The Consultative Committee for Space Data Systems

Proposed Recommendation for
Space Data System Standards

CONJUNCTION DATA MESSAGE

PROPOSED STANDARD

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(WHEN THIS PROPOSED STANDARD IS FINALIZED, IT WILL CONTAIN THE FOLLOWING STATEMENT OF AUTHORITY:)

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FOREWORD

This document is a Proposed Standard for Conjunction Data Messages (CDMs) and has been prepared by the Consultative Committee for Space Data Systems (CCSDS). The CDM described in this Proposed Standard is the baseline concept for conjunction information interchange applications between interested parties.

This Proposed Standard establishes a common framework and provides a common basis for the format of conjunction information exchange between providers of conjunction assessment data and satellite owner/operators. It allows implementing organizations within each Agency to proceed coherently with the development of compatible derived standards for the flight and ground systems that are within their cognizance. Derived Agency standards can implement only a subset of the optional features allowed by the Proposed Standard and can incorporate features not addressed by this Proposed Standard.

Through the process of normal evolution, it is expected that expansion, deletion, or modification of this document can occur. This Proposed Standard is therefore subject to CCSDS document management and change control procedures, which are defined in the *Procedures Manual for the Consultative Committee for Space Data Systems*. Current versions of CCSDS documents are maintained at the CCSDS Web site:

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- United States Geological Survey (USGS)/USA.

PREFACE

This document is a CCSDS Proposed Standard. Its 'White Book' status indicates that the CCSDS believes the document is not technically mature. As such, its technical contents are not stable, and several iterations of it will occur in response to comments received during the standards development process.

Implementers are cautioned **not** to fabricate any final equipment in accordance with this document's technical content.

DOCUMENT CONTROL

Document	Title and Issue	Date	Status
CCSDS 508.0-W-1	Conjunction Data Message (CDM), Proposed Standard, Issue 1	January 2011	Original issue, superceded
CCSDS 508.0-W-2	Conjunction Data Message (CDM), Proposed Standard, Issue 2	February 2011	Issue 2, superceded
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CCSDS 508.0-W-5	Conjunction Data Message (CDM), Proposed Standard, Issue 5	Aug 2011	Issue 5, superceded
CCSDS 508.0-W-6	Conjunction Data Message (CDM), Proposed Standard, Issue 6	Oct 2011	Current issue

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1 INTRODUCTION

1.1 PURPOSE AND SCOPE

1.1.1 This Conjunction Data Message (CDM) Proposed Standard specifies a standard message format for use in exchanging spacecraft conjunction information between data providers of conjunction assessment (CA), satellite owner/operators and other authorized parties. Such exchanges are used to inform satellite operator(s) of conjunctions between objects in space to enable consistent warning by different organizations employing diverse CA techniques.

1.1.2 This Proposed Standard will:

a) facilitate interoperability and enable consistent warning and mitigation between data providers that supply CA and the satellite operators that use it

b) enable the reuse of software modules that read/write/analyze the CA data

c) facilitate automation for the CA processes

d) provide critical information to enable timely CA decisions.

This Proposed Standard has been developed via consensus of the Navigation Working Group of the CCSDS Mission Operations and Information Management Services (MOIMS) area.

1.1.3 This document includes requirements and criteria that the message format has been designed to meet. For exchanges where these requirements do not capture the needs of the participating agencies and satellite operators, another mechanism can be selected.

1.2 APPLICABILITY

1.2.1 This Proposed Standard is applicable to all satellite operations in environments in which close approaches and collisions among satellites is a concern. It contains the specification for a Conjunction Data Message designed for applications involving conjunction information interchange between data providers of CA and recipients. Conjunction information includes data types such as miss distance, probability of collision, time of closest approach (TCA) and closest approach relative position and velocity. Further information describing the conjunction information contained in this message can be found in Section 3.0 and Annex D.

1.2.2 This message is suited for exchanges that involve manual or automated interaction. The attributes of a CDM make it primarily suitable for use in machine-to-machine interfaces due to the large amount of data typically present. The CDM is intended to be a one way message from the originator to a recipient. Ephemeris files can be provided to the CDM originator via other means. The CDM is self contained. However, additional information could be specified in an Interface Control Document (ICD) written jointly by the service provider and recipients.

1.2.3 Users of this Proposed Standard can implement only a subset of the optional features allowed by the Proposed Standard and can incorporate features not addressed by this Proposed Standard. It is desireable that this be documented in an ICD. Also, the definition of the conjunction assessment accuracy underlying a particular CDM is outside of the scope of this Proposed Standard.

1.2.4 This Proposed Standard is applicable only to the message format and content, but not to its transmission nor to the algorithms used to produce the data within. The method of transmitting the message between exchange partners is beyond the scope of this document and could be specified in an ICD. The methods used to predict conjunctions and calculate the probability of collision are also out of the scope of this document.

1.3 DOCUMENT STRUCTURE

Section 2 provides a brief overview of the CCSDS proposed CDM.

Section 3 provides details about the structure and content of the CDM in 'keyword = value notation' (KVN).

Section 4 provides details about the structure and content of the CDM in Extensible Markup Language (XML).

Section 5 addresses the CDM data in general.

Section 6 discusses the syntax considerations of the CDM.

Annex A provides values for REF_FRAME.

Annex B is a list of abbreviations and acronyms applicable to the CDM.

Annex C provides a rationale for orbit data messages.

Annex D provides a description of the conjunction assessment information contained in the CDM.

Annex E provides informative references.

Annex F provides an XML schema for the CDM.

Annex G provides a translator from XML to KVN.

Annex H provides information on security.

1.4 DEFINITIONS

1.4.1 UNIT NOTATIONS

The following conventions for unit notations apply throughout this Proposed Standard. Insofar as possible, an effort has been made to use units that are part of the International System of Units (SI Units); units are either SI base units, SI derived units, or units outside the SI that are accepted for use with the SI (see reference [1]). There is one specific case, that of the notation for degrees of plane angle, where the notation that is more widely used in the navigation community is specified ('deg' instead of '°'), but every effort has been made to minimize these departures from the SI.

deg: degrees of plane angle
km: kilometers
m: meters
d: days, 86400 SI seconds
h: hours, 3600 SI seconds
s: SI seconds
m/s: meters per second
m**2/s: square meters per second
m**2/s**2: square meters per second squared
kg: kilograms
W/kg: watt per kilogram

1.4.2 NOMENCLATURE

The CDM contains information about a conjunction between two space objects (hereafter referred to as 'Object1' and 'Object2').

The following nomenclature applies throughout this Proposed Standard:

a) the words 'shall' and 'must' imply a binding and verifiable specification;
b) the word 'should' implies an optional, but desirable, specification;
c) the word 'may' implies an optional specification;
d) the words 'is', 'are', and 'will' imply statements of fact.

1.4.3 CONVENTIONS

The following conventions for syntax apply throughout this Proposed Standard:

CamelCase. A style of capitalization in which the initial characters of concatenated words are capitalized, as in *CamelCase*.

lowerCamelCase. A variant of CamelCase in which the first character of a character string formed from concatenated words is lowercase, as in *lowerCamelCase*. In the case of a character string consisting of only a single word, only lowercase characters are used.

ASCII. A text character set. In this document, ASCII is used generically to refer to the character set defined in reference [2].

1.5 REFERENCES

The following documents contain provisions which, through reference in this text, constitute provisions of this Proposed Standard. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this Proposed Standard are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS documents.

[1] *The International System of Units (SI)*, 8th edition, Bureau International des Poids et Mesures, Organisation Intergouvernementale de la Convention du Mètre, STEDI MEDIA, Paris, 2006.

[2] *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.

[3] Henry S. Thompson, et al., eds. *XML Schema Part 1: Structures*. 2nd ed. W3C Recommendation. N.p.: W3C, October 2004. <http://www.w3.org/TR/2004/REC-xmlschema-1-20041028/>

[4] Paul V. Biron and Ashok Malhotra, eds. *XML Schema Part 2: Datatypes*. 2nd Edition. W3C Recommendation. N.p.: W3C, October 2004. http://www.w3.org/TR/2004/REC-xmlschema-2-20041028/

[5] Spacewarn Bulletin. Greenbelt, MD, USA: World Data Center for Satellite Information: WDC-SI. <http://nssdc.gsfc.nasa.gov/spacewarn>

[6] *Time Code Formats.* Recommendation for Space Data System Standards, CCSDS 301.0-B-4 . Blue Book. Issue 4. Washington, D.C.:CCSDS, November 2010.

[7] *XML Specification for Navigation Data Messages.* Recommendation for Space Data System Standards, CCSDS 505.0-B-1 . Blue Book. Issue 1. Washington, D.C.:CCSDS, December 2010.

2 OVERVIEW

2.1 GENERAL

This section provides a high-level overview of the CCSDS proposed CDM, a message format designed to facilitate standardized exchange of conjunction information between data providers of CA and satellite owner/operators.

2.2 CDM BASIC CONTENT

2.2.1 The proposed CDM is ASCII format encoded either in plain text or XML (see references [2], [3] and [4]). This CDM document describes a 'keyword = value notation' (KVN) formatted message as well as an Extensible Markup Language (XML) formatted message (it is desireable that the ICD specify which of these formats will be exchanged).

2.2.2 The CDM contains information about a single conjunction between Object1 and Object2. It contains the time of the closest approach between Object1 and Object2 and the position, velocity and covariance of Object1 and Object2 at the time of closest approach. It also contains information about how the position, velocity and covariance were determined as well as the relative positions and velocities of Object1 and Object2 at the time of closest approach. This information is used by satellite owner/operators to evaluate the risk of a conjunction and plan maneuvers if deemed warranted by that agency/organization.

3 CDM CONTENT/STRUCTURE IN KVN

3.1 GENERAL

The CDM in KVN shall be represented as a combination of the following:

a) a header;

b) relative metadata/data (metadata/data describing relative relationships between Object1 and Object2);

c) metadata (data about how Object1 and Object2 data were created)

d) data; and

e) optional comments (explanatory information).

3.2 CDM HEADER

3.2.1 Table 3-1 specifies for each KVN header item:

a) the keyword to be used;

b) a short description of the item;

c) examples of allowed values; and

d) whether the item is obligatory or optional.

Table 3-1: CDM KVN Header

Keyword	Description	Example of Values	Obligatory
CCSDS_CDM_VERS	Format version in the form of 'x.y', where 'y' is incremented for corrections and minor changes, and 'x' is incremented for major changes.	1.0, 2.0	Yes
COMMENT	(See 6.2.4 for formatting rules)	COMMENT This is a comment	No
CREATION_DATE	Message creation date/time in UTC. (For format specification, see 6.2.2.10.)	2010-03-12T22:31:12.000 2010-071T22:31:12.000	Yes
ORIGINATOR	Creating agency or operator (value should be specified in an ICD).	ESA, CNES, JSpOC, JAXA, GSFC, BITTT, ESOC, GSOC, JPL, **SDC**	Yes
CDM_MESSAGE_FOR	Spacecraft name(s) for which	SPOT, ENVISAT,	No

Keyword	Description	Example of Values	Obligatory
	the CDM is provided. There is no CCSDS-based restriction on the value for this keyword, but it is recommended to use names from the SPACEWARN Bulletin (See reference [5]).	IRIDIUM, INTELSAT	
MESSAGE_ID	ID that uniquely identifies a message from a given originator.	201113719185	No

3.3 CDM RELATIVE METADATA/DATA

3.3.1 Table 3-2 specifies for each KVN relative metadata/data item:

a) the keyword to be used;

b) a short description of the item;

c) the units to be used;

d) whether the item is obligatory or optional.

Table 3-2: CDM KVN Relative Metadata/Data

Keyword	Description	Units	Obligatory
COMMENT	(See 6.2.4 for formatting rules)	n/a	No
TCA	The time of closest approach (TCA); the date and time in UTC of the predicted conjunction (See 6.2.2.10 for formatting rules).	n/a	Yes
MISS_DISTANCE	The miss distance is the norm of the components of the relative position vector. It indicates how close the two objects are going to be based upon the conjunction assessment screening results.	m	Yes
RELATIVE_SPEED	The relative speed is the norm of the components of the relative velocity vector. It defines how fast the two objects are moving relative to each other at the time of the predicted encounter.	m/s	No
RELATIVE_REF_FRAME	Name of the Object1 centered reference frame in which the relative position and relative	n/a	Yes

Keyword	Description	Units	Obligatory
	velocity data are given (value must be selected from Annex A and the recommended frame is RTN).		
RELATIVE_POSITION_X	The x component of Object2's position relative to Object1's position in the RELATIVE_REF_FRAME.	m	Yes
RELATIVE_POSITION_Y	The y component of Object2's position relative to Object1's position in the RELATIVE_REF_FRAME.	m	Yes
RELATIVE_POSITION_Z	The z component of Object2's position relative to Object1's position in the RELATIVE_REF_FRAME.	m	Yes
RELATIVE_VELOCITY_X	The x component of Object2's velocity relative to Object1's velocity in the RELATIVE_REF_FRAME.	m/s	No
RELATIVE_VELOCITY_Y	The y component of Object2's velocity relative to Object1's velocity in the RELATIVE_REF_FRAME.	m/s	No
RELATIVE_VELOCITY_Z	The z component of Object2's velocity relative to Object1's velocity in the RELATIVE_REF_FRAME.	m/s	No
CENTER_NAME	Defines the central body which Object1 and Object2 orbit about. If not specified, the center is assumed to be Earth.	n/a	No
NUMBER_SCREENED_OBJECTS	The number of objects screened against Object1.	n/a	No
START_SCREEN_PERIOD	The start time in UTC of the screening period for the conjunction assessment. (See 6.2.2.10 for formatting rules).	n/a	Yes
STOP_SCREEN_PERIOD	The stop time in UTC of the screening period for the conjunction assessment. (See 6.2.2.10 for formatting rules).	n/a	Yes
SCREEN_VOLUME_FRAME	Name of the Object1 centered reference frame in which the screening volume data are given (value must be selected from Annex A and the recommended frame is RTN).	n/a	Yes
SCREEN_VOLUME_SHAPE	Shape of the screening volume: ELLIPSOID or BOX.	n/a	Yes
SCREEN_VOLUME_X	The x component size of the screening volume in the SCREEN_VOLUME_FRAME.	m	Yes
SCREEN_VOLUME_Y	The y component size of the	m	Yes

Keyword	Description	Units	Obligatory
	screening volume in the SCREEN_VOLUME_FRAME.		
SCREEN_VOLUME_Z	The z component size of the screening volume in the SCREEN_VOLUME_FRAME.	m	Yes
ENTRY_TIME	The time in UTC when Object2 enters the screening volume (See 6.2.2.10 for formatting rules).	n/a	No
EXIT_TIME	The time in UTC when Object2 exits the screening volume (See 6.2.2.10 for formatting rules).	n/a	No
COLLISION_PROBABILITY	The collision probability is the probability that Object1 will collide with Object2.	n/a	No
COLLISION_PROBABILITY_METHOD	The method that was used to calculate the collision probability.	n/a	No

3.4 CDM METADATA

3.4.1 Table 3-3 specifies for each KVN metadata item:

a) the keyword to be used;

b) a short description of the item;

c) normative (N) values or examples (E) of allowed values;

d) the distinction of normative values versus examples of allowed values is specified in the "N/E" column in the table; and

e) whether the item is obligatory or optional.

Table 3-3 and Table 3-4 will be used to define both Object1 and Object2 depending on the value of the keyword OBJECT which is specified in Table 3-3.

Table 3-3: CDM KVN Metadata

Keyword	Description	NormativeValues/ Examples	N/E	Obligatory
COMMENT	(See 6.2.4 for formatting rules)	COMMENT This is a comment	E	No
OBJECT	This specifies whether the metadata and data applies to Object1 or Object2.	OBJECT1 OBJECT2	N	Yes
OBJECT_NUMBER	This is the satellite catalog number for the object.	12345	E	Yes

Keyword	Description	NormativeValues/ Examples	N/E	Obligatory
SAT_CATALOG	This is the satellite catalog used for the object.	SATCAT	E	Yes
OBJECT_NAME	Spacecraft name for the object. There is no CCSDS-based restriction on the value for this keyword, but it is recommended to use names from the SPACEWARN Bulletin (See reference [5]).	SPOT, ENVISAT, IRIDIUM, INTELSAT	E	Yes
OBJECT_ID	This is the full international designator for the object. There is no CCSDS-based restriction on the value for this keyword, but it is recommended that values be the international spacecraft designator as published in the SPACEWARN Bulletin (See reference [5]). Values have the format YYYY-NNNP{PP}, where: YYYY = Year of launch. NNN = Three digit serial number of launch (with leading zeros). P{PP} = At least one capital letter for the identification of the part brought into space by the launch. In cases where the object is not listed in the bulletin, or the SPACEWARN format is not used, the value should be specified in an ICD.	2002-021A 2002-009A 1997-020A 1998-037A	E	No
OBJECT_TYPE	This is the object type.	PAYLOAD, ROCKET BODY, DEBRIS, UNKNOWN	E	No
OPERATOR_CONTACT_POSITION	Contact position of the operator of the object.	ORBITAL SAFETY ANALYST (OSA), NETWORK CONTROLLER	E	No
OPERATOR_ORGANIZATION	Contact organization of the object.	EUMETSAT, ESA, INTELSAT, IRIDIUM	E	No
OPERATOR_PHONE	Phone number of the contact position for the object .	+49615130312	E	No
OPERATOR_EMAIL	Email address of the contact organization of the object.	HANS.WALDVOGEL@EUMETSAT.INT	E	No
EPHEMERIS_NAME	Unique name of the external ephemeris file used for the object or NONE. This is	EPHEMERIS SATELLITE A, NONE	E	Yes

Keyword	Description	NormativeValues/ Examples	N/E	Obligatory
	used to indicate whether an external (i.e. owner/operator (O/O) provided) ephemeris file was used to calculate the CA.			
NUMBER_SENSORS	The number of sensors that were used to provide the observations used in the OD of the object.	1,2,3	E	No
TRACKING_DATA_TYPES	Describes the type(s) of tracking data used in the OD of the object.	RADAR, OPTICAL, GPS, DOPPLER	E	No
ADDITIONAL_TRACKING	Has additional sensor tracking been applied to the OD of the object (see Annex D)? YES or NO?	YES, NO	N	No
COVARIANCE_METHOD	Describes if the covariance was calculated during the OD that produced the state vector or a default value was used.	CALCULATED, DEFAULT	N	Yes
MANEUVERABLE	The maneuver capacity of the object. Used if the operator of the object does not wish to share maneuver plans/ephemeris.	YES, NO, UNKNOWN	N	Yes
MAN_INCLUDED	In the event that an external ephemeris was used to calculate the CA, this indicates that a maneuver was included in the ephemeris.	YES, NO	N	No
REF_FRAME	Name of the reference frame in which the state vector data are given (value must be selected from Annex A and be consistent between Object1 and Object2).	ICRF EME2000 ITRF2000 RTN	E	Yes
REF_FRAME_EPOCH	Epoch of reference frame in UTC, if not intrinsic to the definition of the reference frame. (See 6.2.2.10 for formatting rules)	2001-11-06T11:17:33.000	E	No
COV_REF_FRAME	Name of the reference frame in which the covariance data are given (value must be selected from Annex A and the recommended frame is RTN).	RTN	E	Yes
Details About Object Model Parameters (Object Specified by 'OBJECT'' keyword)				
COMMENT	(See 6.2.4 for formatting rules)	COMMENT This is a comment	E	No
GRAVITY_MODEL	The gravity model used for	EGM-96: 36Z 36T,	E	No

Keyword	Description	NormativeValues/ Examples	N/E	Obligatory
	the orbit determination (OD) of the object.	WGS-84_GEOID: 24Z 24T, JGM-2 : 41Z 41T		
ATMOSPHERIC_MODEL	The atmospheric drag model used for the OD of the object.	JACCHIA 70, MSIS, JACCHIA 70 DCA, NONE	E	No
N_BODY_PERTURBATIONS	The N-body gravitational perturbations that were used for the OD of the object.	MOON, SUN, MARS, JUPITER	E	No
SOLAR_RAD_ PRESSURE	Are solar radiation pressure perturbations used for the OD of the object?	ON, OFF	N	No
SOLID_EARTH_TIDES	Solid earth tides used for the OD of the object?	ON, OFF	N	No
INTRACK_THRUST	Is in-track thrust modeling used for the OD of the object?	ON, OFF	N	No

3.5 CDM DATA

3.5.1 Table 3-4 provides an overview of four logical blocks used in the CDM Data section (OD Parameters, Additional Parameters, State Vectors and Covariance) and specifies for each data item:

a) the keyword to be used;

b) a short description of the item;

c) the units to be used;

d) whether the item is obligatory or optional.

Table 3-4: CDM KVN Data

Keyword	Description	Units	Obligatory
COMMENT	(See 6.2.4 for formatting rules)	n/a	No
OD Parameters			
COMMENT	(See 6.2.4 for formatting rules)	n/a	No
TIME_LASTOB	The time in UTC of the last accepted observation used in the OD of the object . This can be entered as the exact time (See 6.2.2.10 for formatting rules) or an elapsed time, from the message creation time, that includes the time of the last accepted observation used in the OD of the object. The rules for the latter case	n/a or h	No

Keyword	Description	Units	Obligatory
	are as follows (see 6.2.2.12 for formatting rules): For all near earth (NE) objects: - Less than 6 hours from message creation time - 6 to 12 hours from message creation time - Greater than 12 hours from message creation time For all far from earth (FE) objects: - Less than 24 hours from message creation time - 24 to 48 hours from message creation time - Greater than 48 hours from message creation time		
RECOMMENDED_OD_SPAN	The recommended OD time span calculated for the object.	d	No
ACTUAL_OD_SPAN	Based on the observations available and the RECOMMENDED_OD_SPAN, this is the actual time span of the OD used for the object.	d	No
MAXIMUM_OBS_GAP	The maximum time between observations accepted for the OD of the object.	h	No
OBS_AVAILABLE	The number of observations available for the OD of the object.	n/a	No
OBS_USED	The number of observations accepted for the OD of the object.	n/a	No
TRACKS_AVAILABLE	The number of sensor tracks available for the OD of the object.	n/a	No
TRACKS_USED	The number of sensor tracks accepted for the OD of the object.	n/a	No
WEIGHTED_RMS	The weighted RMS of the residuals from a batch least squares OD.	n/a	No
TIME_NEXT_UPDATE	The expected elapsed time from the current OD update to the next OD update.	h	No
Additional Parameters			
COMMENT	(See 6.2.4 for formatting rules)	n/a	No
APOAPSIS	The apoapsis of the object.	km	No
PERIAPSIS	The periapsis of the object.	km	No
INCLINATION	The inclination of the object.	deg	No
AREA_ESTIMATE	The average cross sectional estimate of the area of the object.	m**2	No
MASS	The mass of the object.	kg	No
CD_ AREA_OVER_MASS	The object's C_D•A/m, calculated during the OD, used to propagate the state vector and covariance to TCA.	m**2/kg	No
CR_ AREA_OVER_MASS	The object's C_r •A/m, calculated during the OD, used to propagate the state vector and covariance to TCA.	m**2/kg	No

Keyword	Description	Units	Obligatory
THRUST_ACCELERATION	The object's acceleration due to in-track thrust, calculated during the OD, used to propagate the state vector and covariance to TCA.	m/s**2	No
SEDR	SEDR is representative of the amount of energy being removed from the object's orbit by atmospheric drag. This value is an average calculated during the OD.	W/kg	No
State Vector			
COMMENT	(See 6.2.4 for formatting rules).	n/a	No
X	Object Position Vector X component.	km	Yes
Y	Object Position Vector Y component.	km	Yes
Z	Object Position Vector Z component.	km	Yes
X_DOT	Object Velocity Vector X component.	km/s	Yes
Y_DOT	Object Velocity Vector Y component.	km/s	Yes
Z_DOT	Object Velocity Vector Z component.	km/s	Yes
Covariance Matrix (Position/Velocity Covariance Matrix 6x6 Lower Triangular Form. All parameters of the matrix must be given.)			
COMMENT	(See 6.2.4 for formatting rules)	n/a	Yes
CX_X	Object Covariance matrix [1,1]	m**2	Yes
CY_X	Object Covariance matrix [2,1]	m**2	Yes
CY_Y	Object Covariance matrix [2,2]	m**2	Yes
CZ_X	Object Covariance matrix [3,1]	m**2	Yes
CZ_Y	Object Covariance matrix [3,2]	m**2	Yes
CZ_Z	Object Covariance matrix [3,3]	m**2	Yes
CXDOT_X	Object Covariance matrix [4,1]	m**2/s	Yes
CXDOT_Y	Object Covariance matrix [4,2]	m**2/s	Yes
CXDOT_Z	Object Covariance matrix [4,3]	m**2/s	Yes
CXDOT_XDOT	Object Covariance matrix [4,4]	m**2/s**2	Yes
CYDOT_X	Object Covariance matrix [5,1]	m**2/s	Yes
CYDOT_Y	Object Covariance matrix [5,2]	m**2/s	Yes
CYDOT_Z	Object Covariance matrix [5,3]	m**2/s	Yes
CYDOT_XDOT	Object Covariance matrix [5,4]	m**2/s**2	Yes
CYDOT_YDOT	Object Covariance matrix [5,5]	m**2/s**2	Yes
CZDOT_X	Object Covariance matrix [6,1]	m**2/s	Yes
CZDOT_Y	Object Covariance matrix [6,2]	m**2/s	Yes
CZDOT_Z	Object Covariance matrix [6,3]	m**2/s	Yes
CZDOT_XDOT	Object Covariance matrix [6,4]	m**2/s**2	Yes
CZDOT_YDOT	Object Covariance matrix [6,5]	m**2/s**2	Yes
CZDOT_ZDOT	Object Covariance matrix [6,6]	m**2/s**2	Yes

3.6 CDM/KVN EXAMPLE

Figure 3-1 shows an example of a CDM message in KVN.

```
CCSDS_CDM_VERS              = 1.0
CREATION_DATE               = 2010-03-12T22:31:12.000
ORIGINATOR                  = JSPOC
CDM_MESSAGE_FOR             = SATELLITE A
```

MESSAGE_ID	= 201113719185	
COMMENT Relative Metadata/Data		
TCA	= 2010-03-13T22:37:52.618	
MISS_DISTANCE	= 715	[m]
RELATIVE_SPEED	= 14762	[m/s]
RELATIVE_REF_FRAME	= RTN	
RELATIVE_POSITION_X	= 27.4	[m]
RELATIVE_POSITION_Y	= -70.2	[m]
RELATIVE_POSITION_Z	= 711.8	[m]
RELATIVE_VELOCITY_X	= -7.2	[m/s]
RELATIVE_VELOCITY_Y	= -14692.0	[m/s]
RELATIVE_VELOCITY_Z	= -1437.2	[m/s]
NUMBER_SCREENED_OBJECTS	= 21123	
START_SCREEN_PERIOD	= 2010-03-12T18:29:32:212	
STOP_SCREEN_PERIOD	= 2010-03-15T18:29:32:212	
SCREEN_VOLUME_FRAME	= RTN	
SCREEN_VOLUME_SHAPE	= ELLIPSOID	
SCREEN_VOLUME_X	= 200	[m]
SCREEN_VOLUME_Y	= 1000	[m]
SCREEN_VOLUME_Z	= 1000	[m]
ENTRY_TIME	= 2010-03-13T20:25:43.222	
EXIT_TIME	= 2010-03-13T23:44:29.324	
COLLISION_PROBABILITY	= 4.835E-05	
COLLISION_PROBABILITY_METHOD	= ESA METHOD	
COMMENT Object1 Metadata		
OBJECT	= OBJECT1	
OBJECT_NUMBER	= 12345	
SAT_CATALOG	= SATCAT	
OBJECT_NAME	= SATELLITE A	
OBJECT_ID	= 1997-030E	
OBJECT_TYPE	= PAYLOAD	
OPERATOR_CONTACT_POSITION	= ORBITAL ANALYST	
OPERATOR_ORGANIZATION	= EUMETSAT	
OPERATOR_PHONE	= +49615130312	
OPERATOR_EMAIL	= HANS.WALDVOGEL@EUMETSAT.INT	
EPHEMERIS_NAME	= EPHEMERIS SATELLITE A	
NUMBER_SENSORS	= 2	
TRACKING_DATA_TYPES	= GPS, DOPPLER	
ADDITIONAL_TRACKING	= YES	
COVARIANCE_METHOD	= CALCULATED	
MANEUVERABLE	= YES	
MAN_INCLUDED	= YES	
REF_FRAME	= ITRF2000	
COV_REF_FRAME	= RTN	
GRAVITY_MODEL	= EGM-96: 36Z 36T	
ATMOSPHERIC_MODEL	= JACCHIA 70 DCA	
N_BODY_PERTURBATIONS	= MOON, SUN	
SOLAR_RAD_ PRESSURE	= OFF	
SOLID_EARTH_TIDES	= OFF	
INTRACK_THRUST	= OFF	
COMMENT Object1 Data		
COMMENT Object1 OD Parameters		
TIME_LASTOB	= 2010-03-12T02:14:12.746	
RECOMMENDED_OD_SPAN	= 7.88	[d]
ACTUAL_OD_SPAN	= 5.50	[d]
MAXIMUM_OBS_GAP	= 2.4	[h]

OBS_AVAILABLE	= 592	
OBS_USED	= 418	
TRACKS_AVAILABLE	= 123	
TRACKS USED	= 98	
WEIGHTED_RMS	= 0.864	
TIME_NEXT_UPDATE	= 2.0	[h]
COMMENT Object1 Additional Parameters		
APOAPSIS	= 779	[km]
PERIAPSIS	= 765	[km]
INCLINATION	= 86.4	[deg]
AREA_ ESTIMATE	= 5.2	[m**2]
MASS	= 2516	[kg]
CD_AREA_OVER_MASS	= 0.045663	[m**2/kg]
CR_AREA_OVER_MASS	= 0.000000	[m**2/kg]
THRUST_ACCELERATION	= 0.0	[m/s**2]
SEDR	= 4.54570E-05	[W/kg]
COMMENT Object1 State Vector		
X	= 2570.097065	[km]
Y	= 2244.654904	[km]
Z	= 6281.497978	[km]
X_DOT	= 4.418769571	[km/s]
Y_DOT	= 4.833547743	[km/s]
Z_DOT	= -3.526774282	[km/s]
COMMENT Object1 Covariance		
CX_X	= 4.142E+01	
CY_X	= -8.579E+00	[m**2]
CY_Y	= 2.533E+03	[m**2]
CZ_X	= -2.313E+01	[m**2]
CZ_Y	= 1.336E+01	[m**2]
CZ_Z	= 7.098E+01	[m**2]
CXDOT_X	= 2.520E-03	[m**2/s]
CXDOT_Y	= -5.476E+00	[m**2/s]
CXDOT_Z	= 8.626E-04	[m**2/s]
CXDOT_XDOT	= 5.744E-03	[m**2/s**2]
CYDOT_X	= -1.006E-02	[m**2/s]
CYDOT_Y	= 4.041E-03	[m**2/s]
CYDOT_Z	= -1.359E-03	[m**2/s]
CYDOT_XDOT	= -1.502E-05	[m**2/s**2]
CYDOT_YDOT	= 1.049E-05	[m**2/s**2]
CZDOT_X	= 1.053E-03	[m**2/s]
CZDOT_Y	= -3.412E-03	[m**2/s]
CZDOT_Z	= 1.213E-02	[m**2/s]
CZDOT_XDOT	= -3.004E-06	[m**2/s**2]
CZDOT_YDOT	= -1.091E-06	[m**2/s**2]
CZDOT_ZDOT	= 5.529E-05	[m**2/s**2]
COMMENT Object2 Metadata		
OBJECT	= OBJECT2	
OBJECT_NUMBER	= 30337	
SAT_CATALOG	= SATCAT	
OBJECT_NAME	= FENGYUN 1C DEB	
OBJECT_ID	= 1999-025AA	
OBJECT_TYPE	= DEBRIS	
EPHEMERIS_NAME	= NONE	
NUMBER_SENSORS	= 3	
TRACKING_DATA_TYPES	= RADAR	
ADDITIONAL_TRACKING	= NO	

COVARIANCE_METHOD	= CALCULATED	
MANEUVERABLE	= NO	
REF_FRAME	= ITRF2000	
COV_REF_FRAME	= RTN	
GRAVITY_MODEL	= EGM-96: 36Z 36T	
ATMOSPHERIC_MODEL	= JACCHIA 70 DCA	
N_BODY_PERTURBATIONS	= MOON, SUN	
SOLAR_RAD_ PRESSURE	= ON	
SOLID_EARTH_TIDES	= OFF	
INTRACK_THRUST	= OFF	
COMMENT Object2 Data		
COMMENT Object2 OD Parameters		
TIME_LASTOB	= 6-12	[h]
RECOMMENDED_OD_SPAN	= 2.63	[d]
ACTUAL_OD_SPAN	= 2.63	[d]
MAXIMUM_OBS_GAP	= 5.7	[h]
OBS_AVAILABLE	= 59	
OBS_USED	= 58	
TRACKS_AVAILABLE	= 15	
TRACKS USED	= 15	
WEIGHTED_RMS	= 0.864	
COMMENT Object2 Additional Parameters		
APOAPSIS	= 786	[km]
PERIAPSIS	= 414	[km]
INCLINATION	= 98.8	[deg]
AREA_ESTIMATE	= 0.9	[m**2]
CD_AREA_OVER_MASS	= 0.118668	[m**2/kg]
CR_AREA_OVER_MASS	= 0.075204	[m**2/kg]
THRUST_ACCELERATION	= 0.0	[m/s**2]
SEDR	= 5.40900E-03	[W/kg]
COMMENT Object2 State Vector		
X	= 2569.540800	[km]
Y	= 2245.093614	[km]
Z	= 6281.599946	[km]
X_DOT	= -2.888612500	[km/s]
Y_DOT	= -6.007247516	[km/s]
Z_DOT	= 3.328770172	[km/s]
COMMENT Object2 Covariance		
CX_X	= 1.337E+03	[m**2]
CY_X	= -4.806E+04	[m**2]
CY_Y	= 2.492E+06	[m**2]
CZ_X	= -3.298E+01	[m**2]
CZ_Y	= -7.5888E+02	[m**2]
CZ_Z	= 7.105E+01	[m**2]
CXDOT_X	= 2.591E-03	[m**2/s]
CXDOT_Y	= -4.152E-02	[m**2/s]
CXDOT_Z	= -1.784E-06	[m**2/s]
CXDOT_XDOT	= 6.886E-05	[m**2/s**2]
CYDOT_X	= -1.016E-02	[m**2/s]
CYDOT_Y	= -1.506E-04	[m**2/s]
CYDOT_Z	= 1.637E-03	[m**2/s]
CYDOT_XDOT	= -2.987E-06	[m**2/s**2]
CYDOT_YDOT	= 1.059E-05	[m**2/s**2]
CZDOT_X	= 4.400E-03	[m**2/s]
CZDOT_Y	= 8.482E-03	[m**2/s]
CZDOT_Z	= 8.633E-05	[m**2/s]

CZDOT_XDOT	= -1.903E-06	[m**2/s**2]
CZDOT_YDOT	= -4.594E-06	[m**2/s**2]
CZDOT_ZDOT	= 5.178E-05	[m**2/s**2]

Figure 3-1: An Example of a CDM in KVN

4 CDM CONTENT/STRUCTURE IN XML

4.1 THE CDM/XML SCHEMA

The CDM/XML schema shall be available on a CCSDS resource that is internet accessible.

The location of the CDM/XML schema will be:

http://sanaregistry.org/r/ndmxml/ndmxml-1.0-cdm-1.0.xsd

An example CDM/XML schema is currently referenced in Annex F of this document. Once this document is finalized, Annex F will be removed. This will allow updates of the schema on the web site without correspondingly updating the CDM document.

4.2 CDM/XML BASIC STRUCTURE

4.2.1 EACH CDM SHALL CONSIST OF A <HEADER> AND A <BODY>.

4.2.2. The CDM body shall consist of exactly two segment constructs.

4.2.3 Each <segment> shall consist of a <metadata>/<data> pair, as shown in Figure 4-1.

<header>
</header>
<body>
  <relativeMetadataData>
  </relativeMetadataData>
  <segment>
    <metadata>
    </metadata>
    <data>
    </data>
  </segment>
  <segment>
    <metadata>
    </metadata>
    <data>
    </data>
  </segment>
</body>

Figure 4-1 CDM XML Basic Structure

4.3 CONSTRUCTING A CDM/XML INSTANCE

4.3.1 OVERVIEW

This section provides more detailed instructions for the user on how to create an XML message based on the ASCII-text KVN-formatted message described in sections 3.1 through 3.6 (See reference [7])..

4.3.2 XML VERSION

The first line in the instantiation shall specify the XML version:

```
<?xml version="1.0" encoding="UTF-8"?>
```

This line must appear on the first line of each instantiation, exactly as shown.

4.3.3 BEGINNING THE INSTANTIATION: ROOT DATA ELEMENT

4.3.3.1 A CDM instantiation shall be delimited with the <cdm></cdm> root element tags using the standard attributes documented in reference [3].

4.3.3.2 The XML Schema Instance namespace attribute must appear in the root element tag of all CDM/XML instantiations, exactly as shown:

xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance"

If it is desired to validate an instantiation against the CCSDS Web-based schema, the xsi:noNamespaceSchemaLocation attribute must be coded as a single string of non-blank characters, with no line breaks exactly as shown:

xsi:noNamespaceSchemaLocation="http://sanaregistry.org/r/ndmxml/ndmxml-1.0-master.xsd"

NOTE – The value asscoicated with the xsi:noNamespaceSchemaLocation attribute shown in this document is too long to appear on a single line.

4.3.3.3 For use in a local operations environment, the schema set may be downloaded from the CCSDS Web site to a local server that meets local requirments for operations robustness.

4.3.3.4 If a local version is used, the value associated with the xsi:noNamespaceSchemaLocation attribute must be changed to a URL that is accessible to the local server.

4.3.3.5 The final attributes of the <cdm> tag shall be 'id' and 'version'.

4.3.3.6 The 'id' attribute shall be 'id="CCSDS_CDM_VERS"'.

4.3.3.7 The 'version' attribute shall be'version="1.0"'.

4.3.3.8 The following example root element tag for a CDM instantiation combines all the directions in the preceding several subsections:

```
<?xml    version="1.0" encoding="UTF-8?>
<cdm     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:noNamespaceSchemaLocation="http://sanaregistry.org/r/ndmxml/ndmxml-1.0-master.xsd"
         id=CCSDS_CDM_VERS" version="1.0">
```

4.3.4 THE CDM/XML HEADER SECTION

4.3.4.1 The CDM has a standard header format, with tags <header> and </header>.

4.3.4.2 Immediately following the <header> tag the message may have any number of <COMMENT></COMMENT> tag pairs.

4.3.4.3 The standard CDM header shall contain the following element tags:

a) <CREATION_DATE>

b) <ORIGINATOR>

c) <CDM_MESSAGE_FOR>

d) <MESSAGE_ID>

The rules for these keywords are specified in section 3.2. The header would look like this:

```
<header>
   <COMMENT>Some comment string.</COMMENT>
   <CREATION_DATE>2010-03-12T22:31:12.000</CREATION_DATE>
   <ORIGINATOR>JSpOC</ORIGINATOR>
   <CDM_MESSAGE_FOR>SATELLITE A</CDM_MESSAGE_FOR>
   <MESSAGE_ID>201113719185</MESSAGE_ID>
</header>
```

4.3.5 THE CDM/XML BODY SECTION

4.3.5.1 After coding the <header>, the instantiation must include a <body></body> tag pair.

4.3.5.2 Inside the <body></body> tag pair must appear one <relativeMetadataData></relativeMetadataData> tag pair.

4.3.5.3 Inside the <body></body> tag pair must appear two tag pairs, one for Object1 and one for Object2.

4.3.5.4 Each segment must be made up of two <metadata></metadata> and <data></data> tag pairs, one for Object1 and one for Object2.

4.3.6 THE CDM/XML RELATIVE METADATA/DATA SECTION

4.3.6.1 All CDMs must have a relative metadata/data section.

4.3.6.2 The relative metadata/data section shall be set off by the <relativeMetadataData></relativeMetadataData> tag combination. Between the <relativeMetadataData> and </relativeMetadataData> tags, the keywords shall be the same as specified in Table 3-2.

4.3.7 THE CDM/XML METADATA SECTION

4.3.7.1 All CDMs must have two metadata sections, one for Object1 and one for Object2.

4.3.7.2 The metadata section for Object1 shall follow the relative metadata/data section and shall be set off by the <metadata></metadata> tag combination. The metadata section for Object2 shall follow the Object1 data section and shall be set off by the <metadata ></metadata> tag combination.

4.3.7.3 Between the <rmetadata> and </metadata> tags for both Object1 and Object2, the keywords shall be the same as specified in Table 3-3. The value of the keyword OBJECT will be used to define whether the metadata defines Object1 or Object2.

4.3.8 THE CDM DATA SECTION

4.3.8.1 All CDMs must have two data sections, one for Object1 and one for Object2.

4.3.8.2 Each data section shall follow the corresponding metadata section and shall be set off by the <data></data> tag combination.

4.3.8.3 Between the <data> and </data> tags, the keywords shall be the same as specified in Table 3-4. The value of the keyword OBJECT, referenced in Table 3-3, will be used to define whether the data defines Object1 or Object2.

4.3.9 SPECIAL CDM/XML TAGS

The information content in the CDM is separated into constructs described in section 3.5 as 'logical blocks'. Special tags in the CDM are used to encapsulate the information in the logical blocks of the CDM. The following CDM/XML tags are defined:

Table 4-1: Relation of KVN Logical Blocks to Special CDM/XML Tags

CDM Logical Block	Associated CDM/XML Tag
OD Parameters	<odParameters>

Additional Parameters	<additionalParameters>
State Vector	<stateVector>
Covariance Matrix	<covarianceMatrix>

4.3.10 UNITS IN THE CDM/XML

The units in the CDM/XML shall be the same units used in the KVN-formatted CDM which are described in section 3.5. XML attributes are used to explicitly define the units or other important information associated with the given data element.

4.4 CDM/XML EXAMPLE

The following is a sample of a CDM in XML format:

```
<?xml version="1.0" encoding="UTF-8"?>
<cdm xmlns="urn:ccsds:recommendation:navigation:schema:ndmxml"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:noNamespaceSchemaLocation="http://sanaregistry.org/r/ndmxml/ndmxml-1.0-master.xsd"
    id="CCSDS_CDM_VERS" version="1.0">

 <header>
  <COMMENT>Sample CDM - XML version</COMMENT>
  <CREATION_DATE>2010-03-12T22:31:12.000</CREATION_DATE>
  <ORIGINATOR>JSPOC</ORIGINATOR>
  <CDM_MESSAGE_FOR>SATELLITE A</CDM_MESSAGE_FOR>
  <MESSAGE_ID>20111371985</MESSAGE_ID>
 </header>
 <body>
  <relativeMetadataData>
   <COMMENT>Relative MetadataData</COMMENT>
   <TCA>2010-03-13T22:37:52.618</TCA>
   <MISS_DISTANCE units="x">715</MISS_DISTANCE>
   <RELATIVE_SPEED units="m/s">14762</RELATIVE_SPEED>
   <RELATIVE_REF_FRAME>RTN</RELATIVE_REF_FRAME>
   <relativeStateVector>
    <RELATIVE_POSITION_X units="m">27.4</RELATIVE_POSITION_X>
    <RELATIVE_POSITION_Y units="m">-70.2</RELATIVE_POSITION_Y>
    <RELATIVE_POSITION_Z units="m">711.8</RELATIVE_POSITION_Z>
    <RELATIVE_VELOCITY_X units="m/s">-7.2</RELATIVE_VELOCITY_X>
    <RELATIVE_VELOCITY_Y units="m/s">-14692.0</RELATIVE_VELOCITY_Y>
    <RELATIVE_VELOCITY_Z units="m/s">-1437.2</RELATIVE_VELOCITY_Z>
   </relativeStateVector>
   <NUMBER_SCREENED_OBJECTS>21123</NUMBER_SCREENED_OBJECTS>
   <START_SCREEN_PERIOD>2010-03-11T18:29:32.212</START_SCREEN_PERIOD>
   <STOP_SCREEN_PERIOD>2010-03-14T18:29:32.212</STOP_SCREEN_PERIOD>
   <SCREEN_VOLUME_FRAME>RTN</SCREEN_VOLUME_FRAME>
   <SCREEN_VOLUME_SHAPE>ELLIPSOID</SCREEN_VOLUME_SHAPE>
   <SCREEN_VOLUME_X units="m">200</SCREEN_VOLUME_X>
```

```
   <SCREEN_VOLUME_Y units="m">1000</SCREEN_VOLUME_Y>
   <SCREEN_VOLUME_Z units="m">1000</SCREEN_VOLUME_Z>
   <ENTRY_TIME>2010-03-13T20:25:43.222</ENTRY_TIME>
   <EXIT_TIME>2010-03-13T23:44:29.324</EXIT_TIME>
   <COLLISION_PROBABILITY>4.835E-05</COLLISION_PROBABILITY>
   <COLLISION_PROBABILITY_METHOD>ESA METHOD</COLLISION_PROBABILITY_METHOD>
  </relativeMetadataData>
  &lt;segment&gt;
   <metadata>
    <COMMENT>Object1 Metadata</COMMENT>
    <OBJECT>OBJECT1</OBJECT>
    <OBJECT_NUMBER>12345</OBJECT_NUMBER>
    <SAT_CATALOG>SATCAT</SAT_CATALOG>
    <OBJECT_NAME>SATELLITE A</OBJECT_NAME>
    <OBJECT_ID>1997-030E</OBJECT_ID>
    <OBJECT_TYPE>PAYLOAD</OBJECT_TYPE>
    <OPERATOR_CONTACT_POSITION>ORBITAL ANALYST</OPERATOR_CONTACT_POSITION>
    <OPERATOR_ORGANIZATION>EUMETSAT</OPERATOR_ORGANIZATION>
    <OPERATOR_PHONE>+49615130312</OPERATOR_PHONE>
    <OPERATOR_EMAIL>HANS.WALDVOGEL@EUMETSAT.INT</OPERATOR_EMAIL>
    <EPHEMERIS_NAME>EPHEMERIS SATELLITE A</EPHEMERIS_NAME>
    <NUMBER_SENSORS>3</NUMBER_SENSORS>
    <TRACKING_DATA_TYPES>GPS,DOPPLER</TRACKING_DATA_TYPES>
    <ADDITIONAL_TRACKING>YES</ADDITIONAL_TRACKING>
    <COVARIANCE_METHOD>CALCULATED</COVARIANCE_METHOD>
    <MANEUVERABLE>YES</MANEUVERABLE>
    <MAN_INCLUDED>YES</MAN_INCLUDED>
    <REF_FRAME>ITRF2000</REF_FRAME>
    <COV_REF_FRAME>RTN</COV_REF_FRAME>
    <GRAVITY_MODEL>EGM-96: 36Z 36T</GRAVITY_MODEL>
    <ATMOSPHERIC_MODEL>JACCHIA 70 DCA</ATMOSPHERIC_MODEL>
    <N_BODY_PERTUBATIONS>MOON,SUN</N_BODY_PERTUBATIONS>
    <SOLAR_RAD_PRESSURE>OFF</SOLAR_RAD_PRESSURE>
    <SOLID_EARTH_TIDES>OFF</SOLID_EARTH_TIDES>
    <INTRACK_THRUST>OFF</INTRACK_THRUST>
   </metadata>
   <data>
    <COMMENT>Object1 Data</COMMENT>
    <odParameters>
     <COMMENT>Object1 OD Parameters</COMMENT>
     <TIME_LASTOB>
      <lastObAt>2010-03-12T02:14:12.746</lastObAt>
     </TIME_LASTOB>
     <RECOMMENDED_OD_SPAN units="d">7.88</RECOMMENDED_OD_SPAN>
     <ACTUAL_OD_SPAN units="d">5.50</ACTUAL_OD_SPAN>
     <MAXIMUM_OBS_GAP units="h">2.4</MAXIMUM_OBS_GAP>
     <OBS_AVAILABLE>592</OBS_AVAILABLE>
     <OBS_USED>418</OBS_USED>
     <TRACKS_AVAILABLE>123</TRACKS_AVAILABLE>
     <TRACKS_USED>98</TRACKS_USED>
     <WEIGHTED_RMS>0.864</WEIGHTED_RMS>
     <TIME_NEXT_UPDATE units="h">2.0</TIME_NEXT_UPDATE>
    </odParameters>
    <additionalParameters>
     <COMMENT>Object 1 Additional Parameters</COMMENT>
     <APOAPSIS units="km">779</APOAPSIS>
```

<PERIAPSIS units="km">765</PERIAPSIS>
<INCLINATION units="deg">86.4</INCLINATION>
<AREA_ESTIMATE units="m**2">5.2</AREA_ESTIMATE>
<MASS units="kg">2516</MASS>
<CD_AREA_OVER_MASS units="m**2/kg">0.045663</CD_AREA_OVER_MASS>
<CR_AREA_OVER_MASS units="m**2/kg">0.000000</CR_AREA_OVER_MASS>
<THRUST_ACCELERATION units="m/s**2">0.0</THRUST_ACCELERATION>
<SEDR units="W/kg">4.54570E-05</SEDR>
</additionalParameters>
<stateVector>
<COMMENT>Object1 State Vector</COMMENT>
<X units="km">2570.097065</X>
<Y units="km">2244.654904</Y>
<Z units="km">6281.497978</Z>
<X_DOT units="km/s">4.418769571</X_DOT>
<Y_DOT units="km/s">4.833547743</Y_DOT>
<Z_DOT units="km/s">-3.526774282</Z_DOT>
</stateVector>
<covarianceMatrix>
<COMMENT>Object1 Covariance in the RTN Coordinate System </COMMENT>
<CX_X units="m**2">4.142E+01</CX_X>
<CY_X units="m**2">-8.579E+00</CY_X>
<CY_Y units="m**2">2.533E+03</CY_Y>
<CZ_X units="m**2">-2.313E+01</CZ_X>
<CZ_Y units="m**2">1.336E+01</CZ_Y>
<CZ_Z units="m**2">7.098E+01</CZ_Z>
<CXDOT_X units="m**2/s">2.520E-03</CXDOT_X>
<CXDOT_Y units="m**2/s">-5.476E+00</CXDOT_Y>
<CXDOT_Z units="m**2/s">8.626E-04</CXDOT_Z>
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<CYDOT_X units="m**2/s">-1.006E-02</CYDOT_X>
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<CYDOT_Z units="m**2/s">-1.359E-03</CYDOT_Z>
<CYDOT_XDOT units="m**2/s**2">-1.502E-05</CYDOT_CXDOT>
<CYDOT_YDOT units="m**2/s**2">1.049E-05</CYDOT_CYDOT>
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<CZDOT_Z units="m**2/s">1.213E-02</CZDOT_Z>
<CZDOT_XDOT units="m**2/s**2">-3.004E-06</CZDOT_CXDOT>
<CZDOT_YDOT units="m**2/s**2">-1.091E-06</CZDOT_CYDOT>
<CZDOT_ZDOT units="m**2/s**2">5.529E-05</CZDOT_CZDOT>
</covarianceMatrix>
</data>
</segment>
<segment>
<metadata>
<COMMENT>Object2 Metadata</COMMENT>
<OBJECT>OBJECT2</OBJECT>
<OBJECT_NUMBER>30337</OBJECT_NUMBER>
<SAT_CATALOG>SATCAT</SAT_CATALOG>
<OBJECT_NAME>FENGYUN 1C DEB</OBJECT_NAME>
<OBJECT_ID>1999-025AA</OBJECT_ID>
<OBJECT_TYPE>DEBRIS</OBJECT_TYPE>
<EPHEMERIS_NAME>NONE</EPHEMERIS_NAME>
<NUMBER_SENSORS>3</NUMBER_SENSORS>
<TRACKING_DATA_TYPES>RADAR</TRACKING_DATA_TYPES>

```
    <ADDITIONAL_TRACKING>NO</ADDITIONAL_TRACKING>
    <COVARIANCE_METHOD>CALCULATED</COVARIANCE_METHOD>
    <MANEUVERABLE>NO</MANEUVERABLE>
    <REF_FRAME>ITRF2000</REF_FRAME>
    <COV_REF_FRAME>RTN</COV_REF_FRAME>
    <GRAVITY_MODEL>EGM-96: 36Z 36T</GRAVITY_MODEL>
    <ATMOSPHERIC_MODEL>JACCHIA 70 DCA</ATMOSPHERIC_MODEL>
    <N_BODY_PERTUBATIONS>ON</N_BODY_PERTUBATIONS>
    <SOLAR_RAD_PRESSURE>ON</SOLAR_RAD_PRESSURE>
    <SOLID_EARTH_TIDES>OFF</SOLID_EARTH_TIDES>
    <INTRACK_THRUST>OFF</INTRACK_THRUST>
  </metadata>
  <data>
    <COMMENT>Object2 Data</COMMENT>
    <odParameters>
      <COMMENT>Object2 OD Parameters</COMMENT>
      <TIME_LASTOB>
        <timeSince units="h">6-12</timeSince>
      </TIME_LASTOB>
      <RECOMMENDED_OD_SPAN units="d">2.63</RECOMMENDED_OD_SPAN>
      <ACTUAL_OD_SPAN units="d">2.63</ACTUAL_OD_SPAN>
      <MAXIMUM_OBS_GAP units="h">5.7</MAXIMUM_OBS_GAP>
      <OBS_AVAILABLE>59</OBS_AVAILABLE>
      <OBS_USED>58</OBS_USED>
      <TRACKS_AVAILABLE>15</TRACKS_AVAILABLE>
      <TRACKS_USED>15</TRACKS_USED>
      <WEIGHTED_RMS>0.864</WEIGHTED_RMS>
    </odParameters>
    <additionalParameters>
      <COMMENT>Object2 Additional Parameters</COMMENT>
      <APOAPSIS units="km">768</APOAPSIS>
      <PERIAPSIS units="km">414</PERIAPSIS>
      <INCLINATION units="deg">98.8</INCLINATION>
      <AREA_ESTIMATE units="m**2">0.9</AREA_ESTIMATE>
      <MASS units="kg">53.2</MASS>
      <CD_AREA_OVER_MASS units="m**2/kg">0.118668</CD_AREA_OVER_MASS>
      <CR_AREA_OVER_MASS units="m**2/kg">0.075204</CR_AREA_OVER_MASS>
      <THRUST_ACCELERATION units="m/s**2">0.0</THRUST_ACCELERATION>
      <SEDR units="W/kg">5.40900E-03</SEDR>
    </additionalParameters>
    <stateVector>
      <COMMENT>Object2 State Vector</COMMENT>
      <X units="km">2569.540800</X>
      <Y units="km">2245.093614</Y>
      <Z units="km">6281.599946</Z>
      <X_DOT units="km/s">-2.888612500</X_DOT>
      <Y_DOT units="km/s">-6.007247516</Y_DOT>
      <Z_DOT units="km/s">3.328770172</Z_DOT>
    </stateVector>
    <covarianceMatrix>
      <COMMENT>Object2 Covariance in the RTN Coordinate System</COMMENT>
      <CX_X units="m**2">1.337E+03</CX_X>
      <CY_X units="m**2">-4.806E+04</CY_X>
      <CY_Y units="m**2">2.492E+06</CY_Y>
      <CZ_X units="m**2">-3.298E+01</CZ_X>
      <CZ_Y units="m**2">-7.5888E+02</CZ_Y>
```

<CZ_Z units="m**2">7.105E+01</CZ_Z>
<CXDOT_X units="m**2/s">2.591E-03</CXDOT_X>
<CXDOT_Y units="m**2/s">-4.152E-02</CXDOT_Y>
<CXDOT_Z units="m**2/s">-1.784E-06</CXDOT_Z>
<CXDOT_XDOT units="m**2/s**2">6.886E-05</CXDOT_CXDOT>
<CYDOT_X units="m**2/s">-1.016E-02</CYDOT_X>
<CYDOT_Y units="m**2/s">-1.506E-04</CYDOT_Y>
<CYDOT_Z units="m**2/s">1.637E-03</CYDOT_Z>
<CYDOT_XDOT units="m**2/s**2">-2.987E-06</CYDOT_CXDOT>
<CYDOT_YDOT units="m**2/s**2">1.059E-05</CYDOT_CYDOT>
<CZDOT_X units="m**2/s">4.400E-03</CZDOT_X>
<CZDOT_Y units="m**2/s">8.482E-03</CZDOT_Y>
<CZDOT_Z units="m**2/s">8.633E-05</CZDOT_Z>
<CZDOT_XDOT units="m**2/s**2">-1.903E-06</CZDOT_CXDOT>
<CZDOT_YDOT units="m**2/s**2">-4.594E-06</CZDOT_CYDOT>
<CZDOT_ZDOT units="m**2/s**2">5.178E-05</CZDOT_CZDOT>
</covarianceMatrix>
</data>
</segment>
</body>
</cdm>

Figure 4-2: An Example of a CDM in XLM Format

5 CDM DATA IN GENERAL

5.1 RULES THAT APPLY IN KVN AND XML

The following rules apply for both KVN and XML formatted CDMs.

5.1.1 The objects' state vectors and covariance are given 'at the time of closest approach (TCA)', i.e., at the time specified in the TCA keyword.

5.1.2 Table 3-4 is broken into four logical blocks, each of which has a descriptive heading. These descriptive headings shall not be included in a CDM, unless they appear in a properly formatted COMMENT statement for the KVN implementation and values between the <COMMENT> and </COMMENT> tags for the XML implementation.

5.1.3 If $C_R \bullet A/m$, CR_AREA_OVER_MASS (for Object1 or Object2), is set to zero, no solar radiation pressure was taken into account in the orbit determination process.

5.1.4 If $C_D \bullet A/m$, CD_AREA_OVER_MASS (for Object1 or Object2), is set to zero, no atmospheric drag was taken into account in the orbit determination process.

5.1.5 If the acceleration due to in-track thrust, THRUST_ACCELERATION (for Object1 or Object2), is set to zero, no in-track thrust acceleration was taken into account in the orbit determination process.

5.1.6 Values in the covariance matrix shall be presented sequentially from upper left [1,1] to lower right [6,6], lower triangular form, row by row left to right. Variance and covariance values shall be expressed in standard double precision as related in 6.2.2.5.

6 CDM SYNTAX

6.1 OVERVIEW

This section details the syntax requirements for the CDM using both KVN and XML formats.

6.2 THE CDM IN KVN

6.2.1 CDM LINES IN KVN

6.2.1.1 Each CDM file shall consist of a set of CDM lines. Each CDM line shall be one of the following:

– Header line;

- Relative Metadata/Data line;

– Metadata line;

– Data line; or

– Blank line.

6.2.1.2 Each CDM line must not exceed 254 ASCII characters and spaces (excluding line termination character[s]).

6.2.1.3 Only printable ASCII characters and blanks shall be used. Control characters (such as TAB, etc.) shall not be used, with the exception of the line termination characters specified below.

6.2.1.4 Blank lines may be used at any position within the file. Blank lines shall have no assignable meaning, and may be ignored.

6.2.1.5 The first header line must be the first non-blank line in the file.

6.2.1.6 All lines shall be terminated by a single Carriage Return or a single Line Feed, or a Carriage Return/Line Feed pair or a Line Feed/Carriage Return pair.

6.2.1.7 All header, metadata, and data lines shall use ‘keyword = value’ notation. For this purpose, only those keywords shown in table 3-1, table 3-2, table 3-3 and table 3-4 shall be used in a CDM.

6.2.1.8 Some keywords represent obligatory items and some are optional. KVN assignments representing optional items may be omitted.

6.2.1.9 Only a single ‘keyword = value’ assignment shall be made on a line.

6.2.1.10 Keywords must be uppercase and must not contain blanks.

6.2.1.11 Any white space immediately preceding or following the keyword shall not be significant.

6.2.1.12 Any white space immediately preceding or following the 'equals' sign shall not be significant.

6.2.1.13 Any white space immediately preceding the end of line shall not be significant.

6.2.1.14 The order of occurrence of obligatory and optional KVN assignments shall be fixed as shown in the tables in sections 3 that describe the CDM keywords.

6.2.2 CDM VALUES IN KVN

6.2.2.1 A non-empty value field must be specified for each obligatory keyword.

6.2.2.2 Integer values shall consist of a sequence of decimal digits with an optional leading sign ('+' or '-'). If the sign is omitted, '+' shall be assumed. Leading zeroes may be used. The range of values that may be expressed as an integer is:

-2,147,483,648 <= x <= +2,147,483,647 (i.e., $-2^{31} <= x <= 2^{31}-1$).

Note: The commas are listed in the range of values above only for ease of readability.

6.2.2.3 Non-integer numeric values may be expressed in either fixed-point or floating-point notation.

6.2.2.4 Non-integer numeric values expressed in fixed-point notation shall consist of a sequence of decimal digits separated by a period as a decimal point indicator, with an optional leading sign ('+' or '-'). If the sign is omitted, '+' shall be assumed. Leading and trailing zeroes may be used. At least one digit shall appear before and after a decimal point. The number of digits shall be 16 or fewer.

6.2.2.5 Non-integer numeric values expressed in floating point notation shall consist of a sign, a mantissa, an alphabetic character indicating the division between the mantissa and exponent, and an exponent, constructed according to the following rules:

a) The sign may be '+' or '-'. If the sign is omitted, '+' shall be assumed.

b) The mantissa must be a string of no more than 16 decimal digits with a decimal point ('.') in the second position of the ASCII string, separating the integer portion of the mantissa from the fractional part of the mantissa.

c) The character used to denote exponentiation shall be 'E' or 'e'. If the character indicating the exponent and the following exponent are omitted, an exponent value of

zero shall be assumed (essentially yielding a fixed point value).

d) The exponent must be an integer, and may have either a '+' or '-' sign (if the sign is omitted, then '+' shall be assumed).

e) The maximum positive floating point value is approximately 1.798E+308, with 16 significant decimal digits precision. The minimum positive floating point value is approximately 4.94E-324, with 16 significant decimal digits precision.

6.2.2.6 Text value fields must be constructed using only all uppercase or all lowercase.

6.2.2.7 Blanks shall not be permitted within numeric values.

6.2.2.8 Time strings must follow the specified formats in section 6.2.2.10.

6.2.2.9 In value fields that are text, an underscore shall be equivalent to a single blank. Individual blanks shall be retained (shall be significant), but multiple contiguous blanks shall be equivalent to a single blank.

6.2.2.10 In value fields that represent a time tag, times, which are UTC, shall be given in one of the following two formats:

*yyyy-mm-dd***T***hh:mm:ss*[*.d→d*]

or

*yyyy-ddd***T***hh:mm:ss*[*.d→d*]

where '*yyyy*' is the year, '*mm*' is the two-digit month, '*dd*' is the two-digit day-of-month and '*ddd*' is the three-digit day of the year, separated by hyphens, '**T**' is a fixed separator between the date and time portions of the string, and '*hh:mm:ss*[*.d→d*] is the time in hours, minutes, seconds and fractional seconds, separated by colons. As many 'd' characters to the right of the period as required may be used to obtain the required precision, up to the maximum allowed for a fixed point number. Because all times in the CDM are UTC, the "Z" indicator allowed by the CCSDS Time Codes standard should be omitted. All fields require leading zeros. (See reference [6], ASCII Time Code A or B).

6.2.2.11 There are eight values that represent a time tag, as shown in Tables 3-1, 3-2, 3-3 and 3-4, CREATION_DATE, TCA, ENTRY_TIME, EXIT_TIME, REF_FRAME_EPOCH, START_SCREEN_PERIOD, STOP_SCREEN_PERIOD and TIME_LASTOB, all of which shall be UTC.

6.2.2.12 In the value fields that represent TIME_LASTOB, a choice of data types is given that includes the exact time (See 6.2.2.10 for formatting rules) or an elapsed time, from the message creation time, since the last observation used in the OD of the object. When the elapsed time option is chosen, the notation "<", "-", and ""> " will be used. The "<" means

"less than" as in "< 6" means "less than six hours". The "-" means "to" as in "6 -12" means "six to twelve hours". The ">" means "greater than" as in "> 12" means "greater than twelve hours".

6.2.3 CDM UNITS IN KVN

6.2.3.1 If units are applicable, as specified in table 3-2 and/or table 3-4, they must be displayed and must exactly match the units specified in table 3-2 and table 3-4 (including case). When units are displayed, then:

a) there must be at least one blank character between the value and the units text;

b) the units must be enclosed within square brackets (e.g., '[km]');

c) exponents of units shall be denoted with a double asterisk (i.e., '**', for example, m/s^2 = m/s**2).

6.2.3.2 Some of the items in the applicable tables are dimensionless. The table shows a unit value of 'n/a', which in this case means that there is no applicable units designator for these items (e.g., for COLLISION_PROBABILITY, WEIGHTED_RMS). The notation '[n/a]' shall not appear in a CDM.

6.2.4 CDM COMMENTS IN KVN

6.2.4.1 For the CDM comment lines shall be optional.

6.2.4.2 All comment lines shall begin with the 'COMMENT' keyword followed by at least one space. This keyword must appear on every comment line, not just the first such line. The remainder of the line shall be the comment value. White space shall be retained (shall be significant) in comment values.

6.2.4.3 Placement of comments shall be as specified in the tables in section 3 that describe the CDM keywords.

6.3 THE CDM IN XML

6.3.1 CDM LINES IN XML

6.3.1.1 Each CDM file shall consist of a set of CDM lines. Each CDM line shall be one of the following:

– XML version line;

–An XML formatted data line; or

– Blank line.

6.3.1.2 Each CDM line must not exceed 254 ASCII characters and spaces (excluding line termination character[s]).

6.3.1.3 Only printable ASCII characters and blanks shall be used. Control characters (such as TAB, etc.) shall not be used, with the exception of the line termination characters specified below.

6.3.1.4 Blank lines may be used at any position within the file. Blank lines shall have no assignable meaning, and may be ignored.

6.3.1.5 The first line in the instantiation shall specify the XML version.

6.3.1.6 All lines shall be terminated by a single Carriage Return or a single Line Feed, or a Carriage Return/Line Feed pair or a Line Feed/Carriage Return pair.

6.3.1.7 While specific formatting of an XML message is not critical, and white space and line breaks are not significant, it is suggested that the message should be organized and formatted to facilitate human comprehension.

6.3.2 CDM VALUES IN XML

6.3.2.1 Each obligatory XML tag must be present and contain a meaningful value.

6.3.2.2 Integer values shall follow the conventions of the *integer* data type per reference [4]. Additional restrictions on the allowable range or values permitted for any integer data element may also be defined in the CDM XML Schema in Annex F. Examples of such restrictions may include a defined range (e.g., 0 - 100, 1 - 10, etc.) , a set of enumerated values (e.g., 0,1,2,4,8), a pre-defined specific variation such as *positiveInteger*, or a user-defined data type variation.

6.3.2.3 Non-integer numeric values may be expressed in either fixed-point or floating-point notation. Numeric values shall follow the conventions of the *double* data type per reference [4]. Additional restrictions on the allowable range or values permitted for any numeric data element may also be defined in the CDM XML Schema in Annex F. Examples of such restrictions may include a defined range (e.g., 0.0 - 100.0, etc.), or a user-defined data type variation.

6.3.2.4 Text value data shall follow the conventions of the *string* data type per reference [4]. Additional restrictions on the allowable range or values permitted for any data element may also be defined in the CDM XML Schema in Annex F. Examples of such restrictions may include a set of enumerated values (e.g., 'YES'/'NO', or 'ON'/'OFF'), or other user-defined data type variation.

6.3.2.5 In value fields that represent a time tag which are in UTC, values shall follow the conventions of the *dateTime* data type per reference [4]. An example of this format:

*yyyy-mm-dd***T***hh:mm:ss*[*.d→d*]

where '*yyyy*' is the year, '*mm*' is the two-digit month, '*dd*' is the two-digit day-of-month separated by hyphens, '**T**' is a fixed separator between the date and time portions of the string, and '*hh:mm:ss*[*.d→d*]' is the time in hours, minutes, seconds and fractional seconds separated by colons. As many 'd' characters to the right of the period as required may be used to obtain the required precision, up to the maximum allowed for a fixed point number. Because all times in the CDM are UTC, the "Z" indicator allowed by the CCSDS Time Codes standard should be omitted. All fields require leading zeros.

6.3.2.6 In the value fields that represent TIME_LASTOB, a choice of data types is allowed that includes the exact time (See 6.3.2.5 for formatting rules) or an elapsed time, from the message creation time, of the last observation used in the OD of the object . When the elapsed time option is chosen, the notation "LT", "-". and ""GT" will be used. The "LT" means "less than" as in "less than six hours". The "-" means "to" as in "6-12" means "six to twelve hours". The "GT" means "greater than" as in "greater than twelve hours".

6.3.2.7 Annex F describes a CDM XML Schema that explicitly defines the permitted data elements and values acceptable for the XML version of the CDM message.

6.3.3 CDM UNITS IN XML

6.3.3.1 Many of the CDM tags must have a units attribute. In all cases, the units shall match those specified in table 3-2 and table 3-4 (including case). Table 6-1 and Table 6-2, for the relative data and object data respectively, list the keyword tags for which units must be specified.

Table 6-1: Relative Metadata/Data XML Keyword Tags With Specified Units

Tag	Units	Example
MISS_DISTANCE	m	<MISS_DISTANCE units="m">1.0</MISS_DISTANCE>
RELATIVE_SPEED	m/s	<RELATIVE_SPEED units="m/s">1.0</RELATIVE_SPEED>
relativeStateVector	m & m/s	<relativeStateVector> <RELATIVE_POSITION_X units="m">0.0</ RELATIVE_POSITION_X> <RELATIVE_POSITION_Y units="m">0.0</ RELATIVE_POSITION_Y> <RELATIVE_POSITION_Z units="m">0.0</ RELATIVE_POSITION_Z> <RELATIVE_VELOCITY_X units="m/s">0.0</ RELATIVE_VELOCITY_X> <RELATIVE_VELOCITY_Y units="m/s">0.0</ RELATIVE_VELOCITY_Y> <RELATIVE_VELOCITY_Z units="m/s">0.0</ RELATIVE_VELOCITY_Z> </relativeStateVector>
SCREEN_VOLUME_X	m	<SCREEN_VOLUME_X units="m">1.0</SCREEN_VOLUME_X>
SCREEN_VOLUME_Y	m	<SCREEN_VOLUME_Y units="m">1.0</SCREEN_VOLUME_Y>
SCREEN_VOLUME_Z	m	<SCREEN_VOLUME_Z units="m">1.0</SCREEN_VOLUME_Z>

Table 6-2: Object Data XML Keyword Tags With Specified Units

Keyword	Units	Example
odParameters		**Elements below are nested elements.**
TIME_LASTOB	h n/a	<TIME_LASTOB> <timeSince units="h">6-12<timeSince> </TIME_LASTOB> <TIME_LASTOB> <lastObAt>0000-00-00T00:00:00.000<lastObAt> </TIME_LASTOB>
RECOMMENDED_OD_SPAN	d	<RECOMMENDED_OD_SPAN units="d">10.0</RECOMMENDED_OD_SPAN>
ACTUAL_OD_SPAN	d	<ACTUAL_OD_SPAN units="d">5.0</ACTUAL_OD_SPAN >
MAXIMUM_OBS_GAP	h	<MAXIMUM_OBS_GAP units="h">2.3</MAXIMUM_OBS_GAP>
TIME_NEXT_UPDATE	h	<TIME_NEXT_UPDATE units="h">2.0</ TIME_NEXT_UPDATE>
additionalParameters		**Elements below are nested elements.**
APOAPSIS	km	<APOAPSIS units="km">numeric-value</APOAPSIS>
PERIAPSIS	km	<PERIAPSIS units="km">numeric-value</PERIAPSIS>
INCLINATION	deg	<INCLINATION units="deg">28.6</INCLINATION>
AREA_ESTIMATE	m**2	<AREA_ESTIMATE units="m**2">1.0</AREA_ESTIMATE>
MASS	kg	<MASS units="kg">100.0</MASS>
CD_AREA_OVER_MASS	m**2/kg	<CD_AREA_OVER_MASS units="m**2/kg">1.123E-07</ CD_AREA_OVER_MASS >
CR_AREA_OVER_MASS	m**2/kg	<CR_AREA_OVER_MASS units="m**2/kg">0.123E-05</ CR_AREA_OVER_MASS >
SEDR	W/kg	<SEDR units="W/kg>0.001E-06<SEDR>
stateVector	km & km/s	<stateVector> <X units="km">0.0</X> <Y units="km">0.0</Y> <Z units="km">0.0</Z> <X_DOT units="km/s">0.0</X_DOT > <Y_DOT units="km/s">0.0</Y_DOT > <Z_DOT units="km/s">0.0</Z_DOT > </stateVector>
covarianceMatrix		**Elements below are nested elements.**
CX_X	m**2	<CX_X units="m**2">1.0</CX_X>
CY_X	m**2	<CY_X units="m**2">1.0</CY_X>
CY_Y	m**2	CY_Y units="m**2">1.0</CY_Y>
CZ_X	m**2	< CZ_X units="m**2">1.0</CZ_X >
CZ_Y	m**2	<CZ_Y units="m**2">1.0</CZ_Y>
CZ_Z	m**2	<CZ_Z units="m**2">1.0</CZ_Z>
CXDOT_X	m**2/s	<CXDOT_X units="m**2/s">1.0</CXDOT_X>
CXDOT_Y	m**2/s	<CXDOT_Y units="m**2/s">1.0</CXDOT_Y>
CXDOT_Z	m**2/s	<CXDOT_Z units="m**2/s">1.0</CXDOT_Z>
CXDOT_XDOT	m**2/s**2	<CXDOT_CXDOT units="m**2/s**2">1.0</CXDOT_CXDOT>
CYDOT_X	m**2/s	<CYDOT_X units="m**2/s">1.0</CYDOT_X>
CYDOT_Y	m**2/s	<CYDOT_Y units="m**2/s">1.0</CYDOT_Y>
CYDOT_Z	m**2/s	< CYDOT_Z units="m**2/s">1.0</ CYDOT_Z>
CYDOT_XDOT	m**2/s**2	<CYDOT_CXDOT units="m**2/s**2">1.0</CYDOT_CXDOT>

Keyword	Units	Example
CYDOT_YDOT	m**2/s**2	<CYDOT_CYDOT units="m**2/s**2">1.0</CYDOT_CYDOT>
CZDOT_X	m**2/s	<CZDOT_X units="m**2/s">1.0</CZDOT_X>
CZDOT_Y	m**2/s	<CZDOT_Y units="m**2/s">1.0</CZDOT_Y>
CZDOT_Z	m**2/s	<CZDOT_Z units="m**2/s">1.0</CZDOT_Z>
CZDOT_XDOT	m**2/s**2	<CZDOT_CXDOT units="m**2/s**2">1.0</CZDOT_CXDOT>
CZDOT_YDOT	m**2/s**2	<CZDOT_CYDOT units="m**2/s**2">1.0</CZDOT_CYDOT>
CZDOT_ZDOT	m**2/s**2	< CZDOT_CZDOT units="m**2/s**2">1.0</ CZDOT_CZDOT >

6.3.4 CDM COMMENTS IN XML

6.3.4.1 Comments are optional and must be displayed as values between the <COMMENT> and </COMMENT> tags, which may be in any case desired by the user.

6.3.5 CDM XML TAGS

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6.3.5.1 KVN keywords shall be uppercase with '_' as separators. XML tags shall be uppercase and correspond with the keywords in sections 3.2 through 3.6. The XML logical tags related to message structure shall be in lowerCamelCase.

6.3.6 XML TEXT VALUES

Text values in XML instantiations (i.e., the values between the opening and closing tags),

shall consist of all uppercase or all lowercase characters; an exception is made for values between the <COMMENT> and </COMMENT> tags, which may be in any case desired by the user.user.

ANNEX A

VALUES FOR REFERENCE FRAME KEYWORDS

(NORMATIVE)

The values in this annex represent the set of acceptable values for the REF_FRAME, RELATIVE_REF_FRAME, and COV_REF_FRAME keywords in the CDM. (For details and description of these reference frames, see reference [E1].) If exchange partners wish to use different settings, the settings should be documented in the ICD.

A1 REFERENCE_FRAME KEYWORD

Reference Frame Value	Meaning
EME2000	Earth Mean Equator and Equinox of J2000
GCRF	Geocentric Celestial Reference Frame
GRC	Greenwich Rotating Coordinates
ICRF	International Celestial Reference Frame
ITRF2000	International Terrestrial Reference Frame 2000
ITRF-93	International Terrestrial Reference Frame 1993
ITRF-97	International Terrestrial Reference Frame 1997
RTN	Radial, Transverse, Normal ***Recommended value for RELATIVE_POSITION, RELATIVE_VELOCITY, SCREEN_VOLUME and COVARIANCE***
TDR	True of Date, Rotating
TOD	True of Date

ANNEX B

ABBREVIATIONS AND ACRONYMS

(INFORMATIVE)

ASCII	American Standard Code for Information Interchange
CA	Conjunction Assessment
CDM	Conjunction Data Message
CCSDS	Consultative Committee for Space Data Systems
DCA	Dynamic Calibration of the Atmosphere
ECEF	Earth-Centered Earth-Fixed
ECI	Earth Centered Inertial
EGM	Earth Gravitational Model
EME2000	Earth Mean Equator and Equinox of J2000 (Julian Date 2000)
GCRF	Geocentric Celestial Reference Frame
GRC	Greenwich Rotating Coordinate Frame
ICD	Interface Control Document
ICRF	International Celestial Reference Frame
ITRF	International Terrestrial Reference Frame
KVN	Keyword = Value Notation
OD	Orbit Determination
RCS	Radar Cross Section
RMS	Root Mean Square
RTN	Radial, Transverse and Normal

SEDR	Specific Energy Dissipation Rate
TCA	Time of Closest Approach
TDR	True of Date Rotating
TOD	True Equator and Equinox of Date
UTC	Coordinated Universal Time
WGS	World Geodetic System
XML	Extensible Markup Language

ANNEX C

RATIONALE FOR CONJUNCTION DATA MESSAGES

(INFORMATIVE)

C1 OVERVIEW

This annex presents the rationale behind the design of this message.

A specification of requirements agreed to by all parties is essential to focus design and to ensure the product meets the needs of the Member Agencies and satellite operators. There are many ways of organizing requirements, but the categorization of requirements is not as important as the agreement to a sufficiently comprehensive set. In this section the requirements are organized into three categories:

a) Primary Requirements: These are the most elementary and necessary requirements. They would exist no matter the context in which the CCSDS is operating, i.e., regardless of pre-existing conditions within the CCSDS, its Member Agencies, or other independent users.

b) Heritage Requirements: These are additional requirements that derive from pre-existing Member Agency or other independent user requirements, conditions or needs. Ultimately these carry the same weight as the Primary Requirements. This Proposed Recommended Standard reflects heritage requirements pertaining to some of the CCSDS Areas' home institutions collected during the preparation of the document; it does not speculate on heritage requirements that could arise from other sources. Corrections and/or additions to these requirements are expected during future updates.

c) Desirable Characteristics: These are not requirements, but they are felt to be important or useful features of the Proposed Recommended Standard.

C2 PRIMARY REQUIREMENTS ACCEPTED BY THE CDM

Table C-1: Primary Requirements

Requirement	Accepted for CDM?
Data must be provided in digital form (computer file).	Y
The file specification must not require of the receiving exchange partner the separate application of, or modeling of, spacecraft dynamics or gravitational force models, or integration or propagation.	Y
State vector information must be provided in a reference frame that is clearly identified and unambiguous.	Y
Identification of the object and the center(s) of motion must be clearly identified and unambiguous.	Y
Time measurements (time stamps, or epochs) must be provided in a commonly used, clearly specified system.	Y
The Proposed Recommended Standard must provide for clear specification of units of measure.	Y
Files must be readily ported between, and useable within, 'all' computational environments in use by Member Agencies.	Y
Files must have means of being uniquely identified and clearly annotated. The file name alone is considered insufficient for this purpose.	Y
File name syntax and length must not violate computer constraints for those computing environments in use by Member Agencies.	Y
A means to convey information about the uncertainty of the state shall be provided.	Y

Table C-2: Heritage Requirements

Requirement	Accepted for CDM?
The Proposed Recommended Standard is, or includes, an ASCII format.	Y
The Proposed Recommended Standard does not require software supplied by other Agencies.	Y

Table C-3: Desirable Characteristics

Requirement	Accepted for CDM?
The Proposed Recommended Standard is extensible with no disruption to existing users/uses.	Y
The Proposed Recommended Standard is as consistent as reasonable with any related CCSDS Recommended Standards used for earth-to-spacecraft or spacecraft-to-spacecraft applications.	Y

ANNEX D

CONJUNCTION INFORMATION DESCRIPTION

(INFORMATIVE)

D1 RELATIVE DATA

TCA (Time of Closest Approach). This is the date and time of the predicted conjunction. This time tag is also the epoch of the relative state vector, Object1 and Object2 state vectors, as well as the effective time of the covariance matrices for both Object1 and Object2.

COLLISION_PROBABILITY. The probability that Object1 will collide with Object2.

MISS_DISTANCE. The miss distance tells how close the two objects are going to be based upon the conjunction assessment screening results.

RELATIVE_SPEED. The relative speed defines how fast the two objects are moving relative to each other at the time of the predicted encounter.

RELATIVE_POSITION/RELATIVE_VELOCITY. Object2's position/velocity relative to Object1's position/velocity in the Object1-centered coordinate frame at the time of closest approach.

RTN Coordinate Frame. The Object1-centered RTN coordinate frame is defined as: R is the unit vector in the radial direction, N is the unit vector normal to the satellite's inertial orbit plane (in the direction of the satellite's angular momentum), and T is the unit vector that completes the right-handed coordinate frame.

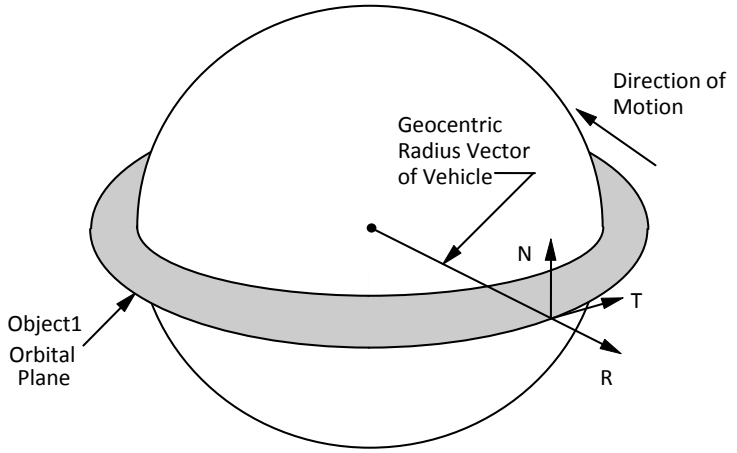

Figure D-1: Definition of the RTN Coordinate Frame

SCREEN_VOLUME_SHAPE/SCREEN_VOLUME: The screening volume shape (ellipsoid or box), is the shape of the screening volume used to screen the satellite catalog for possible conjunctors with Object1. The screening volume is the component size of the screening volume shape (in the Object1 centered orbital reference frame).

D2 METADATA

ADDITIONAL_TRACKING. This parameter provides information concerning whether additional sensor tracking has been applied to the orbit determination of the object. Once a potential conjunction has been determined, it is common practice to then use additional sensor resources where possible, beyond what is normally used, to better define the object's orbit.

D3 ORBIT DETERMINATION PARAMETERS

Observation. Provides a unique measurement of a satellite's location from a single sensor at a single time (e.g. azimuth from a single sensor at a single time).

TIME_LASTOB. This parameter provides information about the time of the last accepted observation that was used in the creation of the object's state vector. It can be entered as an exact time or an elapsed time, from the message creation time, that includes the time of the last good observation that was used in the creation of the object's state vector. The rules for the latter case are defined below for near earth (NE) and far from earth (FE) objects (FE is defined as any object with a period greater than 225 minutes):

For all NE objects:

<6 hours from message creation time

6 to 12 hours from message creation time

>12 hours from message creation time

For all FE objects:

<24 hours from message creation time

24 to 48 hours from message creation time

>48 hours from message creation time

RECOMMENDED_OD_SPAN. Describes how many days of observations were recommended for the orbit determination (OD).

ACTUAL_OD_SPAN. The actual span describes how many days of observations were actually used in the OD.

OBS_AVAILABLE. This parameter provides the number of observations, for the recommended time span, that were available for the OD.

OBS_USED. This parameter provides the number of observations, for the recommended time span, that were accepted for the OD.

Sensor Track. A sensor track is defined as a set of at least three observations for the same object, observed by the same sensor, where each observation is within a specified number of minutes (which is dependent on the orbit regime of the object) of the other observations in the track.

TRACKS_AVAILABLE. This parameter provides the number of sensor tracks, for the recommended time span, that were available for the OD. This provides information about the independence of the observational data used in the OD.

TRACKS_USED. This parameter provides the number of sensor tracks, for the recommended time span, that were accepted for the OD. This provides information about the independence of the observational data used in the OD.

MAXIMUM_OBS_GAP. The maximum time between observations in the OD of the object.

WEIGHTED_RMS. The weighted RMS is defined as:

$$Weighted\ RMS = \sqrt{\frac{\sum_{i=1}^{N} w_i (y_i - \hat{y}_i)^2}{N}}$$

Where

y_i is the observation measurement at the ith time

$\hat{y}_i$ is the current estimate of y_i,

$w_i = \frac{1}{\sigma_i^2}$ is the weight (sigma) associated with the measurement at the ith time

and N is the number of observations.

This is a value that can generally identify the quality of the most recent vector update, and is used by the analyst in evaluating the OD process. A value of 1.00 is ideal.

D4 MODEL PARAMETERS

GRAVITY_MODEL. Indicates the geopotential model used in the state vector update.

ATMOSPHERIC_MODEL. Indicates the atmospheric drag model used in the state vector update.

N_BODY_PERTURBATIONS. Indicates whether N-body gravitational perturbations were included in the state vector update.

SOLAR_RAD_PRESSURE. Indicates whether perturbations due to solar radiation pressure were included in the state vector update.

SOLID_EARTH_TIDES. Indicates whether perturbations due to solid earth tides were included in the state vector update.

D5 ADDITIONAL PARAMETERS

APOAPSIS, PERIAPSIS and INCLINATION. These parameters describe the orbit in terms of osculating elements at TCA, with distances referred to a spherical central body of equatorial radius.

AREA_ESTIMATE. This is the estimated area of the object (m**2). The area could be estimated by using a radar cross section (RCS).

CD_AREA_OVER_MASS. The current atmospheric drag perturbation value (m**2/kg), solved for in the OD, for each object. Defined as $C_D \bullet A/m$, where C_D is the drag coefficient, A is the area of the object and m is the mass of the object.

CR_AREA_OVER_MASS. The current solar radiation pressure perturbation value, solved for in the OD, for each object. Defined as $C_R \bullet A/m$, where C_R is the solar radiation pressure coefficient, A is the area of the object and m is the mass of the object.

THRUST_ACCELERATION. The object's acceleration (m/s**2) due to in-track thrust, calculated during the OD, used to propagate the state vector and covariance of the object to TCA.

SEDR. SEDR (Specific Energy Dissipation Rate) (W/kg) is representative of the amount of energy being removed from a satellite's orbit by atmospheric drag. It is a very useful metric for characterizing satellites since it takes into account both the drag environment (atmospheric density) and the "area to mass ratio" of the specific object. It does this by including *drag acceleration* in the computation. Drag acceleration is proportional to atmospheric density and to satellite area to mass.

SEDR is computed as follows:

Instantaneous SEDR at time t is given by

$$SEDR(t) = -\vec{A}_D \bullet \vec{V}$$

where,

$\vec{A}_D$ = drag acceleration vector (inertial)

$\vec{V}$ = velocity vector (inertial)

Average SEDR over the orbit determination interval is given by

$$\frac{1}{T}\int_0^t SEDR(t)dt$$

where,

in order to correctly average over a complete orbital revolution, T is an integer multiple of the satellite period. This consideration is primarily for eccentric orbits. Aside from this consideration, T is the orbit determination interval.

ANNEX E

INFORMATIVE REFERENCES

(INFORMATIVE)

[E1] *Navigation Data—Definitions and Conventions*. Report Concerning Space Data System Standards, CCSDS 500.0-G-3. Green Book. Issue 3. Washington, D.C.: CCSDS, May 2010.

ANNEX F

CDM XML SCHEMA DEFINITION

(INFORMATIVE)

```
<?xml version="1.0" encoding="UTF-8"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
            xmlns:ndm="urn:ccsds:recommendation:navigation:schema:ndmxml"
            targetNamespace="urn:ccsds:recommendation:navigation:schema:ndmxml"
            elementFormDefault="unqualified"
            attributeFormDefault="unqualified">

<!--================================================================-->
<!-- NOTE: This is version 1.0 of the CDM/XML Schema (10/17/2011).  -->
<!--                                                                -->
<!-- Compatible document versions are:                              -->
<!--    NDM/XML 505.0-B-1   Blue Book (12/2010)                     -->
<!--    ODM     502.0-B-2   Blue Book (11/2009)                     -->
<!--                                                                -->
<!-- ********************  BLUE BOOK CHANGE LOG  ******************** -->
<!--                                                                -->
<!--================================================================-->

<!--================================================================-->
<!-- Include common schemas                                         -->
<!--================================================================-->
<xsd:include schemaLocation="./ndmxml-1.0-navwg-common.xsd"/>
<xsd:include schemaLocation="./ndmxml-1.0-ccsds-common.xsd"/>

<!--================================================================-->
<!-- A CDM consists of a "header" and a "body".                     -->
<!--================================================================-->
  <xsd:complexType name="cdmType">
    <xsd:sequence>
      <xsd:element name="header" type="ndm:cdmHeader"/>
      <xsd:element name="body" type="ndm:cdmBody"/>
    </xsd:sequence>
    <xsd:attribute name="id" use="required" fixed="CCSDS_CDM_VERS"/>
    <xsd:attribute name="version" use="required" fixed="1.0"/>
  </xsd:complexType>

<!--================================================================-->
<!-- A CDM header.                                                  -->
<!--================================================================-->
  <xsd:complexType name="cdmHeader">
    <xsd:sequence>
      <xsd:element name="COMMENT" type="xsd:string" minOccurs="0"
maxOccurs="unbounded"/>
      <xsd:element name="CREATION_DATE" type="xsd:dateTime"/>
      <xsd:element name="ORIGINATOR" type="xsd:string"/>
      <xsd:element name="CDM_MESSAGE_FOR" type="xsd:string" minOccurs="0"/>
      <xsd:element name="MESSAGE_ID" type="xsd:string" minOccurs="0"/>
```

```
    </xsd:sequence>
  </xsd:complexType>

<!--=================================================================-->
<!-- The CDM "body" consists of relative metadata/data and           -->
<!-- two segments, described below.                                  -->
<!--=================================================================-->
  <xsd:complexType name="cdmBody">
    <xsd:sequence>
      <xsd:element name="relativeMetadataData" type="ndm:relativeMetadataData"/>
      <xsd:element name="segment" type="ndm:cdmSegment" minOccurs="2"
maxOccurs="2" />
    </xsd:sequence>
  </xsd:complexType>


<!--=================================================================-->
<!-- The CDM relative metadata and data section.                     -->
<!--=================================================================-->
  <xsd:complexType name="relativeMetadataData">
    <xsd:sequence>
      <xsd:element name="COMMENT" type="xsd:string" minOccurs="0"
maxOccurs="unbounded"/>
      <xsd:element name="TCA" type="xsd:dateTime"/>
      <xsd:element name="MISS_DISTANCE" type="ndm:lengthType"/>
      <xsd:element name="RELATIVE_SPEED" type="ndm:dvType" minOccurs="0"/>
      <xsd:element name="RELATIVE_REF_FRAME" type="xsd:string"/>
      <xsd:element name="relativeStateVector" type="ndm:relativeStateVectorType"
/>
      <xsd:element name=”ORBIT_CENTER” type=“xsd:string” minOccurs="0" />
      <xsd:element name="NUMBER_SCREENED_OBJECTS" type="xsd:positiveInteger"
minOccurs="0"/>
      <xsd:element name="START_SCREEN_PERIOD" type="xsd:dateTime"/>
      <xsd:element name="STOP_SCREEN_PERIOD" type="xsd:dateTime"/>
      <xsd:element name="SCREEN_VOLUME_FRAME" type="xsd:string"/>
      <xsd:element name="SCREEN_VOLUME_SHAPE" type="xsd:string"/>
      <xsd:element name="SCREEN_VOLUME_X" type="ndm:lengthType"/>
      <xsd:element name="SCREEN_VOLUME_Y" type="ndm:lengthType"/>
      <xsd:element name="SCREEN_VOLUME_Z" type="ndm:lengthType"/>
      <xsd:element name="ENTRY_TIME" type="xsd:dateTime" minOccurs="0"/>
      <xsd:element name="EXIT_TIME" type="xsd:dateTime" minOccurs="0"/>
      <xsd:element name="COLLISION_PROBABILITY" type="ndm:nonNegativeDouble"
minOccurs="0"/>
      <xsd:element name="COLLISION_PROBABILITY_METHOD" type="xsd:string"
minOccurs="0"/>
    </xsd:sequence>
  </xsd:complexType>


<!--=================================================================-->
<!-- The CDM "segment" consists of a "metadata" section and a "data"    -->
<!-- section.                                                        -->
<!--=================================================================-->
  <xsd:complexType name="cdmSegment">
    <xsd:sequence>
      <xsd:element name="metadata" type="ndm:cdmMetadata"/>
      <xsd:element name="data" type="ndm:cdmData"/>
```

```
    </xsd:sequence>
  </xsd:complexType>


<!--=============================================================-->
<!-- CDM metadata section.                                       -->
<!--=============================================================-->
  <xsd:complexType name="cdmMetadata">
    <xsd:sequence>
      <xsd:element name="COMMENT" type="xsd:string" minOccurs="0"
maxOccurs="unbounded"/>
      <xsd:element name="OBJECT" type="xsd:string" />
      <xsd:element name="OBJECT_NUMBER" type="xsd:positiveInteger" />
      <xsd:element name="SAT_CATALOG" type="xsd:string" />
      <xsd:element name="OBJECT_NAME" type="xsd:string" />
      <xsd:element name="OBJECT_ID" type="xsd:string" minOccurs="0" />
      <xsd:element name="OBJECT_TYPE" type="xsd:string" minOccurs="0" />
      <xsd:element name="OPERATOR_CONTACT_POSITION" type="xsd:string"
minOccurs="0" />
      <xsd:element name="OPERATOR_ORGANIZATION" type="xsd:string" minOccurs="0"
/>
      <xsd:element name="OPERATOR_PHONE" type="xsd:string" minOccurs="0" />
      <xsd:element name="OPERATOR_EMAIL" type="xsd:string" minOccurs="0" />
      <xsd:element name="EPHEMERIS_NAME" type="xsd:string" />
      <xsd:element name="NUMBER_SENSORS" type="xsd:positiveInteger"
minOccurs="0" />
      <xsd:element name="TRACKING_DATA_TYPES" type="xsd:string" minOccurs="0" />
      <xsd:element name="ADDITIONAL_TRACKING" type="ndm:yesNoType" minOccurs="0"
/>
      <xsd:element name="COVARIANCE_METHOD" type="xsd:string" />
      <xsd:element name="MANEUVERABLE" type="ndm:maneuverableType" />
      <xsd:element name="MAN_INCLUDED" type="ndm:yesNoType" minOccurs="0" />
      <xsd:element name="REF_FRAME" type="xsd:string" />
      <xsd:element name="REF_FRAME_EPOCH" type="xsd:dateTime" minOccurs="0" />
      <xsd:element name="COV_REF_FRAME" type="xsd:string" />
      <xsd:element name="GRAVITY_MODEL" type="xsd:string" minOccurs="0" />
      <xsd:element name="ATMOSPHERIC_MODEL" type="xsd:string" minOccurs="0" />
      <xsd:element name="N_BODY_PERTURBATIONS" type="xsd:string" minOccurs="0"
/>
      <xsd:element name="SOLAR_RAD_PRESSURE" type="ndm:onOffType" minOccurs="0"
/>
      <xsd:element name="SOLID_EARTH_TIDES" type="ndm:onOffType" minOccurs="0"
/>
      <xsd:element name="INTRACK_THRUST" type="ndm:onOffType" minOccurs="0" />
    </xsd:sequence>
  </xsd:complexType>


<!--=============================================================-->
<!-- CDM data section.                                           -->
<!--=============================================================-->
  <xsd:complexType name="cdmData">
    <xsd:sequence>
      <xsd:element name="COMMENT" type="xsd:string" minOccurs="0"
maxOccurs="unbounded"/>
      <xsd:element name="odParameters" type="ndm:odParametersType"
minOccurs="0"/>
```

```
      <xsd:element name="additionalParameters"
type="ndm:additionalParametersType" minOccurs="0"/>
      <xsd:element name="stateVector" type="ndm:cdmStateVectorType"/>
      <xsd:element name="covarianceMatrix" type="ndm:cdmCovarianceType"/>
    </xsd:sequence>
  </xsd:complexType>


<!--================================================================-->
<!-- Other complex types unique to the CDM.                         -->
<!--================================================================-->
  <xsd:complexType name="odParametersType">
    <xsd:sequence>
      <xsd:element name="COMMENT" type="xsd:string" minOccurs="0"
maxOccurs="unbounded"/>
      <xsd:element name="TIME_LASTOB" type="ndm:timeObType"/>
      <xsd:element name="RECOMMENDED_OD_SPAN" type="ndm:dayIntervalType"/>
      <xsd:element name="ACTUAL_OD_SPAN" type="ndm:dayIntervalType"/>
      <xsd:element name="MAXIMUM_OBS_GAP" type="ndm:hourIntervalType"/>
      <xsd:element name="OBS_AVAILABLE" type="xsd:positiveInteger"/>
      <xsd:element name="OBS_USED" type="xsd:positiveInteger"/>
      <xsd:element name="TRACKS_AVAILABLE" type="xsd:positiveInteger"/>
      <xsd:element name="TRACKS_USED" type="xsd:positiveInteger"/>
      <xsd:element name="WEIGHTED_RMS" type="ndm:nonNegativeDouble"/>
      <xsd:element name="TIME_NEXT_UPDATE" type="ndm:hourIntervalType"/>
    </xsd:sequence>
  </xsd:complexType>

  <xsd:complexType name="additionalParametersType">
    <xsd:sequence>
      <xsd:element name="COMMENT" type="xsd:string" minOccurs="0"
maxOccurs="unbounded"/>
      <xsd:element name="APOAPSIS" type="ndm:positionType"/>
      <xsd:element name="PERIAPSIS" type="ndm:positionType"/>
      <xsd:element name="INCLINATION" type="ndm:inclinationType"/>
      <xsd:element name="AREA_ESTIMATE" type="ndm:areaType"/>
      <xsd:element name="MASS" type="ndm:massType"/>
      <xsd:element name="CD_AREA_OVER_MASS" type="ndm:m2kgType"/>
      <xsd:element name="CR_AREA_OVER_MASS" type="ndm:m2kgType"/>
      <xsd:element name="THRUST_ACCELERATION" type="ndm:ms2Type"/>
      <xsd:element name="SEDR" type="ndm:wkgType"/>
    </xsd:sequence>
  </xsd:complexType>

  <xsd:complexType name="relativeStateVectorType">
    <xsd:sequence>
      <xsd:element name="COMMENT" type="xsd:string" minOccurs="0"
maxOccurs="unbounded"/>
      <xsd:element name="RELATIVE_POSITION_X" type="ndm:lengthType"/>
      <xsd:element name="RELATIVE_POSITION_Y" type="ndm:lengthType"/>
      <xsd:element name="RELATIVE_POSITION_Z" type="ndm:lengthType"/>
      <xsd:element name="RELATIVE_VELOCITY_X" type="ndm:dvType" minOccurs="0"/>
      <xsd:element name="RELATIVE_VELOCITY_Y" type="ndm:dvType" minOccurs="0"/>
      <xsd:element name="RELATIVE_VELOCITY_Z" type="ndm:dvType" minOccurs="0"/>
    </xsd:sequence>
  </xsd:complexType>
```

```
  <xsd:complexType name="cdmStateVectorType">
    <xsd:sequence>
      <xsd:element name="COMMENT" type="xsd:string" minOccurs="0"
maxOccurs="unbounded"/>
      <xsd:element name="X" type="ndm:positionType"/>
      <xsd:element name="Y" type="ndm:positionType"/>
      <xsd:element name="Z" type="ndm:positionType"/>
      <xsd:element name="X_DOT" type="ndm:velocityType"/>
      <xsd:element name="Y_DOT" type="ndm:velocityType"/>
      <xsd:element name="Z_DOT" type="ndm:velocityType"/>
    </xsd:sequence>
  </xsd:complexType>

  <xsd:complexType name="cdmCovarianceType">
    <xsd:sequence>
      <xsd:element name="COMMENT" type="xsd:string" minOccurs="0"
maxOccurs="unbounded"/>
      <xsd:element name="CX_X" type="ndm:m2Type"/>
      <xsd:element name="CY_X" type="ndm:m2Type"/>
      <xsd:element name="CY_Y" type="ndm:m2Type"/>
      <xsd:element name="CZ_X" type="ndm:m2Type"/>
      <xsd:element name="CZ_Y" type="ndm:m2Type"/>
      <xsd:element name="CZ_Z" type="ndm:m2Type"/>
      <xsd:element name="CXDOT_X" type="ndm:m2sType"/>
      <xsd:element name="CXDOT_Y" type="ndm:m2sType"/>
      <xsd:element name="CXDOT_Z" type="ndm:m2sType"/>
      <xsd:element name="CXDOT_XDOT" type="ndm:m2s2Type"/>
      <xsd:element name="CYDOT_X" type="ndm:m2sType"/>
      <xsd:element name="CYDOT_Y" type="ndm:m2sType"/>
      <xsd:element name="CYDOT_Z" type="ndm:m2sType"/>
      <xsd:element name="CYDOT_XDOT" type="ndm:m2s2Type"/>
      <xsd:element name="CYDOT_YDOT" type="ndm:m2s2Type"/>
      <xsd:element name="CZDOT_X" type="ndm:m2sType"/>
      <xsd:element name="CZDOT_Y" type="ndm:m2sType"/>
      <xsd:element name="CZDOT_Z" type="ndm:m2sType"/>
      <xsd:element name="CZDOT_XDOT" type="ndm:m2s2Type"/>
      <xsd:element name="CZDOT_YDOT" type="ndm:m2s2Type"/>
      <xsd:element name="CZDOT_ZDOT" type="ndm:m2s2Type"/>
    </xsd:sequence>
  </xsd:complexType>

  <xsd:complexType name="timeObType">
    <xsd:choice>
      <xsd:element name="lastObAt" type="xsd:dateTime"/>
      <xsd:element name="timeSince" type="ndm:timeBucketHourType"/>
    </xsd:choice>
  </xsd:complexType>

  <xsd:complexType name="timeBucketHourType">
    <xsd:simpleContent>
      <xsd:extension base="ndm:timeBucketType">
        <xsd:attribute ref="ndm:units" fixed="h"/>
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>

  <xsd:complexType name="lengthType">
```

```
    <xsd:simpleContent>
      <xsd:extension base="xsd:double">
        <xsd:attribute ref="ndm:units" fixed="m"/>
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>

  <xsd:complexType name="dvType">
    <xsd:simpleContent>
      <xsd:extension base="xsd:double">
        <xsd:attribute ref="ndm:units" fixed="m/s"/>
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>

  <xsd:complexType name="hourIntervalType">
    <xsd:simpleContent>
      <xsd:extension base="ndm:positiveDouble">
        <xsd:attribute ref="ndm:units" fixed="h"/>
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>

  <xsd:complexType name="dayIntervalType">
    <xsd:simpleContent>
      <xsd:extension base="ndm:positiveDouble">
        <xsd:attribute ref="ndm:units" fixed="d"/>
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>


<!--================================================================-->
<!-- Simple types unique to the CDM.                                -->
<!--================================================================-->
  <xsd:simpleType name="onOffType">
    <xsd:restriction base="xsd:string">
      <xsd:enumeration value="ON"/>
      <xsd:enumeration value="OFF"/>
    </xsd:restriction>
  </xsd:simpleType>

  <xsd:simpleType name="maneuverableType">
    <xsd:restriction base="xsd:string">
      <xsd:enumeration value="ON"/>
      <xsd:enumeration value="OFF"/>
      <xsd:enumeration value="UNKNOWN"/>
    </xsd:restriction>
  </xsd:simpleType>

  <xsd:simpleType name="timeBucketType">
    <xsd:restriction base="xsd:string">
      <xsd:enumeration value="LT 6"/>
      <xsd:enumeration value="6-12"/>
      <xsd:enumeration value="GT 12"/>
      <xsd:enumeration value="LT 24"/>
      <xsd:enumeration value="24-48"/>
```

```
      <xsd:enumeration value="GT 48"/>
    </xsd:restriction>
  </xsd:simpleType>

  <xsd:complexType name="m2Type">
    <xsd:simpleContent>
      <xsd:extension base="xsd:double">
        <xsd:attribute ref="ndm:units" fixed="m**2"/>
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>

  <xsd:complexType name="m2sType">
    <xsd:simpleContent>
      <xsd:extension base="xsd:double">
        <xsd:attribute ref="ndm:units" fixed="m**2/s"/>
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>

  <xsd:complexType name="m2s2Type">
    <xsd:simpleContent>
      <xsd:extension base="xsd:double">
        <xsd:attribute ref="ndm:units" fixed="m**2/s**2"/>
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>

  <xsd:complexType name="m2kgType">
    <xsd:simpleContent>
      <xsd:extension base="xsd:double">
        <xsd:attribute ref="ndm:units" fixed="m**2/kg"/>
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>

  <xsd:complexType name="ms2Type">
    <xsd:simpleContent>
      <xsd:extension base="xsd:double">
        <xsd:attribute ref="ndm:units" fixed="m/s**2"/>
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>

  <xsd:complexType name="wkgType">
    <xsd:simpleContent>
      <xsd:extension base="ndm:nonNegativeDouble">
        <xsd:attribute ref="ndm:units" fixed="W/kg"/>
      </xsd:extension>
    </xsd:simpleContent>
  </xsd:complexType>

<!--================================================================-->
<!-- Attributes unique to the CDM.                                  -->
<!--================================================================-->
  <xsd:attribute name="units">
    <xsd:simpleType>
```

```
      <xsd:restriction base="xsd:string">
        <xsd:enumeration value="h"/>
        <xsd:enumeration value="d"/>
        <xsd:enumeration value="m"/>
        <xsd:enumeration value="m**2"/>
        <xsd:enumeration value="m**2/s"/>
        <xsd:enumeration value="m**2/s**2"/>
        <xsd:enumeration value="m/s"/>
        <xsd:enumeration value="m/s**2"/>
        <xsd:enumeration value="m**2/kg"/>
        <xsd:enumeration value="W/kg"/>
      </xsd:restriction>
    </xsd:simpleType>
  </xsd:attribute>

</xsd:schema>
```

Figure F-1: An Example of a CDM XML Schema

ANNEX G

CDM XML TO KVN TRANSLATOR - XLST IMPLEMENTATION

(INFORMATIVE)

- TO BE SUPPLIED -

Pending finalization of CDM message definition.

Figure G-1: An XSLT Implementation to Translate a CDM From XML to KVN

ANNEX H

SECURITY

(NORMATIVE)

H1 OVERVIEW

H1.1 ANALYSIS OF SECURITY CONSIDERATIONS

This section presents the results of an analysis of security considerations applied to the technologies specified in this Proposed Standard.

H1.2 CONSEQUENCES OF NOT APPLYING SECURITY TO THE TECHNOLOGY

The consequences of not applying security to the systems and networks on which this Proposed Standard is implemented could include potential loss, corruption, and theft of data. Because these messages are used in collision avoidance analyses and potential maneuvers, the consequences of not applying security to the systems and networks on which this Proposed Standard is implemented could include compromise or loss of the mission if malicious tampering of a particularly severe nature occurs.

H1.3 POTENTIAL THREATS AND ATTACK SCENARIOS

Potential threats or attack scenarios include, but are not limited to, (a) unauthorized access to the programs/processes that generate and interpret the messages, and (b) unauthorized access to the messages during transmission between exchange partners. Protection from unauthorized access during transmission is especially important if the mission utilizes open ground networks such as the Internet to provide ground station connectivity for the exchange of data formatted in compliance with this Proposed Standard. It is strongly recommended that potential threats or attack scenarios applicable to the systems and networks on which this Proposed Standard is implemented be addressed by the management of those systems and networks.

H2 SECURITY CONCERNS RELATED TO THIS PROPOSED STANDARD

H2.1 DATA PRIVACY

Privacy of data formatted in compliance with the specifications of this Proposed Standard should be assured by the systems and networks on which this Proposed Standard is implemented.

H2.2 DATA INTEGRITY

Integrity of data formatted in compliance with the specifications of this Proposed Standard should be assured by the systems and networks on which this Proposed Standard is implemented.

H2.3 AUTHENTICATION OF COMMUNICATING ENTITIES

Authentication of communicating entities involved in the transport of data which complies with the specifications of this Proposed Standard should be provided by the systems and networks on which this Proposed Standard is implemented.

H2.4 DATA TRANSFER BETWEEN COMMUNICATING ENTITIES

The transfer of data formatted in compliance with this Proposed Standard between communicating entities should be accomplished via secure mechanisms approved by the IT Security functionaries of exchange participants.

H2.5 CONTROL OF ACCESS TO RESOURCES

Control of access to resources should be managed by the systems upon which provider formatting and recipient processing are performed.

H2.6 AUDITING OF RESOURCE USAGE

Auditing of resource usage should be handled by the management of systems and networks on which this Proposed Standard is implemented.

H3 UNAUTHORIZED ACCESS

Unauthorized access to the programs/processes that generate and interpret the messages should be prohibited in order to minimize potential threats and attack scenarios.

H4 DATA SECURITY IMPLEMENTATION SPECIFICS

Specific information-security interoperability provisions that may apply between agencies and other independent users involved in an exchange of data formatted in compliance with this Proposed Standard should be specified in an ICD.