The Consultative Committee for Space Data Systems

Draft Recommendation for Space Data System Standards

SPACECRAFT ONBOARD INTERFACE SERVICES— SPECIFICATION FOR DICTIONARY OF TERMS FOR ELECTRONIC DATA SHEETS

PROPOSED DRAFT RECOMMENDED PRACTICE

CCSDS 876.1-R-0

PROPOSED RED BOOK

March 2015

AUTHORITY

Issue:	Proposed Red Book, Issue 0
Date:	March 2015
Location:	Not Applicable

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FOREWORD

This document is a technical Recommended Standard for use in developing flight and ground systems for space missions and has been prepared by the Consultative Committee for Space Data Systems (CCSDS). The Dictionary of Terms described herein is intended for missions that are cross-supported between Agencies of the CCSDS, in the framework of the Spacecraft Onboard Interface Services (SOIS) CCSDS area.

This Recommended Standard specifies a dictionary of terms to be used as a vocabulary in electronic data sheets which describe components that communicate within a spacecraft network. The data sheets are for use by tool chains in the design, assembly, integration, testing, and operation of space missions. The SOIS Dictionary of Terms provides a common vocabulary regardless of the particular tool chain being used.

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- Korea Aerospace Research Institute (KARI)/Korea.
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PREFACE

This document is a draft CCSDS Recommended Standard. Its ‘Red Book’ status indicates that the CCSDS believes the document to be technically mature and has released it for formal review by appropriate technical organizations. As such, its technical contents are not stable, and several iterations of it may occur in response to comments received during the review process.

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

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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DOCUMENT CONTROL

Document	Title	Date	Status
CCSDS 876.1-R-0	Spacecraft Onboard Interface Services—Specification for Dictionary of Terms for Electronic Data Sheets for Onboard Components, Proposed Draft Recommended Practice, Issue 0	March 2015	Current draft

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1 INTRODUCTION

1.1 PURPOSE AND SCOPE OF THIS DOCUMENT

This document is one of a family of documents specifying the Spacecraft Onboard Interface Services (SOIS)-compliant service to be provided in support of applications.

This document defines the SOIS Specification for Dictionary of Terms (DoT) for Electronic Data Sheet (EDS) for Onboard Components. The SOIS DoT provides the vocabulary for electronically defining the interfaces offered by flight components such as sensors, actuators, and software components over the SOIS Services.

This edition encompasses the vocabulary for representation of the data interfaces including functional interfaces and protocols used to access the data interfaces.

1.2 APPLICABILITY

This document applies to any mission or equipment claiming to provide CCSDS SOIS-compatible EDS for Onboard Components.

1.3 RATIONALE

SOIS provides a DoT specification in order to enable toolchain compatibility and optional portability of components amongst systems implementing interfaces defined by SOIS EDS.

1.4 DOCUMENT STRUCTURE

This document has the following major sections:

– Section 1, this section, contains administrative information, definitions and references.

– Section 2 provides an overview of the Dictionary of Terms for Electronic Data Sheets for onboard devices. It also provides a summary of ontology and the justification for a model-based dictionary of terms.

– Section 3 provides a normative description of the structure of the ontology, and maintenance procedures

– Section 4 provides an informative description of a procedure for integrating new information into the DoT.

In addition, the following annexes are provided:

– Annex A comprises an Implementation Conformance Statement (PICS) Proforma.

– Annex B discussing security, Space Assigned Numbers Authority (SANA), and patent considerations relating to the specifications of this document.

– Annex C contains a list of acronyms.

– Annex D contains a list of informative references.

– Annex E provides for illustrative purposes one or more example instantiations of EDSes.

1.5 TERMS DEFINED IN THIS RECOMMENDED STANDARD

For the purposes of this Recommended Standard, the following definitions apply:

application: A component of the onboard software that communicates through one or more data interfaces described by an Electronic Data Sheet (EDS) and that may have one or more instances that exist during the operation of onboard processors. At the architectural base, there is a layer of applications that interface with the Command and Data Acquisition Services (CDAS). The DoT provides the terms that match an application interface with relevant parts of the CDAS interface.

NOTE – Such components include flight software applications and higher-layer services.

component: A manufactured unit that may be combined with other units in an assembly by matching interfaces between the units. Each unit has one or more interfaces described in an EDS using terms in the DoT. The DoT provides the terms that enable a designer to match interfaces. The set of components is the union of the set of devices and the set of applications.

device: A physical hardware spacecraft component that communicates with the Device Access Service (DAS) through a subnetwork interface. The DAS presents an abstraction of the device data interface on its CDAS side. The sub-network interface is defined in the EDS for the device. The CDAS interface for a device may also be defined in the EDS for the device. The CDAS interface of the DAS is the union of the interfaces for the devices that communicate with DAS.

NOTE – Examples of such components are sensors and actuators.

dictionary of terms, DoT: The model that contains information about terms used in SOIS Electronic Data Sheets (see 2.4).

Electronic Data Sheet, EDS: A description of the interfaces of a component. The description is structured and encoded to facilitate reading and interpretation both by human engineers and also by computer algorithms. The description facilitates the combination of components into an inter-operating assembly, such as a space vehicle.

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engineering profile: A type of data that is defined by attributes for conceptual usage, which differs from syntactic usage. A standardized engineering profile may also be called a 'semantic type'. For example, the reference frame of a measurement is an attribute of a semantic type, while the encoding of a number in a string of bits is a syntactic attribute that does not apply to semantic types. The reason for this distinction is to enable definition of engineering profiles without binding them to syntactic implementations.

glossary: A collection of terms with explanations of their usage in a particular document. The list in which this explanation appears is a glossary. One of the artefacts that can be generated from the dictionary of terms is a file that can be rendered for reading by people. That file is called the 'glossary' for the dictionary of terms.

ontology: A collection of concepts named by terms, and relationships among those concepts (see 2.4). The particular collection that is the dictionary of terms may be called the 'DoT ontology' to emphasise its implementation.

portability: The capability of a component to be integrated into an assembly without change either to the component or to the assembly interfaces. Portability requires that the definitions of interfaces be consistent across all systems to which they may be ported. Consistency requires that the terms used to define an interface are defined in the DoT. (See 'toolchain compatibility'.)

semantic attribute: A property of a semantic type. (See the description of 'semantic type' for an example.)

semantic type: A standard engineering profile. The quaternion produced by star trackers, without defining the encoding of the numbers or the format of the array, is an example of a semantic type; it has attributes including the frame measured and the coordinate system to which the quaternion rotates.

syntactic type: A type of data that is defined by attributes for encoding the data for storage (transmission through time) or communication (transmission through space). An example of an attribute for a syntactic type is the enumerated choice of interpretation of bits as an integer, as a floating point number, or other choices.

term: A word or phrase that has a formally defined interpretation in a particular context of usage. The terms in the SOIS dictionary of terms are defined in the context of describing spacecraft components in Electronic Data Sheets.

timestamp: Time associated with a value.

NOTES

1 For timestamps produced by a device, the format is specified in the EDS for the device. For timestamps associated with data by applications, the format is implementation-specific, but still specified in the EDS.

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2 The timestamp may indicate the time the value was generated by the device, emitted by the device, or acquired by the service. For timestamps produced by the device, this relationship is defined in the EDS for the device. For timestamps associated with data by applications, this relationship is implementation-specific.

toolchain compatibility: Capability to function in a sequence of computer-assisted engineering steps, optionally with locally defined ontology extensions. Toolchain compatibility is a weaker form of interface consistency than portability. The locally defined ontology extensions make it possible for SOIS Electronic Data Sheets to function in a toolchain early in the life of a project without waiting for terms to be defined in the core DoT ontology. For complete portability, all terms in an Electronic Data Sheet must be defined in the core DoT ontology.

transducer: A measurement probe in a sensor; the active part of an actuator. A transducer has a coordinate system that has a relationship to device coordinates (for fixed transducers) or to vehicle coordinates (for independently deployable transducers). The coordinate system for fixed transducers is specified in the device EDS. For independently deployable transducers, the coordinate system is defined in the vehicle manifest.

type: A conceptual class that is defined in an EDS as a class. The instances of a type share some properties that define the type. The properties are defined in the dictionary of terms.

value: A formatted instance of data that is acquired from or used as a command to a component. The acquisition and commands move the value across a data interface.

vocabulary: A collection of words used in some context. The context is often implicit in casual descriptions (see 2.4).

1.6 NOMENCLATURE

1.6.1 NORMATIVE TEXT

The following conventions apply for the normative specifications in this Recommended 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.

NOTE – These conventions do not imply constraints on diction in text that is clearly informative in nature.

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1.6.2 INFORMATIVE TEXT

In the normative sections of this document, informative text is set off from the normative specifications either in notes or under one of the following subsection headings:

– Overview;

– Background;

– Rationale;

– Discussion.

1.7 REFERENCES

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

[1] *Spacecraft Onboard Interface Services—XML Specification for Electronic Data Sheets for Onboard Devices*. Issue 0. Proposed Draft Recommendation for Space Data System Standards (Proposed Red Book), CCSDS 876.0-R-0. Washington, D.C.: CCSDS, March 2015.

[2] Tim Bray, et al., eds. “Extensible Markup Language (XML) 1.0.” W3C Recommendation. 5th ed., 26 November 2008. http://www.w3.org/TR/2008/REC-xml-20081126/.

[3] Shudi (Sandy) Gao, C. M. Sperberg-McQueen, and Henry S. Thompson, eds. “W3C XML Schema Definition Language (XSD) 1.1 Part 1: Structures.” W3C Recommendation. Version 1.1, 5 April 2012. http://www.w3.org/TR/xmlschema11-1/.

[4] David Peterson, et al., eds. “W3C XML Schema Definition Language (XSD) 1.1 Part 2: Datatypes.” W3C Recommendation. Version 1.1, 5 April 2012. http://www.w3.org/TR/xmlschema11-2/.

[5] Jonathan Marsh, David Orchard, and Daniel Veillard, eds. “XML Inclusions (XInclude) Version 1.0.” W3C Recommendation. 2nd ed., 15 November 2006. http://www.w3.org/TR/xinclude/.

[6] W3C OWL Working Group, ed. “OWL 2 Web Ontology Language Document Overview.” W3C Recommendation. 2nd ed., 11 December 2012. http://www.w3.org/TR/xinclude/.

[7] "Dublin Core Annotation Properties." http://protege.stanford.edu/plugins/owl/dc/protege-dc.owl.

NOTE – Informative references are contained in annex D.

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2 OVERVIEW

2.1 CONTEXT

The SOIS Dictionary of Terms (DoT) for Electronic Datasheets (EDS) is defined within the context of the overall SOIS architecture (see reference [D1]). The terms describe the format of information in a data sheet for an onboard device accessed using the Command and Data Acquisition Services of the Application Support Layer and the Packet and Memory Access Services of the Subnetwork Layer, as illustrated in figure 2-1.

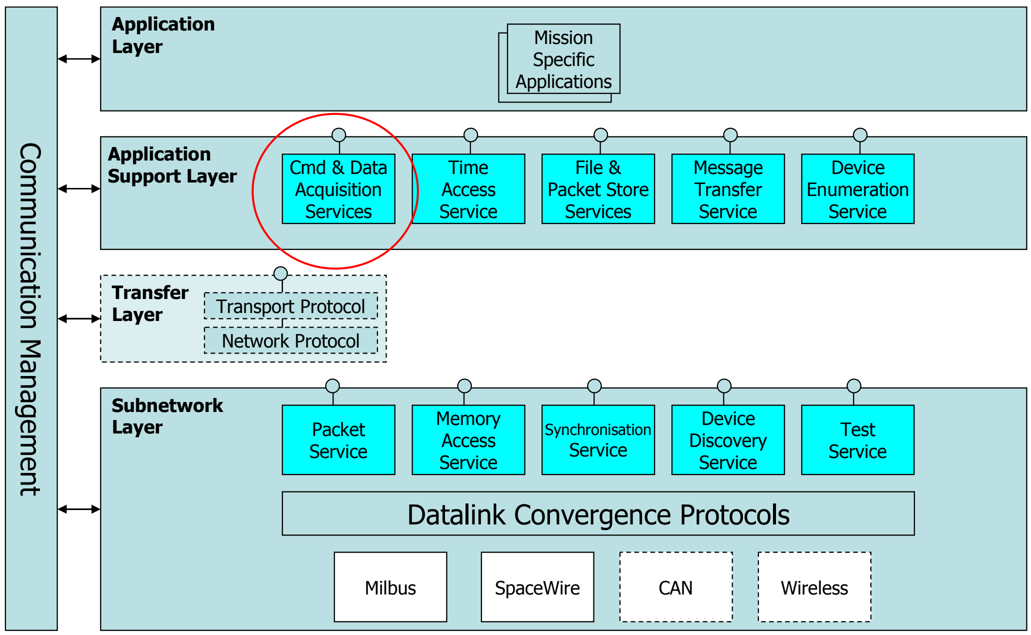

Figure 2-1: Command and Data Acquisition Services Context

The relationship between the services that compose Command and Data Acquisition Services is illustrated in figure 2-2.

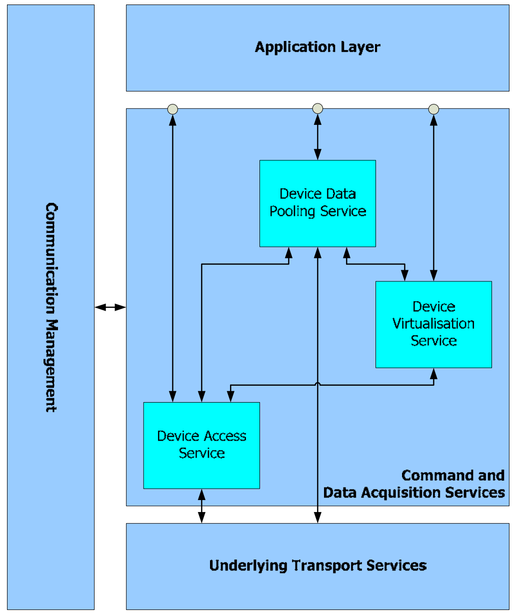

Figure 2-2: Relationship between Command and Data Acquisition Services

The DAS (reference [D2]) provides applications with raw interfaces to simple onboard hardware devices such as sensors and actuators, abstracted from the subnetwork protocols used for exchanging data with the devices. The data items in the DAS interface are typically 'raw' measurements, often presented through an analogue-to-digital converter; the DoT contains terms to describe these data. The Device Virtualisation Service (DVS) (reference [D3]) provides applications with functional interfaces to devices, abstracted from the protocols used for accessing the devices and the data encodings used in those protocols. The data items in the DVS interface are typically refined to engineering units and may be associated with other relevant data items; the DoT contains terms to describe these data and relations. The Device Data Pooling Service (DDPS) (reference [D4]) provides a standard interface that enables applications to access pooled data acquired from devices, without explicitly requesting an acquisition from the real device.

The Subnetwork Layer provides standard services mapped onto subnetwork-specific protocols to send and receive discrete packets (reference [D5]), to access remote memory (reference [D6]), to synchronise (reference [D7]) with the subnetwork, and to discover (reference [D8]) and test (reference [D9]) devices on the subnetwork.

2.2 PURPOSE AND FUNCTION OF DICTIONARY OF TERMS FOR ELECTRONIC DATA SHEETS FOR ONBOARD DEVICES

An Electronic Data Sheet is intended to be a machine-interpretable mechanism for describing devices which may be accessed using the SOIS Command and Data Acquisition Services. The SOIS Electronic Data Sheet is intended, in its fullest form, to replace the traditional user manuals, specifications, and data sheets which accompany a device and are necessary to determine the operation of the device and how to communicate with it. The function of

Electronic Data Sheets is described in reference [1]. The dictionary of terms provides the formal vocabulary for Electronic Data Sheets, enabling the functions listed below. The indexes and other functions mentioned in the list are not specified by this document; rather, they are phenomena that are expected to develop as engineers and entrepreneurs write software to exploit the machine-readable information that will be available in EDSes. Prior to EDS technology, information about quantities, units, dimensions, values, and provenance and usage of data was informal and therefore inaccessible for these functions. The functions are:

– assuring that two different EDSes do not use the same term with different meanings;

– enabling a market index to components based on their interfaces;

– enabling an index to components in a vehicle, based on their interfaces;

– enabling an index to data in the spacecraft database;

– enabling an index to topics published and subscribed on a software bus;

– enabling matching of interfaces of two components during design or during adaptive reconfiguration, so the two components can interact through the mutual interface: one component acts as a provider of data and services through the interface, while the other component acts as a consumer of data and services through the interface;

– enabling matching of interfaces of a device with interfaces of simulation models, to configure and to validate testing and simulation software;

– providing a glossary for human-readable documentation generated from EDSes;

– enabling alternative conversions between DAS and DVS, beyond the conversion described in the EDS.

A full Electronic Data Sheet for a device specifies the following information, using terms in the DoT:

– a recommended functional, or virtual, interface to the device, which can be accessed using the DVS service interface;

– the raw data interface to the device, which can be accessed using the DAS service interface;

– the Device Abstraction Control Procedure (DACP) which recommends a mapping between the virtual device interface and the raw data interface;

– the Device-specific Access Protocol (DAP) which maps the raw data interface onto the SOIS subnetwork services appropriate for the device;

– information specifying the use of the subnetwork by the device, and any constraints placed on the subnetwork.

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As a part of the rationale for the implementation of the DoT, the following features may be included in Electronic Data Sheets in the future:

- structural mounting interface;
- geometric properties, including device coordinate system and locations and orientations of fixed transducers on the device;
- mass properties, including moments of inertia and rotational momentum storage capacity, related to device coordinates;
- electrical power interface, including manufacturer-recommended operating extremes, and any applicable storage and generation characteristics;
- thermal interface, including manufacturer-recommended operating and storage extremes and any applicable storage and generation characteristics;
- radiation aspect, including manufacturer-recommended tolerances and generation characteristics;
- other information, to be determined, that must be transferred through traditional user manuals, specifications, and data sheets which accompany a device and are necessary to determine the operation of the device.

In order to be able to relate the elements of the data sheet to physical (and non-physical) concepts, and to promote standardisation and interoperability, the DoT provides core ontology for data sheet authors and users. These core semantic terms effectively form part of the language that is used to write SOIS Electronic Data Sheets. Where the semantics provided by the common DoT are insufficient, a data sheet author may utilise an additional custom DoT which must then be supplied with the data sheet itself. This provides a standard, flexible, and extensible mechanism for capturing the semantics of device operation in a machine-interpretable form. The extension ontologies will later be integrated into the DoT with mappings for synonyms, perhaps as an alternative name space with comments and formal relationships to explain the relation of the new namespace to existing namespaces. The use of an extension ontology reduces the portability of an EDS, so it is toolchain compatible in the project where the extension ontology was developed; to become truly portable outside the original project, it is necessary to assimilate the extension ontology into the core ontology, and to adapt the EDS to use the terms of the new core ontology.

The DoT can provide a powerful mechanism for future extensions of the EDS, in cases where the extension can be obtained by adding terms to structure that is already present in the EDS schema.

2.3 USE OF W3C RECOMMENDATIONS

The specification and use of SOIS Electronic Data Sheets makes use of a number of World-Wide Web Consortium (W3C) standards:

– XML—The Extensible Markup Language (reference [2]) is used to mark up data sheet documents in a machine-readable manner.

– XSD—The XML Schema Definition language (references [3] and [4]) is used to specify valid construction rules for data sheet documents. Version 1.1 of the XSD recommendation is used.

– OWL/RDF—In some cases a data sheet author may wish to specify a custom dictionary of terms. This may be accomplished by accompanying the data sheet document with a dictionary of terms document specified according to the Web Ontology Language and using the syntax of the Resource Description Framework (reference [6]).

2.4 PRINCIPLES OF THE DICTIONARY OF TERMS

The DoT is a model-based vocabulary. This idea is a variation on the idea of model-based engineering. In a model-based vocabulary, the model is the single source of information that is distributed to a variety of artefacts in a toolchain. Among those artefacts are a glossary of terms for humans to read and a schema of terms to be included in the EDS schema.

The following example will elucidate the relation between the model and the terms. The semantic attributes of items of data in an interface can be misused. For example, an EDS author might specify that a given item of data has quantity kind ‘length’ and unit of measure ‘arc-second’. The mistake here is that only certain units of measure are possible for a given quantity kind. The author is going to have to change the quantity kind to ‘angle’, or to choose a unit of measure that measures length, such as ‘meter’. The model for the terms contains this kind of information, so it can be enforced at some point in the validation of EDSes. In this example, the model would contain an association between quantity kinds and their meaningful units of measure.

Another example is important for appreciation of the ability to specify quantity kinds. A person may at first think that specifying the unit of measure is sufficient to identify the physical property in a measurement. However, the units of measure for torque and energy are the same, when reduced to base units. There is an informal reliance upon convention in the use of derived units to disambiguate situations like this example; for example, torque is often expressed as newton-meters, while energy is often expressed as Joules. The fact that torque is a vector is not always explicit when the axis is obvious. These conventions may be widespread, but they are fundamentally unreliable, because they are *de facto* conventions that may not be accessible to algorithmic interpretation of Electronic Data Sheets. To be clear, the quantity kind property provides an explicit disambiguation, which is defined in the ontology.

A traditional dictionary is a list of terms, and each term has an explanation. In order to put the association in the examples into a traditional dictionary, a person could use one or the other of the following techniques:

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- Place the association into the explanation of each term that needs it, using the natural language of the explanation.
- Extend the normal dictionary structure with a table of associations between units of measure and quantity kinds.

The first item is inefficient for two reasons. It requires an algorithm to interpret natural language in order to make the information accessible for use in a validation program. It doubles the number of statements of the association, because it is necessary to state the association in both the unit terms and in the quantity kind terms.

The second item is a little better, because it removes the doubling problem. Also, the table of associations can be interpreted algorithmically. However, it is necessary to invent a new table for every association.

An ontology is an alternative to the extended dictionary model described above. The alternative model has built-in structures for writing, interpreting, and validating associations between terms. As a bonus it is also possible to invoke a reasoning program to infer additional relations among terms, given the relations that are present. The structure chosen here is somewhat arbitrary, but the consistency defined in this document enables successful interpretation by people and by algorithms.

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3 BASIC STRUCTURE OF THE DICTIONARY OF TERMS

3.1 OVERVIEW

This section describes the structure of the DoT ontology. The structure defined here is normative, in order to assure the capability of the DoT to provide terms that are compatible with usage in EDSes and in the EDS schema. Each part of this section addresses a separate issue of expression or usage in EDSes.

3.2 DISCUSSION—ACCESS

3.2.1 GENERAL

The Dictionary of Terms will be accessible for public use at least to the extent defined in this subsection.

3.2.2 ACCESS TO ONTOLOGY

The Dictionary of Terms ontology will be accessible for public use on a CCSDS resource that is internet accessible. Any included ontologies that are not already publicly accessible shall be accessible on the same CCSDS resource.

NOTE – The DoT ontology is currently available as described in B2.

3.2.3 ACCESS TO DERIVATIVES

The files listed in this section, which are generated from the content of the ontology, will be accessible for public use on the CCSDS resource where the ontology is accessible:

– the human-readable Dictionary of Terms;

– the schema representing the Dictionary of Terms, which is included by the EDS schema.

NOTE – The files above are currently available as described in B2.

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3.3 BASIC CONCEPTS

3.3.1 GENERAL

The dictionary of terms shall contain the basic concepts described in this subsection, for use in more specific concepts.

3.3.2 HUMAN-READABLE COMMENTS

The ‘dc:description’ annotation property shall contain a carefully written human-readable description of the meaning of each class, object property, data property, and individual defined in the dictionary of terms ontology.

NOTE – The comment annotation can be extracted from the ontology along with terms to build a human-readable artefact called the ‘glossary’. The namespace ‘dc’ indicates that the annotation property is defined in the ‘Dublin core’ (reference [7]).

3.3.3 ENUMERATED EDS ATTRIBUTE

A class that represents an attribute whose range is an enumeration, and which is used in an element of an EDS, shall map to the EDS schema such that the name of the class is the name of the attribute, and the names of the individuals in the class are the names of the labels of the enumeration. When two consecutive layers of names are needed, the more inclusive layer shall consist of the names of subclasses of the class whose name is the attribute name.

NOTE – The enumerations described here are the ranges of attributes in an Electronic Data Sheet. Enumerations of possible values for discrete data variables in component interfaces are the subject of 3.5.2.5, which also provides an example of the two-layer mapping of names between ontology and schema.

3.4 SYNTACTIC ATTRIBUTES

3.4.1 GENERAL

3.4.1.1 The dictionary of terms may define terms that can be used to describe the arrangement and interpretation of bits that represent numbers.

NOTE – Examples of such terms are number of bits, and encoding. These terms also include the aggregation of numbers into various data structures, such as arrays and messages. These terms are called ‘syntactic attributes’. Syntactic attributes deal only with representation of numbers; they do not represent the interpretations of numbers as such concepts as lengths or as enumerations. The latter kinds of concepts are reserved for semantic attributes, which are defined in a peer subsection of this document.

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3.4.1.2 The definitions of syntactic terms shall be consistent with the definitions in the EDS schema; in case of conflict, the schema shall prevail, and the DoT shall be corrected to agree.

NOTES

1 This subsection describes the provision of terms to describe the representation of numbers. Syntactic terms are defined by the EDS schema. Syntactic terms may also be defined in the dictionary of terms, but only to reflect the schema. By defining syntactic terms in the dictionary of terms, the generation of human-readable artefacts from the dictionary of terms can include syntactic terms.

2 The authors of the EDS schema may request that certain terms used in the representation of numbers or to define data structures be defined in the DoT, in order to utilize the capability for the ontology to describe restrictions on the usage of the terms, or simply to have the definitions in a common location that feeds the human-readable glossary.

3.4.2 ONTOLOGY FOR SYNTACTIC ATTRIBUTES

3.4.2.1 General

The dictionary of terms shall represent each syntactic attribute as a class derived from the class ‘SyntacticAttribute’, and the name of the derived class shall be the name of the attribute in the schema.

3.4.2.2 Enumerated Syntactic Attributes

For syntactic attributes whose range of values is an enumeration, the names of individuals in the class shall be the names of the values of the attribute in the schema (see 3.3.3).

NOTE – An example of an enumerated syntactic attribute is ‘encoding’, which may have individuals with names like ‘IEEE754_1985’ or ‘twosComplement’.

3.4.2.3 Numeric Syntactic Attributes

3.4.2.3.1 For syntactic attributes whose range is one or more intervals of integers, the constraints on the values shall be expressed as follows: The numeric syntactic attribute class shall have data properties ‘lowerBound’ and ‘upperBound’, with range ‘xsd:integer’, and the individuals in the class shall represent the intervals.

3.4.2.3.2 When an individual in such a class lacks a bound, the interpretation shall be that the interval is unbounded in the direction of the missing bound.

3.4.2.3.3 The bounds shall be interpreted as including their value.

NOTE – The need to use more than one bounded interval or to have numeric syntactic attributes with values that are not integers has not yet been seen. An example of a numeric syntactic attribute is ‘lengthInBits’, which may have values in the interval with lower bound 1 and with no upper bound.

3.4.2.4 Schema for Syntactic Types

3.4.2.4.1 The dictionary of terms may be accompanied by open-source software for extraction of a schema that can be included in the EDS schema to define syntactic attributes.

3.4.2.4.2 The extracted schema shall contain an attribute group named ‘CoreSyntaxAttributeGroup’, which contains syntactic attributes and restricts their values.

3.4.2.4.3 If the EDS schema does not include the extracted schema, and the EDS schema disagrees with the extracted schema, then the EDS schema shall prevail.

3.4.3 COMBINATORIAL CONSTRAINTS ON SYNTAX

3.4.3.1 The dictionary of terms may define any necessary constraints on legal combinations of syntactic attributes. Each such constraint shall be an individual in the class ‘ExcludedSyntax’.

3.4.3.2 The class ‘ExcludedSyntax’ may have an object property for each enumerated syntactic attribute, with the name [‘value’ prefixed to the name of the enumerated syntactic attribute class].

3.4.3.3 The class ‘ExcludedSyntax’ may have data properties for each numeric syntactic attribute, with the names [‘lowerBound’ or ‘upperBound’ prefixed to the name of the numeric syntactic attribute class].

3.4.3.4 An individual in ‘ExcludedSyntax’ shall be interpreted as an illegal combination of attributes.

NOTE – The combinatorial constraint is expressed as an excluded possibility, so the more common case of unconstrained expression is the default. For example, to define an illegal combination of ‘lengthInBits’ and ‘encoding=IEEE754_1985’, the constraint would have valueEncoding=IEEE754_1985 and upperBoundLengthInBits=31, which says that this format of numbers cannot be shorter than 32 bits.

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3.4.4 STANDARD TYPES OF NUMBERS

3.4.4.1 Overview

Some combinations of syntactic attributes will be used so often that it will be useful to define those combinations with standard names. Examples of standard syntactic types are 32-bit IEEE 754 floating point numbers (1985) and 64-bit two's complement integers.

3.4.4.2 Ontology for Standard Syntactic Types

3.4.4.2.1 The dictionary of terms may define each standard combination of syntactic attributes as an individual in the class 'SyntacticType'.

3.4.4.2.2 The class 'SyntacticType' may have an object property, with cardinality 1, for each enumerated syntactic attribute, with the name ['value' prefixed to the name of the enumerated syntactic attribute class].

3.4.4.2.3 The class 'SyntacticType' may have a data property, with cardinality 1, for each numeric syntactic attribute, with the name ['value' prefixed to the name of the numeric syntactic attribute class].

3.4.4.2.4 Standard syntactic types whose numeric syntactic attribute values do not fall in an interval defined for the corresponding numeric syntactic attribute shall be treated as errors.

3.4.4.3 Electronic Data Sheet for Standard Syntactic Types

The dictionary of terms may be accompanied by open-source software for extraction of an EDS that contains the definitions of standard syntactic types.

NOTE – Other EDSes can include this artefact.

3.5 SEMANTIC ATTRIBUTES

3.5.1 GENERAL

The dictionary of terms shall define terms that can be used to describe the interpretation of numbers and data structures.

NOTE – Examples of such terms are 'referenceFrame' and 'unit'. The combination of semantic attributes of an item of data is called its 'engineering profile'.

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3.5.2 ONTOLOGY FOR SEMANTIC ATTRIBUTES

3.5.2.1 General

The dictionary of terms shall represent each semantic attribute as a class derived from the class 'SemanticProperty', and the name of the class shall be the name of the attribute in the schema.

3.5.2.2 Enumerated Semantic Attributes

For semantic attributes whose range of values is an enumeration, the names of individuals in the class shall be the names of the values of the attribute in the schema (see 3.3.3).

NOTE – An example of an enumerated semantic attribute is 'referenceFrame', which may have individuals with names like 'device' or 'ECI'.

3.5.2.3 QUDV Semantics

3.5.2.3.1 The dictionary of terms shall include the QUDV ontology to obtain definitions of quantity kinds and units of measure.

3.5.2.3.2 The dictionary of terms shall extend the QUDV ontology as necessary.

NOTES

1 Users of the dictionary of terms, both people and software, will treat the QUDV classes for quantity kinds and units of measure as subclasses of 'SemanticProperty'.

2 This formula generalizes the description of enumerated semantic attributes to include subclasses of the class that names the attribute. The names of the subclasses are not used, but the names of the individuals in the subclasses are used as the enumeration values. The quantity kind class and the unit class are not defined as subclasses of 'SemanticProperty' in order to keep the DoT ontology separate from the QUDV ontology.

3.5.2.4 Referential Semantics

3.5.2.4.1 General

3.5.2.4.1.1 The dictionary of terms shall contain a class named 'ModelOfOperation'.

3.5.2.4.1.2 The dictionary of terms shall define a subclass of the class 'SemanticProperty' named 'RefersToModel'.

3.5.2.4.1.3 A class derived from RefersToModel may be called a referential class, and shall have no individual members.

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3.5.2.4.1.4 A semantic attribute in the EDS schema that corresponds to a referential class shall have a range of values in 'xsd:string'.

3.5.2.4.1.5 The prefix of the string shall be the name of an individual in the 'ModelOfOperation' class or the name of a class derived from ModelOfOperation.

3.5.2.4.1.6 The remainder of the string shall be a path expression delimited by '.', which consists of alternating names of object relations and names of classes or individuals in the core or user-provided ontology.

3.5.2.4.1.7 The definition of the semantic attribute shall relate the part of the Electronic Data Sheet that bears the attribute to the individuals or classes in the ontology that are at the end of the path specified by the value of the attribute.

3.5.2.4.2 Discussion

The purpose of a model of operation is to identify the objects whose properties are represented by data items in interfaces described in an Electronic Data Sheet.

A model of operation is a description of the parts of a component and the context in which the component operates. A model of operation may be expressed in a data modelling language, such as MOF or SysML, and then extracted into a set of OWL classes and relations. The OWL model of operation contains an individual in the ModelOfOperation class, called the anchor. The anchor has object relations to individuals in other classes that form a graph. A semantic attribute that corresponds to a referential class has for its value a string that describes a path through the graph starting from the name of the anchor and traversing relations by name to a set of target individuals. The meaning of the attribute is a relationship between the EDS object in which the attribute appears and target individuals in the model of operation.

For example, the dictionary of terms may define a referential class named 'subject'. The description of the class could say that a parameter in an EDS that has the 'subject' attribute is a property of the target individuals in the model of operation.

More specifically, and continuing the 'subject' example above, an imaging device may carry some thermistors to measure temperature at different points in the instrument. The focal plane is often a point of interest. There could be an electronics package attached to the imager for processing the images, and the temperature of that package could be of interest. In order to recognize which thermistor measures the temperature of which part of the imager, it is necessary to define a model of the parts of the imager, and then it is necessary to attach a semantic attribute to the measurement from each thermistor that refers to the model part where the thermistor is located.

For an example of context in a model of operation, a device that tracks signals from ships at sea would have a model of operation that contains the device, the vehicle, the Earth, and the ships at sea. This model of operation would likely be defined in a user-provided ontology (3.6) during its development.

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3.5.2.4.3 Standard Models of Operation

3.5.2.4.3.1 The dictionary of terms may define standard models of operation, with standard names for the parts of the model that can be referenced.

3.5.2.4.3.2 The standard models of operation shall be individuals of the class 'ModelOfOperation' or classes derived from ModelOfOperation.

3.5.2.4.3.3 The parts of the standard models of operation shall be related classes and individuals in related classes.

NOTE – A navigation application that uses the nadir point of its satellite could be designed to ignore latitude-longitude parameters whose 'subject' attribute is not 'GNS.onBoard.artificialSatellite.over.nadirPoint'. This would allow other applications onboard the vehicle to produce latitude-longitude parameters that are relevant to other objects of interest on the planet orbited by the satellite, without harming the navigation application.

3.5.2.4.4 User-Provided Models of Operation

3.5.2.4.4.1 The document object model of an EDS shall be treated as a model of operation with the anchor being the trunk element of the EDS.

3.5.2.4.4.2 The dictionary of terms shall define a referential class named 'memberOf', which shall have the interpretation that an element bearing the attribute in the document object model of an EDS is a member of the class in a standard or user-provided model of operation, named by the value of the attribute.

3.5.2.4.5 Discussion

Authors of Electronic Data Sheets may write a user-provided ontology that adds individuals to the 'ModelOfOperation' class, plus related classes for reference by attributes in the EDS.

Making each EDS a model of operation enables the semantic properties of one parameter to refer to another parameter. For example, a measure of variance could refer to a separate parameter that contains the central value.

Standard models of operation cannot efficiently represent the variety of details that may occur in a specific instrument. To address this difficulty, the parts of a standard model of operation, which are classes, can be interpreted as a skeletal model. Individuals in the classes of a standard model of operation can be defined in an Electronic Data Sheet, and can be related to those classes by a referential attribute, 'memberOf'. This convention allows EDSes to define a variety of operating models without needing a user-provided ontology, which would diminish their portability.

Continuing the example of an imaging device above, the EDS could describe part of the model of operation of a particular instrument with an element that represents the focal plane, which contains the attributes <… name="focalPlane" memberOf="imager.hasA.focalPlane" …>, where the imager.hasA.focalPlane is a path through a standard model of operation of an imager in the core ontology. The EDS could also contain two elements, one with attributes <… name="processor1" memberOf="imager.mayHaveSome.processor" …>, and the other with attributes <… name="processor2" memberOf="imager.mayHaveSome.processor" …>. In a description of a housekeeping interface in the EDS, one parameter that is a measure of temperature could have the attribute subject="focalPlane", while another parameter in the same interface that is also a measure of temperature could have the attribute subject="processor1".

3.5.2.5 Enumeration Data

3.5.2.5.1 General

3.5.2.5.1.1 An Electronic Data Sheet may associate enumeration tags with numbers, to describe the representation of discrete variables in a data interface.

3.5.2.5.1.1.1 The dictionary of terms shall define the meanings of enumeration tags.

3.5.2.5.1.1.2 The association of tags with numbers may be local to Electronic Data Sheets.

3.5.2.5.1.2 The dictionary of terms shall define a subclass of ‘SemanticProperty’ named ‘enumeration’, whose derived classes are enumerations of the possible values of discrete data items described by an EDS.

3.5.2.5.1.2.1 The range of values of the ‘enumeration’ attribute in the schema shall be the names of the classes derived from the class ‘enumeration’.

3.5.2.5.1.2.2 The ‘enumeration’ attribute may appear in the ‘Semantics’ element of an enumerated data type in an EDS.

3.5.2.5.1.2.3 The values of the ‘label’ attributes of enumeration members of the enumerated data type shall be the names of individuals in the class named by the ‘enumeration’ attribute, if it is present.

3.5.2.5.2 Discussion

The ‘label’ attributes are used in Electronic Data Sheets to assign semantics to enumeration members for discrete data variables in interfaces. The ‘label’ attributes may also be used in the user interface of mission control systems to present discrete variables to human controllers. The annotation properties in the ontology may be used to provide additional help to controllers.

The normative statement above says that there will be a semantic attribute ‘enumeration=x’ that can be applied to enumerated data types in an EDS. The ‘x’ is the name of a class in the ontology derived from the class ‘enumeration’. The meaning of this semantic attribute is to

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say that an item of data will contain integer values that correspond to enumeration values of individuals in the enumeration class 'x'. The Electronic Data Sheet provides the association between integer values and names of individuals in each enumeration class that it uses. An enumerated data type for a discrete variable does not need to use all the individuals in its enumeration class. If the 'enumeration' attribute is absent an enumerated data type, then an interface that uses that type in one EDS cannot be matched to an interface that uses an enumerated type with similar names in another EDS; if the 'enumeration' attribute is present, then matching, perhaps with conversion, is possible.

3.5.2.5.3 Standard Enumerations

3.5.2.5.3.1 The dictionary of terms shall define standard enumerations, with standard names for the enumerated values.

3.5.2.5.3.2 The standard enumerations shall be classes derived from the class 'enumeration'.

3.5.2.5.4 Discussion—User-Provided Enumerations

Authors of Electronic Data Sheets may write a user-provided ontology that adds classes derived from the 'enumeration' class. These classes can then be named in the 'enumeration' attribute of a data item to indicate its meaning.

3.5.2.6 Schema for Engineering Profiles

3.5.2.6.1 The dictionary of terms shall be accompanied by open-source software for extraction of a schema that can be included in the EDS schema to define semantic attributes.

3.5.2.6.2 The schema shall contain an attribute group named 'CoreSemanticsAttributeGroup', which contains semantic attributes and restricts their values.

3.5.3 COMBINATORIAL CONSTRAINTS ON SEMANTICS

3.5.3.1 Overview

This subsection describes how to constrain combinations of semantic attribute values.

3.5.3.2 Excluded Semantics

3.5.3.2.1 The dictionary of terms may define any necessary constraints on legal combinations of semantic attributes.

3.5.3.2.2 Each such constraint shall be an individual in the class 'ExcludedSemantics'.

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3.5.3.2.3 The class 'ExcludedSemantics' shall have an object property for each enumerated semantic attribute, with the name ['value' prefixed to the name of the enumerated semantic attribute class].

3.5.3.2.4 An individual in 'ExcludedSemantics' shall be interpreted as an illegal combination of attributes.

NOTE – The combinatorial constraint is expressed as an excluded possibility, so the more common case of unconstrained expression is the default. For example, to define an illegal combination of 'quantityKind=length' and 'unit=arc-second', the constraint would have valueQuantityKind=length and valueUnit=arc-second. This example is better handled as described in 3.5.3.3.

3.5.3.3 External Constraints

The dictionary of terms shall instantiate the 'sysml-qudv:quantityKind' object property for individuals in classes derived from 'unit'.

NOTE – It would be more efficient to express the preceding constraint as saying that the unit attribute must have a value that is associated with the value of the quantityKind attribute. This association is present in the ontology as the sysml-qudv:quantityKind object property. External software can use this information to validate the pairing of quantityKind and unit attributes.

3.5.4 STANDARD ENGINEERING PROFILES

3.5.4.1 Overview

Some engineering profiles will be used so often that it will be useful to define those combinations with standard names. Examples of standard engineering profiles include the description of the quaternion provided by a star tracker, and the description of the torque to be distributed to a single-axis actuator onboard the vehicle.

3.5.4.2 Ontology for Standard Engineering Profiles

3.5.4.2.1 The dictionary of terms shall define each standard combination of semantic attributes as an individual in the class 'EngineeringProfile'.

3.5.4.2.2 The class 'EngineeringProfile' shall have an object property for each enumerated semantic attribute in a profile, with the name ['value' prefixed to the name of the enumerated semantic attribute class].

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3.5.4.3 Electronic Data Sheet for Standard Engineering Profiles

The dictionary of terms shall be accompanied by open-source software for extraction of an EDS that contains the definitions of standard engineering profiles.

3.6 USER-PROVIDED ONTOLOGIES

3.6.1 OVERVIEW

This subsection describes how user-provided ontologies may be used to extend the core ontology when the latter lacks information necessary for a description.

NOTE – Electronic Data Sheets that contain user-provided ontologies may be useful within a project, but the components that they describe are not portable outside the project. Agencies with a policy of promoting portable components will have to require their suppliers to use only terms that are in the core ontology.

3.6.2 STRUCTURE OF USER-PROVIDED ONTOLOGIES

3.6.2.1 General

3.6.2.1.1 The structure of a user-provided ontology shall be consistent with the structure of the Dictionary of Terms ontology.

3.6.2.1.2 The EDS schema may provide a shorthand for a subset of possible user-provided ontologies; if this occurs, then the toolchain software that interprets shorthand user-provided ontologies shall generate user-provided ontologies that are consistent with the structure of the DoT ontology.

3.6.2.2 Discussion

If the purpose is simply to provide additional term(s) within the existing structure, then a user-provided ontology can define the additional term(s) as individuals in the appropriate class. In this case, the programs that generate derivatives from the ontology will be able to include the term(s) without change.

When the user-provided ontology must add new structure that is absent the Dictionary of Terms ontology, it may add some new classes to the Dictionary of Terms that do not inherit any information from classes already present. In this case, the programs that generate derivatives from the ontology will require modification in order to generate the new structure. This action is not a violation of this standard.

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3.6.3 OMISSIONS

NOTE – Section 3 in this document may omit some issues that are needed for particular components or for particular kinds of interfaces. For example, the present description only covers data interfaces; it does not cover physical interfaces, such as thermal, electrical, mass, geometry, and others. Unforeseen issues of data interfaces may have been omitted.

3.6.3.1 In case an issue is omitted that is needed for a particular interface, the EDS author may provide a user-provided ontology to cover the issue.

3.6.3.2 After appropriate consideration, the SOIS working group, or their delegate, shall decide whether to integrate the user-provided ontology into the DoT ontology.

3.6.3.3 If the decision is positive, then the SOIS working group, or its delegate, shall integrate the new ontology, and amend this document to cover the issue.

NOTE – The process of integration can alter the new ontology.

3.6.4 VALIDATION

The Dictionary of Terms ontology shall be accompanied by open source software that reads a user-provided ontology and reports its level of compatibility with the core ontology. The following reports shall be possible:

– The user-provided ontology adds terms in a way that is compatible with the design of toolchain software, so the latter can use the user-provided ontology without change within a project.

– The user-provided ontology adds new structure that cannot be used by the toolchain software, unless the latter is modified.

– The user-provided ontology redefines core terms and relationships, so even the routine content of the ontology no longer can be expected to function correctly with the toolchain software.

3.7 DISCUSSION—MAINTAINING THE ONTOLOGY

While standard terminology is important for reusable application software, innovative applications and new technologies will not always fit within those constraints. The freedom to define new terms and new relationships among terms is built into the SOIS architecture for Electronic Data Sheets.

The procedure for extending the dictionary of terms is the same as the procedure for constructing the dictionary of terms initially.

a) A manufacturer builds a new device that has innovative features that must be described in an Electronic Data Sheet.

b) The manufacturer writes the Electronic Data Sheet using new terms as necessary. The new terms are defined in a user-provided ontology.

c) The managing authority for the dictionary reviews the user-provided ontology and decides whether it should be integrated with the existing ontology.

d) If the decision in step c) is to proceed, then the managing authority integrates the user-provided ontology.

    1) As a result of step d), it may be discovered that some of the novel terms represent concepts that can be expressed by other existing terms.

    2) Another result of step d) is the recognition of new terms.

    3) Yet another result is the addition of new structure to the ontology.

    4) If the integration results in changes to terms in the user-provided ontology, the managing authority notifies the manufacturer. The manufacturer can decide to keep the user-provided ontology or to issue new EDSes that are compatible with the revised core ontology.

e) The managing authority for the dictionary publishes the latest version periodically.

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ANNEX A

DICTIONARY OF TERMS FOR ELECTRONIC DATA SHEETS FOR ONBOARD DEVICES IMPLEMENTATION CONFORMANCE STATEMENT PROFORMA

(NORMATIVE)

A1 INTRODUCTION

This annex provides the Implementation Conformance Statement (ICS) Requirements List (RL) for implementation of the DoT, CCSDS 876.1-R-0, March 2015. The ICS for an implementation is generated by completing the RL in accordance with the instructions below. An implementation shall satisfy the mandatory conformance requirements of the base standards referenced in the RL.

The RL in this annex is blank. An implementation's complete RL is called a ICS. The ICS states which capabilities and options of the services have been implemented. The following can use the ICS:

– An author of an EDS that contains user-provided ontologies, as a checklist to reduce the risk of failure to conform to the standard through oversight;

– An author of toolchain software, as a basis for extracting information from the core DoT and from user-provided ontologies, for use by the toolchain.

A2 NOTATION

The following are used in the RL to indicate the status of features:

<u>Status Symbols</u>

M	mandatory
O	optional

<u>Support Column Symbols</u>

The support of every item as claimed by the implementer is stated by entering the appropriate answer (Y, N or N/A) in the Support column:

Y	Yes, supported by the implementation
N	No, not supported by the implementation

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N/A Not applicable

A3 REFERENCED BASE STANDARDS

The base standards references in the RL are:

– Dictionary of Terms for Electronic Data Sheets for Onboard Devices – this document.

A4 GENERATION INFORMATION

A4.1 IDENTIFICATION OF ICS

Ref	Question	Response
1	Date of Statement (DD/MM/YYYY)	
2	ICS serial number	
3	System Conformance statement cross-reference	

A4.2 IDENTIFICATION OF IMPLEMENTATION UNDER TEST (IUT)

Ref	Question	Response
1	Implementation name	
2	Implementation version	
3	Special configuration	
4	Other information	

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A4.3 IDENTIFICATION

Ref	Question	Response
1	Supplier	
2	Contact Point for Queries	
3	Implementation name(s) and Versions	
4	Other information necessary for full identification, e.g., name(s) and version(s) for machines and/or operating systems: System Name(s)	

A4.4 ONTOLOGY SUMMARY

Ref	Question	Response
1	Service Version	
2	Addenda implemented	
3	Amendments implemented	
4	Have any exceptions been required? NOTE – A YES answer means that the implementation does not conform to the service. Non-supported mandatory capabilities are to be identified in the ICS, with an explanation of why the implementation is non-conforming.	Yes ______ No ______

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A4.5 INSTRUCTIONS FOR COMPLETING THE RL

An implementer shows the extent of compliance to the specification by completing the RL; that is, compliance to all mandatory requirements and the options that are not supported are shown. The resulting completed RL is called a ICS. In the Support column, each response shall be selected either from the indicated set of responses or it shall comprise one or more parameter values as requested. If a conditional requirement is inappropriate, N/A shall be used. If a mandatory requirement is not satisfied, exception information must be supplied by entering a reference X*i*, where *i* is a unique identifier, to an accompanying rationale for the non-compliance.

A5 GENERAL/MAJOR CAPABILITIES

Service Feature	Reference	Status	Support
Basic Concepts	3.3	M	
Syntactic Attributes	3.4	O	
Semantic Attributes	3.5	M	
User-Provided Ontologies	3.6	O	

A6 SOFTWARE EXTRACTING INFORMATION FROM ONTOLOGY

This subsection provides identification of the software that extracts information from the ontology.

Service Feature	Reference	Status	Support
Human-readable Comments	3.3.2	M	
Enumerated EDS Attributes	3.3.3	M	
Runtime Enumerations	3.5.2.5	M	
Ontology for Syntactic Attributes	3.4.2	O	
Combinatorial Constraints on Syntax	3.4.3	O	
Standard Types of Numbers	3.4.4	O	
Ontology for Semantic Attributes	3.5.2	M	
Combinatorial Constraints on Semantics	3.5.3	O	
Standard Engineering Profiles	3.5.4	O	
Validation of User-Provided Ontologies	3.6.4	O	

ANNEX B

SECURITY, SANA, AND PATENT CONSIDERATIONS

(INFORMATIVE)

B1 SECURITY CONSIDERATIONS

B1.1 SECURITY BACKGROUND

The SOIS dictionary of terms for Electronic Data Sheets for onboard devices is publicly available for use in design toolchains, and is designed do accommodate extension by its users. This openness may be exploited to affect adversely the operation of a toolchain. Users must rely upon trusted manufacturers to provide safe Electronic Data Sheets. The specification of such security services is out of scope of this document.

B1.2 SECURITY CONCERNS

At the time of writing there are no identified security concerns. If confidentiality of data is required within a project, some degree of proprietary control may be obtained by using user-provided ontologies that are never submitted to the Dictionary of Terms managing authority for integration into the core.

B1.3 POTENTIAL THREATS AND ATTACK SCENARIOS

Potential threats and attack scenarios typically derive from outside the mission-manufacturer relationship and are therefore not the direct concern of the SOIS dictionary of terms. It is assumed that all Electronic Data Sheets within the spacecraft have been thoroughly tested and cleared for use by the mission implementer.

B1.4 CONSEQUENCES OF NOT APPLYING SECURITY

The security services are out of scope of this document and are expected to be applied at organizational layers above or below those specified in this document. If confidentiality is not implemented, science data or other parameters transmitted within the spacecraft might be misused.

B1.5 RELIABILITY

While it is assumed that the underlying mechanisms used to implement a toolchain operate correctly, the initial implementation of the dictionary of terms can make no promises of reliability. After a sufficient body of experience with real Electronic Data Sheets has developed, useful estimates of reliability will be possible.

B2 SANA CONSIDERATIONS

The recommendations of this document request SANA to create a registry named 'Spacecraft Onboard Interface Services Dictionary of Terms' that consists of a set of files that constitute an ontology and related files.

The registration rule for change to this registry requires an engineering review by a designated expert. The expert shall be assigned by the SOIS-APP working group Chair, or in absence, Area Director.

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ANNEX C

ABBREVIATIONS

(INFORMATIVE)

CCSDS	Consultative Committee for Space Data Standards
DACP	Device Abstraction Control Procedure
DAP	Device-specific Access Protocol
DAS	Device Access Service
DDPS	Device Data Pooling Service
DoT	Dictionary of Terms
DVS	Device Virtualisation Service
EDS	Electronic Data Sheet
SOIS	Spacecraft Onboard Interface Services
XML	Extensible Markup Language

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ANNEX D

INFORMATIVE REFERENCES (INFORMATIVE)

[D1] *Spacecraft Onboard Interface Services*. Issue 2. Report Concerning Space Data System Standards (Green Book), CCSDS 850.0-G-2. Washington, D.C.: CCSDS, December 2013.

[D2] *Spacecraft Onboard Interface Services—Device Access Service*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 871.0-M-1. Washington, D.C.: CCSDS, March 2013.

[D3] *Spacecraft Onboard Interface Services—Device Data Pooling Service*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 871.1-M-1. Washington, D.C.: CCSDS, November 2012.

[D4] *Spacecraft Onboard Interface Services—Device Virtualization Service*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 871.2-M-1. Washington, D.C.: CCSDS, March 2014.

[D5] *Spacecraft Onboard Interface Services—Subnetwork Packet Service*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 851.0-M-1. Washington, D.C.: CCSDS, December 2009.

[D6] *Spacecraft Onboard Interface Services—Subnetwork Memory Access Service*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 852.0-M-1. Washington, D.C.: CCSDS, December 2009.

[D7] *Spacecraft Onboard Interface Services—Subnetwork Synchronisation Service*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 853.0-M-1. Washington, D.C.: CCSDS, December 2009.

[D8] *Spacecraft Onboard Interface Services—Subnetwork Device Discovery Service*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 854.0-M-1. Washington, D.C.: CCSDS, December 2009.

[D9] *Spacecraft Onboard Interface Services—Subnetwork Test Service*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 855.0-M-1. Washington, D.C.: CCSDS, December 2009.

[D10] *XML Telemetric and Command Exchange (XTCE)*. Issue 1. Recommendation for Space Data System Standards (Blue Book), CCSDS 660.0-B-1. Washington, D.C.: CCSDS, October 2007.

ANNEX E

EXAMPLE DOT/XML ONTOLOGY INSTANTIATIONS (INFORMATIVE)

The following excerpt from an EDS for a star tracker contains three variables. The first uses semantic attributes that are available in the standard ontology. The second uses a local ontology to add an enumeration value (rotorMount) to a standard attribute (referenceFrame). The third uses a local ontology to define a new attribute (named axis).

```
<seds:InterfaceType name="rawRateIType">
  <seds:ParameterSet>
    <seds:Parameter name="rate" type="foundation/angularRate" shortDescription="rate vector provided by star tracker">
      <seds:Semantics purpose="measurement" coordinateType="J2000" referenceFrame="device" relationToTimestamp="generation" unit="aToDCount"/>
      <seds:FloatDataEncoding encodingAndPrecision="IEEE754_2008_double"/>
    </seds:Parameter>
    <seds:Parameter name="sample" type="foundation/angularRate" shortDescription="sample">
      <seds:Semantics purpose="measurement" referenceFrame="rotorMount" prefix="localOntology.owl"/>
    </seds:Parameter>
    <seds:Parameter name="anotherExample" type="foundation/angularRate" shortDescription="sample">
      <seds:Semantics purpose="measurement" axis="1,0,0" prefix="localOntology.owl">
        <seds:Term ref="Axis"/>
      </seds:Semantics>
    </seds:Parameter>
  </seds:ParameterSet>
</seds:InterfaceType>
```

The local ontology for the extensions above contains the following definitions, in a file named 'localOntology.owl'.

```
<owl:Class rdf:about="http://www.andropogon.org/ontologies/2013/1/eds.semantics.owl#ReferenceFrame">
  <owl:equivalentClass>
    <owl:Class>
      <owl:oneOf rdf:parseType="Collection">
        <rdf:Description rdf:about="http://www.andropogon.org/ontologies/2013/1/eds.semantics.owl#rotorMount"/>
      </owl:oneOf>
    </owl:Class>
  </owl:equivalentClass>
  <rdfs:subClassOf rdf:resource="http://www.andropogon.org/ontologies/2013/1/eds.semantics.owl#SemanticProperty"/>
</owl:Class>

<owl:Class rdf:about="http://www.andropogon.org/ontologies/2013/1/eds.semantics.owl#Axis">
  <rdfs:subClassOf rdf:resource="http://www.andropogon.org/ontologies/2013/1/eds.semantics.owl#SemanticProperty"/>
  <dc:description>
    sample descriptive text here
  </dc:description>
</owl:Class>
```


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