



The Consultative Committee for Space Data Systems

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## Recommendation for Space Data System Practices

# SPACECRAFT ONBOARD INTERFACE SERVICES— SUBNETWORK PACKET SERVICE

RECOMMENDED PRACTICE

CCSDS 851.0-M-1

MAGENTA BOOK

December 2009

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## FOREWORD

This document is a technical **Recommended Practice** 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 *Subnetwork Packet Service* 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 Practice** specifies a set of related services to be used by space missions to transfer data over an onboard subnetwork. The SOIS Subnetwork Packet Service can support various transport and network protocols like TCP/IP and can directly support applications that only need to use a single subnetwork. The SOIS Subnetwork Packet Service provides quality of service features and also provides a common service interface regardless of the particular type of data link being used for communication.

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## DOCUMENT CONTROL

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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 SOIS-compliant services to be provided by onboard subnetworks.

The purpose of this document is to define services and service interfaces provided by the SOIS Subnetwork Packet Service. Its scope is to specify the service only and not to specify methods of providing the service over a variety of onboard data links.

This document conforms to the principles set out in the Spacecraft Onboard Interface Services Green Book (reference [A1]) and is intended to be applied together with it. The protocols which provide this service are to be documented for individual links, and this can be in the purview of individual missions, agencies, or CCSDS, depending on future circumstance.

## **1.2 APPLICABILITY**

This document applies to any mission or equipment claiming to provide a CCSDS SOIS-compliant Packet Service.

## **1.3 RATIONALE**

SOIS provide service interface specifications in order to promote interoperability and development reuse via peer-to-peer and vertical standardisation.

## **1.4 DOCUMENT STRUCTURE**

The document has five major sections:

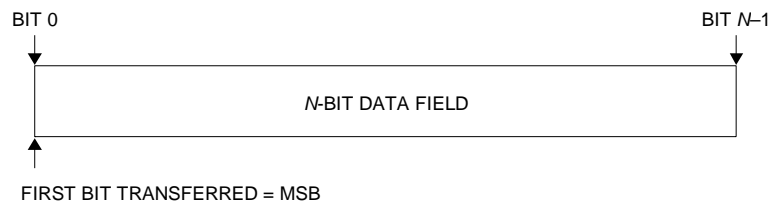
- this section, containing administrative information, definitions, and references;
- section 2, describing general concepts and assumptions;
- section 3, containing the Subnetwork Packet Service specification;
- section 4, containing the Management Information Base (MIB) for the service;
- section 5, comprising a Service Conformance Statement Proforma.

In addition, annex A contains informative references.

## 1.5 CONVENTIONS AND DEFINITIONS

### 1.5.1 BIT NUMBERING CONVENTION AND NOMENCLATURE

In this document, the following convention is used to identify each bit in an  $N$ -bit field. The first bit in the field to be transmitted (i.e., the most left justified when drawing a figure) is defined to be 'Bit 0'; the following bit is defined to be 'Bit 1' and so on up to 'Bit  $N-1$ '. When the field is used to express a binary value (such as a counter), the Most Significant Bit (MSB) shall be the first transmitted bit of the field, i.e., 'Bit 0' (see figure 1-1).



**Figure 1-1: Bit Numbering Convention**

In accordance with modern data communications practice, spacecraft data fields are often grouped into eight-bit 'words' widely known as bytes. Throughout this Recommended Practice, such an eight-bit word is called an 'octet'.

The numbering for octets within a data structure starts with zero. By CCSDS convention, any 'spare' bits are permanently set to '0'.

### 1.5.2 DEFINITIONS

#### 1.5.2.1 General

For the purpose of this document the following definitions apply.

#### 1.5.2.2 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 [A3]). 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 [A3]:

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

**packet service access point (PSAP):** the point at which SOIS Packet service is provided by a Packet service entity to a Packet service user entity.

**packet service access point address (PSAP Address):** a Packet service address that is used to identify a single PSAP. The PSAP Address may be a Packet Source SAP Address (PSSAP) or Packet Destination SAP Address (PDSAP).

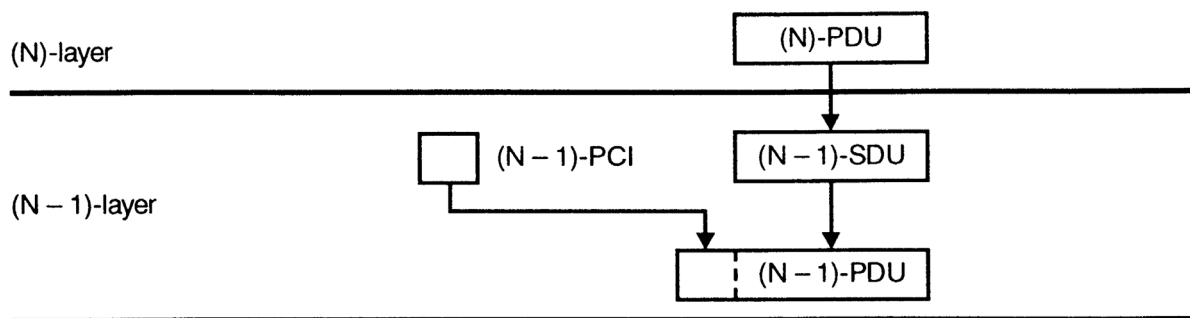
**protocol data unit (PDU):** unit of data specified in a protocol and consisting of Protocol Control Information (PCI) and possibly user data.

**protocol ID:** identifier which uniquely identifies a SOIS Subnetwork user within a data system.

**service:** capability of a layer (service provider) together with the layers beneath it, which is provided to the service users.

**service data unit (SDU):** an amount of data whose identity is preserved when transferred between peer packet service user entities and which is not interpreted by the SOIS Subnetwork service provider entities.

NOTE – The relationship between PDU, SDU and PCI is shown in figure 1-2.



**Figure 1-2: Relationship between PDU, SDU and PCI**

**subnetwork:** an abstraction of a collection of equipment and physical media, such as a local area network or a data bus, which forms an autonomous whole and can be used to interconnect real systems for the purpose of data transfer.

**user data:** the data transferred between Packet service entities on the behalf of the Packet service user entities for whom the Packet service entities are providing a service.

### 1.5.2.3 Terms Defined in this Recommended Practice

For the purposes of this Recommended Practice, the following definitions also apply. Many other terms that pertain to specific items are defined in the appropriate sections.

**channel:** identifier for subnetwork resources associated with a resource reservation.

**NOTE** – A channel can be a list of time slots in a time division multiplexed system or a bandwidth limit in a bandwidth division multiplexed system. The subnetwork resources required for the communication can also be defined to allow simultaneous use of non-conflicting resources on subnetworks that support this feature.

**data system:** addressable entity, situated in a subnet, which hosts an instance of the subnetwork protocols, subnetwork services, and subnetwork users.

**NOTE** – The subnetwork users are uniquely identifiable in a subnetwork by a combination of data system address and a protocol ID. A data system is typically a computer or a device.

**data system address:** identifier which uniquely identifies a data system in a subnetwork.

**NOTE** – The data system address can be referred to as a destination address or a source address depending on the context of its invocation at the subnetwork service interface.

**error:** data bit received with the inverse value from that with which it was sent.

**maximum transmission unit (MTU):** maximum size of data that a data link can transmit as a single PDU.

**NOTE** – The MTU is required to ensure that different sources of data get fair access to the transmission medium, by multiplexing traffic on a packet-by-packet basis. SDUs larger than the MTU will be segmented into smaller PDUs.

**octet:** eight-bit word.

**NOTE** – An eight-bit word is commonly referred to as a byte.

**packet:** an arbitrary integer number of octets.

**NOTE** – The SDU for the packet service takes the form of a packet.

**priority:** transmit precedence of an SDU relative to other SDUs.

**quality of service (QoS):** ability of a communication system to provide predictable and differentiated services.

**NOTE** – Quality of service for a communication service can be characterised in terms of important features relevant to that communications service, for example: reliability, transmission rate, effective bandwidth and latency, error rate.

**segmentation:** division of subnetwork service data units by the subnetwork into shorter sections (segments) that are short enough to be sent over the data link.

NOTE – The subnetwork is responsible for reassembling the segments back into subnetwork service data units when delivering to the subnetwork user entity.

**service class:** quality of service indicating whether resource reservation or reliability is required.

## 1.6 DOCUMENT NOMENCLATURE

The following conventions apply throughout 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.

## 1.7 REFERENCES

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

None.

NOTE – Informative references are contained in annex A.

## 2 OVERVIEW

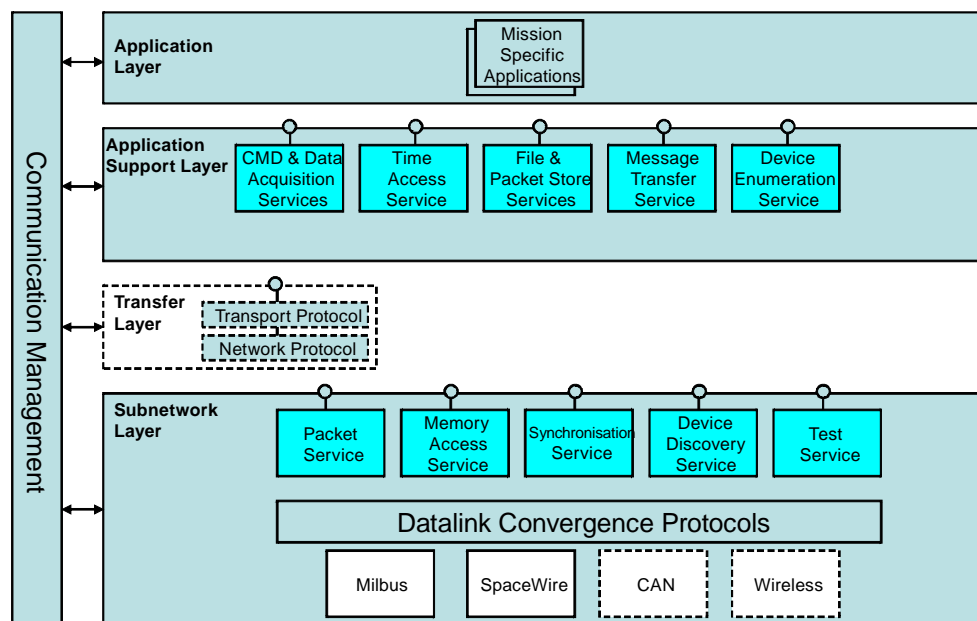
### 2.1 FUNCTION

The SOIS Subnetwork Packet Service transfers Service Data Units, which comprise variable length, delimited octet strings, from one endpoint on a data link/subnetwork to another endpoint on the same data link/subnetwork, using the SOIS data link functions to move the information across the data link/subnetwork.

### 2.2 CONTEXT

The SOIS Subnetwork layer provides for the movement of an SDU over a subnetwork to a variety of user applications, Space Internet Services (SIS), and others. The service may be provided over a variety of data links, and the method of such provision is not in the scope of this document.

Data to be transported is passed to the Subnetwork Packet Service via the Subnetwork Packet Service interface with a requested QoS. As shown in figure 2-1, the service is one of a number of services which may be provided by the SOIS Subnetwork.



**Figure 2-1: Subnetwork Packet Service Context**

The Subnetwork Packet Service makes use of the data link to transfer data and control information. A variety of data links may be suited to provision of the service, and the strategy for such service provision is outlined in reference [A1].

A Subnetwork Management function is also provided for configuring, managing, and collecting status information from the Subnetwork Packet Services.

## 2.3 ASSUMPTIONS

The following assumptions have been made in designing the SOIS Subnetwork Packet Services:

- SOIS Subnetwork Packet Services are provided across single subnetworks.
- SOIS Subnetwork Packet Services are made available to protocol entities in the Transfer, Application Support, and User Application Layers.

## 2.4 QUALITY OF SERVICE

The requested QoS is the concatenation of service class (Best-effort, Assured, Reserved, or Guaranteed), priority, and, where appropriate, a channel identifier. Semantics and use of the priority parameter are dependent on which service class is being invoked.

There are four communication service classes provided by the SOIS Subnetwork Packet Service:

- Best-effort service class, as specified in 3.1.5.2 a);
- Assured service class, as specified in 3.1.5.2 b);
- Reserved service class, as specified in 3.1.5.2 c);
- Guaranteed service class, as specified in 3.1.5.2 d).

All service classes are sequence preserving within a channel or at a priority level. There is no service-wide sequence preservation unless all users operate with no channelisation and at a single priority.

The Best-effort and Reserved service classes deliver data in sequence and without errors; the implication of these qualities is that PDUs that are received out of sequence or with errors will not be delivered to the user. The user (sending or receiving) is not informed of such non-delivery. It is therefore recommended that underlying data links be themselves inherently sequence preserving.

## 2.5 SECURITY

### 2.5.1 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 outside the scope of this document.

### **2.5.2 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. More information regarding the choice of service and where it can be implemented can be found in reference [A2].

### **2.5.3 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.

### **2.5.4 CONSEQUENCES OF NOT APPLYING SECURITY**

The security services are outside the 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.



### **3 SUBNETWORK PACKET SERVICE**

#### **3.1 SERVICE PARAMETERS**

##### **3.1.1 GENERAL**

The Subnetwork Packet Service shall use the parameters defined in 3.1.2 to 3.1.8.

##### **3.1.2 DATA**

The Data parameter shall be used as the Service Data Unit (SDU) of the SOIS Subnetwork Packet Service.

##### **3.1.3 PACKET SOURCE SERVICE ACCESS POINT (PSSAP) ADDRESS**

The PSSAP Address shall be used to identify the SAP Address that identifies the user entity that wishes to send a Packet Service SDU.

##### **3.1.4 PACKET DESTINATION SERVICE ACCESS POINT (PDSAP) ADDRESS**

The PDSAP Address shall be used to identify the SAP Address that identifies the user entity to which a Packet Service SDU is required to be delivered.

##### **3.1.5 SERVICE CLASS**

###### **3.1.5.1 General**

The service class parameter shall refer to one of the following qualities of service:

- a) Best-effort, as specified in 3.1.5.2 a);
- b) Assured, as specified in 3.1.5.2 b);
- c) Reserved, as specified in 3.1.5.2 c);
- d) Guaranteed, as specified in 3.1.5.2 d).

###### **3.1.5.2 Possible Values of the Service Class**

- a) The Best-effort service class shall:
  - 1) make a single attempt to deliver data to its destination but cannot ensure that it will be delivered successfully;

- 2) assure the delivery of all SDUs to the Destination in the same sequential order in which they are produced by the Source (within a priority value), without errors, and without duplication;
  - 3) use a priority parameter to determine the precedence of PDUs;
  - 4) ensure that SDUs extracted from PDUs containing errors are not delivered;
  - 5) ensure that individual SDUs being sent are not larger than the MTU.
- b) The Assured service class shall:
- 1) ensure delivery of data to its destination;
  - 2) indicate to the sending entity if it is not possible to provide the assured service;
  - 3) assure the delivery of all SDUs to the Destination in the same sequential order in which they are produced by the Source (within a priority value), complete, without errors, and without duplication;
  - 4) use a priority parameter to determine the precedence of PDUs;
  - 5) ensure that SDUs extracted from PDUs containing errors are not delivered;
  - 6) ensure that individual SDUs being sent are not larger than the MTU.

NOTE – Where both Best-effort and Assured service classes are provided, prioritisation CAN be performed amongst PDUs belonging to both service classes and informed by priority and an understanding of packet lifetime with regard to timeouts which provide the assured service.

- c) The Reserved service class shall:
- 1) make a single attempt to deliver data to its destination but cannot ensure that it will be delivered successfully;
  - 2) assure the delivery of all SDUs to the Destination in the same sequential order in which they are produced by the Source (within the channel and within a priority value), without errors, and without duplication;
  - 3) use a channel that defines the resources that are used to transmit the SDU;
  - 4) ensure that SDUs extracted from PDUs containing errors are not delivered;
  - 5) ensure that individual SDUs being sent are not larger than the MTU.
- d) The Guaranteed service class shall:
- 1) ensure delivery of data to its destination;
  - 2) indicate to the sending entity if it is not possible to provide the Guaranteed service (i.e., the user is informed if it is not possible to deliver the data);

- 3) assure the delivery of all SDUs to the Destination in the same sequential order in which they are produced by the Source (within the channel and within a priority value), complete, without errors, and without duplication;
- 4) use a channel that defines the resources that are used to transmit the SDU;
- 5) ensure that SDUs extracted from PDUs containing errors are not delivered;
- 6) ensure that individual SDUs being sent are not larger than the MTU.

### **3.1.6 CHANNEL**

- a) The Channel parameter shall be used only for Reserved or Guaranteed service classes, in accordance with 3.1.5.
- b) The Channel parameter shall be used to fully specify an end-to-end resource reservation for a subnetwork communication, as follows:
  - 1) For time division multiplexed (scheduled) systems, the Channel parameter identifies a list of time slots that may be used to support transmission of the channel data.
  - 2) For systems based on bandwidth reservation, the Channel parameter identifies the amount of subnetwork capacity that may be used to support the transmission.

NOTE – The time-slot allocation or bandwidth reservation for each channel is defined by management parameters of the protocol providing the packet service.

### **3.1.7 PRIORITY**

The Priority parameter shall be used as follows:

- a) If resource reservation is not present, the Priority parameter indicates the importance of the data to the system.
- b) Where resource reservation is invoked the priority level is interpreted within a channel.

### **3.1.8 FAILURE METADATA**

The Failure Metadata parameter shall be used to provide the information generated by the Subnetwork Packet Service provider to the sending entity to provide information related to a failure of service provision.

NOTE – A service class and/or a channel and/or priority can be associated with a packet source service access point by management, negating the need to explicitly invoke these parameters in the service primitive.

## 3.2 PACKET SERVICE PRIMITIVES

### 3.2.1 GENERAL

- a) The SOIS Subnetwork Packet Service shall not use primitives other than the following three primitives:
  - 1) **PACKET\_SEND.request** (which requests to send an SDU), as specified in 3.2.2;
  - 2) **PACKET\_RECEIVE.indication** (which indicates that a packet has been received and which passes the corresponding SDU to the end system), as specified in 3.2.3;
  - 3) **PACKET\_FAILURE.indication** (which indicates a failure to provide an Assured or Guaranteed service), as specified in 3.2.4.
- b) A data system may not implement one or other of the **PACKET\_SEND.request** or **PACKET\_RECEIVE.indication** primitives.

NOTE – In this case, the data system is only capable of simplex packet communication.

- c) A data system implementing the Subnetwork Packet Service shall implement the **PACKET\_FAILURE.indication** primitive in the case of Guaranteed and Assured service classes.

### 3.2.2 PACKET\_SEND.REQUEST

#### 3.2.2.1 Function

The **PACKET\_SEND.request** primitive shall be used to request the service to send an SDU to a destination protocol entity which is a user of the service.

NOTE – The SDU is assigned a priority level which determines the urgency with which it will be sent and forwarded through the onboard subnetwork.

#### 3.2.2.2 Semantics

The **PACKET\_SEND.request** primitive shall use the following semantics, with the meaning of the parameters defined in 3.2.2.5:

**PACKET\_SEND.request** (PSSAP Address, PDSAP Address, Service Class, Priority, Channel, Data)

#### 3.2.2.3 When Generated

The **PACKET\_SEND.request** primitive shall be passed to the SOIS Subnetwork Packet Service provider to request that the Data be sent.

#### 3.2.2.4 Effect on Receipt

Receipt of the **PACKET\_SEND.request** primitive shall cause the SOIS Subnetwork service provider to encapsulate the SDU and to issue a PDU over the underlying data link/subnetwork.

#### 3.2.2.5 Additional Comments

- a) The PDSAP Address parameter shall identify the user entity to which the data is directed.
- b) The PSSAP Address parameter shall identify the user entity that is sending the data.
- c) The Data parameter shall provide the information to be sent from the Source to the Destination user entity.
- d) The Priority parameter shall indicate the level of precedence that should be given to the data compared to other SDUs being serviced or other PDUs in the same channel on the subnetwork.
- e) The Channel parameter shall provide the identifier of the set of reserved resources that are to be used to send the data in the Reserved or Guaranteed service classes.
- f) The Service Class parameter shall indicate the quality of service which was applied to the service request, as specified in 3.1.5.

### 3.2.3 PACKET\_RECEIVE.INDICATION

#### 3.2.3.1 Function

The **PACKET\_RECEIVE.indication** primitive shall be used to pass the contents of a received packet service PDU to the user protocol entity.

#### 3.2.3.2 Semantics

The **PACKET\_RECEIVE.indication** primitive shall use the following semantics, with the meaning of the parameters specified in 3.2.3.5:

**PACKET\_RECEIVE.indication** (PSSAP Address, PDSAP Address, Service Class, Channel, Data)

#### 3.2.3.3 When Generated

The **PACKET\_RECEIVE.indication** primitive shall be issued by the service provider to the receiving application on receipt of a Data PDU.

#### 3.2.3.4 Effect on Receipt

The response of the user entity to a **PACKET\_RECEIVE.indication** primitive is unspecified.

#### 3.2.3.5 Additional Comments

- a) The PDSAP Address parameter shall identify the user entity that is receiving the data.
- b) The PSSAP Address parameter shall identify the user entity that sent the data.
- c) The Data parameter shall provide the data received by the packet protocol entity and directed to the specified user entity.
- d) The Channel parameter shall be passed to define the channel in which sequence preservation is provided.
- e) The Service Class parameter shall indicate the quality of service which was applied to the service request, as specified in 3.1.5.

### 3.2.4 PACKET\_FAILURE.INDICATION

#### 3.2.4.1 Function

The **PACKET\_FAILURE.indication** primitive shall be used, for the Guaranteed and Assured service classes, to indicate to the user that requested to send data, that it has been impossible to send and confirm delivery of an SDU.

#### 3.2.4.2 Semantics

The **PACKET\_FAILURE.indication** primitive shall use the following semantics, with the meaning of the parameters specified in 3.2.4.5.

**PACKET\_FAILURE.indication** (PSSAP Address, PDSAP Address, Failure Metadata)

#### 3.2.4.3 When Generated

The **PACKET\_FAILURE.indication** primitive shall be issued by the service provider to the service user when, for whatever reason, it has proved impossible to satisfy the service request.

#### 3.2.4.4 Effect on Receipt

The effect of receipt of the **PACKET\_FAILURE.indication** primitive is unspecified.

#### **3.2.4.5 Additional Comments**

- a) The PACKET\_FAILURE.indication primitive shall be invoked only in relation to transactions related to the Assured or Guaranteed service classes.
- b) The PDSAP Address parameter shall identify the user entity where the data should have been received.
- c) The PSSAP Address parameter shall identify the user entity that sent the data and the recipient of the PACKET\_FAILURE.indication primitive.
- d) The Failure Metadata parameter shall provide information about the type of error that occurred resulting in the failure to send and confirm delivery of the Data PDU to the specified destination.

## **4 MANAGEMENT INFORMATION BASE**

### **4.1 OVERVIEW**

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

### **4.2 SPECIFICATIONS**

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

### **4.3 MIB GUIDANCE**

The MIB of the protocol providing the Packet service should consider the following aspects:

- allowable priority levels per PSAP Address;
- allowable channelisation per PSAP Address;
- allowable priorities per channel;
- resource allocation per channel;
- Failure Metadata semantics;
- MTU size;
- managed allocation of PSAP Addresses to:
  - priority,
  - channel,
  - service class.

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



## 5 SERVICE CONFORMANCE STATEMENT PROFORMA

For any protocol specification claiming to provide this service, this proforma shall be completed, giving details of the capabilities of the specification, and made available to any party evaluating the use of the specification to which the completed proforma refers.

<b>Service Conformance Statement</b> <b>SOIS Subnetwork Packet Service</b>
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### Specification Information

Protocol Specification Identification	
Version	
Underlying Data link	

### Mandatory Features

Best-Effort Service Class	√
PACKET_SEND.request	*
PACKET_RECEIVE.indication	*

\* at least one of these primitives to be implemented.

### Optional Features

Assured Service Class	
Reserved Service Class	
Guaranteed Service Class	
Channel Parameter	
Priority Parameter	
PACKET_FAILURE.indication	

### Other Information

Priority Levels	
Channelisation	
Failure Metadata	
MTU size	In octets

## ANNEX A

### INFORMATIVE REFERENCES

- [A1] *Spacecraft Onboard Interface Services*. Report Concerning Space Data System Standards, CCSDS 850.0-G-1. Green Book. Issue 1. Washington, D.C.: CCSDS, June 2007.
- [A2] *The Application of CCSDS Protocols to Secure Systems*. Report Concerning Space Data System Standards, CCSDS 350.0-G-2. Green Book. Issue 2. Washington, D.C.: CCSDS, January 2006.
- [A3] *Information Technology—Open Systems Interconnection—Basic Reference Model: The Basic Model*. International Standard, ISO/IEC 7498-1:1994. 2nd ed. Geneva: ISO, 1994.

NOTE – Normative references are listed in 1.7.