
**Space data and information transfer
systems — Encapsulation service**

*Systèmes de transfert des informations et données spatiales — Service
d'encapsulation*

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
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Published in Switzerland

Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10537 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 661.0-B-1, September 2008) and was adopted (without modifications except those stated in Clause 2 of this International Standard) by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 13, *Space data and information transfer systems*.

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Space data and information transfer systems — Encapsulation service

1 Scope

This International Standard specifies the encapsulation service, which is used by space missions to transfer data units that are not directly transferred by the space data link protocols over a ground-to-space or space-to-space communications link.

The scope and field of application are further detailed in subclauses 1.2 and 1.3 of the enclosed CCSDS publication.

2 Requirements

Requirements are the technical recommendations made in the following publication (reproduced on the following pages), which is adopted as an International Standard:

CCSDS 133.1-B-1, June 2006, *Encapsulation service*

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 133.1-B-1.

Pages i to v

This part is information which is relevant to the CCSDS publication only.

Page 1-5

Add the following information to the reference indicated:

- [1] Document CCSDS 132.0-B-1, September 2003, is equivalent to ISO 22645:2005.
- [2] Document CCSDS 232.0-B-1, September 2003, is equivalent to ISO 22664:2005.
- [3] Document CCSDS 732.0-B-2, July 2006, is equivalent to ISO 22666:2007.
- [4] Document CCSDS 211.0-B-4, July 2006, is equivalent to ISO 22663:2007.
- [5] Document CCSDS 133.0-B-1, September 2003, is equivalent to ISO 22646:2005.
- [7] Document CCSDS 135.0-B-1, January 2002, is equivalent to ISO 22647:2006.

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Add the following information to the reference indicated:

[B3] Document CCSDS 102.0-B-5, November 2000, is equivalent to ISO 13419:2003.

[B4] Document CCSDS 203.0-B-2, June 2001, is equivalent to ISO 12174:2003.

3 Revision of publication CCSDS 133.1-B-1

It has been agreed with the Consultative Committee for Space Data Systems that Subcommittee ISO/TC 20/SC 13 will be consulted in the event of any revision or amendment of publication CCSDS 133.1-B-1. To this end, NASA will act as a liaison body between CCSDS and ISO.

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Recommendation for Space Data System Standards

ENCAPSULATION SERVICE

Recommended Standard

CCSDS 133.1-B-1

Blue Book
June 2006

Note:
This current
issue includes
all updates through
Technical Corrigendum 1,
dated October 2006.

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AUTHORITY

Issue:	Recommended Standard, Issue 1
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 Recommendations is detailed in the *Procedures Manual for the Consultative Committee for Space Data Systems*, and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the address below.

This document is published and maintained by:

CCSDS Secretariat
Office of Space Communication (Code M-3)
National Aeronautics and Space Administration
Washington, DC 20546 USA

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STATEMENT OF INTENT

The Consultative Committee for Space Data Systems (CCSDS) is an organization officially established by the management of its members. The Committee meets periodically to address data systems problems that are common to all participants, and to formulate sound technical solutions to these problems. Inasmuch as participation in the CCSDS is completely voluntary, the results of Committee actions are termed **Recommended Standards** and are not considered binding on any Agency.

This **Recommended Standard** is issued by, and represents the consensus of, the CCSDS members. Endorsement of this **Recommendation** is entirely voluntary. Endorsement, however, indicates the following understandings:

- o Whenever a member establishes a CCSDS-related **standard**, this **standard** will be in accord with the relevant **Recommended Standard**. Establishing such a **standard** does not preclude other provisions which a member may develop.
- o Whenever a member establishes a CCSDS-related **standard**, that member will provide other CCSDS members with the following information:
 - The **standard** itself.
 - The anticipated date of initial operational capability.
 - The anticipated duration of operational service.
- o Specific service arrangements shall be made via memoranda of agreement. Neither this **Recommended Standard** nor any ensuing **standard** is a substitute for a memorandum of agreement.

No later than five years from its date of issuance, this **Recommended Standard** will be reviewed by the CCSDS to determine whether it should: (1) remain in effect without change; (2) be changed to reflect the impact of new technologies, new requirements, or new directions; or (3) be retired or canceled.

In those instances when a new version of a **Recommended Standard** is issued, existing CCSDS-related member standards and implementations are not negated or deemed to be non-CCSDS compatible. It is the responsibility of each member to determine when such standards or implementations are to be modified. Each member is, however, strongly encouraged to direct planning for its new standards and implementations towards the later version of the Recommended Standard.

CCSDS RECOMMENDED STANDARD FOR ENCAPSULATION SERVICE

FOREWORD

This document is a **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 Encapsulation Service described herein is intended for missions that are cross-supported between Agencies of the CCSDS.

This **Recommended Standard** specifies a communications service to be used by space missions to transfer protocol data units that are not directly transferred by the Space Data Link Protocols (references [1]-[3]) over a ground-to-space or space-to-space communications link. The data units transferred with this service are encapsulated in either Space Packets, defined in reference [5], or Encapsulation Packets, defined in this document.

This **Recommended Standard** is developed from the Encapsulation Service that was defined in the Advanced Orbiting Systems (AOS) Recommended Standard (reference [B2]). In this **Recommended Standard**, that service is re-defined so that it can be used with any of the Space Data Link Protocols (references [1]-[3]). Also, the Encapsulation Packet that was defined in references [B2]-[B4] is included in this **Recommended Standard** as an alternative packet structure for encapsulation.

In order to define all Space Data Link Protocols in a unified way, a few technical specifications of the Encapsulation Service in reference [B2] have been changed. Also, some technical terms in references [B2]-[B4] have been changed in order to unify the terminology used in all the CCSDS Recommended Standards that define space link protocols. These changes are listed in annex C of this **Recommended Standard**.

Through the process of normal evolution, it is expected that expansion, deletion or modification to this document may occur. This Recommended Standard is therefore subject to CCSDS document management and change control procedures, as defined in reference [B1]. Current versions of CCSDS documents are maintained at the CCSDS Web site:

<http://www.ccsds.org/>

Questions relating to the contents or status of this document should be addressed to the CCSDS Secretariat at the address indicated on page i.

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- National Aeronautics and Space Administration (NASA)/USA.

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- European Telecommunications Satellite Organization (EUTELSAT)/Europe.
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- KFKI Research Institute for Particle & Nuclear Physics (KFKI)/Hungary.
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- United States Geological Survey (USGS)/USA.

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DOCUMENT CONTROL

Document	Title and Issue	Date	Status
CCSDS 133.1-B-1	Encapsulation Service, Recommended Standard, Issue 1	June 2006	Current issue

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1 INTRODUCTION

1.1 PURPOSE

The purpose of this Recommended Standard is to specify the Encapsulation Service. This service is to be used by space missions to transfer data units that are not directly transferred by the Space Data Link Protocols (references [1]-[4]) over a ground-to-space or space-to-space communications link.

1.2 SCOPE

This Recommended Standard defines the Encapsulation Service in terms of:

- a) the service primitives provided to the users of this service;
- b) the protocol data units employed by the service provider; and
- c) the procedures performed by the service provider.

It does not specify:

- a) individual implementations or products;
- b) the implementation of service interfaces within real systems;
- c) the methods or technologies required to perform the procedures; or
- d) the management activities required to configure and control the service.

1.3 APPLICABILITY

This Recommended Standard applies to the creation of Agency standards and to the future data communications over space links between CCSDS Agencies in cross-support situations. The Recommended Standard includes comprehensive specification of the service for inter-Agency cross support. It is neither a specification of, nor a design for, real systems that may be implemented for existing or future missions.

The Recommended Standard specified in this document is to be invoked through the normal standards programs of each CCSDS Agency, and is applicable to those missions for which cross support based on capabilities described in this Recommended Standard is anticipated. Where mandatory capabilities are clearly indicated in sections of the Recommended Standard, they must be implemented when this document is used as a basis for cross support. Where options are allowed or implied, implementation of these options is subject to specific bilateral cross support agreements between the Agencies involved.

1.4 RATIONALE

The CCSDS believes it is important to document the rationale underlying the recommendations chosen, so that future evaluations of proposed changes or improvements will not lose sight of previous decisions. Concept and rationale behind the decisions that formed the basis for this Recommended Standard is documented in reference [B5].

1.5 DOCUMENT STRUCTURE

This document is divided into five numbered sections and three annexes:

- a) Section 1 presents the purpose, scope, applicability and rationale of this Recommended Standard and lists the conventions, definitions, and references used throughout the document;
- b) Section 2 provides an overview of the Encapsulation Service;
- c) Section 3 defines the service primitives provided for this service;
- d) Section 4 specifies the protocol data units and procedures employed by the service provider;
- e) Section 5 lists the managed parameters associated with this service;
- f) Annex A lists all acronyms used within this document;
- g) Annex B provides a list of informative references;
- h) Annex C lists the changes from older CCSDS Recommendations [B2]-[B4].

1.6 CONVENTIONS AND DEFINITIONS

1.6.1 DEFINITIONS

1.6.1.1 Definitions from the Open Systems Interconnection (OSI) Basic Reference Model

This Recommended Standard makes use of a number of terms defined in reference [6]. The use of those terms in this Recommended Standard shall be understood in a generic sense; i.e., in the sense that those terms are generally applicable to any of a variety of technologies that provide for the exchange of information between real systems. Those terms are:

- a) blocking;
- b) connection;
- c) entity;
- d) flow control;

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- e) protocol data unit;
- f) real system;
- g) segmenting;
- h) service;
- i) Service Access Point (SAP);
- j) SAP address;
- k) service data unit.

1.6.1.2 Definitions from OSI Service Definition Conventions

This Recommended Standard makes use of a number of terms defined in reference [7]. The use of those terms in this Recommended Standard shall be understood in a generic sense; i.e., in the sense that those terms are generally applicable to any of a variety of technologies that provide for the exchange of information between real systems. Those terms are:

- a) indication;
- b) primitive;
- c) request;
- d) service provider;
- e) service user.

1.6.1.3 Terms Defined in This Recommended Standard

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

asynchronous: not *synchronous* (see below).

delimited: having a known (and finite) length; applies to data in the context of data handling.

Physical Channel: a stream of bits transferred over a space link in a single direction.

space link: a communications link between a spacecraft and its associated ground system, or between two spacecraft. A space link consists of one or more Physical Channels in one or both directions.

synchronous: of or pertaining to a sequence of events occurring in a fixed time relationship (within specified tolerance) to another sequence of events.

1.6.2 NOMENCLATURE

The following conventions apply throughout 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.

1.6.3 CONVENTIONS

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).

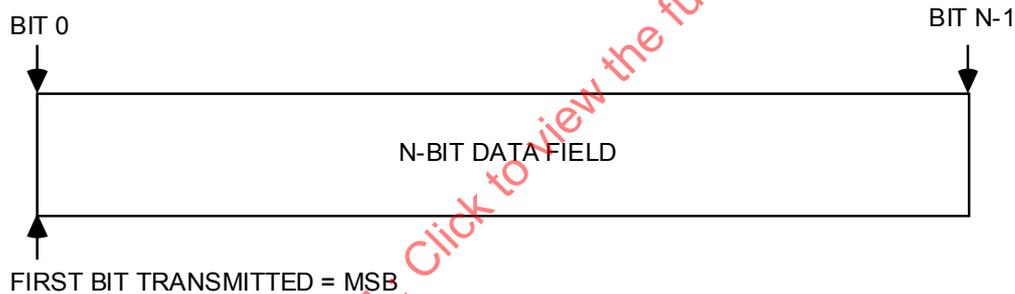


Figure 1-1: Bit Numbering Convention

In accordance with standard data-communications practice, data fields are often grouped into 8-bit 'words' which conform to the above convention. Throughout this Recommended Standard, such an 8-bit word is called an 'octet'.

The numbering for octets within a data structure starts with 0.

By CCSDS convention, all 'spare' bits shall be permanently set to value 'zero'.

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1.7 REFERENCES

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

- [1] *TM Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 132.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.
- [2] *TC Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 232.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.
- [3] *AOS Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 732.0-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, July 2006.
- [4] *Proximity-1 Space Link Protocol—Data Link Layer*. Recommendation for Space Data System Standards, CCSDS 211.0-B-4. Blue Book. Issue 4. Washington, D.C.: CCSDS, July 2006.
- [5] *Space Packet Protocol*. Recommendation for Space Data System Standards, CCSDS 133.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.
- [6] *Information Technology—Open Systems Interconnection—Basic Reference Model: The Basic Model*. International Standard, ISO/IEC 7498-1. 2nd ed. Geneva: ISO, 1994.
- [7] *Information Technology—Open Systems Interconnection—Basic Reference Model—Conventions for the definition of OSI services*. International Standard, ISO/IEC 10731:1994. Geneva: ISO, 1994.
- [8] *Space Link Identifiers*. Recommendation for Space Data System Standards, CCSDS 135.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, January 2002.

NOTE – Informative references are listed in annex B.

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2 OVERVIEW

2.1 CONCEPT OF ENCAPSULATION SERVICE

The Encapsulation Service is a data transfer service to be used by space missions to transfer data units that are not directly transferred by the Space Data Link Protocols (references [1]-[4]) over a ground-to-space or space-to-space communications link (hereafter called a space link).¹

Data units that are directly transferred by the Space Data Link Protocols have a Packet Version Number (PVN) authorized by CCSDS. (A list of the Packet Version Numbers presently authorized by CCSDS is contained in reference [8].) The main purpose of the Encapsulation Service is to provide a mechanism to transfer data units without an authorized PVN over a space link.

The Encapsulation Service is a service provided by the Data Link Layer of the OSI Basic Reference Model [6] (see figure 2-1). It is an extra service of the Space Data Link Protocols defined in references [1]-[4], and therefore shall be used together with one of these references.

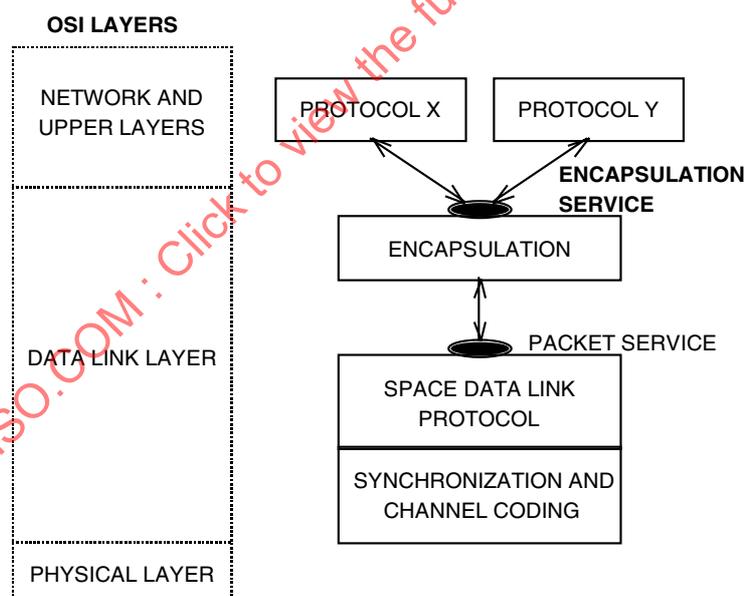


Figure 2-1: Concept of Encapsulation Service

Figure 2-1 illustrates the concept of this service. Protocol data units of Protocols X and Y, which do not have an authorized PVN, are transferred with the Encapsulation Service within the Data Link Layer. Protocol data units of Protocols X and Y are encapsulated in either

¹ An IPv4 datagram can be optionally transferred by the Space Data Link Protocols within a CCSDS Encapsulation Packet. This alternative provides a migration path from IPv4 to IPv6, since an IPv6 datagram is required to be transferred within an Encapsulation Packet.

Space Packets defined in reference [5] or Encapsulation Packets defined in subsection 4.2 of this document, and are transferred using the Packet Service of a Space Data Link Protocol. When Space Packets are used for encapsulation, some rules on their format (described in subsection 4.1) shall be applied. Management shall establish which Space Data Link Protocol is to be used to transfer encapsulated data units.

2.2 FEATURES OF ENCAPSULATION SERVICE

The Encapsulation Service transfers a sequence of variable-length, delimited, octet-aligned data units with a Space Data Link Protocol over a space link. A user of this service is a protocol entity that sends or receives protocol data units that do not have an authorized PVN. The format and content of data units transferred with this service are unknown to the service provider.

A data unit supplied by the service user is encapsulated unchanged into a Space Packet or an Encapsulation Packet and no more than one data unit is encapsulated into a single packet. An implementation is conformant if it implements either the Space Packet or the Encapsulation Packet; i.e., both are not required.

The service permits a data unit to be of any length which is an integral number of octets, and which is subject to the maximum and minimum sizes established by the project organization. Although the maximum length of a data unit that can be accommodated by an encapsulating packet is 65,536 octets (if the Space Packet is used) or 4,294,967,291 octets (if the Encapsulation Packet is used), individual project organizations may establish the maximum and minimum sizes for the encapsulated data unit.

The point at which an instance of this service is provided to a user is called a Service Access Point (SAP) [6]. Data units submitted to a SAP are processed in the order of submission. No processing order is maintained for data units submitted to different SAPs.

NOTE – Implementations may be required to perform flow control at an SAP between the service user and the service provider. However, CCSDS does not recommend a scheme for flow control between the user and the provider.

Features of the Encapsulation Service are as follows:

- a) Unidirectional (one way) service: one end of a connection can send, but not receive, data through the space link, while the other end can receive, but not send, data through the space link.
- b) Asynchronous service: There are no timing relationships between the transfer of data units supplied by the user and any data transmission mechanism within the Data Link Layer. The user may request data transfer at any time, but there may be restrictions imposed by the service provider on the data generation rate.
- c) Unconfirmed service: the sending user does not receive confirmation from the receiving end indicating that data has been received.

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- d) Incomplete service: the service does not guarantee completeness, but the service provider may signal gaps in the sequence of data units delivered to the receiving user.
- e) Sequence preserving service: the sequence of data units supplied by the sending user is preserved through the transfer over the space link, although there may be gaps in the sequence of data units delivered to the receiving user.

2.3 ADDRESSING

A user of the Encapsulation Service is identified by the combination of the following:

- a) a Packet Version Number (PVN) that indicates whether Space Packets (PVN=1) or Encapsulation Packets (PVN=8) are used for encapsulation, and
- b) an Encapsulated Protocol Identifier (EPI).

An Encapsulated Protocol Identifier is either:

- a) an Application Process Identifier (APID) defined in reference [5] (if Space Packets are used); or
- b) a Protocol ID defined in section 4 of this document (if Encapsulation Packets are used).

The APIDs used by the Encapsulation Service must be registered as ‘reserved APIDs’ in reference [8]. The Protocol IDs used by the Encapsulation Service must be registered as ‘defined Protocol IDs’ in reference [8].

An SAP is identified by the combination of a PVN, an EPI, and a Global Virtual Channel Identifier (GVCID). The GVCID identifies the Virtual Channel of the underlying Space Data Link Protocol through which the data units supplied by the user are to be transferred.

NOTE – Definitions of the Virtual Channel and the Global Virtual Channel Identifier are contained in references [1]-[4].

2.4 SERVICE DESCRIPTION

The Encapsulation Service is described in terms of:

- a) the service primitives provided to the users of this service;
- b) the protocol data units employed by the service provider for encapsulation; and
- c) the procedures performed by the service provider.

The service primitives present an abstract model of the logical exchange of data and control information between the service provider and the service user. The definitions of primitives are independent of specific implementation approaches.

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The protocol data units (i.e., the Space Packet and the Encapsulation Packet) define the data structure in which data units supplied by the service user are encapsulated.

The procedure specifications define the procedures performed by the service provider for the transfer of data units. The definitions of procedures are independent of specific implementation methods or technologies.

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3 SERVICE DEFINITION

3.1 OVERVIEW

This section provides service definition in the form of primitives, which present an abstract model of the logical exchange of data and control information between the service provider and the service user. The definitions of primitives are independent of specific implementation approaches.

The parameters of the primitives are specified in an abstract sense and specify the information to be made available to the user of the primitive. The way in which a specific implementation makes this information available is not constrained by this specification. In addition to the parameters specified in this section, an implementation may provide other parameters to the service user (e.g., parameters for controlling the service, monitoring performance, facilitating diagnosis, and so on).

3.2 SERVICE PARAMETERS

NOTE – The parameters used by the Encapsulation Service primitives are described in subsections 3.2.1 through 3.2.5.

3.2.1 DATA UNIT

The parameter Data Unit is the service data unit transferred by the Encapsulation Service, and it shall be a delimited, octet-aligned data unit.

Although the maximum length of a data unit that can be accommodated in an encapsulating packet is 65,536 octets (if the Space Packet is used) or 4,294,967,291 octets (if the Encapsulation Packet is used), individual project organizations may establish the maximum and minimum sizes for the encapsulated data unit.

3.2.2 GVCID

The Global Virtual Channel Identifier (GVCID) is part of the SAP address of the Encapsulation Service, and it shall indicate the Virtual Channel of the underlying Space Data Link Protocol through which the Data Unit is to be transferred.

3.2.3 PVN

The Packet Version Number (PVN) is part of the SAP address of the Encapsulation Service, and it shall indicate whether the Space Packet or the Encapsulation Packet is to be used for encapsulating the Data Unit. The value of the PVN shall be either 1 (if the Space Packet is used) or 8 (if the Encapsulation Packet is used).

3.2.4 EPI

The Encapsulated Protocol Identifier (EPI) is part of the SAP address of the Encapsulation Service. It shall be either an Application Process Identifier (APID) as defined in reference [5] (if the Space Packet is used), or a Protocol ID as defined in section 4 of this document (if the Encapsulation Packet is used).

3.2.5 DATA UNIT LOSS FLAG

The Data Unit Loss Flag is an optional parameter that may be used to notify the user at the receiving end of the Encapsulation Service that a sequence discontinuity has been detected and that one or more Data Units have been lost. This flag may be used only if the Space Packet is used for encapsulation. If implemented, the flag shall be derived by examining the Packet Sequence Count in the Packet Primary Header of the Space Packet (defined in reference [5]).

3.3 SERVICE PRIMITIVES

3.3.1 GENERAL

The service primitives associated with this service are:

- a) ENCAPSULATION.request. The ENCAPSULATION.request primitive shall be passed from the Encapsulation Service user at the sending end to the service provider to request that a Data Unit be transferred, through the underlying Space Data Link Protocol, to the user at the receiving end.
- b) ENCAPSULATION.indication. The ENCAPSULATION.indication shall be passed from the service provider to the Encapsulation Service user at the receiving end in order to deliver a Data Unit.

3.3.2 ENCAPSULATION.REQUEST

3.3.2.1 Function

The ENCAPSULATION.request primitive shall be the service request primitive for the Encapsulation Service.

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3.3.2.2 Semantics

The ENCAPSULATION.request primitive shall provide parameters as follows:

ENCAPSULATION.request	(Data Unit, GVCID, PVN, EPI)
-----------------------	---------------------------------------

NOTE – Information on the management of the GVCID, PVN, and EPI parameters, and where applicable values are defined, is contained in reference [8].

3.3.2.3 When Generated

The ENCAPSULATION.request primitive shall be passed to the service provider to request it to send the Data Unit.

3.3.2.4 Effect On Receipt

Receipt of the ENCAPSULATION.request primitive shall cause the service provider to transfer the Data Unit.

3.3.2.5 Additional Comments

The ENCAPSULATION.request primitive shall be used to transfer Data Units across the space link through the underlying Space Data Link Protocol.

3.3.3 ENCAPSULATION.INDICATION**3.3.3.1 Function**

The ENCAPSULATION.indication primitive shall be the service indication primitive for the Encapsulation Service.

3.3.3.2 Semantics

The ENCAPSULATION.indication primitive shall provide parameters as follows:

ENCAPSULATION.indication	(Data Unit, GVCID, PVN, EPI, Data Unit Loss Flag (optional))
--------------------------	--

NOTE – Information on the management of the GVCID, PVN, and EPI parameters, and where applicable values are defined, is contained in reference [8].

3.3.3.3 When Generated

The ENCAPSULATION.indication primitive shall be passed from the service provider to the Encapsulation Service user at the receiving end in order to deliver a Data Unit.

3.3.3.4 Effect On Receipt

The effect on receipt of the ENCAPSULATION.indication primitive by the Encapsulation Service user is undefined.

3.3.3.5 Additional Comments

The ENCAPSULATION.indication primitive shall be used to deliver Data Units to the Encapsulation Service user identified by the GVCID, PVN and EPI.

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4 DATA UNITS AND PROCEDURES**4.1 SPACE PACKET**

The format of the Space Packet is defined in reference [5].

The following rules on the format of the Space Packet shall be applied when the Space Packet is used for encapsulating data units supplied by the service user:

- a) the Packet Secondary Header shall be absent, and the value of the Secondary Header Flag shall be '0';
- b) the Application Process Identifier (APID) shall be chosen from one of the reserved APIDs in the 2040 to 2044 range documented in reference [8];
- c) the value of the Sequence Flags shall be '11';
- d) the Packet Sequence Count shall always be used instead of a Packet Name;
- e) one data unit supplied by the service user shall be placed in the User Data Field of a Space Packet.

4.2 ENCAPSULATION PACKET**4.2.1 GENERAL**

An Encapsulation Packet shall encompass the major fields, positioned contiguously, in the following sequence:

- a) Packet Header (1 to 8 octets, mandatory);
- b) Encapsulated Data Unit (from 0 to 4,294,967,291 octets, optional).

An Encapsulation Packet shall consist of at least 1 and at most 4,294,967,296 octets.

NOTE – The maximum Encapsulation Packet length allowed by a particular spacecraft or ground implementation may be less than the maximum specified here.

The structural components of the Encapsulation Packet are shown in figure 4-1.

NOTE – The definition of the Encapsulation Packet Header, below, differs from and is incompatible with the initial definition contained in references [B2]-[B4]. The definition below replaces the initial definition and renders it obsolete.

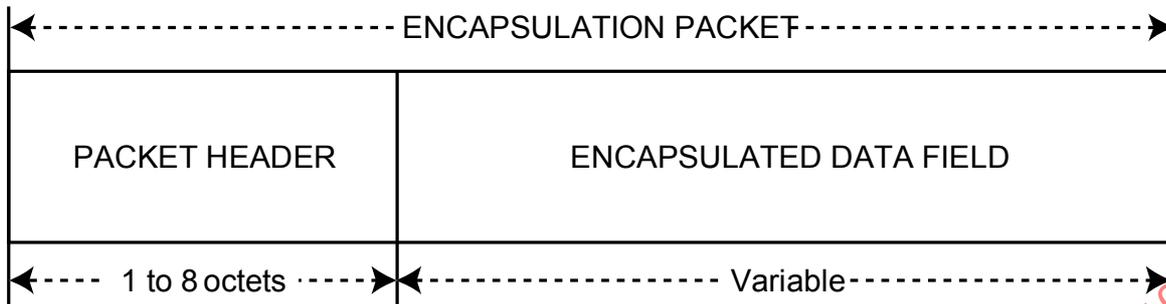


Figure 4-1: Encapsulation Packet Structural Components

4.2.2 ENCAPSULATION PACKET HEADER

4.2.2.1 General

The Packet Header is mandatory and shall consist of three, four, five, or six fields, positioned contiguously, in the following sequence:

- a) Packet Version Number (3 bits, mandatory);
- b) Protocol ID (3 bits, mandatory);
- c) Length of Length (2 bits, mandatory);
- d) User Defined Field (4 bits; mandatory in 4- and 8-octet headers; not used in 1- and 2-octet headers—see figure 4-2);
- e) Protocol ID Extension Field (4 bits; mandatory in 4- and 8-octet headers; not used in 1- and 2-octet headers—see figure 4-2);
- f) CCSDS Defined Field (2 octets; mandatory in 8-octet headers; not used in 1-, 2-, and 4-octet headers—see figure 4-2);
- g) Packet Length (0, 1, 2, or 4 octets; mandatory in 2-, 4-, and 8-octet headers; not used in 1-octet headers—see figure 4-2).

The format of the Packet Header is shown in figure 4-2.

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←———— ENCAPSULATION PACKET HEADER —————→

PACKET VERSION NUMBER 3 bits	PROTOCOL ID 3 bits	LENGTH OF LENGTH 2 bits	USER DEFINED FIELD 0 or 4 bits	PROTOCOL ID EXTENSION 0 or 4 bits	CCSDS DEFINED FIELD 0 or 2 octets	PACKET LENGTH 0 to 4 octets
'111'	'XXX'	'00'	0 bits	0 bits	0 octets	0 octets
'111'	'XXX'	'01'	0 bits	0 bits	0 octets	1 octet
'111'	'XXX'	'10'	4 bits	4 bits	0 octets	2 octets
'111'	'XXX'	'11'	4 bits	4 bits	2 octets	4 octets

Figure 4-2: Packet Header

4.2.2.2 Packet Version Number

Bits 0-2 of the Packet Header shall contain the (Binary Encoded) Packet Version Number.

This 3-bit field shall identify the data unit as an Encapsulation Packet defined by this subsection; it shall be set to '111'.

NOTE – The Version Number is used to reserve the possibility of introducing other packet structures. This subsection defines 'Encapsulation Packet (Version 8 CCSDS Packet)' whose Binary Encoded Version Number is '111'.

4.2.2.3 Protocol ID

Bits 3-5 of the Packet Header shall contain the Protocol ID.

The Protocol ID shall be used to identify the protocol whose data units are being encapsulated.

The Protocol IDs allowed by CCSDS for the Encapsulation Packet shall be registered in reference [8].

The value '110' in the Protocol ID field shall signal that the 4-bit Protocol ID Extension field is used for protocol identification.

NOTE – The protocol ID '111' is used for sending mission-specific, privately defined data (i.e., not data units of a protocol to which a Protocol ID is assigned in reference [8]) with the Encapsulation Packet).

4.2.2.4 Length of Length

Bits 6-7 of the Packet Header shall contain the Length of Length.

The Length of Length shall be used to specify the length of the Packet Length field.

The values of this field shall be interpreted as shown in table 4-1.

Table 4-1: Interpretation of Length of Length Field

Value of 'Length of Length' Field (binary)	Length of 'Packet Length' Field
00	0
01	1 octet
10	2 octets
11	4 octets

The value '00' of the Length of Length field shall only be used for Encapsulation Packets with Protocol ID '000' (i.e., Fill Packets).

NOTE – When the value of the Length of Length field is '00', there is no Packet Length field in the Packet Header, and there is no Encapsulated Data Unit field in the Encapsulated Packet. Therefore the length of the Encapsulated Packet is one octet. *This one-octet Encapsulation Packet can thus also be used as a single, self-identified octet of fill which may be cascaded to provide any number of octets to fill a fixed-length Transfer Frame used in references [1] and [2].*

4.2.2.5 User Defined Field

If present, the User Defined field shall be four bits in length and shall follow, without gap, the Length of Length field.

The User Defined field shall be used for sending mission-specific, privately defined header data.

4.2.2.6 Protocol ID Extension

If present, the Protocol ID Extension field shall be four bits in length and shall follow, without gap, the User Defined Field.

The Protocol ID Extension field shall be used to identify the protocol whose data units are being encapsulated.

The extended protocol IDs allowed by CCSDS for the Encapsulation Packet shall be registered in reference [8].

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4.2.2.7 CCSDS Defined Field

If present, the CCSDS Defined field shall be two octets in length and shall follow, without gap, the User Defined field.

The CCSDS Defined field is reserved for future use by CCSDS and is by convention set to 'all zeros'.

4.2.2.8 Packet Length

If present, the Packet Length field shall be the final field in the Encapsulation Packet header (see figure 4-2).

If the value of the Length of Length field is '00', the Packet Length field shall be absent. Otherwise, the Packet Length field shall contain a binary number corresponding to the total length of the Encapsulation Packet (in octets), including the Packet Header.

NOTES

- 1 Although unlikely to be used in space, a 4-octet Packet Length field permits accommodating IPv6 (reference [B6]) 'Jumbograms' up to 4,294,967,291 ($=2^{32}-5$) octets in length.
- 2 If the Packet Length field is absent (i.e., the value of the Length of Length field is '00'), then the length of the Encapsulation Packet is one octet.

4.2.3 ENCAPSULATED DATA FIELD

If present, the Encapsulated Data Field shall follow, without gap, the Packet Length field.

If the value of the Length of Length field is '00', the Encapsulated Data Field shall be absent. Otherwise, it shall contain a data unit, supplied by the service user, consisting of an integral number of octets.

4.3 PROCEDURES AT THE SENDING END

NOTE – This subsection describes procedures for providing the Encapsulation Service at the sending end (see figure 4-3). The procedures described here are defined in an abstract sense and are not intended to imply any particular implementation approach of the service.

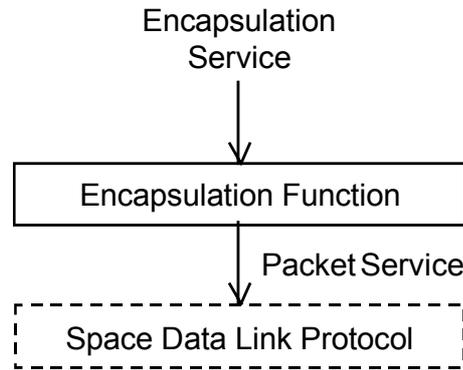


Figure 4-3: Internal Organization of Encapsulation Service (Sending End)

The Encapsulation Function (see figure 4-1) shall be used to encapsulate data units supplied by the service users. There is an instance of the Encapsulation Function for each packet structure used for encapsulation (i.e., one instance for Space Packets and one for Encapsulation Packets).

The Encapsulation Function receives data units from the service users. Any data unit that violates the limits of the size shall be rejected. Each valid data unit shall be encapsulated, either in a Space Packet or in an Encapsulation Packet, and passed to the Packet Service of the underlying Space Data Link Protocol.

4.4 PROTOCOL PROCEDURES AT THE RECEIVING END

NOTE – This subsection describes procedures for providing the Encapsulation Service at the receiving end (see figure 4-4). The procedures described here are defined in an abstract sense and are not intended to imply any particular implementation approach of the service.

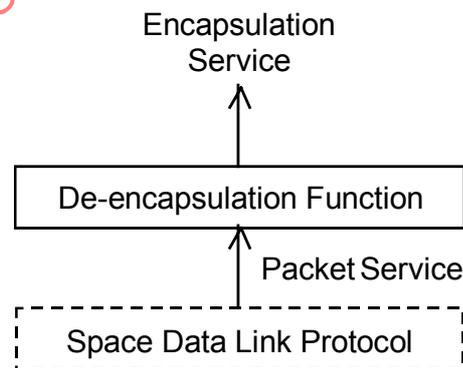


Figure 4-4: Internal Organization of Encapsulation Service (Receiving End)

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The De-encapsulation Function (see figure 4-2) shall be used to extract data units supplied by the service users. There is an instance of the Encapsulation Function for each packet structure used for encapsulation (i.e., one instance for Space Packets and one for Encapsulation Packets).

The De-Encapsulation Function shall receive Space Packets or Encapsulation Packets, from the Packet Service of the underlying Space Data Link Protocol, and extract original data units by stripping the headers of the encapsulating packets. If Space Packets are used, the De-Encapsulation Function optionally checks the continuity of the Packet Sequence Count to determine if one or more data units have been lost during transmission; the De-encapsulation Function then generates the optional Data Unit Loss Indicator parameter accordingly. Extracted data units shall be delivered to the service user identified by the APID (if Space Packets are used) or Protocol ID (if Encapsulation Packets are used).

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