

BS ISO 20618:2015



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**Space data and information
transfer systems — Spacecraft
onboard interface services —
Device enumeration service**

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Published by BSI Standards Limited 2016

ISBN 978 0 580 89887 7

ICS 49.140

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 29 February 2016.

Amendments/corrigenda issued since publication

Date	Text affected
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INTERNATIONAL STANDARD

ISO
20618

First edition
2015-12-15

Space data and information transfer systems — Spacecraft onboard interface services — Device enumeration service

*Systèmes de transfert des informations et données spatiales —
Services d'interface à bord du vaisseau spatial — Service
d'énumération du dispositif*



Reference number
ISO 20618:2015(E)

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Recommendation for Space Data System Practices

SPACECRAFT ONBOARD INTERFACE SERVICES— DEVICE ENUMERATION SERVICE

RECOMMENDED PRACTICE

CCSDS 871.3-M-1

MAGENTA BOOK

October 2014

AUTHORITY

Issue:	Recommended Practice, Issue 0
Date:	June 2006
Location:	Washington, DC, USA

This document has been approved for publication by the Management Council of the Consultative Committee for Space Data Systems (CCSDS) and represents the consensus technical agreement of the participating CCSDS Member Agencies. The procedure for review and authorization of CCSDS documents is detailed in *Organization and Processes for the Consultative Committee for Space Data Systems* (CCSDS A02.1-Y-4), and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the e-mail address below.

This document is published and maintained by:

CCSDS Secretariat
National Aeronautics and Space Administration
Washington, DC, USA
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FOREWORD

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DOCUMENT CONTROL

Document	Title	Date	Status
CCSDS 871.3-M-1	Spacecraft Onboard Interface Services—Device Enumeration Service, Recommended Practice, Issue 1	October 2014	Original issue

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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.

The purpose of this document is to define services and service interfaces provided by the SOIS Device Enumeration Service (DES). Its scope is to specify the service only and not to specify methods of providing the service, although use of the SOIS subnetwork services is assumed.

This document conforms to the principles set out in the SOIS Green Book (reference [D3]) and is intended to be applied together with it.

1.2 APPLICABILITY

This document applies to any mission or equipment claiming to provide a SOIS-compatible DES.

1.3 RATIONALE

SOIS provide service interface specifications in order to promote commonality of functionality amongst systems implementing well-defined services. These interfaces do not dictate implementation of interfaces or protocols supporting the services.

1.4 DOCUMENT STRUCTURE

This document comprises three sections:

- this section, containing administrative information, definitions, and references;
- section 2 containing general concepts and assumptions;
- section 3 containing the DES specification.

In addition, one normative and three informative annexes are provided:

- annex A, comprising a Protocol Implementation Conformance Proforma;
- annex B, discussing security considerations relating to the specifications of this document;
- annex C, containing a list of acronyms;
- annex D containing a list of informative references.

1.5 DEFINITIONS

1.5.1 GENERAL

For the purpose of this document the following definitions apply.

1.5.2 DEFINITIONS FROM THE OPEN SYSTEMS INTERCONNECTION (OSI) BASIC REFERENCE MODEL

This document is defined using the style established by the Open Systems Interconnection (OSI) Basic Reference Model (reference [D2]). This model provides a common framework for the development of standards in the field of systems interconnection.

The following terms used in this Recommended Practice are adapted from definitions given in reference [D2]:

layer: A subdivision of the architecture, constituted by subsystems of the same rank.

service: A capability of a layer, and the layers beneath it (a service provider), which is provided to the service-users at the boundary between the service-providers and the service-users.

1.5.3 TERMS DEFINED IN THIS RECOMMENDED PRACTICE

For the purposes of this Recommended Practice, the following definitions also apply.

application: Any component of the onboard software that makes use of the DES. This includes flight software applications and higher-layer services.

device: A real hardware component of the spacecraft, such as a sensor or actuator, or a single register within such a component.

notification: A service interface provided by applications that is invoked by a service implementation to provide a means for the service implementation to deliver a message to a set of applications.

1.6 NOMENCLATURE

1.6.1 NORMATIVE TEXT

The following conventions apply for the normative specifications in this Recommended Practice:

- 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.

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—Device Access Service*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 871.0-M-1. Washington, D.C.: CCSDS, March 2013.
- [2] *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.
- [3] *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.
- [4] *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.

- [5] *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.

NOTE – Informative references are contained in annex D.

2 OVERVIEW

2.1 CONTEXT

The SOIS DES is defined within the context of the overall SOIS architecture (reference [D3]) as one of the services of the Application Support Layer, as illustrated in figure 2-1.

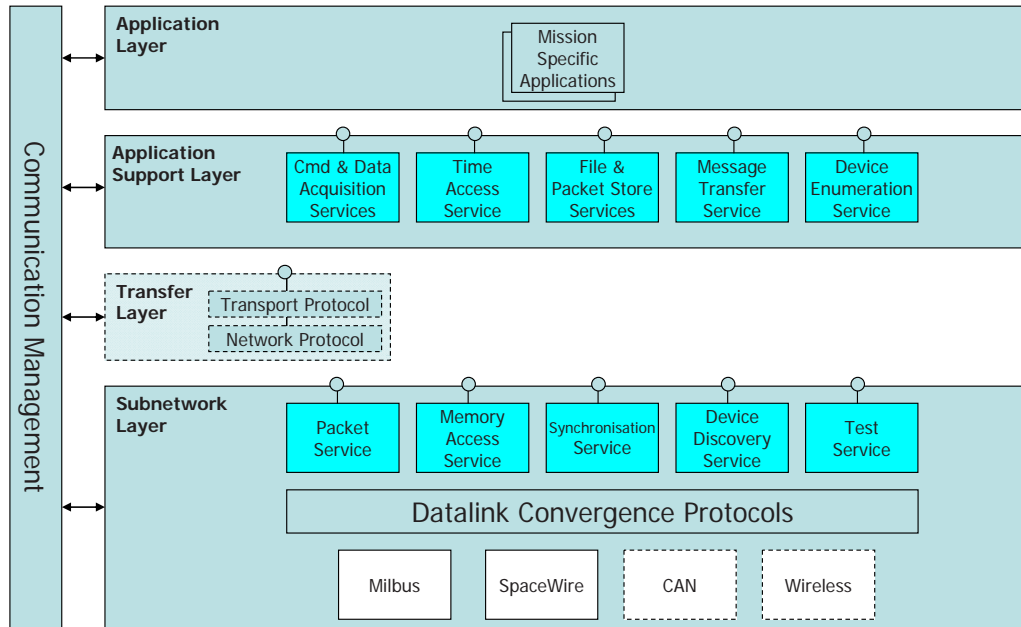


Figure 2-1: Device Enumeration Service Context

The relationship of the DES to the other SOIS services is illustrated in figure 2-2.

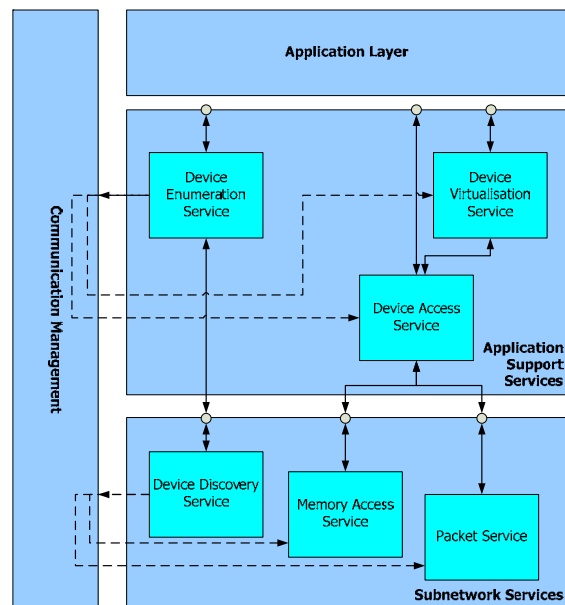


Figure 2-2: Relationship between Device Enumeration Service and Other SOIS Services

The DES provides management and user notification of added or removed devices from a spacecraft. Management of added devices consists of assigning a (system-wide unique) virtual device identifier and verifying that the functions and configuration of the discovered device match the ones required by the system. Management of removed devices consists of revoking the (system-wide unique) virtual device identifier so that the user can no longer access the functions provided by the device using the other Application Support Services.

The service also provides the capability to enumerate the identifiers associated with the devices currently added and to perform queries on device metadata such as device serial number.

The DES main goal is to assist the onboard reconfiguration functions, such as mode management or fault detection, isolation, and recovery regarding the notification of changes in the spacecraft configuration, and the execution of the needed operations to adjust the onboard software to the new configuration. While the reconfiguration strategy is the responsibility of the user applications, the DES is charged with detecting the addition or removal of devices and the reconfiguration of the other SOIS services used to access these devices. In addition the DES also supports the spacecraft integration and test by managing the verification of the correct configuration of the onboard devices with respect to the spacecraft desired configuration or by easing the insertion/removal of device simulators in replacement of the real equipment.

The basic identification information for the devices installed in the system is retrieved by the subnetwork Device Discovery Service (DDS), reference [3], and used by the DES to assign a system-wide unique identifier to each device so that each can be accessed by the user applications using the appropriate functional interface (using the Device Virtualisation Service [DVS], reference [2]), device access protocol (using the Device Access Service [DAS], reference [1]), and subnetwork services (namely Memory Access Service [MAS], reference [4], or Packet Service [PS], reference [5]).

The mapping between the identifiers used by the services and protocols is also illustrated in figure 2-3.

Command & Data Acquisition Service and protocol parameters as well as device-specific access algorithms are preinstalled in the onboard software. The use of DES does not imply any dynamic code generation or compilation at run-time; instead, it allows selection of predefined service instances already available in the onboard software system.

The interactions within the other SOIS services for what concerns the device IDs and subnetwork addresses assignments are done via the Communication Management entity; therefore these operations are not covered by the service interface specified in this document.

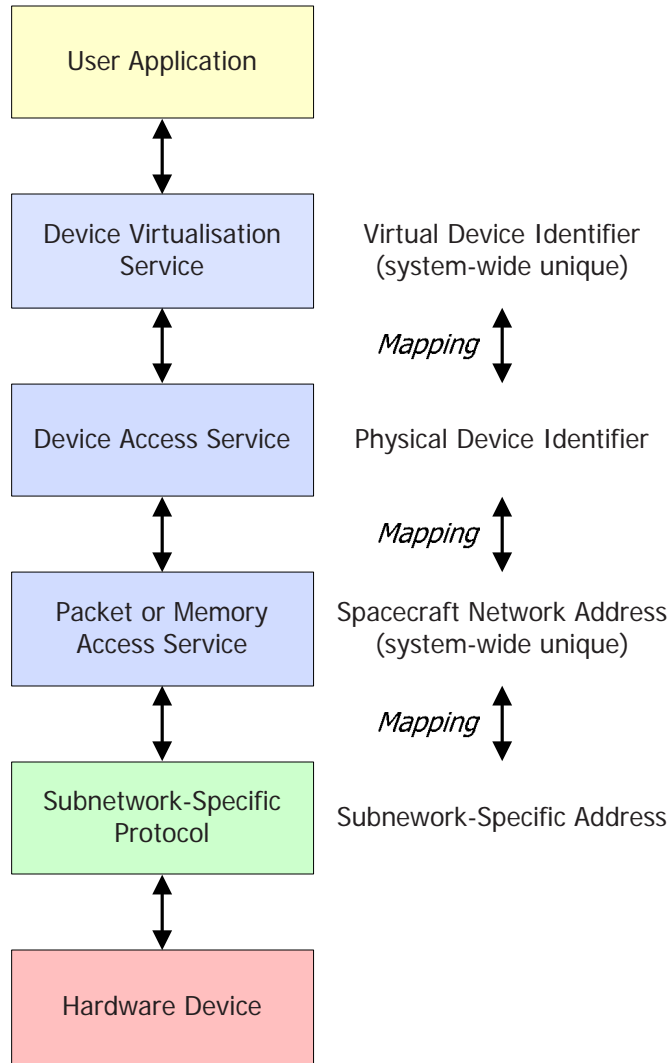


Figure 2-3: Identifiers Mapping in SOIS Services

2.2 DEVICES

2.2.1 ADDING DEVICES

Two mechanisms are available for adding a device by means of the DES:

- a) 'Bottom-up'. Discovery of added devices is provided by DDSes within the different subnetworks and notified to the DES (mandatory feature).
- b) 'Top-down'. Service users (higher-level services or applications) notify the DES of an added device (optional feature).

In either case, the following information is provided to the DES:

- a) Device Serial Number, the unique identifier of the physical device to distinguish between devices of the same type (e.g., gyro mounted on axis X, gyro mounted on axis Y, etc.);
- b) Device Type, the identifier of the functional interface supported by the device when accessed using the DVS;
- c) Spacecraft Network Address, the identifier of the device in the spacecraft network, identifying the subnetwork and the device within the subnetwork.

The DES joins information from two sources. One is the DDS (real configuration), which provides as minimum the Spacecraft Network Address and Device Serial Number. The other is the spacecraft configuration data provided by the spacecraft designers as a configuration table (stored inside the DES or made available through an onboard file system) and providing for each device the association between Device Serial Number, Spacecraft Network Address, and Device Type, and device location/orientation.

Matching these two sets of information, the DES then reconfigures DVS and DAS (by using DVS and DAS management interfaces to modify their Management Information Bases [MIBs]) to enable user access to the service provided by the device. Management consists of:

- a) verification that a device with the attributes mentioned above is foreseen by the spacecraft configuration (if the check is negative an error is reported); otherwise
- b) assignment of the Virtual Device Identifier (system-wide unique) to be used in the DVS primitives;

NOTE – To ease system integration and space operations, it is advised to use a deterministic algorithm to assign the device identifiers so that a given device always receives the same identifier every time it is added/discovered.

- c) association of the Virtual Device Identifier assigned at b) with the Physical Device Identifier used by DAS to the added device in the DVS MIB (reference [2]);
- d) association of the Physical Device Identifier (system-wide unique) with the Spacecraft Network Address in the DAS MIB (reference [1]) to, in order to access the device in its subnetwork.

Finally, the DES notifies any associated application of the added device by means of a *notification*. A notification is a service interface provided by applications that is invoked by a service implementation to provide a means for the service implementation to deliver a message to a set of applications. The parameters of this DES notification include the device attributes defined at a), b), c) and d).

NOTE – The mechanism to associate an application with DES notification is implementation-dependent.

2.2.2 REMOVING DEVICES

Two mechanisms are available for removing devices by mean of the DES:

- a) 'Bottom-up'. Discovery of removed devices is provided by the DDS within the different subnetworks and notified to the DES (mandatory feature).

In this case, the following information is provided to the DES:

Spacecraft Network Address associated to the removed device.

The remaining associated device identifiers can be derived from the Spacecraft Network Address using the MIBs of the DAS and DVS where the associations between identifiers are maintained.

- b) 'Top-down'. Service users (higher-level services or applications) notify the DES of a removed device (optional feature).

In this case, the following information is provided to the DES:

Virtual Device Identifier, the system-wide unique identifier for the removed device.

The DES then reconfigures the DAS and DVS to remove user access to the service provided by the device. Management consists of:

- a) invalidation of the Spacecraft Network Address in the DAS MIB;
- b) invalidation of the Physical Device Identifier in the DVS MIB;
- c) revocation of the Virtual Device Identifier.

Finally, the DES notifies any associated applications of the removed device by means of a *notification*. The parameters of this DES notification include the Virtual Device Identifier of the removed device.

NOTE – The mechanism to associate an application with the DES notification is implementation-dependent.

2.2.3 MIB CONSIDERATIONS

The DES MIB contains the following information:

- Virtual Device and Value Identifier Resolution Table, being a set of managed parameters that map logical device and value identifiers onto individual underlying services and their associated available addressing mechanisms.
- Physical Device and Value Identifier Resolution Table, being a set of managed parameters that map physical device and value identifiers onto individual underlying services and their associated available addressing mechanisms.

As described in 2.2.1 and 2.2.2, so as to assign or revoke the device identifiers and network addresses in accordance with the detected spacecraft configuration, upon modification of its MIB, the DES uses a DAS management interface to change the DAS MIB to align it with the contents of its Virtual Device and Value Identifier Resolution Table and use a DVS management interface to change the DVS MIB to align it with the contents of the Physical Device and Value Identifier Resolution Table.

2.2.4 REDUNDANCY CONSIDERATIONS

The DES does not explicitly manage redundancies among devices of the same type. It however provides the redundancy control function in the Application Layer with the mechanisms to configure the SOIS services in accordance with the spacecraft’s Fault Detection, Identification/Isolation and Recovery (FDIR) strategy.

Figure 2-4 shows the relationship between the DES, the redundancy control application and the regular user applications making use of Command and Data Acquisition Services configured by the DES.

In the figure it is assumed that the redundancy control gives visibility only of DVS-1 (device in use) to the rest of the applications and filters out DVS-2 (backup).

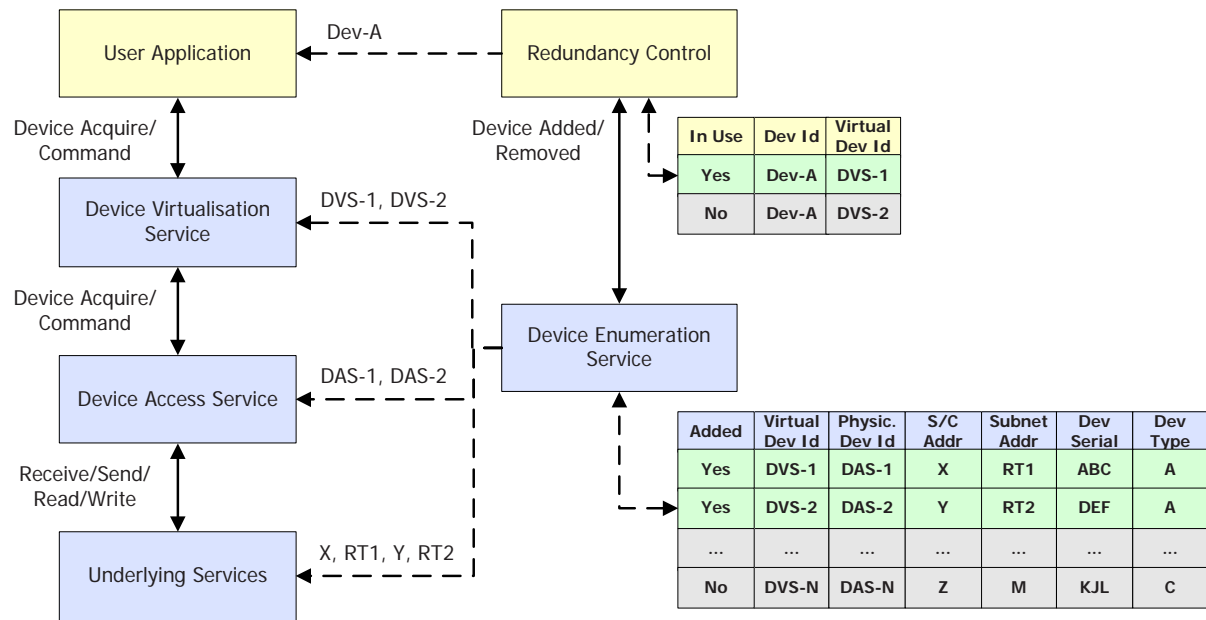


Figure 2-4: Device Enumeration Service and Redundancy

It is out of scope of the DES to actually command the switch on or off of the devices. This can be achieved by means of the Command and Data Acquisition services.

2.3 PURPOSE AND OPERATION OF THE DEVICE ENUMERATION SERVICE

Application software uses the DES to manage (and be notified or notify it of) added or removed devices from a spacecraft, rather than having to discover the added or removed devices itself. Applications are notified by receiving device found and lost indications from DES, and applications notify DES by sending device found and lost requests, as described in 3.1. From the application software perspective, use of the DES will result in applications that are more portable, that are easier to develop, and that can tolerate changes in the spacecraft hardware configuration, communications, or physical devices. From the spacecraft platform implementers' perspective, use of the DES will make it easier to control the configuration of the hardware resources.

The DES is part of the SOIS Plug-and-Play architecture; however, it can also be adopted in a traditional non-plug-and-play software architecture to help the application software in the configuration management of the devices and Command and Data Acquisition Services.

The DES is operated by service indications passed from the service provider and the service user, optionally using service requests and associated service indications passed between the service user and the service provider.

3 DEVICE ENUMERATION SERVICE

3.1 PROVIDED SERVICE

3.1.1 GENERAL

The DES shall provide management and notification of added or removed devices from a spacecraft.

3.1.2 MANAGEMENT OF ADDED DEVICES

3.1.2.1 Management of added devices shall consist of assigning virtual and physical device identifiers and using DAS and DVS management interfaces to update their MIBs to add the virtual and physical device identifier mappings in order to enable user access to the functions provided by the physical device via the DVS and DAS services.

3.1.2.2 The detection of added devices or device attributes not originally foreseen by the spacecraft design shall be flagged as an error (see 3.3.3).

3.1.3 NOTIFICATION OF ADDED DEVICES

Notification of an added device shall consist of an indication to a service user of the device identifier, together with the device's type and device's serial number.

3.1.4 MANAGEMENT OF REMOVED DEVICES

Management of removed devices shall consist of revoking the related virtual and physical device identifiers and using DAS and DVS management interfaces to update their MIBs to remove the virtual and physical device identifier mappings in order to disable the user access to the functions that were provided by the device via the SOIS services.

3.1.5 NOTIFICATION OF REMOVED DEVICES

Notification of a removed device shall consists of an indication to a service user of the device identifier, together with the device's class and type.

3.2 EXPECTED SERVICE FROM UNDERLYING LAYERS

3.2.1 The minimum expected service from the underlying layers is a DDS (reference [3]) for each supported subnetwork type.

3.2.2 An interface to provide access to and configuration of the MIB of the DVS (reference [2]) implementation to assign/revoke identifiers is expected.

3.2.3 An interface to provide access to and configuration of the MIB of the DAS (reference [1]) implementation to assign/revoke identifiers is expected.

NOTE – It is expected that in future there may be standardisation of protocols to discover the services provided by a physical device directly from the physical device itself. These protocols will have associated expected services from the underlying layers.

3.3 DEVICE ENUMERATION SERVICE PARAMETERS

3.3.1 GENERAL

The DES shall use the parameters specified in 3.3.2 to 3.3.9.

3.3.2 TRANSACTION IDENTIFIER

3.3.2.1 The Transaction Identifier parameter shall be a value, assigned by the invoking user entity, which is subsequently used to associate indication primitives with the causal request primitives.

NOTE – The user entity is thus able to correlate all indications and confirmations with the originating service request.

3.3.2.2 Transaction Identifier shall be unique within the user application entity.

3.3.2.3 Uniqueness in the service provider shall be achieved by Transaction Identifier.

3.3.3 RESULT METADATA

The Result Metadata parameter shall be used to provide information generated by the DES provider to the service invoking entity to provide information related to the successful or failed result of a device enumeration operation.

NOTE – The parameter can also include other information indicating failure conditions, e.g., that the specified device type does not match the device types supported by the spacecraft.

3.3.4 VIRTUAL DEVICE IDENTIFIER

The Virtual Device Identifier shall be the system-wide unique device identifier assigned by the service when the device is successfully added.

NOTE – The identifier is used in the DVS primitive.

3.3.5 PHYSICAL DEVICE IDENTIFIER

The Physical Device Identifier shall be the device identifier used in the DAS primitive.

3.3.6 DEVICE SERIAL NUMBER

The Device Serial Number shall be the unique identifier of the physical device added.

NOTES

- 1 The parameter allows distinguishing between devices of the same type installed on the spacecraft. The device type does not provide complete discrimination of the functions that devices can provide. For example, there may be three identical reaction wheels onboard a spacecraft, each spanning a different part of the attitude actuation space; in order for an attitude control system to use those reaction wheels correctly, it must know the orientations of the wheels in the vehicle frame. The function that a device can provide on board a spacecraft typically depends upon the transformation between device coordinates and vehicle coordinates.
- 2 This document assumes (without specifying the implementation) that the designers of a spacecraft have provided a manifest of devices with serial numbers and with the appropriate transformation for each device. Given the manifest, the device serial number completely identifies the function that the device may serve on board the spacecraft.

3.3.7 DEVICE TYPE

The Device Type shall be the identifier of the type of the device added. The parameter shall identify the functional interface supported by the device itself.

NOTE – The Device Type identifier may be included in the Common Dictionary of Terms (reference [D5]—standardisation of this is in progress) and thus identify to a standardised functional interface (standardisation of functional interfaces is proposed).

3.3.8 SPACECRAFT NETWORK ADDRESS

3.3.8.1 The Spacecraft Network Address shall be the spacecraft network address of the device added.

3.3.8.2 The Spacecraft Network Address shall identify the subnetwork and the device within the subnetwork.

3.3.8.3 The Spacecraft Network Address shall be system-wide unique.

3.3.9 DEVICE QUERY CONSTRAINTS

3.3.9.1 The Device Query Constraints shall be a list of constraints on a device query, which DES compares to the manifest of the devices in its inventory and optionally to the electronic datasheets if available onboard.

3.3.9.2 The constraints of the list shall filter the values of attributes in the manifest or in the electronic data sheets.

3.3.9.3 The conjunction of constraints shall define the set of devices to be returned.

3.3.9.4 Each constraint shall consist of the name of an attribute, a value of the attribute, and a relation.

3.3.9.5 The relations shall have the following values:

- a) The Equal relation shall indicate that the value of a discrete attribute must be equal to the value in the constraint.
- b) The LessThan relation shall indicate that the value of an ordered attribute must be less than the value in the constraint.
- c) The GreaterThan relation shall indicate that the value of an ordered attribute must be greater than the value in the constraint.
- d) The NotEqual relation shall indicate that the value of a discrete attribute must be not equal to the value in the constraint.
- e) The LessThanOrEqual relation shall indicate that the value of an ordered attribute must be less than or equal to the value in the constraint.
- f) The GreaterThanOrEqual relation shall indicate that the value of an ordered attribute must be greater than or equal to the value in the constraint.

3.3.9.6 The names of a minimal set of attributes shall be:

- a) deviceSerialNumber;
- b) deviceType;
- c) spacecraftNetworkAddress.

NOTE – Other attributes and relations will be defined in the dictionary of terms for electronic data sheets.

3.4 DEVICE ENUMERATION SERVICE PRIMITIVES

3.4.1 GENERAL

3.4.1.1 The DES interface shall provide the following primitives:

- a) `DEVICE_FOUND.indication`, as specified in 3.4.4;
- b) `DEVICE_LOST.indication`, as specified in 3.4.7;
- c) `ENUMERATE_DEVICES.request` as specified in 3.4.8;
- d) `ENUMERATE_DEVICES.indication` as specified in 3.4.9.

3.4.1.2 The DES interface may provide the following primitives:

- a) `ADD_DEVICE.request`, as specified in 3.4.2;
- b) `ADD_DEVICE.indication`, as specified in 3.4.3;
- c) `REMOVE_DEVICE.request`, as specified in 3.4.5;
- d) `REMOVE_DEVICE.indication`, as specified in 3.4.6;
- e) `QUERY_DEVICES.request` as specified in 3.4.10;
- f) `QUERY_DEVICES.indication` as specified in 3.4.11.

3.4.2 ADD_DEVICE.REQUEST

3.4.2.1 Function

The **ADD_DEVICE.request** primitive shall be used to request that a physical device be assigned virtual and physical device identifiers and user communication with the associated physical device using DVS and DES be enabled.

3.4.2.2 Semantics

The **ADD_DEVICE.request** primitive shall use the following semantics, with the meaning of the parameters specified in 3.3:

ADD_DEVICE.request (Transaction Identifier, Device Serial Number,
Device Type, Spacecraft Network Address)

3.4.2.3 When Generated

The **ADD_DEVICE.request** primitive shall be passed to the DES provider to request assignment of the logical and physical device identifiers and to enable user communication with the associated physical device using the DVS and DES using the addressing specified by the primitive parameters.

3.4.2.4 Effect on Receipt

Receipt of the **ADD_DEVICE.request** primitive shall cause the DES provider to retrieve the physical device attributes using DDS and to verify that they match with input parameters.

If the match is positive new virtual and physical device identifiers shall be assigned and, using the DVS and DAS management interfaces used to update their MIBs respectively, DVS and DAS shall be configured to support the access to the associated physical device.

3.4.3 ADD_DEVICE.INDICATION

3.4.3.1 Function

The **ADD_DEVICE.indication** shall be used to pass the result of a previous **ADD_DEVICE.request** to the user entity.

3.4.3.2 Semantics

The **ADD_DEVICE.indication** primitive shall use the following semantics, with the meaning of the parameters specified in 3.3:

ADD_DEVICE.indication (Transaction Identifier, Device Serial Number, Device Type, Spacecraft Network Address, Virtual Device Identifier, Physical Device Identifier, Result Metadata)

3.4.3.3 When Generated

The **ADD_DEVICE.indication** shall be issued by the service provider to the receiving user entity on the addition of a device in response to an **ADD_DEVICE.request**.

3.4.3.4 Effect on Receipt

The response of the user entity to an **ADD_DEVICE.indication** primitive is unspecified.

3.4.3.5 Result Notification

The Result Metadata parameter shall be used to indicate if the addition of the device was successful or not.

3.4.4 DEVICE_FOUND.INDICATION

3.4.4.1 Function

The **ADD_DEVICE.indication** shall be used to notify the user entity that an added device has been detected by DDS.

3.4.4.2 Semantics

The **DEVICE_FOUND.indication** primitive shall use the following semantics, with the meaning of the parameters specified in 3.3:

DEVICE_FOUND.indication (Device Serial Number, Device Type, Spacecraft
Network Address, Virtual Device Identifier,
Physical Device Identifier, Result Metadata)

3.4.4.3 When Generated

The **DEVICE_FOUND.indication** shall be issued by the service provider to the receiving user entity on the addition of a device as a consequence of notification by a subnetwork's DDS that an added device has been detected.

3.4.4.4 Effect on Receipt

The response of the user entity to a **DEVICE_FOUND.indication** primitive is unspecified.

3.4.4.5 Result Notification

The Result Metadata parameter shall be used to indicate if the addition of the device was successful or not.

3.4.5 REMOVE_DEVICE.REQUEST

3.4.5.1 Function

The REMOVE_DEVICE.request primitive shall be used to request revocation of the virtual and physical device identifiers (obtained by ADD_DEVICE.indication) and user communication with the associated physical device using DVS and DES be disabled.

3.4.5.2 Semantics

The REMOVE_DEVICE.request primitive shall use the following semantics, with the meaning of the parameter specified in 3.3:

REMOVE_DEVICE.request (Transaction Identifier, Virtual Device Identifier, Physical Device Identifier)

3.4.5.3 When Generated

The REMOVE_DEVICE.request primitive shall be passed to the DES provider to request revocation of the logical and physical device identifiers and disabling of user communication with the associated physical device using DVS and DAS.

3.4.5.4 Effect on Receipt

Receipt of the REMOVE_DEVICE.request primitive shall cause the DES provider to revoke the specified virtual and physical device identifiers, and using the DVS and DAS management interfaces used to update their MIBs respectively, DVS and DAS shall be configured to have no access the associated physical device.

3.4.6 REMOVE_DEVICE.INDICATION

3.4.6.1 Function

The REMOVE_DEVICE.indication shall be used to pass the result of a previous REMOVE_DEVICE.request to the user entity.

3.4.6.2 Semantics

The REMOVE_DEVICE.indication primitive shall use the following semantics, with the meaning of the parameters specified in 3.3:

REMOVE_DEVICE.indication (Transaction Identifier, Virtual Device Identifier,
Physical Device Identifier, Result Metadata)

3.4.6.3 When Generated

The REMOVE_DEVICE.indication shall be issued by the service provider to the receiving user entity on the removal of a device in response to a REMOVE_DEVICE.request.

3.4.6.4 Effect on Receipt

The response of the user entity to a REMOVE_DEVICE.indication primitive is unspecified.

3.4.6.5 Result Notification

The Result Metadata parameter shall be used to indicate if the removal of the device was successful or not.

3.4.7 DEVICE_LOST.INDICATION

3.4.7.1 Function

The **DEVICE_LOST.indication** shall be used to notify the user entity that the loss of a device has been detected by DDS.

3.4.7.2 Semantics

The **DEVICE_LOST.indication** primitive shall use the following semantics, with the meaning of the parameters specified in 3.3:

DEVICE_LOST.indication (Virtual Device Identifier, Physical Device Identifier,
Result Metadata)

3.4.7.3 When Generated

The **DEVICE_LOST.indication** shall be issued by the service provider to the receiving user entity on the removal of a device as a consequence of notification by a subnetwork's DDS that the loss of a device has been detected.

3.4.7.4 Effect on Receipt

The response of the user entity to a **DEVICE_LOST.indication** primitive is unspecified.

3.4.7.5 Result Notification

The Result Metadata parameter shall be used to indicate if the removal of the device was successful or not.

3.4.8 ENUMERATE_DEVICES.REQUEST

3.4.8.1 Function

The **ENUMERATE_DEVICES.request** primitive shall be used to request a list of all devices known to DES.

3.4.8.2 Semantics

The **ENUMERATE_DEVICES.request** primitive shall use the following semantics, with the meaning of the parameter specified in 3.3:

ENUMERATE_DEVICES.request (Transaction Identifier)

3.4.8.3 When Generated

The **ENUMERATE_DEVICES.request** primitive shall be passed to the DES provider to request a list of all devices known to the DES.

3.4.8.4 Effect on Receipt

Receipt of the **ENUMERATE_DEVICES.request** primitive shall cause the DES provider to report the list of all known devices through **ENUMERATE_DEVICES.indication**.

3.4.9 ENUMERATE_DEVICES.INDICATION

3.4.9.1 Function

The **ENUMERATE_DEVICES.indication** shall be used to pass the list of all known devices to the user entity that generated a previous **ENUMERATE_DEVICES.request**.

3.4.9.2 Semantics

The **ENUMERATE_DEVICES.indication** primitive shall use the following semantics for each device, with the meaning of the parameters specified in 3.3:

ENUMERATE_DEVICES.indication (Transaction Identifier, Virtual Device Identifier, Physical Device Identifier, Device Serial Number, Device Type, Spacecraft Network Address, Result Metadata)

3.4.9.3 When Generated

3.4.9.3.1 The **ENUMERATE_DEVICES.indication** shall be issued by the service provider to the receiving user entity once for each known device.

3.4.9.3.2 Optionally, the service provider may issue an array of **ENUMERATE_DEVICES.indication** once for each request, with the number of items in the array preceding the array.

3.4.9.3.3 Any enumerable container may be used to return a set of **ENUMERATE_DEVICES.indication** when the implementation of the DES interface is an application programming interface without messaging.

3.4.9.4 Effect on Receipt

The response of the user entity to a **ENUMERATE_DEVICES.indication** primitive is unspecified.

3.4.9.5 Result Notification

The Result Metadata parameter shall contain the following information:

- a) a sequence number for each indication issued for the request, starting with 1;
- b) a count of the number of iterations being issued.

3.4.10 QUERY_DEVICES.REQUEST

3.4.10.1 Function

The **QUERY_DEVICES.request** primitive shall be used to request a list of all devices known to the DES that satisfy specific criteria.

3.4.10.2 Semantics

The **QUERY_DEVICES.request** primitive shall use the following semantics, with the meaning of the parameters specified in 3.3:

QUERY_DEVICES.request (Transaction Identifier, Device Query Constraints)

3.4.10.3 When Generated

3.4.10.3.1 The **QUERY_DEVICES.request** primitive shall be passed to the DES provider to request a list of all devices known to the DES that satisfy the conditions of the Device Query Constraints parameter.

3.4.10.3.2 If the Device Query list is empty, the effect shall be the same as **ENUMERATE_DEVICES.request**.

3.4.10.4 Effect on Receipt

Receipt of the **QUERY_DEVICES.request** primitive shall cause the DES provider to report the list of all known devices that satisfy the device query constraints through **QUERY_DEVICES.indication**.

3.4.11 QUERY_DEVICES.INDICATION

3.4.11.1 Function

The **QUERY_DEVICES.indication** shall be used to pass the list of all known devices that satisfy the constraints of a query to the user entity that generated a previous **QUERY_DEVICES.request**.

3.4.11.2 Semantics

The **QUERY_DEVICES.indication** primitive shall use the following semantics for each device, with the meaning of the parameters specified in 3.3:

QUERY_DEVICES.indication (Transaction Identifier, Virtual Device Identifier, Physical Device Identifier, Device Serial Number, Device Type, Spacecraft Network Address, Result Metadata)

3.4.11.3 When Generated

3.4.11.3.1 The **QUERY_DEVICES.indication** shall be issued by the service provider to the receiving user entity once for each known device that satisfies the query constraints.

3.4.11.3.2 Optionally, the service provider may issue an array of **QUERY_DEVICES.indication** once for each request, with the number of items in the array preceding the array.

3.4.11.3.3 Any enumerable container may be used to return a set of **ENUMERATE_DEVICES.indication** when the implementation of the DES interface is an application programming interface without messaging.

3.4.11.4 Effect on Receipt

The response of the user entity to a **QUERY_DEVICES.indication** primitive is unspecified.

3.4.11.5 Result Notification

The Result Metadata parameter shall contain the following information:

- a) a sequence number for each indication issued for the request, starting with 1;
- b) a count of the number of iterations being issued.

4 MANAGEMENT INFORMATION BASE

4.1 OVERVIEW

There is currently no formal Management Information Base specified for this service. All management items are associated with the implementation providing the service. However, guidance is provided as to MIB contents in 4.3.

4.2 SPECIFICATIONS

Any implementation claiming to provide this service in a SOIS-compliant manner shall publish its Management Information Base as part of the protocol specification.

Any implementation claiming to provide this service in a SOIS-compliant manner shall provide a management interface to allow the contents of its Management Information Base to be accessed and updated.

4.3 MIB GUIDANCE

The MIB of the protocol providing the DES should consider the following aspects:

- Virtual Device and Value Identifier Resolution Table, as specified in 4.4;
- Physical Device and Value Identifier Resolution Table, as specified in 4.5.

NOTE – These aspects are not in any way an indication of the complete contents of a MIB for an implementation providing the DES but are offered as guidance as to those aspects of the MIB which may relate to DES interface.

4.4 VIRTUAL DEVICE AND VALUE IDENTIFIER RESOLUTION TABLE

4.4.1 The Virtual Device and Value Identifier Resolution Table shall contain a set of managed parameters that map logical device and value identifiers onto individual underlying services and their associated available addressing mechanisms.

4.4.2 The table specified in 4.4.1 should indicate to the service whether or not a specific device will generate a response.

4.4.3 Any entity managing the service should be able to:

- a) access the table specified in 4.4.1; and
- b) update it to reflect changes in the flight hardware configuration and relocation of devices.

NOTE – Whether the Virtual Device and Value Identifier Resolution Table can be updated dynamically during service operation is not specified here. This question is an implementation issue to be decided according to the needs of the particular mission for which the service implementation is being developed.

4.5 PHYSICAL DEVICE AND VALUE IDENTIFIER RESOLUTION TABLE

4.5.1 The **Physical Device and Value Identifier Resolution Table** shall contain a set of managed parameters that map physical device and value identifiers onto individual Device-specific Access Protocol identifiers, underlying services, and their associated available addressing mechanisms.

4.5.2 The table specified in 4.5.1 should indicate to the service whether or not a specific device will generate a response.

4.5.3 Any entity managing the service should be able to:

- a) access the table specified in 4.5.1; and
- b) update it to reflect changes in the flight hardware configuration and relocation of devices.

NOTE – Whether the Physical Device and Value Identifier Resolution Table can be updated dynamically during service operation is not specified here. This question is an implementation issue to be decided according to the needs of the particular mission for which the service implementation is being developed.

ANNEX A

DEVICE ENUMERATION SERVICE PROTOCOL IMPLEMENTATION CONFORMANCE STATEMENT PROFORMA

(NORMATIVE)

A1 INTRODUCTION

This annex provides the Protocol Implementation Conformance Statement (PICS) Requirements List (RL) for implementation of the DES, CCSDS 871.3-M-1, October 2014. The PICS 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 PICS. The PICS states which capabilities and options of the services have been implemented. The following can be used in the PICS:

- The service implementer, as a checklist to reduce the risk of failure to conform to the standard through oversight;
- The supplier and acquirer or potential acquirer of the implementation, as a detailed indication of the capabilities of the implementation, stated relative to the common basis for understanding provided by the standard PICS proforma;
- The user or potential user of the implementation, as a basis for initially checking the possibility of interoperability with another implementation;
- A service tester, as a basis for selecting appropriate tests against which to assess the claim for conformance of the implementation.

A2 NOTATION

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

Status Symbols

M	mandatory
O	optional

Support Column Symbols

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
N/A Not applicable

A3 REFERENCED BASE STANDARDS

The base standards references in the RL are:

- Device Enumeration Service – this document.

A4 GENERATION INFORMATION

A4.1 IDENTIFICATION OF PICS

Ref	Question	Response
1	Date of Statement (DD/MM/YYYY)	
2	PICS 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	

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 SERVICE SUMMARY

Ref	Question	Response
1	Service Version	
2	Addenda implemented	
3	Amendments implemented	
4	<p>Have any exceptions been required?</p> <p style="text-align: right;">Yes _____ No _____</p> <p>NOTE – A YES answer means that the implementation does not conform to the service. Non-supported mandatory capabilities are to be identified in the PICS, with an explanation of why the implementation is non-conforming.</p>	

A5 INSTRUCTIONS FOR COMPLETING THE RL

An implementer shows the extent of compliance to the protocol 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 PICS. 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.

A6 GENERAL/MAJOR CAPABILITIES

Service Feature	Reference (Magenta Book)	Status	Support
DEVICE_FOUND.indication	3.4.4	M	
DEVICE_LOST.indication	3.4.7	M	
ENUMERATE_DEVICES.request	3.4.7.5	M	
ENUMERATE_DEVICES.indication	3.4.9	M	
ADD_DEVICE.request	3.4.2	O	
ADD_DEVICE.indication	3.4.3	O	
REMOVE_DEVICE.request	3.4.4.5	O	
REMOVE_DEVICE.indication	3.4.6	O	
QUERY_DEVICES.request	3.4.10	O	
QUERY_DEVICES.indication	3.4.11	O	

A7 UNDERLYING LAYERS PROVIDING SERVICES TO IMPLEMENTATION

This subsection provides identification of the underlying layers providing services to the implementation.

Service Feature	Reference	Status	Support
DEVICE_DISCOVERY.indication	3.2.1	M	
DEVICE_DISCOVERY.request	3.2.1	O	
DEVICE_DISCOVERY_LOSS.indication	3.2.1	M	
Device Virtualisation Service Management Interface	3.2.2	M	
Device Access Service Management Interface	3.2.3	M	

ANNEX B

SECURITY CONSIDERATIONS

(INFORMATIVE)

B1 SECURITY BACKGROUND

The SOIS services are intended for use with protocols that operate solely within the confines of an onboard subnet. It is therefore assumed that SOIS services operate in an isolated environment which is protected from external threats. Any external communication is assumed to be protected by services associated with the relevant space-link protocols. The specification of such security services is out of scope of this document.

B2 SECURITY CONCERNS

At the time of writing there are no identified security concerns. If confidentiality of data is required within a spacecraft it is assumed it is applied at the Application Layer. (For more information regarding the choice of service and where it can be implemented, see reference [D4].)

B3 POTENTIAL THREATS AND ATTACK SCENARIOS

Potential threats and attack scenarios typically derive from external communication and are therefore not the direct concern of the SOIS services, which make the assumption that the services operate within a safe and secure environment. It is assumed that all applications executing within the spacecraft have been thoroughly tested and cleared for use by the mission implementer. Confidentiality of applications can be provided by Application Layer mechanisms or by specific implementation methods such as time and space partitioning. Such methods are outside the scope of SOIS.

B4 CONSEQUENCES OF NOT APPLYING SECURITY

The security services are out of scope of this document and are expected to be applied at 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 visible to other applications resident within the spacecraft, resulting in disclosure of sensitive or private information.

ANNEX C

ACRONYMS

(INFORMATIVE)

CCSDS	Consultative Committee for Space Data Systems
DAS	Device Access Service
DDS	Device Discovery Service
DES	Device Enumeration Service
DVS	Device Virtualisation Service
FDIR	Fault Detection, Isolation/Identification, and Recovery
ID	Identifier
MAS	Memory Access Service
MIB	Management Information Base
OSI	Open Systems Interconnection
PS	Packet Service
SOIS	Spacecraft Onboard Interface Services

ANNEX D

INFORMATIVE REFERENCES

- [D1] *Organization and Processes for the Consultative Committee for Space Data Systems*. Issue 4. CCSDS Record (Yellow Book), CCSDS A02.1-Y-4. Washington, D.C.: CCSDS, April 2014.
- [D2] *Information Technology—Open Systems Interconnection—Basic Reference Model: The Basic Model*. 2nd ed. International Standard, ISO/IEC 7498-1:1994. Geneva: ISO, 1994.
- [D3] *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.
- [D4] *The Application of CCSDS Protocols to Secure Systems*. Issue 2. Report Concerning Space Data System Standards (Green Book), CCSDS 350.0-G-2. Washington, D.C.: CCSDS, January 2006.
- [D5] *Spacecraft Onboard Interface Services—Common Dictionary of Terms for Onboard Devices and Software Components*. Forthcoming.

NOTE – Normative references are listed in 1.7.

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