Recommendations on Standards for Provision of Space Situational Awareness Data from Department of Commerce Traffic Coordination System for Space (TraCSS)

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1. Purpose

Data exchange between the Department of Commerce (DOC) Office of Space Commerce (OSC) Traffic Coordination System for Space (TraCSS) and other platforms is essential for DOC and the receiving platforms to perform their space traffic coordination (STC) functions operations. Identifying and defining the communication and data handling standards is necessary for enhanced government and commercial interoperability and cross-support, while also improving capability, reducing cost, and providing a clear path for technology insertion to TraCSS and other platforms. By identifying and defining space situational awareness (SSA) data types and standardized approaches for data exchange, STC and SSA functions will be easier to manage. New system needs can be adopted more quickly and efficiently when STC and SSA functions are coherently managed. In addition, there are uninterrupted SSA data exchanges between STC systems, such as TraCSS, other SSA operation platforms and satellite operators. This document provides a listing of identified and described SSA data types that will be provided by TraCSS to other SSA platforms and satellite operators. In addition, recommendations are provided for published standards to represent and transmit these data types out from TraCSS. 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 2.1. in this document.

It is important to note that this document does not specify the level of sharing of the data types, that determination is still underway per the development of TraCSS. In other words, how data are shared between operators and with other satellite operators on TraCSS, and public sharing of data, have not been determined yet and are not described in this document. Again, the purpose of this document is to describe data types and identified standards and formats determined to be most applicable to TraCSS

and to announce the opportunity for the listening session and input on these determinations as noted in the previous paragraph.

2. Background

SSA needs have been evolving and growing over time for commercial, civil, and national security missions. There is an urgent need for better SSA as Earth's orbits become increasingly congested, putting space missions at risk of collisions. Commercial space companies have launched thousands of new satellites over the past few years and plan to launch tens of thousands more. OSC is implementing DOC's responsibility under the 2018 Space Policy Directive-3 National Space Traffic Management Policy (SPD-3) to provide SSA services to civil and commercial stakeholders while growing the U.S. SSA industry and enhancing SSA technologies. SPD-3 transfers responsibility from DOD to DOC for providing basic SSA services to commercial and civil operators. DOD will share unclassified data from its space tracking assets with DOC TraCSS and vice versa.

This paper provides recommendations for standards to support provision of SSA data from TraCSS to other SSA platforms and satellite operators. These standards are open and internationally viable for a diverse set of users to enhance interoperability and enable cross-support participating entities. See Section 4 of this document and Table 1 for a presentation and description, respectively, of the recommendations. As described in Section 2.1., 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 listening session.

This document does not provide a full overview of TraCSS. While a summary of TraCSS is provided in Section 2.2., more information on TraCSS, including videos, is available at the TraCSS website[1].

2.1. 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 Tuesday, December 19, 2023[2]. Registration will be required to receive the link to the listening session, please visit the website referenced in footnote 2 to register. During the webinar, there will be 15 minutes of presentation time from OSC on the data types and recommended standards 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

[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/listening-session-about-tracss-standards-for-data-exchange/ for more information on the listening session.

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 (15 commenters). 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, January 18, 2024, following the webinar (Thursday, January 18, 2024), written comments may be sent by email to the following email address tracss.commerce@noaa.gov with the subject identified as "Comments on space data standards". See Section 4 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.

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).

2.2. What is TraCSS?

To meet its responsibilities under SPD-3, OSC is building TraCSS [pronounced "Tracks"] as the U.S. civil SSA capability to provide basic SSA safety services free to civil and commercial space operators. TraCSS will be a modern, cloud-based, federal IT platform for SSA and STC. The platform will ingest, archive, process, and disseminate SSA data and products for civil, private, and commercial space interests. TraCSS will provide conjunction (i.e., potential collision) analysis and warning services to commercial satellite owner/operators. The system will store data from DOD, commercial SSA data providers, commercial and civil satellite owner/operators, and select international civil partners. TraCSS will operate 24 hours per day, 7 days a week, with a primary and backup operations center. TraCSS mission drivers are spaceflight safety, space sustainability, and international coordination. See the website in footnote 1 in this paper for more information.

2.3. DOD Collaboration

The U.S. Space Command (USSPACECOM), working with allies and partners, plans, executes, and integrates civil, commercial, and defense space assets into multi-domain global operations. This includes the tracking of all space objects using DOD-certified space and Earth-based optical and radar sensors, providing space object orbital location information for the protection of space assets. These certified sensors make up the Space Surveillance Network (SSN).

Currently USSPACECOM also has responsibility for notifications of potential impending near misses or collisions of space objects to commercial, government, domestic and international spacecraft operators. This includes maintaining a catalog of known positions of space objects available to operators and researchers via a global public service (https://www.space-track.org). Space-Track.org promotes space flight safety, protection of the space environment and the peaceful use of space worldwide by sharing SSA services and information with U.S. and international satellite owners, operators, academia, and other entities.

SPD-3 acknowledges the DOC should be the focal point for administering and providing SSA and STC services for commercial and civil entities. DOD and DOC signed a Memorandum of Agreement (MOA)[3] in September 2022, framing the departments' relationship on SSA and STC. This MOA began discussions on transition priorities and coordination. Working groups were established and are continuing work on defining data transfer needs and roles and responsibilities across the transition.

2.4. Interoperability

Achieving Interoperability among data providers comes by way of efforts relating to standards development. For the seamless transmission of data from TraCSS to other SSA platforms and satellite operators, successful interoperability will be necessary. Successful interoperability will help reduce the risk of disruptions to data transfer and SSA services. Ingest and access to short- and long-term data archives will be easier and automation may be possible for data transfers.

As commercial satellite communication providers are not inherently interoperable, it is essential to achieve desired interoperability to the best extent possible through interoperable messages. Rules for data messaging can be formally specified through either standards that codify norms of behavior that are expected or accepted through best practices, or through standards that establish international consensus formats, terminology and content for data exchange. International standards developing organizations provide the essential forums for the development of commercial standards that help ensure successful interoperability.

[3] Visit https://www.space.commerce.gov/department-of-commerce-and-department-of-defense-sign-memorandum-of-agreement-to-advance-coordination-in-space/ for more information on the MOA.

3. International Standards Developing Organizations

Standards are often developed via consensus building on what the standard addresses, most often through international standards developing organizations, such as the International Organization for Standardization (ISO) and Consultative Committee for Space Data Systems (CCSDS). Standards from these organizations are voluntary consensus standards and are usually appropriate or adaptable for the Government's purposes. As described in the U.S. Office of Management and Budget Memorandum A-119[4], the use of such standards for the Government's purposes, whenever practicable and appropriate, is intended to achieve the following goals:

a. eliminating the cost to the Federal government of developing its own standards and decreasing the cost of goods procured and the burden of complying with agency regulation;
b. providing incentives and opportunities to establish standards that serve national needs, encouraging long-term growth for U.S. enterprises and promoting efficiency, economic competition, and trade; and
c. furthering the reliance upon private sector expertise to supply the Federal government with cost-efficient goods and services.

ISO is a multi-national forum that enables the development and publication of international standards through its members by bringing together experts to share knowledge and develop voluntary, consensus-based, market relevant international standards[5]. Technical Committee (TC) 20, Aircraft and Space Vehicles, has subcommittees (SC) focused on the standardization of materials, components and equipment for construction and operation of aircraft and space vehicles as well as equipment used in the servicing and maintenance of these vehicles. TC 20 has published to date 674 ISO standards with 18 participating member countries and 28 observing member countries. There are two subcommittees (SCs) supporting space data messaging and SSA: SC 13 Space data and information transfer systems, and SC 14 Space systems and operations. OSC is focused on products from SC 13[6], which are identical to products from the Consultative Committee for Space Data Systems (CCSDS, see next paragraph) via formal arrangements between ISO and CCSDS.

The CCSDS is a multi-national organization of international space agencies and develops open communications and data standards for space systems. The products

[4] OMB Circular A-119**,** revised by the Office of Management and Budget (OMB) in January 2016, spells out the government strategy for standards development. It promotes agency participation on standards bodies, specifies reporting requirements on conformity assessment activities, and informs agencies of their statutory obligations related to standards setting. Visit https://www.nist.gov/standardsgov/what-we-do/federal-policy-standards/key-federal-directives for more information.

[5] Visit https://www.iso.org/committee/46484.html for more information.

[6] Visit https://www.iso.org/committee/46612.html for more information.

are available through ISO and at the CCSDS website[7]. 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 5 years and cover a wide range of messages and formats.

4. Identified Data Types, Descriptions, and Suggested Standards for Data Transfer – Comments Welcome

Tables 1 and 2 provide a listing of the data types that have been determined by OSC to be relevant for the transfer of data from TraCSS to other SSA platforms and satellite operators. Table 1 provides a description of each data type and a listing of applicable CCSDS standards that are published and recognized to have direct or derivative application to the data types listed. Table 2 lists each data type where there is an applicable CCSDS standard that is not yet published, i.e., the standard is either newly in development, being proposed, or is a potential future candidate for STC and STM data exchange standardization.

Sections 5 and 6 provide a brief description of the CCSDS standards and some basic information about each one for those that are published and under development, respectively.

Comments are welcome to our determinations listed in Tables 1 and 2 on:

1) the applicability of the published CCSDS standards to the listed data types;
2) the applicability of the draft CCSDS standards to the listed data types;
3) the availability of other published or draft standards that are currently not provided by CCSDS (such suggestions may include, for example, published or draft standards available from other standard developing organizations material that is available as published best practices or guidance); or
4) the availability of other published or draft standards that are not considered in Table 1.

We additionally request comments about the following formats currently not used in CCSDS standard messages (see Section 7 for more information on these formats):

1) JSON versions of CCSDS standard messages;
2) binary serialization (e.g., Flatbuffer) versions of CCSDS standard messages; or

[7] Visit https://public.ccsds.org/default.aspx for more information.

3) combination of JSON and/or binary serialization versions of CCSDS standard messages.

OSC does not wish to receive comments on the descriptions of the data types in Table 1. OSC has determined these descriptions to be relevant to its TraCSS mission and any information suggesting edits to the data type descriptions will not be read.

There will be no adjudication of comments received orally during the webinar on December 19, 2023 or written per the processes described in Section 2.1 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.

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.

Section 8 provides a bibliography which provides reference information pertaining to information presented in this document, including electronic links to where the published CCSDS standards are available. As noted in Table 2, there are CCSDS standards that are not yet published. In these cases, it is envisioned where there is a fully developed standard, it will fulfill and facilitate the execution of navigation events currently not covered by published standards.

Table 1. Listing of data types and applicable published CCSDS standards, listed in alphabetical order per acronyms in the last column.

Data Type	Description	Applicable Standard	Acronyms
Conjunction Assessments	Details for a specific conjunction event between two objects.	Conjunction Data Message (CDM) 508.0-P-1	CDM
Owner/Operator (O/O) Ephemeris	Data that represents the trajectory of an object over time	Within the Orbit Data Messages (ODM) 502.0-B-3, Issue 3[8]: Orbit Ephemeris Message (OEM) or Orbit Comprehensive Message (OCM)	ODM
O/O Contact Information	O/O POC Names, Phone Numbers, Email Addresses, etc.	Within the ODM: OCM; may be able to use Space Data	ODM

[8] See the bibliography in Section 8.1 in this document for website links to the listed CCSDS standards.

Data Type	Description	Applicable Standard	Acronyms
	used to collaborate with O/Os	Standard User Profile Message	
O/O-provided satellite characteristics information	Information regarding size, mission, maneuverability, unique capabilities, (e.g., radar reflectors, owner, launch vehicle, etc.)	Some information is in ODM; may be able to use Satellite Catalog Message for additional information	ODM
O/O Maneuver Plans	In support of space traffic coordination and space domain awareness	Within ODM: Orbit Parameter Message (OPM) and OCM	ODM
Satellite Identification	Confirmation from O/O of identity of on-orbit object, particularly for multi-payload launches (e.g., transporter, mega-constellations).	Currently no specific CCSDS standard, however within the ODM there is an opportunity for a free-text field containing the name of the constellation to which this space object belongs and where a constellation scenario in which states (OPM, Orbit Mean-Elements Message (OMM) and/or ephemeris data (OEM, OCM) for all the spacecraft in the constellation are combined in a single XML message in the ODM	ODM
Deployment Schedules	O/O schedule for deployment of objects.	Within ODM: OCM includes fields for deployment times	ODM
Launch Trajectories	Trajectory nominals for each phase of launch.	ODM, noting the ODM family of standardized orbit messages is applicable to all phases of the spacecraft and launch vehicle life cycle	ODM

Data Type	Description	Applicable Standard	Acronyms
Satellite Characterization Data	Satellite status, size, mission, payloads, activities associated with a satellite.	Within ODM: OCM or can combine into the LDM when it is available	ODM
DOC/Commercial State Vectors	Provides high precision position, velocity, and covariance data on an object.	Within ODM: OPM	ODM
DOC/Commercial Element Sets	Describes general location of a satellite.	Within ODM: OMM	ODM
Reentry Assessments	Prediction of time and location on earth's geographic area a re-entering object may impact.	Re-entry Data Message (RDM) 508.1-B-1, Issue 1	RDM
O/O Spectrum Use Information	Radio frequency (RF) signal parameters for passive RF tracking, space domain awareness	Radio Frequency and Modulation Systems—Part 1(RFMS-I): Earth Stations and Spacecraft, Recommended Standard, Issue 32, which has applicable information data to this data type.	RFMS-I
Commercial Metric Observations	Metric observations collected by commercial space traffic coordination or space domain awareness providers.	Tracking Data Message (TDM) 503.0-B-2, Issue 2	TDM

Table 2. Listing of data types and applicable CCSDS standards not yet published[9], listed in alphabetical order per acronyms in the last column.

[9] This refers to standards that are either newly in development, being proposed, or are potential future candidates for STC and STM data exchange standardization.

Data Type	Description	Applicable Standard Not Yet Published	Acronyms
Satellite Anomaly Notification/Information	Any information from O/Os relating to anomaly indications.	The Anomaly Message (AM) is a potential future candidate for development.	AM
Breakup/Debris Generating Event Notification	Notification from DOC of a breakup or debris generating event.	There is one CCSDS standard newly in development: the Events Message (EM) and there are two CCSDS standards that have been proposed: the Fragmentation Data Message (FDM) and Navigation Composite Message (NCM).	EM FDM NCM
Breakup/Debris Generating Event Reports	Report detailing a breakup or debris generating event.	The EM is newly in development and the FDM and NCM are proposed.	EM FDM NCM
Launch Information (R-15 Form)	O/O information pertaining to launch contained in R-15 Form	There is a draft Launch Data Message (LDM) newly in development.	LDM
Launch Updates	Updates to launch information, schedules, deployments	LDM is newly in development.	LDM
O/O Spectrum Use Information	Radio frequency (RF) signal parameters for passive RF tracking, space domain awareness	There are 2 potential future candidates for standard development: the Radio Frequency Characteristics Message (RFCM) and Radio Frequency Interference Data Message (RFIDM).	RFCM RFIDM
Mission CONOPS	Information on significant missions that may impact space domain awareness	Currently no specific CCSDS standard for Mission CONOPS but this information could	none

Data Type	Description	Applicable Standard Not Yet Published	Acronyms
	operations (e.g., new mega-constellations, active debris removal, launch/deployment of small objects, and anything that would pose risk to human space flight)	be readily captured in a text file.	

5. Description of Applicable Published Standard Messages Listed in Table 1[10]

5.1. Conjunction Data Message (CDM)

The CDM recommended standard is in wide usage. The CDM specifies a standard message format for use in exchanging spacecraft conjunction information between originators of conjunction assessments, satellite owner/operators, and other authorized parties. Such exchanges are used to inform affected satellite operator(s) of conjunctions between space objects to facilitate development of an effective response should one be necessary. This message is suited for exchanges that involve manual or automated interaction. The attributes of a CDM make it suitable for use in machine-to-machine interfaces because of the large amount of data typically present.

5.2. Orbit Data Message (ODM)

The ODM recommended standard is a set of orbit data messages that are a baseline concept for trajectory representation in data interchange applications. The recommended standard specifies four standard message formats for use in transferring spacecraft orbit information between space agencies and commercial or governmental spacecraft operators:

- Orbit Parameter Message (OPM);
- Orbit Mean-Elements Message (OMM);
- Orbit Ephemeris Message (OEM); and
- Orbit Comprehensive Message (OCM).

Such exchanges are used for:

- pre-flight planning for tracking or navigation support;
- scheduling tracking support;

[10] Listed in the order of appearance in Table 1, see Section 8.1 for links to these published standards.

- 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 family of orbit data standards is suitable for the exchange of positional ephemeris, covariance, maneuver, physical parameters, operator contact information, force model settings, and orbit determination data using the CCSDS ODM family of formats. While the OPM, OMM, and OEM may be used to exchange select elements of information, use of the new OCM format is highly recommended for its ability to exchange a comprehensive spectrum of spacecraft data and metadata required by the STC enterprise.

5.3. Re-entry Data Message (RDM)

The RDM recommended standard is used in the exchange of spacecraft reentry information between SSA or space surveillance and tracking data providers, satellite owners and operators, and other parties. This message can be used to inform spacecraft owners/operators of predicted re-entries or warn civil protection agencies about potential ground impacts. The standard includes informative descriptions of re-entry prediction methods and data. It can be paired with other navigation data messages to enhance its functionality and examples of these pairings are provided in the document.

5.4. Radio Frequency and Modulation Systems (RFMS-I)

The RFMS part 1: earth stations and spacecraft recommended standard is intended for use by participating space agencies in their development of radio frequency and modulation systems for Earth stations and spacecraft. These recommendations allow implementing organizations within each agency to proceed coherently with the development of compatible standards for the flight and ground systems that are within their cognizance. These recommendations were developed for conventional near-Earth and deep-space missions having moderate communications requirements.

5.5. Tracking Data Message (TDM)

The TDM recommended standard specifies a standard message format for use in exchanging spacecraft tracking data between space agencies. Such exchanges are used for distributing tracking data output from routine interagency cross supports in which spacecraft missions managed by one agency are tracked from a tracking station managed by a second agency. The standardization of tracking data formats facilitates space agency allocation of tracking sessions to alternate tracking resources.

6. Description of Applicable Standard Messages Not Yet Published Listed in Table 2[11]

6.1. Anomaly Message (AM) – potential future candidate standard

This is a potential future candidate standate envisioned to contain anomaly information on active spacecraft. The AM format can include information on the spacecraft components, manufacturers, lot numbers, installation procedures, failure indications, and root cause analyses. AMs are expected to be exchanged between spacecraft operators and spacecraft manufacturers, other spacecraft operators, SSA centers, STCM centers, and state actors.

6.2. Events Message (EM) – newly in development

This is a draft standard newly in development proposed to provide a generic message for details of an “event,” including a description, time of occurrence, timescale definition, and associated metadata. It is foreseen to provide a method of exchanging a sequence of navigation related orbital events for a spacecraft or mission. These messages would enable the capability to handle exchanges of information not currently handled by CCSDS standard messages for the classical data types of orbit, attitude, and other measurements. Orbital events (and more precisely, predicted orbital events) constitute a major data type used in control centers for operations and science planning. Orbital events describe when, and possibly how, certain situations related to one or more satellites occur. Examples of typical events are:

- – when, generally, some geometric condition is met (in relation to onboard sensors, celestial bodies, possibly other satellites, etc.);
- – when certain orbit parameters have some specific value (e.g., a satellite crosses the Equator). (See reference CCSDS (2023) listed in Section 8.3 in this document)

6.3. Fragmentation Data Message (FDM) – proposed standard

[11] Listed in the order of appearance in Table 2.

This is a proposed standard to contain information relevant to a specific fragmentation event which occurred in orbit. This will provide a standard message format for the exchange of fragmentation information, respectively. Fragmentation data are expected to be exchanged between entities monitoring the space object environment (networks of space surveillance and tracking sensors), event modelers, and users of a fragmentation analysis service, among them the potentially affected spacecraft operators.

6.4. Navigation Composite Message (NCM) – proposed standard

This is a proposed standard to provide a container for other messages where other data are available, such as metadata, point of contacts and many other data types, including event data such as a description, time of occurrence, and timescale definition. This is something that is envisioned as being a "universal, modular message" concept where users can combine one or more standardized message blocks (i.e., containers) within a single composite message, tailored to achieve specific mission needs.

6.5. Launch Data Message (LDM) – newly in development

This is a draft standard newly in development proposed to improve all data exchange, coordination, and inter-organizational aspects of both domestic and international launches, thereby reducing operations costs, increasing overall efficiency and minimizing operational risk. LDMs are expected to be exchanged between entities monitoring the space environment (SSA and STCM centers, state actors, on-orbit (existing) spacecraft operators, launch range operators, launch system operators, operators of payloads being launched, and downrange tracking sensor operators.

6.6. RF Characteristics Message (RFCM) – potential future candidate standard

This is a potential future candidate standard to allow the comprehensive sharing and complete RF specificity of a spacecraft communication system. Expected users of the RFI Data Message include spacecraft operators, RFI geolocation service providers, state actors, ITU, and STCM centers.

6.7. RFI Data Message (RFIDM) – potential future candidate standard

This is a potential future candidate standard to allow spacecraft operators and customers of space communications systems who are experiencing RFI to record the conditions of the interference for sharing, record-keeping, and mitigation. Expected users of the RFIDM include spacecraft operators, RFI geolocation service providers, state actors, ITU, and STCM centers.

7. Consideration of Format

CCSDS participants are required to test all formats. To prevent numerous considerations for testing, CCSDS formats are in key/value notation (KVN) and extensive mark-up language (XML[12]):

- KVN: original CCSDS message format representing basic key/value data structures as legible strings: example: TIME_SYSTEM = UTC
- XML schema: added to CCSDS messages in approximately 2010 and used since then: example: <TIME_SYSTEM>UTC</TIME_SYSTEM>

Selection of KVN or XML format is something that is mutually agreed between message exchange partners in advance of using the CCSDS standard. In the immediate future, OSC is planning to leverage the existing KVN or XML formats

Other possible formats for CCSDS standards could include the following:

- Java Script Object Notation (JSON) - a collection of name/value pairs and an ordered list of values: example: '{"object":"plate", "shape":round, "pattern":null}'
- Flatbuffers – an efficient cross platform serialization library for C++, C#, C, Go, Java, Kotlin, JavaScript, Lobster, Lua, TypeScript, PHP, Python, Rust and Swift. It was originally created at Google for game development and other performance-critical applications. It represents hierarchical data in a flat binary buffer in such a way that it can still be accessed directly without parsing/unpacking, while also still supporting data structure evolution (forwards/backwards compatibility)[13].

OSC is considering supporting development of JSON and binary serialization formats for CCSDS messages and welcomes feedback on these and other formats.

8. Bibliography

8.1. CCSDS Published Standards (in order of presentation in Table 1)

CDM - Conjunction Data Message Recommended Standard CCSDS 508.0-B-1 (2013, the current version of this document contains all updates through technical corrigendum 2, dated October 2021) CCSDS, Washington D.C.). Available at https://public.ccsds.org/Pubs/508x0b1e2c2.pdf (Accessed January 10, 2024)

[12] 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.

[13] Visit https://flatbuffers.dev/ for more information.

ODM - Orbit Data Messages Recommended Standard CCSDS 502.0-B-3, Issue 3 (2023, CCSDS, Washington, D.C.). Available at https://public.ccsds.org/Pubs/502x0b3e1.pdf (Accessed January 10, 1024)

RDM - Re-entry Data Message Recommended Standard CCSDS 508.1-B-1, Issue 1. (2019, CCSDS, Washington, D.C.). Available at https://public.ccsds.org/Pubs/508x1b1c1.pdf (Accessed January 10, 2024)

RFMS-I - Radio Frequency and Modulation Systems—Part 1: Earth Stations and Spacecraft Recommended Standard CCSDS 401.0-B-32, Issue 32 (2021, CCSDS, Washington, D.C.). Available at https://public.ccsds.org/Pubs/401x0b32.pdf (Accessed January 10, 2024)

TDM - Tracking Data Message Recommended Standard CCSDS 503.0-B-2, Issue 2. (2020, CCSDS, Washington, DC). Available at https://public.ccsds.org/Pubs/503x0b2c1.pdf (Accessed January 10, 2024)

8.2. CCSDS Not Yet Published (Proposed, Newly in Development, or Potential Candidates (in order from presentation in Table 2)

AM - Anomaly Message (potential future candidate for a proposal)

EM - Events Message (newly in development)

FDM – Fragmentation Data Message (proposed)

NCM – Navigation Composite Message (proposed)

LDM – Launch Data Message (newly in development)

RFCM - RF Characteristics Message (potential future candidate for a proposal)

RFIDM - RFI Data Message (potential future candidate for a proposal)

8.3. Additional Sources

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Oltrogge, D; Koury, TJ; Leonard, SA; Mulholland M; Bates, B; Poster DL. (2023) Survey of Open Access, Space Traffic Coordination Relevant Data Exchange Standards (National Institute of Standards and Technology, Gaithersburg, MD). Under development.

Oltrogge, D. (2022) ISO and CCSDS Standards. Presented to the GEOINT Interagency Working Group, December 8, 2022, Washington D.C.