		
OEB_QC	O	O	I		
OEB_MAX	O	O	I		
OEB_INT	O	O	I		
OEB_MIN	O	O	I		
AREA_ALONG_ OEB_MAX	O	O	I		
AREA_ALONG_ OEB_INT	O	O	I		
AREA_ALONG_ OEB_MIN	O	O	I		
AREA_MIN_FO R_PC	O	O	F		
AREA_MAX_FO R_PC	O	O	F		
AREA_TYP_FO R_PC	O	M/O	K		Mandatory for Owner/Operator provided data This will be treated as the area of a circle for determining the Hard Body Radius for Pc calculation

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refine ment	TraCSS Restriction	Additional Information
RCS	O	O	K		May be refined to be mandatory in future for data provided by third party SSA capability contributors.
RCS_MIN	O	O	K		May be refined to be mandatory in future for data provided by third party SSA capability contributors.
RCS_MAX	O	O	K		May be refined to be mandatory in future for data provided by third party SSA capability contributors.
SRP_CONST_A REA	O	O	K		
SOLAR_RAD_C OEFF	O	O	K		
SOLAR_RAD_U NCERTAINTY	O	O	F		
VM_ABSOLUTE	O	O	K		May be refined to be mandatory in future for data provided by third party SSA capability contributors.
VM_APPARENT _MIN	O	O	K		May be refined to be mandatory in future for data provided by third party SSA capability contributors.
VM_APPARENT	O	O	K		May be refined to be mandatory in future for

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
					data provided by third party SSA capability contributors.
VM_APPARENT_MAX	O	O	K		May be refined to be mandatory in future for data provided by third party SSA capability contributors.
REFLECTANCE	O	O	K		
ATT_CONTROL_MODE	O	O	I		
ATT_ACTUATOR_TYPE	O	O	I		
ATT_KNOWLEDGE	O	O	I		
ATT_CONTROL	O	O	I		
ATT_POINTING	O	O	I		
AVG_MANEUV ER_FREQ	O	O	F		
MAX_THRUST	O	O	F		
DV_BOL	O	O	F		
DV_REMAININ G	O	O	F		
IXX	O	O	I		

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
IYY	O	O	I		
IZZ	O	O	I		
IXY	O	O	I		
IXZ	O	O	I		
IYZ	O	O	I		
PHYS_STOP	M	M	K		

**Table 7. OCM covariance data per Table 6.6 in the OCM Recommended Standard. This table provides an overview of the OCM covariance time history section.**

Notes:

- 1) There shall be a one-to-one correspondence between orbit data section(s) and covariance data section(s).
- 2) there shall be a one-to-one correspondence between orbit data time history lines, and covariance data time history lines within each pair of sections and each pair of time history lines shall have identical epochs.

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
COV_START	M	M	K		
COV_ID	O	M	R	Covariance Data sections must be numbered consecutiv	

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
				ely starting with 1	
COV_PREV_ID	O	O	I		
COV_NEXT_ID	O	O	I		
COV_BASIS	O	M	R	Enumerated Value	<p>OPERATIONAL: The trajectory expected to be flown, including maneuvers and other considerations. This is to be used by satellite owner/operators</p> <p>PREDICTED: The expected trajectory based on propagation of an OD solution, without insight into vehicle operations</p> <p>CANDIDATE: A candidate trajectory for the purpose of maneuver screening, corresponds to DoD SPECIAL</p> <p>DETERMINED: Retrospective reconstruction of a trajectory for quality control monitoring or post-event analysis</p>
COV_BASIS_ID	O	O	I		
COV_REF_FRAME	M	M	R	TNW_INERTIAL	<a href="https://sanaregistry.org/r/orbit_relative_reference_frames/">https://sanaregistry.org/r/orbit_relative_reference_frames/</a>

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
COV_FRAME_EPOCH	C	C	I		Irrelevant for chosen local reference frame
COV_SCALE_MIN	O	O	I		Covariance is expected to be scaled appropriately as presented
COV_SCALE_MAX	O	O	I		Covariance is expected to be scaled appropriately as presented
COV_CONFIDENCE	O	O	F		
COV_TYPE	M	M	R	TCARTP, TCARTPV	<a href="https://sanaregistry.org/r/orbital_covariance_matrix_types/">https://sanaregistry.org/r/orbital_covariance_matrix_types/</a>
COV_ORDERING	M	M	R	UTM	
COV_UNITS	O	O	I		The SANA registry specifies the units based on COV_TYPE
<covariance time history data>	M	M	K		
COV_STOP					

**Table 8. OCM maneuver data per Table 6.7 in the OCM Recommended Standard. This table provides an overview of the OCM maneuver specification section.**

Notes:

- 1) The purpose of the Maneuver Data section for TraCSS is to:
  - a. Indicate the presence of maneuver(s) within the time span of the file
  - b. Indicate the start time and duration(s) of maneuver(s) within the file

- 2) The expected trajectory during and after any maneuvers shall be represented in the Orbit Data section(s)
- a. Impulsive maneuvers shall be represented by consecutive Orbit Data sections where the `USABLE_STOP_EPOCH` of the pre-maneuver Orbit Data section and the `USABLE_START_EPOCH` of the post-maneuver Orbit Data section are both equal to the maneuver epoch

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
MAN_START	M	M	K		
MAN_ID	M	M	R	Maneuver Data sections must be numbered consecutively starting with 1	
MAN_PREV_ID	O	O	I		
MAN_NEXT_ID	O	O	I		
MAN_BASIS	O	M	R	Enumerated Value	<p><b>OPERATIONAL:</b> The trajectory expected to be flown, including maneuvers and other considerations. This is to be used by satellite owner/operators</p> <p><b>PREDICTED:</b> The expected trajectory based on propagation of an OD solution, without insight into vehicle operations</p> <p><b>CANDIDATE:</b> A candidate trajectory for the purpose of maneuver screening, corresponds to DoD SPECIAL</p>

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refine ment	TraCSS Restriction	Additional Information
					DETERMINED: Retrospective reconstruction of a trajectory for quality control monitoring or post- event analysis
MAN_BASIS_ID	O	O	I		
MAN_DEVICE_I D	O	O	I		
MAN_PREV_EP POCH	O	O	I		
MAN_NEXT_EP POCH	O	O	I		
MAN_PURPOS E	O	O	I		
MAN_PRED_S OURCE	O	O	K		
MAN_REF_FRA ME	O	O	I		
MAN_FRAME_E POCH	C	C	I		
GRAV_ASSIST_ NAME	O	O	I		
DC_TYPE	M	M	I		
DC_WIN_OPEN	C	C	I		



Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refine ment	TraCSS Restriction	Additional Information
DC_WIN_CLOS E	C	C	I		
DC_MIN_CYCL ES	C	C	I		
DC_MAX_CYCL ES	C	C	I		
DC_EXEC_STA RT	C	C	I		
DC_EXEC_STO P	C	C	I		
DC_REF_TIME	C	C	I		
DC_TIME_PUL SE_DURATION	C	C	I		
DC_TIME_PUL SE_PERIOD	C	C	I		
DC_REF_DIR	C	C	I		
DC_BODY_FRA ME	C	C	I		
DC_BODY_TRI GGER	C	C	I		
DC_PA_START _ANGLE	C	C	I		
DC_PA_STOP_ ANGLE	C	C	I		
MAN_COMPOSI TION	M	M	R		Each maneuver data line must contain the fields

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
					TIME_ABSOLUTE or TIME_RELATIVE and MAN_DURA as the first two fields
MAN_UNITS	O	O	I		
<maneuver data lines>	M	M	R		Maneuver time history data Impulsive maneuvers shall have a duration of 0 seconds
MAN_STOP	M	M	K		

**Table 9. OCM perturbations data per Table 6.10 in the OCM Recommended Standard. This table provides an overview of the OCM perturbations specification section.**

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
PERT_START	M	M	K		
ATMOSPHERIC_MODEL	O	O	R	Enumerated Value	<a href="https://sanaregistry.org/r/atmosphere_models/">https://sanaregistry.org/r/atmosphere_models/</a>
GRAVITY_MODEL	O	O	K	Enumerated Value	<a href="https://sanaregistry.org/r/gravity_models/">https://sanaregistry.org/r/gravity_models/</a> plus spherical harmonics as described by CCSDS
EQUATORIAL_RADIUS	O	O	I		
GM	O	O	I		

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
N_BODY_PERTURBATIONS	O	O	K	Enumerated Values	<a href="https://sanaregistry.org/r/orbit_centers/">https://sanaregistry.org/r/orbit_centers/</a> (Moon, Sun and Planets only)
CENTRAL_BODY_ROTATION	O	O	I		
OBLATE_FLATTENING	O	O	I		
OCEAN_TIDES_MODEL	O	O	K		
SOLID_TIDES_MODEL	O	O	K		
REDUCTION_THEORY	O	O	I		
ALBEDO_MODEL	O	O	I		
ALBEDO_GRID_SIZE	O	O	I		
SHADOW_MODEL	O	O	I		
SHADOW_BODIES	O	O	I		
SRP_MODEL	O	O	I		
SW_DATA_SOURCE	O	O	I		
SW_DATA_EPOCH	O	O	I		

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refine ment	TraCSS Restriction	Additional Information
SW_INTERP_M METHOD	O	O	I		
FIXED_GEOMA G_KP	O	O	I		
FIXED_GEOMA G_AP	O	O	I		
FIXED_GEOMA G_DST	O	O	I		
FIXED_F10P7	O	O	I		
FIXED_F10P7_ MEAN	O	O	I		
FIXED_M10P7	O	O	I		
FIXED_M10P7_ MEAN	O	O	I		
FIXED_S10P7	O	O	I		
FIXED_S10P7_ MEAN	O	O	I		
FIXED_Y10P7	O	O	I		
FIXED_Y10P7_ MEAN	O	O	I		
PERT_STOP	M	M	K		

**Table 10. OCM orbit determination data per Table 6.11 in the OCM Recommended Standard. This table provides an overview of the OCM provides an overview of the OCM orbit determination data section.**

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refinement	TraCSS Restriction	Additional Information
OD_START	M	M	K		
OD_ID	O	M	R	UTC epoch that the OD was accomplished in ISO8601 format	Additional comma separated fields may follow the time stamp.
OD_PREV_ID	O	O	F		
OD_METHOD	O	O	K		
OD_EPOCH	O	M	K		
DAYS_SINCE_FIRST_OBS	O	O	K		
DAYS_SINCE_LAST_OBS	O	O	K		
RECOMMENDED_OD_SPAN	O	O	I		
ACTUAL_OD_SPAN	O	O	I		Redundant to DAYS_SINCE_FIRST_OBS, DAYS_SINCE_LAST_OBS
OBS_AVAILABLE	O	O	I		
OBS_USED	O	O	K		

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refine ment	TraCSS Restriction	Additional Information
TRACKS_AVAILABLE	O	O	I		
TRACKS_USED	O	O	K		
MAXIMUM_OBS_GAP	O	O	I		
OD_EPOCH_EIGMAJ	O	O	I		
OD_EPOCH_EIGINT	O	O	I		
OD_EPOCH_EIGMIN	O	O	I		
OD_MAX_PRED_EIGMAJ	O	O	I		
OD_MIN_PRED_EIGMIN	O	O	I		
OD_CONFIDENCE	O	O	I		
GDOP	O	O	I		
SOLVE_N	O	O	K		
SOLVE_STATES	O	O	K		
CONSIDER_N	O	O	I		
CONSIDER_PARAMS	O	O	I		

Keyword	CCSDS M/O/C	TraCSS M/O/C	TraCSS Refine ment	TraCSS Restriction	Additional Information
SEDR	O	O	I		
SENSORS_N	O	O	I		
SENSORS	O	O	I		
WEIGHTED_RM S	O	O	I		
DATA_TYPES	O	O	I		
OD_STOP	M	M	K		

#### 4. Webinar and Opportunity to Comment

OSC will be holding a no-cost listening session describing the constraints on the fields and implementation of the OCM as necessary to meet the needs of TraCSS as detailed in this document on Thursday, May 9th, 2024. Registration<sup>12</sup> will be required to receive the link to the listening session; please visit the website referenced in footnote 12 to register.

OSC is interested in feedback regarding the following items:

1. if there are operational considerations if the information in certain fields was not available;
2. if any of the proposed fields are considered to be not necessary;
3. if there are additional fields that should be included in the proposed list;
4. if there are issues with not including comments;
5. thoughts on the USABLE\_START\_TIME, USABLE\_END\_TIME parameters; and
6. other comments.

During the webinar, there will be 15 minutes of presentation time from OSC on the recommendations described in this paper. The presentation time will be followed by 45 minutes for registered participants to provide up to three minutes of comments on the

<sup>12</sup> Visit the TraCSS website to register for the listening session at: <https://www.space.commerce.gov/traffic-coordination-system-for-space-tracss/>

recommendations. Registered participants will need to indicate during their registration or via the raise hand feature of the webinar if they would like to provide oral comments and will be called upon during the webinar in the order of registrations received or hand raise order. The number of registered commenters will be allowed up to the maximum time allowed for comments to be received.

If you are not able to provide oral comments during the webinar for any reason, including not being provided time during the allotted time due to the capacity of the time being reached by the number of commenters or you are not able to attend the webinar for any reason, including electrical or power outages to your media systems due to weather or other events Force Majeure, you have the option to provide written comments as described below in the next paragraph.

For up to 5:00 pm Eastern Time Thursday, May 23, 2024 and following the webinar on Thursday, May 9, 2024, written comments may be sent by email to the following email address [tracss.commerce@noaa.gov](mailto:tracss.commerce@noaa.gov) with the subject identified as “Comments on OCM format”.

Written comments should be no more than ten (10) electronic word-processed pages that are sized “8.5 inches x 11 inches” with “1 inch” margins top, bottom, left, and right and a font of any type at a “12-point” size. If more than ten (10) word-processed pages are submitted in a document but are within the physical criteria provided, only the first 10 pages will be read, the remaining pages will not be read, and will not be returned.

No confidential business information, or otherwise sensitive or protected information, should be submitted orally or in writing. Any such information will be ignored.

Except as described above, there will be no adjudication of comments received orally during the webinar on May 9, 2024, or written per the processes described in Section 4 of this document. Received oral or written comments may be summarized by OSC or its collaborators in presentations that will be presented in future webinars, workshops, or conferences that may or may not be open to the public, or through publications that may be publicly available and free of charge to readers on government or government-supported websites pertaining to TraCSS.

Any questions regarding this document may be sent by email to the following address: [tracss.commerce@noaa.gov](mailto:tracss.commerce@noaa.gov).

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