Recommendations on Conjunction Data Message Fields for Department of Commerce Traffic Coordination System for Space (TraCSS)

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1. Purpose

The purpose of this document is to provide the space situational awareness (SSA) community with information on the recommended conjunction data messages (CDM) fields in the CDM product that Department of Commerce (DOC) Traffic Coordination System for Space (TraCSS) will deliver for on-orbit conjunction assessment (CA). The format TraCSS will use is that recommended by the Consultative Committee for Space Data Systems (CCSDS) CDM recommended standard 508.0.P1.0.1, with plans to modify as necessary to meet the needs of the SSA community. Section 3 in this document is a comprehensive description of the recommended fields.

This document also describes an opportunity to learn about the content of this document through an OSC listening session and provide comments during the listening session or by email following the webinar as described in Section 4 in this document.

This document does not provide an overview of TraCSS. More information on TraCSS, including videos, is available at the TraCSS website[1]. 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)"[2]. The document referenced in footnote two provides highlights on TraCSS and gives a listing of identified and described SSA data types that will be provided by TraCSS to other SSA platforms and satellite operators. The document referenced in footnote two also provides

[1] Visit https://www.space.commerce.gov/traffic-coordination-system-for-space-tracss/ for more information on TraCSS, including videos.

[2] 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.

information on international standards developing organizations, interoperability, data exchange, and recommendations are provided for published standards to represent and transmit these data types out from TraCSS.

2. Background

2.1. Consultative Committee for Space Data Systems

The Consultative Committee for Space Data Systems (CCSDS)[3] is a multi-national organization of international space agencies and develops open communications and data standards for space systems. The products are available through the International Organization for Standardization (ISO) Technical Committee 20, Aircraft and Space Vehicles, Subcommittee 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 to be used by space launch operators, spacecraft operators, SSA service data providers, analysts, 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 Conjunction Data Message

As detailed by the CCSDS in its March 2023 report[4], the currently available CCSDS Conjunction Data Message (CDM) 508.0-B-1[5] specifies a standard message format for exchanging spacecraft conjunction information between providers of CA results and spacecraft owners and operators. CA is the process of predicting conjunction events by comparing orbit predictions derived from observations and orbit determination solutions for more than one space object. The CA results provide information associated with the closest point of approach or local minimum in the difference between the position components of two space object trajectories at their time of closest approach (TCA).

Within the overall CA processes, the owner/operator (o/o) of a spacecraft exchanges ODMs with the CA providers/CDM originators. Once the CA process or screening of conjunction events is completed, a CDM is transmitted to the owner/operator of a spacecraft or the group that performs the conjunction assessment analysis. CA considerations when assessing the conjunction risk include the trajectory geometry,

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[3] Visit https://public.ccsds.org/default.aspx for more information on the CCSDS.

[4] Navigation Data Messages, Overview, Informational Report (Green Book), CCSDS 500.2-G-3 Washington, D.C.: CCSDS, March 2023. Available at: https://public.ccsds.org/Pubs/500x2g3.pdf

[5] Conjunction Data Message. Issue 1. Recommendation for Space Data System Standards (Blue Book), CCSDS 508.0-B-1. Washington, D.C.: CCSDS, June 2013 (This current issue includes all updates through Technical Corrigendum 2, dated October 2021. Available at: https://public.ccsds.org/Pubs/508x0b1e2c2.pdf (Accessed March 22, 2024)

collision probability and variability, evolution and trends, prediction quality, as well as mitigation strategies and maneuver evaluation. The assessment of each solution is based on the number of tracks and observations, last observations, sensor geometry and observability, fit span, residual acceptance, weighted root-mean square, ballistic coefficient, solar radiation pressure coefficient, energy dissipation rate, radar cross sectional area, force modeling (e.g., solid Earth tides), and consistency between solutions.

In summary, the CDM is the final product of CA results and is intended to provide spacecraft owner/operators with sufficient information they can use to assess the risk of collision and design collision avoidance maneuvers, if necessary. The CDM can also tell the operator when insufficient information is available and so follow up tasking is required to reduce uncertainty. Therefore, the information exchanged within a CDM notifies the spacecraft operator(s) of possible conjunctions with another space object and enables consistent warning by different organizations employing diverse CA techniques. Conjunction information includes data types such as the identity of the affected objects, miss distance, probability of collision (POC), TCA, closest approach relative position and velocity, Cartesian states of the affected objects at TCA, and a covariance matrix that reflects the uncertainty of the states. Full information describing the conjunction information contained in this message can be found in the document cited in footnote five.

It is important to note the CCSDS CDM is currently undergoing revision because of the mandatory CCSDS five-year review, but the document cited in footnote five is in use today. For example, the 18th and 19th (18 & 19) Space Defense Squadron (SDS), Combined Force Space Component Command, Vandenberg Space Force Base, California, USA, has fully implemented the CCSDS CDM in operations. It is their primary means of notifying an operator of a conjunction assessment. A full description of the 18 & 19 SDS processes for on-orbit conjunction assessment and collision avoidance is provided in the document "Spaceflight Safety Handbook for Satellite Operators" [6]. See Annex C in footnote 6 for a comprehensive reference on the fields included in a 18 & 19 SDS (i.e., 19 SDS) CDM, noting Annex C makes use of the CCSDS CDM 508.0-P-1.0.1, where the "P" stands for "pink book". This "P" version is the CCSDS draft recommended standard that is an update to 508.0-B-1 (where the "B" is a blue book" and is released for formal review. All CCSDS obligatory fields are in the 19 SDS CDM.

The CCSDS CDM is also used at the National Aeronautics and Space Administration Johnson Space Center in support of human spaceflight operations and at Goddard Space Flight Center for the support of conjunction assessment risk analysis (CARA) operations.

[6] Spaceflight Safety Handbook for Satellite Operators, Version 1.7, April 2023; 18th & 19th Space Defense Squadron, Combined Force Space Component Command, Vandenberg Space Force Base, California, USA. Available at: https://www.space-track.org/documents/SFS_Handbook_For_Operators_V1.7.pdf (Accessed March 25, 2024)

3. CDM Fields for TraCSS

As noted above, the CDM will be the primary product that TraCSS will deliver for on-orbit CA. The format will be that recommended by CCSDS CDM 508.0-B-1, noting 508.0-P-1.0.1 will be used once that version's formal review is completed and the document is published by CCSDS. As all CCSDS obligatory fields are in the 19 SDS CDM, so will be the case for TraCSS. Table 1 is a comprehensive reference on the fields that will be included in a TraCSS CDM for TraCSS Phase 1.0. It is noted that CCSDS CDM data fields are comma-separated variable fields, in a particular order as shown, but a message string can be customized and vary in length.

In summary, the TraCSS Phase 1.0 CDM fields recommendations are to:

1. include all CCSDS CDM 508.0-B-1 fields, even for those fields that are not published in the 19 SDS CDM;
2. continue to use COMMENT fields for instances where the 19 SDS CDM uses COMMENT fields, until CCSDS CDM 508.0-B-1 is updated;
3. add new keywords for data that the 19 SDS CDM currently has in COMMENT fields where there are no existing keywords to help with tagging, indexing, and searching;
4. announce TraCSS will deprecate TraCSS CDM COMMENT fields if CCSDS CDM 508.0-B-1 is updated; and
5. continuously work with the CCSDS Navigation Working Group to update the CCSDS CDM standard.

Table 1. The proposed total list of fields for a TraCSS CDM:

Keyword	Description	Example
CCSDS_CDM_VERS	CDM format version in the form of X.Y.	1.0
COMMENT	A comment can be placed here for reader's information. Currently 18 SPCS places the CDM ID in the comment section	CDM_ID:XXXXXXXXX
CREATION_DATE	File creation date/time in UTC	2015-07-04T12:00:00.000000
ORIGINATOR	Creating agency or operator	JSPOC
MESSAGE_FOR	Spacecraft name for which the CDM is provided	STARLINK-61
MESSAGE_ID	ID that uniquely identifies the CDM message.	000012345_conj_000054321_2022067143221_06514372256137
TCA	The Date and Time of the conjunction in UTC	2015-07-04T12:00:00.000000

MISS_DISTANCE	The overall separation distance of both objects at TCA in meters	437
RELATIVE_SPEED	The magnitude of the relative velocity vector in meters/sec. The speed at which both objects are moving relative to each other at TCA in meters/second	15031
RELATIVE_POSITION_R	The R component of Object 2's position relative to Object 1 in an RTN coordinate frame in meters	43.2, -574
RELATIVE_POSITION_T	The T component of Object 2's position relative to Object 1 in an RTN coordinate frame in meters	43.2, -57
RELATIVE_POSITION_N	The N component of Object 2's position relative to Object 1 in an RTN coordinate frame in meters	43.2, -574
RELATIVE_VELOCITY_R	The R component of Object 2's velocity relative to Object 1's velocity in an RTN coordinate frame in meters/second	-36.3, 41.7, 12971.8
RELATIVE_VELOCITY_T	The T component of Object 2's velocity relative to Object 1's velocity in an RTN coordinate frame in meters/second	-36.3, 41.7, 12971.8
RELATIVE_VELOCITY_N	The N component of Object 2's velocity relative to Object 1's velocity in an RTN coordinate frame in meter/second	-36.3, 41.7, 12971.8
COLLISION_PROBABILITY	If applicable, the probability of collision (PoC) calculated by 18 SPCS from values of 0.0 to 1.0	0.000003656957
COLLISION_PROBABILITY_METHOD	The method utilized to calculate probability of collision	FOSTER-1992

COMMENT Screening Option	The screening mode used by the 18 SPCS to predict the conjunction contained in the CDM. Options include stand-off radius, ellipsoid and covariance	Stand-Off, Ellipsoid, Covariance
COMMENT Screened with	The data used by 18 SPCS to generate the CDM	inertial state vector unknown state vector type
START_SCREEN_PERIOD	The start time in UTC of the screening period for the conjunction assessment	
STOP_SCREEN_PERIOD	The stop time in UTC of the screening period for the conjunction assessment	
SCREEN_VOLUME_SHAPE	Shape of the screening volume: ELLIPSOID or BOX.	
SCREEN_VOLUME_FRAME	Name of the Object1 centered reference frame in which the screening volume data are given. Available options are RTN and Transverse, Velocity, and Normal (TVN)	
SCREEN_VOLUME_X	The R or T (depending on if RTN or TVN is selected) component size of the screening volume in the SCREEN_VOLUME_FRAME	
SCREEN_VOLUME_Y	The T or V (depending on if RTN or TVN is selected) component size of the screening volume in the SCREEN_VOLUME_FRAME	
SCREEN_VOLUME_Z	The N component size of the screening volume in the SCREEN_VOLUME_FRAME	

SCREEN_ENTRY_TIME	The time in UTC when Object2 enters the screening volume	
SCREEN_EXIT_TIME	The time in UTC when Object2 exits the screening volume	
ORBIT_CENTER	The central body about which Object1 and Object2 orbit. If not specified, the center is assumed to be Earth.	EARTH, SUN
FIELDS BELOW REPEATED FOR OBJECT 1 AND 2		
OBJECT	The object for which the metadata applies for	OBJECT 1 OBJECT 2
OBJECT_DESIGNATOR	The SCC or NORAD CAT ID for the object	25544
CATALOG_NAME	The satellite catalog used for the object	SATCAT
OBJECT_NAME	The common name for the object	STARLINK-61, COSMOS 1408 DEB
INTERNATIONAL_DESIGNATOR	The International Designator for the object in a YYYY-DDDXXX format notating the year and day of launch followed by at least one capital letter to discern between objects of the same launch.	1998-06
OBJECT_TYPE	Category of type of object	PAYLOAD, ROCKET BODY, DEBRIS, UNKNOWN, OTHER
OPERATOR_CONTACT_POSITION	The contact position of the owner/operator of the object. Space-Track will place a URL for a query that will lead to this information	
OPERATOR_ORGANIZATION	The organization of the owner/operator of the object	SpaceX, Iridium, CNES
OPERATOR_PHONE	The phone number of the owner/operator of the object. Space-Track will	

	place a URL for a query that will lead to this information	
OPERATOR_EMAIL	The e-mail of the owner/operator of the object. Space-Track will place a URL for a query that will lead to this information	
EPHEMERIS_NAME	The name of the ephemeris utilized if the data source is ephemeris	NONE MEME_25544_ISS_1651200_oper__unclassified.txt
COVARIANCE_METHOD	The method of which covariance is calculated. When covariance cannot be calculated, default values may be used. Caution should be used when using default values when calculating PoC	CALCULATED DEFAULT
MANEUVERABLE	The maneuver capability of the object	YES, NO, N/A
REF_FRAME	Name of the reference frame for the provided state vectors	ITRF
GRAVITY_MODEL	The name of the gravity model used for propagation	EGM-96: 36D 360
ATMOSPHERIC_MODEL	The name of the atmospheric model used for propagation	JBH09
N_BODY_PERTURBATIONS	The gravitational perturbation models used in a comma separated format	MOON, SUN
SOLAR_RAD_PRESSURE	Indicates whether solar radiation pressure was used during the Orbit Determination (OD) of the object	YES NO
EARTH_TIDES	Indicates whether solid Earth and ocean tides were used in the OD of object	YES NO
INTRACK_THRUST	Indicates whether in-track thrust modeling was used	YES NO

	for the OD and propagation of the object	
COMMENT Covariance Scale Factor	The scale that covariance is multiplied by	1.000000
COMMENT Exclusion Volume Radius	The radius of a sphere in meters to create a spherical volume representative of the object and used in the PoC calculation	5.000000
TIME_LASTOB_START	The time in UTC of the start of the timespan that contains observations used in the OD. This time will start at the latest accepted observation	2015-07-04T12:00:00.000000
TIME_LASTOB_END	The time in UTC of the end of the timespan that contains observations used in the OD. This time will end at the most recent accepted observation	2015-07-04T12:00:00.000000
RECOMMENDED_OD_SPAN	The recommended time span for the OD of the object in days	2.76
ACTUAL_OD_SPAN	The actual time span used in the OD of the object in days	2.76
OBS_AVAILALBE	Total amount of observations available for the OD of the object	57
OBS_USED	Actual number of observations used in the OD of the object	57
RESIDUALS_ACCEPTED	The percentage of residuals accepted in the OD of the object	99.3
WEIGHTED_RMS	The weighted Root Mean Square (RMS) of the residuals from a batch least squares	1.4
COMMENT Apogee Altitude	The apogee of the object in km	460
COMMENT Perigee Altitude	The perigee of the object in km	437

COMMENT Inclination	The inclination of the object in deg	60.7
COMMENT Operator Hard Body Radius	If input by an owner/operator, the Hard Body Radius of the object in meters	0.00
AREA_PC	The area of the object used in the PoC calculation in m2	2.2642
CD_AREA_OVER_MASS	The object's CD•A/m used in the propagation of the vector and covariance to TCA in m2/kg	0.161615504658
CR_AREA_OVER_MASS	The object's CR•A/m used in the propagation of the vector and covariance to TCA in m2/kg	0
THRUST_ACCELERATION	The object's acceleration in the In-track or R direction (RTN) used for propagating the state vector and covariance until TCA in m/s2	0 0.634
SEDR	The average amount of energy being removed from an object's orbit due to atmospheric drag in W/kg	0.020492
AREA_DRG	The effective area of the object exposed to atmospheric drag in m2	
AREA_SRP	The effective area of the object exposed to solar radiation pressure in m2	
MASS	The mass of the object	
X	Object position vector X component in km	1670.352554
Y	Object position vector Y component in km	-6834.579872
Z	Object position vector Z component in km	-1430.950837
X_DOT	Object velocity vector X component in km/s	2.780391335
Y_DOT	Object velocity vector Y component in km/s	2.808606433

Z_DOT	Object velocity vector Z component in km/s	-5.751722603
COMMENT DCP Density Forecast Uncertainty	The dynamic considers parameter (DCP) 1-sigma uncertainty of the relative atmospheric density for the specified object (given as a simple ratio). This is the uncertainty of the average atmospheric density exerting drag on the object, relative to the nominal (measured) atmospheric density	2.143370310000000E-0
COMMENT DCP Sensitivity Vector RTN Pos	The DCP position sensitivity vector expressed in the object's radial-transverse-normal (RTN) reference frame in meters. This sensitivity vector relates changes in the object's TCA position vector to variations in relative atmospheric density	-7.345809012167026E+02 3.865957136169006E+05 -1.456925086066596E+02
DCP Sensitivity Vector RTN Vel	The DCP velocity sensitivity vector relates changes in the object's TCA inertial velocity vector to variations in relative atmospheric density and is in meters/sec	-2.195009966872100E+02 2.630946954519584E-01 3.265607422364180E-01

CR_R	Object covariance matrix [1,1] in m2
CT_R	Object covariance matrix [2,1] in m2
CT_T	Object covariance matrix [2,2] in m2
CN_R	Object covariance matrix [3,1] in m2
CN_T	Object covariance matrix [3,2] in m2
CN_N	Object covariance matrix [3,3] in m2
CRDOT_R	Object covariance matrix [4,1] in m2/s
CRDOT_T	Object covariance matrix [4,2] in m2/s
CRDOT_N	Object covariance matrix [4,3] in m2/s
CRDOT_RDOT	Object covariance matrix [4,4] in m2/s2
CTDOT_R	Object covariance matrix [5,1] in m2/s
CTDOT_T	Object covariance matrix [5,2] in m2/s
CTDOT_N	Object covariance matrix [5,3] in m2/s
CTDOT_RDOT	Object covariance matrix [5,4] in m2/s2

CTDOT_TDOT	Object covariance matrix [5,5] in m2/s2
CNDOT_R	Object covariance matrix [6,1] in m2/s
CNDOT_T	Object covariance matrix [6,2] in m2/s
CNDOT_N	Object covariance matrix [6,3] in m2/s
CNDOT_RDOT	Object covariance matrix [6,4] in m2/s2
CNDOT_TDOT	Object covariance matrix [6,5] in m2/s2
CNDOT_NDOT	Object covariance matrix [6,6] in m2/s2
CDRG_R	Object covariance matrix [7,1] in m3/kg
CDRG_T	Object covariance matrix [7,2] in m3/kg
CDRG_N	Object covariance matrix [7,3] in m3/kg
CDRG_RDOT	Object covariance matrix [7,4] in m3/(kg*s)
CDRG_TDOT	Object covariance matrix [7,5] in m3/(kg*s)
CDRG_NDOT	Object covariance matrix [7,6] in m3/(kg*s)
CDRG_DRG	Object covariance matrix [7,7] in m4/kg2
CSRP_R	Object covariance matrix [8,1] in m3/kg
CSRP_T	Object covariance matrix [8,2] in m3/kg
CSRP_N	Object covariance matrix [8,3] in m3/kg
CSRP_RDOT	Object covariance matrix [8,4] in m3/(kg*s)
CSRP_TDOT	Object covariance matrix [8,5] in m3/(kg*s)
CSRP_NDOT	Object covariance matrix [8,6] in m3/(kg*s)
CSRP_DRG	Object covariance matrix [8,7] in m4/kg2
CSRP_SRP	Object covariance matrix [8,8] in m4/kg

Below is information included in the 19 SDS CDM COMMENT fields. These are not explicitly in the CCSDS standard. DOC welcomes comments on the use of this information in COMMENT fields vs. having a data field:

1. CDM_ID
2. Screening Option
3. Screened with
4. Covariance Scale Factor
5. Exclusion Volume Radius
6. Apogee Altitude
7. Perigee Altitude
8. Inclination
9. Operator Hard Body Radius
10. DCP Density Forecast Uncertainty
11. DCP Sensitivity Vector RTN Pos

12. DCP Sensitivity Vector RTN Vel

4. Webinar and Opportunity to Comment

OSC will be delivering a no-cost listening session describing the data types and recommendations for standards described in this document on Wednesday, April 3, 2024. Registration[7] will be required to receive the link to the listening session, please visit the website referenced in footnote 7 to register.

During the webinar, there will be 15 minutes of presentation time from OSC on the recommended CDM data fields for the provision of CDMs for TraCSS as 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 recommendations. Registered participants will need to indicate during their registration if they would like to provide oral comments and will be called upon during the webinar in the order of registrations received. 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 Wednesday, May 3, 2024, following the webinar (Wednesday, April 3, 2024), written comments may be sent by email to the following email address tracss.commerce@noaa.gov with the subject identified as "Comments on CDM data fields". See Section X for information on the type of comments OSC is seeking.

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 these conditions are not followed, written comments will not be read, will not be returned, and will be deleted from the cache of received email. 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, will not be returned, and will be deleted from the document.

There will be no adjudication of comments received orally during the webinar on April 3, 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

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[7] Visit the TraCSS website to register for the listening session at: https://www.space.commerce.gov/traffic-coordination-system-for-space-tracss/

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.

No confidential business information should be submitted orally or in writing. Any such information will be ignored and destroyed via appropriate Department of Commerce policy for the destruction of such information.

Any questions regarding this document may be sent by email to the following address: tracss.commerce@noaa.gov or by calling the Office of Space Commerce at +1(202) 482-6125 (U.S. toll number, charges may apply).

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