

Space data and information transfer systems — TC (telecommand) space data link protocol

ICS 49.140

National foreword

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The UK participation in its preparation was entrusted to Technical Committee ACE/68, Space systems and operations, which has the responsibility to:

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This document comprises a front cover, an inside front cover, the ISO title page, pages ii and iii, a blank page, pages 1 to 110, an inside back cover and a back cover.

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INTERNATIONAL STANDARD

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Space data and information transfer systems — TC (telecommand) space data link protocol

*Systèmes de transfert des données et informations spatiales —
Protocole de liaison pour données spatiales TC (télécommande)*



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Foreword

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ISO 22664 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 232.0-B-1, September 2003) 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*.

Space data and information transfer systems — TC (telecommand) space data link protocol

1 Scope

This International Standard specifies the telecommand (TC) space data link protocol, a data link layer protocol as defined in ISO/IEC 7498-1, that is to be used over ground-to-space or space-to-space communications links by space missions.

The scope and field of application are furthermore detailed in subclauses 1.1 and 1.2 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 232.0-B-1, September 2003, *TC space data link protocol*.

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 232.0-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 references indicated:

- [3] Document CCSDS 231.0-B-1, September 2003, is equivalent to ISO 22642:2005.
- [4] Document CCSDS 232.1-B-1, September 2003, is equivalent to 22667:2005.
- [5] Document CCSDS 135.0-B-1, January 2002, is equivalent to ISO 22647:—¹⁾.

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Add the following information to the references indicated:

- [B2] Document CCSDS 202.0-B-3, June 2001, is equivalent to ISO 12172:2003.
- [B4] Document CCSDS 910.4-B-1, May 1996, is equivalent to ISO 15396:1998.
- [B5] Document CCSDS 132.0-B-1, September 2003, is equivalent to ISO 22645:2005.

1) To be published.

[B6] Document CCSDS 732.0-B-1, September 2003, is equivalent to ISO 22666:2005.

[B7] Document CCSDS 102.0-B-5, November 2000, is equivalent to ISO 13419:2003.

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 232.0-B-1. To this end, NASA will act as a liaison body between CCSDS and ISO.

Consultative Committee for Space Data Systems

RECOMMENDATION FOR SPACE
DATA SYSTEM STANDARDS

TC SPACE DATA LINK PROTOCOL

CCSDS 232.0-B-1

BLUE BOOK

September 2003



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CCSDS RECOMMENDATION FOR TC SPACE DATA LINK PROTOCOL

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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 reference [B1], and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the address below.

This Recommendation is published and maintained by:

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Washington, DC 20546, USA

STATEMENT OF INTENT

The Consultative Committee for Space Data Systems (CCSDS) is an organization officially established by the management of member space Agencies. 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 **Recommendations** and are not considered binding on any Agency.

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

CCSDS RECOMMENDATION FOR TC SPACE DATA LINK PROTOCOL

FOREWORD

This document is a technical Recommendation 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 TC Space Data Link Protocol described herein is intended for missions that are cross-supported between Agencies of the CCSDS.

This Recommendation specifies a communications protocol to be used by space missions to transfer space application data over ground-to-space or space-to-space communications links. This Recommendation is developed from the specifications of an older CCSDS Recommendation (reference [B2]), which defines essentially the same protocol and services but in a slightly different context.

This Recommendation does not change the major technical contents defined in reference [B2], but the presentation of the specification has been changed so that:

- a) this protocol can be used to transfer any data over any space link in either direction;
- b) all CCSDS space link protocols are specified in a unified manner;
- c) the specification matches the Open Systems Interconnection (OSI) Basic Reference Model (references [1] and [2]).

Together with the change in presentation, a few technical descriptions in reference [B2] have been changed to allow flexibility for future extensions of the CCSDS protocol suite. Also, some technical terms in reference [B2] have been changed in order to unify the terminology used in all the CCSDS Recommendations that define space link. These changes are listed in annex C of this Recommendation.

Through the process of normal evolution, it is expected that expansion, deletion or modification to this document may occur. This Recommendation 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:

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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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1 INTRODUCTION

1.1 PURPOSE

The purpose of this Recommendation is to specify the Telecommand (TC) Space Data Link Protocol. This protocol is a Data Link Layer protocol (see reference [1]) to be used over ground-to-space or space-to-space communications links by space missions.

1.2 SCOPE

This Recommendation defines the TC Space Data Link Protocol in terms of:

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

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 protocol.

1.3 APPLICABILITY

This Recommendation applies to the creation of Agency standards and to future data communications over space links between CCSDS Agencies in cross-support situations. The Recommendation includes comprehensive specification of the services and protocol 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 Recommendation 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 Recommendation is anticipated. Where mandatory capabilities are clearly indicated in sections of the Recommendation, 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.

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 Recommendation and lists the conventions, definitions, and normative references used throughout the Recommendation;
- b) section 2 provides an overview of the TC Space Data Link Protocol;
- c) section 3 defines the services provided by the protocol entity;
- d) section 4 specifies the protocol data units and procedures employed by the protocol entity;
- e) section 5 specifies the managed parameters used by the protocol entity;
- 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 the older CCSDS Recommendation (reference [B2]).

1.6 CONVENTIONS AND DEFINITIONS

1.6.1 DEFINITIONS

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

This Recommendation makes use of a number of terms defined in reference [1]. The use of those terms in this Recommendation 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) Data Link Layer;
- d) entity;
- e) flow control;

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- f) Network Layer;
- g) peer entities;
- h) Physical Layer;
- i) protocol control information;
- j) protocol data unit;
- k) real system;
- l) segmenting;
- m) service;
- n) Service Access Point (SAP);
- o) SAP address;
- p) service data unit.

1.6.1.2 Definitions from OSI Service Definition Conventions

This Recommendation makes use of a number of terms defined in reference [1]. The use of those terms in this Recommendation 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) confirmation;
- b) indication;
- c) primitive;
- d) request;
- e) response;
- f) service provider;
- g) service user.

1.6.1.3 Terms Defined in this Recommendation

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

asynchronous: not *synchronous* (see below).

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

Mission Phase: a period of a mission during which specified communications characteristics are fixed. The transition between two consecutive Mission Phases may cause an interruption of the communications services.

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 Recommendation:

- 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).

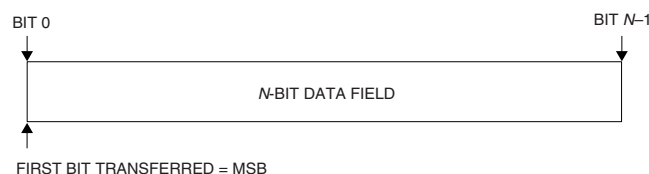


Figure 1-1: Bit Numbering Convention

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In accordance with standard data-communications practice, data fields are often grouped into eight-bit ‘words’ which conform to the above convention. Throughout this Recommendation, such an eight-bit word is called an ‘octet’.

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

By CCSDS convention, all ‘spare’ bits shall be permanently set to ‘0’.

1.7 NORMATIVE REFERENCES

The following documents contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this Recommendation 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 Recommendations.

- [1] *Information Technology—Open Systems Interconnection—Basic Reference Model: The Basic Model*. International Standard, ISO/IEC 7498-1. 2nd ed. Geneva: ISO, 1994.
- [2] *Information Technology—Open Systems Interconnection—Basic Reference Model—Conventions for the Definition of OSI Services*. International Standard, ISO/IEC 10731:1994. Geneva: ISO, 1994.
- [3] *TC Synchronization and Channel Coding*. Recommendation for Space Data System Standards, CCSDS 231.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.
- [4] *Communications Operation Procedure-1*. Recommendation for Space Data System Standards, CCSDS 232.1-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.
- [5] *Space Link Identifiers*. Recommendation for Space Data System Standards, CCSDS 135.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, January 2002.
- [6] *CCSDS Global Spacecraft Identification Field Code Assignment Control Procedures*. Recommendation for Space Data System Standards, CCSDS 320.0-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, April 2003.

NOTE – Informative references are listed in annex B.

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2 OVERVIEW

2.1 CONCEPT OF TC SPACE DATA LINK PROTOCOL

2.1.1 ARCHITECTURE

The TC Space Data Link Protocol is a Data Link Layer protocol (see reference [1]) to be used by space missions. This protocol has been designed to meet the requirements of space missions for efficient transfer of space application data of various types and characteristics over ground-to-space or space-to-space communications links (hereafter called space links).

Figure 2-1 illustrates the relationship of this protocol to the Open Systems Interconnection (OSI) reference model (reference [1]). Two sublayers of the Data Link Layer are defined for CCSDS space link protocols as shown in reference [B]. The TC Space Data Link Protocol corresponds to the Logical Link Sublayer and provides functions of transferring various data using a variable-length protocol data unit called the Transfer Frame. The Channel Coding Sublayer provides some additional functions necessary for transferring Transfer Frames over a space link. These functions are the delimiting/synchronizing of Transfer Frames, error-correction coding/decoding, and bit transition generation/removal (optional). For the Channel Coding Sublayer, the Channel Coding and Synchronization Recommendation (reference [3]) must be used with the TC Space Data Link Protocol. How the TC Space Data Link Protocol is used in overall space data systems is shown in reference [B3].

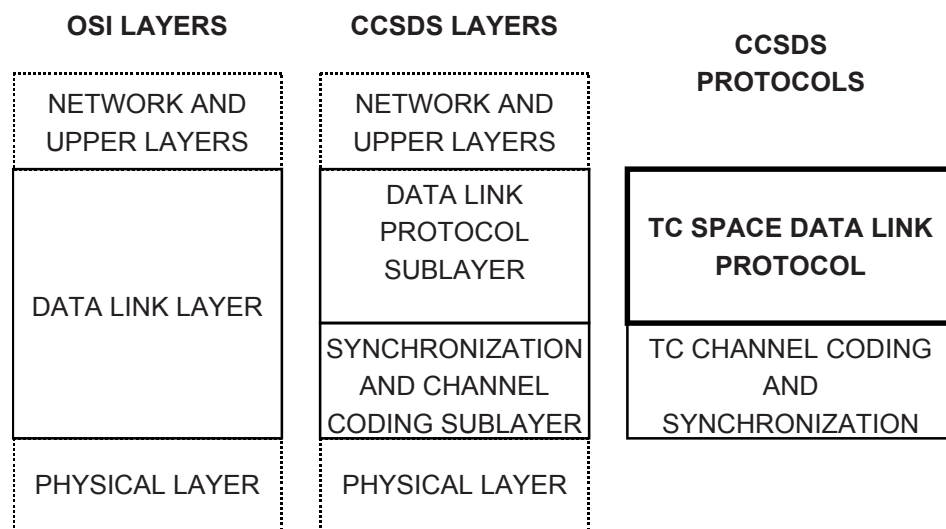


Figure 2-1: Relationship with OSI Layers

2.1.2 PROTOCOL FEATURES

The TC Space Data Link Protocol provides the users with several services to transfer service data units over a space link. The major functions performed by this protocol are (1) segmentation and blocking of service data units and (2) transmission control of service data units.

Because the underlying space link inherently includes a noisy signal path, there is a finite probability that it will introduce an error. It is desirable to break large service data units into relatively small pieces so that each piece has a lower probability of being invalidated by transmission error than if the entire service data unit were sent contiguously. System throughput efficiency is improved because only small pieces have to be retransmitted when errors are detected. However, there may also be situations in which the service data units are very small. For efficient transfer of service data units, it is desirable to group these small units into larger pieces. The TC Space Data Link Protocol provides the capability to break large service data units into relatively small pieces (segmentation) and to group small service data units into larger pieces (blocking).

The TC Space Data Link Protocol controls the transmission of service data units through the space link performing retransmissions needed to ensure delivery of service data units in sequence and without gaps or duplication. This function is provided by a retransmission control mechanism called the Communications Operation Procedure (COP). The specification of the COP is given in reference [4].

The protocol data units employed by this protocol are the TC Transfer Frame (unless otherwise stated, the terms ‘Transfer Frame’ and ‘Frame’ in this document refer to the TC Transfer Frame) and the Communications Link Control Word (CLCW). Each Transfer Frame contains a header, which provides protocol control information, and a variable-length data field, within which higher-layer service data units are carried. Transfer Frames are sent in the direction of the flow of service data units. Each CLCW contains a report that describes the status of acceptance of Transfer Frames. CLCWs are sent from the receiver to the sender of Transfer Frames.

A key feature of the TC Space Data Link Protocol is the concept of ‘Virtual Channels’. The Virtual Channel facility allows one Physical Channel to be shared among multiple higher-layer data streams, each of which may have different service requirements. A single Physical Channel may therefore be divided into several separate logical data channels, each known as a ‘Virtual Channel’ (VC). Each Transfer Frame transferred over a Physical Channel belongs to one of the Virtual Channels of the Physical Channel.

Optionally, this protocol enables service data units from different sources to be multiplexed together in one Virtual Channel using ‘Multiplexer Access Points’ (MAPs). If MAPs are used, service data units arriving at the service access point for a MAP at the sending end are transferred to the corresponding MAP at the receiving end.

2.1.3 ADDRESSING

There are three identifier fields in the header of Transfer Frames: Transfer Frame Version Number (TFVN), Spacecraft Identifier (SCID), and Virtual Channel Identifier (VCID). The concatenation of a TFVN and a SCID is known as a Master Channel Identifier (MCID), and the concatenation of an MCID and a VCID is called a Global Virtual Channel Identifier (GVCID). Therefore,

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$$\begin{aligned}\text{MCID} &= \text{TFVN} + \text{SCID}; \\ \text{GVCID} &= \text{MCID} + \text{VCID} \\ &= \text{TFVN} + \text{SCID} + \text{VCID}.\end{aligned}$$

Each Virtual Channel on a Physical Channel is identified by a GVCID. Therefore, a Virtual Channel consists of Transfer Frames having the same GVCID.

All Transfer Frames with the same MCID on a Physical Channel constitute a Master Channel (MC). A Master Channel consists of one or more Virtual Channels. In most cases, a Physical Channel carries only Transfer Frames of a single MCID, and the Master Channel will be identical with the Physical Channel. However, a Physical Channel may carry Transfer Frames with multiple MCIDs (with the same TFVN). In such a case, the Physical Channel consists of multiple Master Channels. A Physical Channel is identified with a Physical Channel Name, which is set by management and not included in the header of Transfer Frames.

In the optional Segment Header, there is a field called Multiplexer Access Point Identifier (MAP ID). All Transfer Frames with the same GVCID and MAP ID constitute a MAP Channel. If the Segment Header is used, a Virtual Channel consists of one or multiple MAP Channels. The concatenation of a GVCID and a MAP ID is known as a Global MAP ID (GMAP ID). Therefore,

$$\begin{aligned}\text{GMAP ID} &= \text{GVCID} + \text{MAP ID} \\ &= \text{MCID} + \text{VCID} + \text{MAP ID} \\ &= \text{TFVN} + \text{SCID} + \text{VCID} + \text{MAP ID}.\end{aligned}$$

The relationships between these Channels are shown in figure 2-2.

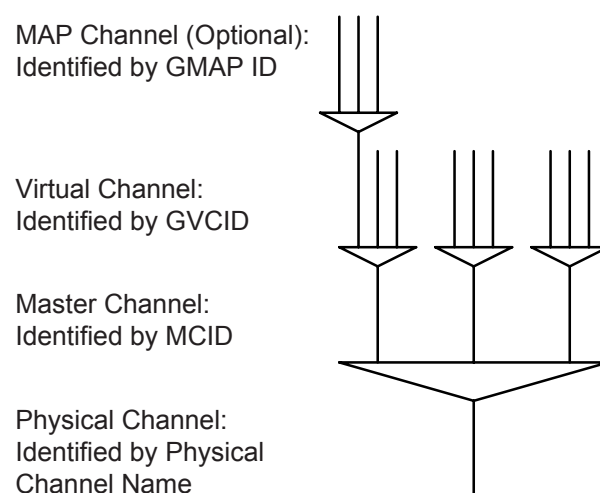


Figure 2-2: Relationships Between Channels

2.1.4 PROTOCOL DESCRIPTION

The TC Space Data Link Protocol is described in terms of:

- a) the services provided to the users;
- b) the protocol data units; and
- c) the procedures performed by the protocol.

The service definitions are given in the form of primitives, which present an abstract model of the logical exchange of data and control information between the protocol entity and the service user. The definitions of primitives are independent of specific implementation approaches.

The procedure specifications define the procedures performed by protocol entities for the transfer of information between peer entities. The definitions of procedures are independent of specific implementation methods or technologies.

This protocol specification also specifies the requirements for the underlying services provided by the Channel Coding Sublayer and the Physical Layer.

2.2 OVERVIEW OF SERVICES

2.2.1 COMMON FEATURES OF SERVICES

The TC Space Data Link Protocol provides users with data transfer services. The point at which a service is provided by a protocol entity to a user is called a Service Access Point (SAP) (see reference [1]). Each service user is identified by a SAP address. At a SAP, two ports may be provided, each of which is for one of the service types described in 2.2.2.

Service data units of the same type submitted to a SAP (or a port if implemented) are processed in the order of submission. No processing order is maintained for service data units submitted to different SAPs (or ports).

NOTE – Implementations may be required to perform flow control at a SAP (or a port if present) between the service user and the service provider. However, CCSDS does not make any recommendations for a scheme for flow control between the user and the provider.

The followings features are common to all the services defined by this Recommendation:

- a) Unidirectional (one way) services: one end of a connection can send, but not receive, data through the space link, while the other end can receive, but not send.
- b) Asynchronous services: there are no predefined timing rules for the transfer of service data units supplied by the service user or for the transmission of Transfer Frames generated by the service provider. The user may request data transfer at any

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time, but there may be restrictions imposed by the service provider on the data generation rate. The timing of data transfer is determined by the provider in accordance with mission-specific rules and may depend on the traffic at the time of transfer.

- c) Sequence preserving services: the sequence of service data units supplied by the sending user is preserved through the transfer over the space link, although for the Expedited Service, described below, there may be gaps in the sequence of service data units delivered to the receiving user.

NOTE – This Recommendation assumes that these services are provided at the end points of a space link. However, this Recommendation makes no assumptions concerning how these end points are composed or configured either on-board a spacecraft or in a ground system. In a ground system, the services defined by this Recommendation may be extended or enhanced with Space Link Extension Services (reference [B]).

2.2.2 SERVICE TYPES

2.2.2.1 Overview

The TC Space Data Link Protocol provides two service types (Sequence-Controlled and Expedited) that determine how reliably service data units supplied by the sending user are delivered to the receiving user.

Both of these two service types are provided at any Service Access Point except for the Virtual Channel Frame, Master Channel Frame, and COP Management Services. The user requests with a parameter of the service request primitive whether the Sequence-Controlled or Expedited Service Type should be applied to each service data unit. Alternatively, the service provider may provide two separate ports (one for the Sequence-Controlled Service Type and the other for the Expedited Service Type) within a Service Access Point.

For the Virtual Channel Frame and Master Channel Frame Services, the service provider does not make any distinction between Sequence-Controlled and Expedited service types applicable to service data units supplied by the user. The user should perform necessary procedures to provide Sequence-Controlled and Expedited Service Types for its service data units.

2.2.2.2 Sequence-Controlled Service (Type-A Service)

The Sequence-Controlled Service (Type-A Service) utilizes an Automatic Repeat Request (ARQ) procedure of the ‘go-back-*n*’ type with sequence-control mechanisms at both sending and receiving ends and a standard report returned from the receiving end to the sending end.

For Type-A Service, service data units supplied by a sending user at a SAP are inserted into Transfer Frames (after MAP multiplexing when applicable) and transmitted on a Virtual

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Channel in the order in which they are presented at the SAP. The retransmission mechanism ensures with a high probability of success that:

- a) no service data unit is lost;
- b) no service data unit is duplicated;
- c) no service data unit is delivered out of sequence.

The Type-A Service guarantees, with a high probability, complete in-sequence delivery of service data units supplied by a user on a single MAP or Virtual Channel. Because retransmission is performed independently on each Virtual Channel, there is no guarantee that Type-A service data units transmitted on separate Virtual Channels will be delivered to the receiving users in the order initially presented. Further, because MAP multiplexing is performed before the sequence-control mechanisms are applied, there is no guarantee that Type-A service data units transmitted on separate MAP Channels will be delivered to the receiving users in the order initially presented.

NOTE – Some implementations of this protocol may not distinguish service data units transferred with Type-A Service from service data units transferred with Type-B Service at the receiving end. In this case, if both Type-A Service and Type-B Service are used simultaneously on one MAP Channel, the receiving end may not be able to reconstruct service data units transferred with Type-A Service even though the ARQ procedure has been applied to them (because, for example, the Type-A Transfer Frames derived from a single service data unit may be interlaced, at the receiving end, with Type-B Transfer Frames derived from a different service data unit). For this implementation, the sending end should terminate any ongoing Type-A Service before starting a Type-B Service on the same Virtual Channel.

2.2.2.3 Expedited Service (Type-B Service)

The Expedited Service (Type-B Service) is normally used either in exceptional operational circumstances, typically during spacecraft recovery operations, or when a higher layer protocol provides a retransmission capability.

For Type-B Service, service data units supplied by the sending user are transmitted only once (i.e., no retransmission). There is no guarantee that all Type-B service data units are delivered to the receiving user.

NOTE – Although Type-B Service carries the name ‘Expedited’, it is neither a required method nor a faster method for sending urgent data to the receiving end. If the service provider is supporting a reliable Type-A Service, then Type-A Service should be used exclusively.

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2.2.3 SUMMARY OF SERVICES**2.2.3.1 Overview**

Seven services are provided by the TC Space Data Link Protocol. Two of them (MAP Packet and MAP Access) are provided for a MAP Channel. Four of them (VC Packet, Virtual Channel Access, Virtual Channel Frame, and COP Management) are provided for a Virtual Channel. One of them (Master Channel Frame) is provided for a Master Channel. Table 2-1 summarizes these services.

Table 2-1: Summary of Services Provided by TC Space Data Link Protocol

Service	Service Type	Service Data Unit	SAP Address
MAP Packet (MAPP)	Type-A and Type-B	Packet	GMAP ID + Packet Version Number
Virtual Channel Packet (VCP)	Type-A and Type-B	Packet	GVCID + Packet Version Number
MAP Access (MAPA)	Type-A and Type-B	MAP_SDU	GMAP ID
Virtual Channel Access (VCA)	Type-A and Type-B	VCA_SDU	GVCID
Virtual Channel Frame (VCF)	N/A	Transfer Frame	GVCID
Master Channel Frame (MCF)	N/A	Transfer Frame	MCID
COP Management	N/A	N/A	GVCID

2.2.3.2 MAP Packet (MAPP) Service

The MAP Packet (MAPP) Service transfers a sequence of variable-length, delimited, octet-aligned service data units known as Packets across a space link on a specified MAP Channel. The Packets transferred by this service must have a Packet Version Number (PVN) authorized by CCSDS. For the PVNs presently authorized by CCSDS, see reference [5].

The service is unidirectional and asynchronous. Both Sequence-Controlled (Type-A) and Expedited (Type-B) service types are provided for the MAPP Service. The user requests with a parameter of the service request primitive whether Type-A or Type-B should be applied for each Packet or uses one port for Type-A Packets and another port for Type-B Packets.

In the context of a given GMAP ID (i.e., a GVCID and a MAP ID), a user of this service is a protocol entity that sends or receives Packets with a single PVN. A user is identified with a PVN and a GMAP ID. Different users (i.e., Packets with different versions) can share a single MAP Channel, and if there are multiple users on a MAP Channel, the service provider multiplexes Packets of different versions to form a single stream of Packets to be transferred on that MAP Channel.

2.2.3.3 Virtual Channel Packet (VCP) Service

The Virtual Channel Packet (VCP) Service transfers a sequence of variable-length, delimited, octet-aligned service data units known as Packets across a space link on a specified Virtual Channel. The Packets transferred by this service must have a PVN authorized by CCSDS. For the PVNs presently authorized by CCSDS, see reference [5].

The service is unidirectional and asynchronous. Both Sequence-Controlled (Type-A) and Expedited (Type-B) service types are provided for the VCP Service. The user requests with a parameter of the service request primitive whether Type-A or Type-B should be applied for each Packet, or uses one port for Type-A Packets and another port for Type-B Packets.

Within the context of a given GVCID, a user of this service is a protocol entity that sends or receives Packets with a single PVN. A user is identified with a PVN and a GVCID. Different users (i.e., Packets with different versions) can share a single Virtual Channel, and if there are multiple users on a Virtual Channel, the service provider multiplexes Packets of different versions to form a single stream of Packets to be transferred on that Virtual Channel.

2.2.3.4 MAP Access (MAPA) Service

The MAP Access (MAPA) Service provides transfer of a sequence of privately formatted service data units of variable length across a space link. The length of the service data units transferred by this service is not constrained by the length of the Data Field of the Transfer Frame.

The service is unidirectional and asynchronous. Both Sequence-Controlled (Type-A) and Expedited (Type-B) service types are provided for the MAPA Service. The user requests with a parameter of the service request primitive whether Type-A or Type-B should be applied for each service data unit, or uses one port for Type-A service data units and another port for Type-B service data units.

For a given service instance, only one user, identified with the GMAP ID (i.e., GVCID and MAP ID) of the MAP Channel, can use this service on a MAP Channel. Service data units from different users are not multiplexed together within one MAP Channel.

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2.2.3.5 Virtual Channel Access (VCA) Service

The Virtual Channel Access (VCA) Service provides transfer of a sequence of privately formatted service data units of variable length across a space link. The length of the service data units transferred by this service can not exceed the maximum length of the Data Field of the Transfer Frame.

The service is unidirectional and asynchronous. Both Sequence-Controlled (Type-A) and Expedited (Type-B) service types are provided for the VCA Service. The user requests with a parameter of the service request primitive whether Type-A or Type-B should be applied for each service data unit, or uses one port for Type-A service data units and another port for Type-B service data units.

For a given service instance, only one user, identified with the GVCID of the Virtual Channel, can use this service on a Virtual Channel. Service data units from different users are not multiplexed together within one Virtual Channel.

2.2.3.6 Virtual Channel Frame (VCF) Service

The Virtual Channel Frame (VCF) Service provides transfer of a sequence of TC Transfer Frames, created by an independent protocol entity, on a Virtual Channel across a space link. The service does not guarantee completeness nor does it make any distinction between Sequence-Controlled and Expedited service types applicable to service data units supplied by the user. The user should perform necessary procedures to provide Sequence-Controlled and Expedited service types.

For a given service instance, only one user, identified with the GVCID of the Virtual Channel, can use this service on a Virtual Channel. Service data units from different users are not multiplexed together within one Virtual Channel.

The Virtual Channel Frame Service transfers the independently created TC Transfer Frames through a space link, together with TC Transfer Frames created by the service provider itself. This service is made available to trusted users who are certified during the design process to ensure that the independently created protocol data units do not violate the operational integrity of the space link.

2.2.3.7 Master Channel Frame (MCF) Service

The Master Channel Frame (MCF) Service provides transfer of a sequence of TC Transfer Frames of a Master Channel, created by an independent protocol entity, across a space link. The service does not guarantee completeness nor does it make any distinction between Sequence-Controlled and Expedited service types applicable to service data units supplied by the user. The user should perform necessary procedures to provide Sequence-Controlled and Expedited service types.

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For a given service instance, only one user, identified with the MCID of the Master Channel, can use this service on a Master Channel. Service data units from different users are not multiplexed together within one Master Channel.

The Master Channel Frame Service transfers the independently created TC Transfer Frames through the space link, together with TC Transfer Frames created by the service provider itself. This service is made available to trusted users who are certified during the design process to ensure that the independently created protocol data units do not violate the operational integrity of the space link.

2.2.3.8 COP Management Service

The COP Management Service is used by a user at the sending end for managing the operations of the COP for a particular Virtual Channel. The user manages the operations of the COP by invoking Directives defined in reference [4]. The user is notified by the service provider of events associated with Directives and events that occur asynchronously with Directives.

A user of this service must be authorized to manage the COP for a particular Virtual Channel. For a given service instance, only one user, identified with the GVCID of the Virtual Channel, is allowed to use this service on a Virtual Channel.

2.2.4 RESTRICTIONS ON SERVICES

There are some restrictions on the services provided on a Physical Channel.

- a) If the Master Channel Frame Service exists on a Master Channel, other services shall not exist simultaneously on that Master Channel.
- b) If the Virtual Channel Frame Service exists on a Virtual Channel, other services shall not exist simultaneously on that Virtual Channel.
- c) If the Virtual Channel Access Service exists on a Virtual Channel, other services shall not exist simultaneously on that Virtual Channel.
- d) If the Virtual Channel Packet Service exists on a Virtual Channel, other services shall not exist simultaneously on that Virtual Channel.
- e) On one MAP Channel, the MAP Access Service shall not exist simultaneously with the MAP Packet Service.

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2.3 OVERVIEW OF FUNCTIONS**2.3.1 GENERAL FUNCTIONS**

Using services of lower layers, the TC Space Data Link Protocol transfers various service data units, supplied by sending users, encapsulated in a sequence of protocol data units. The protocol data units, known as TC Transfer Frames, have variable lengths and are transferred over a Physical Channel asynchronously.

The protocol entity performs the following protocol functions:

- a) generation and processing of protocol control information (i.e., headers and trailers) to perform data identification, loss detection, and error detection;
- b) segmenting and blocking of service data units to transfer service data units of various sizes in protocol data units suitable for efficient transfer;
- c) multiplexing/demultiplexing in order for various service users to share a single Physical Channel;
- d) retransmission of missing protocol data units, rejection of out-of-sequence and duplicated protocol data units, and control of sequence-control mechanisms at sending and receiving ends to guarantee complete and in-order delivery (for Type-A Service only);
- e) flow control (for Type-A Service only).

The protocol entity does not perform the following protocol function: connection establishment and release.

2.3.2 INTERNAL ORGANIZATION OF PROTOCOL ENTITY

Figures 2-3 and 2-4 show the internal organization of the protocol entity of the sending and receiving ends, respectively. Data flow from top to bottom in figure 2-3 and from bottom to top in figure 2-4. The four functions in the upper part of these figures are collectively called the Segmentation Sublayer, and the other four functions in the lower part are collectively called the Transfer Sublayer.

These figures identify data-handling functions performed by the protocol entity. The purpose of these figures is to show logical relationships among the functions of the protocol entity. The figures are not intended to imply any hardware or software configuration in a real system. Depending on the services actually used for a real system, not all of the functions may be present in the protocol entity.

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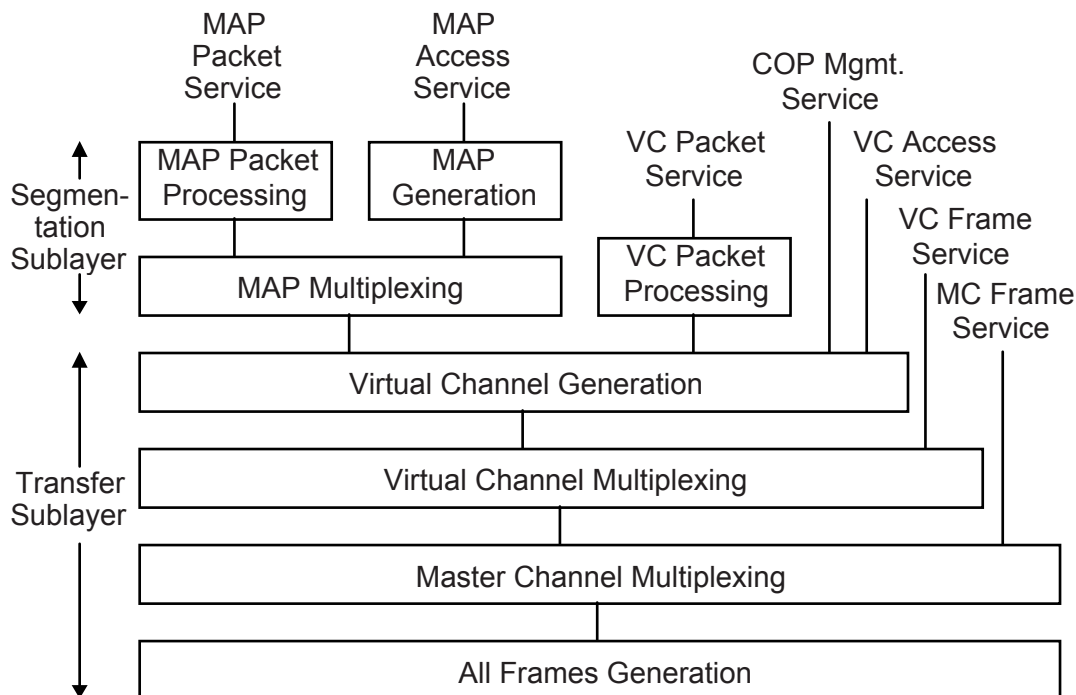


Figure 2-3: Internal Organization of Protocol Entity (Sending End)

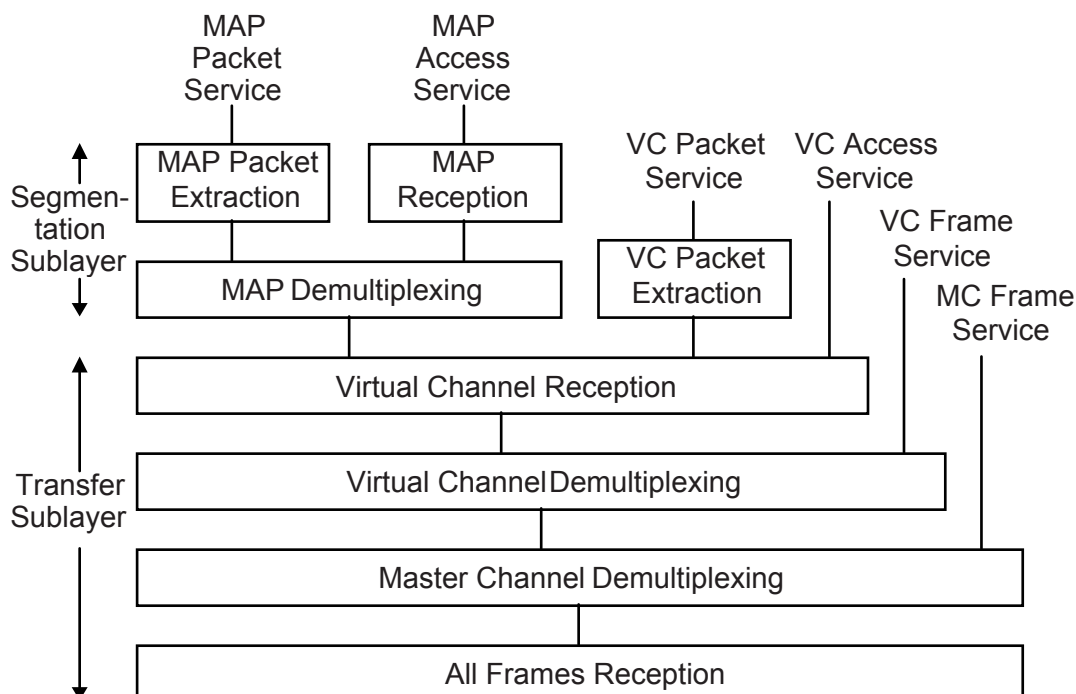


Figure 2-4: Internal Organization of Protocol Entity (Receiving End)