

Space data and information transfer systems — Proximity-1 space link protocol — Data link layer

ICS 49.140

National foreword

This British Standard is the UK implementation of ISO 22663:2007. It supersedes BS ISO 22663:2006 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ACE/68/-/7, Space systems and operations - Space data and information transfer systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Space data and information transfer systems — Proximity-1 space link protocol — Data link layer

*Systèmes de transfert des informations et données spatiales —
Protocole pour liaisons spatiales de proximité 1 — Couche de liaisons
de données*



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Foreword

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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 22663 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 13, *Space data and information transfer systems*.

This second edition cancels and replaces the first edition (ISO 22663:2006), which has been technically revised.

ISO 22663 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 211.0-B-4, July 2006) 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 — Proximity-1 space link protocol — Data link layer

1 Scope

This International Standard defines the Proximity-1 space link protocol data link layer (framing, media access, data services, and input-output sublayers). It specifies the protocol data units, framing, media access control, expedited and sequenced controlled data transfer, timing service, i/o control, as well as the procedures for establishing and terminating a session between a caller and responder. The coding and synchronization sublayer is defined in ISO 21459. The physical layer is defined in ISO 21460.

This International Standard does not specify

- a) individual implementations or products;
- b) 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.

The scope and field of application are furthermore detailed in subclause 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 211.0-B-4, July 2006, *Proximity-1 space link protocol — Data link layer*.

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 211.0-B-4.

Pages i to v

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

Page 1-6

Add the following information to the reference indicated:

- [2] Document CCSDS 232.1-B-1, September 2003, is equivalent to ISO 22667:2005.
- [3] Document CCSDS 232.0-B-1, September 2003, is equivalent to ISO 22664:2005.
- [4] Document CCSDS 132.0-B-1, September 2003, is equivalent to ISO 22645:2005.
- [5] Document CCSDS 131.0-B-1, September 2003, is equivalent to ISO 22641:2005.

Page 1-7

Add the following information to the reference indicated:

- [7] Document CCSDS 301.0-B-3, January 2002, is equivalent to ISO 11104:2003.
- [8] Document CCSDS 211.2-B-1, April 2003, is equivalent to ISO 21459:2006.
- [9] Document CCSDS 211.1-B-3, March 2006, is equivalent to ISO 21460:2007.

3 Revision of publication CCSDS 211.0-B-4

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 211.0-B-4. To this end, NASA will act as a liaison body between CCSDS and ISO.



Recommendation for Space Data System Standards

PROXIMITY-1 SPACE LINK PROTOCOL— DATA LINK LAYER

RECOMMENDED STANDARD

CCSDS 211.0-B-4

BLUE BOOK

July 2006

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CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 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 *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 Recommendation is published and maintained by:

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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.

This **Recommendation** is issued by, and represents the consensus of, the CCSDS Plenary body. Agency endorsement of this **Recommendation** is entirely voluntary. Endorsement, however, indicates the following understandings:

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 - The **standard** itself.
 - The anticipated date of initial operational capability.
 - The anticipated duration of operational service.
- Specific service arrangements are made via memoranda of agreement. Neither this Recommendation nor any ensuing standard is a substitute for a memorandum of agreement.

No later than five years from its date of issuance, this **Recommendation** 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 **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 RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

FOREWORD

Through the process of normal evolution, it is expected that expansion, deletion, or modification of this document may occur. This Recommendation is therefore subject to CCSDS document management and change control procedures which are defined in the *Procedures Manual for the Consultative Committee for Space Data Systems*. 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.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

At time of publication, the active Member and Observer Agencies of the CCSDS were:

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- British National Space Centre (BNSC)/United Kingdom.
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- Swedish Space Corporation (SSC)/Sweden.
- United States Geological Survey (USGS)/USA.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

DOCUMENT CONTROL

Document	Title and Issue	Date	Status
CCSDS 211.0-B-1	Proximity-1 Space Link Protocol	October 2002	Superseded
CCSDS 211.0-B-2	Proximity-1 Space Link Protocol— Data Link Layer	April 2003	Superseded
CCSDS 211.0-B-3	Proximity-1 Space Link Protocol— Data Link Layer	May 2004	Superseded
CCSDS 211.0-B-4	Proximity-1 Space Link Protocol— Data Link Layer, Recommended Standard, Issue 4	July 2006	Current Issue: – modifies rules for frame selection prioritization, – adds CARRIER ONLY RECEIVED condition to state tables and to annex D Notifications to Vehicle Controller, – clarifies some terminology.

NOTE – Changes from the previous issue are flagged by change bars in the inside margin.

CONTENTS

<u>Section</u>	<u>Page</u>
1 INTRODUCTION	1-1
1.1 PURPOSE	1-1
1.2 SCOPE	1-1
1.3 APPLICABILITY	1-1
1.4 RATIONALE	1-2
1.5 CONVENTIONS AND DEFINITIONS	1-2
1.6 REFERENCES	1-6
2 OVERVIEW	2-1
2.1 CONCEPT OF PROXIMITY-1	2-1
2.2 OVERVIEW OF SERVICES	2-6
3 PROTOCOL DATA UNITS	3-1
3.1 CONTEXT OF THE VERSION-3 TRANSFER FRAME	3-1
3.2 VERSION-3 TRANSFER FRAME	3-1
4 DATA LINK LAYER	4-1
4.1 FRAME SUBLAYER	4-1
4.2 MEDIUM ACCESS CONTROL (MAC) SUBLAYER	4-2
4.3 DATA SERVICES SUBLAYER	4-5
4.4 I/O INTERFACE SUBLAYER	4-8
5 PROXIMITY-1 TIMING SERVICES	5-1
5.1 COUPLED NON-COHERENT PROXIMITY TIMING SERVICE	5-1
5.2 PROXIMITY TIME CORRELATION	5-1
6 DATA SERVICES OPERATIONS	6-1
6.1 OVERVIEW	6-1
6.2 PROXIMITY-1 STATE TABLES	6-1
6.3 ELEMENTS AND EVENTS THAT AFFECT STATE STATUS	6-13
6.4 STATE TRANSITION TABLES AND DIAGRAMMS	6-18
6.5 SIMPLEX OPERATIONS	6-28
6.6 INTERFACES WITH THE PHYSICAL LAYER	6-29
6.7 SENDING OPERATIONS	6-29
6.8 RECEIVING OPERATIONS	6-31

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

CONTENTS (continued)

<u>Section</u>	<u>Page</u>
7 COMMUNICATION OPERATIONS PROCEDURE FOR PROXIMITY LINKS (COP-P)	7-1
7.1 SENDING PROCEDURES (FOP-P)	7-1
7.2 RECEIVING PROCEDURES (FARM-P)	7-7
8 INPUT/OUTPUT (I/O) SUBLAYER OPERATIONS	8-1
8.1 SENDING OPERATIONS	8-1
8.2 RECEIVING OPERATIONS	8-2
ANNEX A VARIABLE-LENGTH SUPERVISORY PROTOCOL DATA FIELD FORMATS (Normative)	A-1
ANNEX B MANAGEMENT INFORMATION BASE (MIB) PARAMETERS (Normative)	B-1
ANNEX C NASA MARS SURVEYOR PROJECT 2001 ODYSSEY ORBITER PROXIMITY SPACE LINK CAPABILITIES (Informative)	C-1
ANNEX D NOTIFICATIONS TO VEHICLE CONTROLLER (Normative)	D-1
ANNEX E ABBREVIATIONS AND ACRONYMS (Informative)	E-1
ANNEX F INFORMATIVE REFERENCES (Informative)	F-1

Figure

1-1 Bit Numbering Convention.....	1-6
2-1 Proximity-1 Layered Protocol Model.....	2-4
3-1 Proximity-1 Protocol Data Unit Context Diagram	3-1
3-2 Version-3 Transfer Frame.....	3-2
3-3 Transfer Frame Header	3-3
3-4 Proximity-1 Transfer Frame Data Field Structure	3-7
3-5 Proximity Link Control Word Fields.....	3-12
4-1 COP-P Process.....	4-7
5-1 Proximity Time Tagging and Time Correlation	5-3
5-2 Transferring Time to a Remote Asset.....	5-4
6-1 Full Duplex State Transition Diagram.....	6-19
6-2 Half Duplex State Transition Diagram	6-23
6-3 Simplex Operations.....	6-28
A-1 Type 1 SPDU Data Field Contents.....	A-2
A-2 SET TRANSMITTER PARAMETERS Directive	A-3
A-3 SET CONTROL PARAMETERS Directive	A-6
A-4 SET RECEIVER PARAMETERS Directive	A-8

CONTENTS (continued)

<u>Figure</u>	<u>Page</u>
A-5 SET V(R) Directive	A-10
A-6 Report Request.....	A-11
A-7 Proximity Link Control Word	A-13
A-8 SET PL EXTENSIONS	A-15
A-9 Report Source Spacecraft ID	A-19
A-10 Type 2 SPDU Data Field Contents.....	A-20
C-1 NASA Mars Surveyor Project 2001 Odyssey SET TRANSMITTER PARAMETERS Directive	C-2
C-2 NASA Mars Surveyor Project 2001 Odyssey SET RECEIVER PARAMETERS Directive	C-4
C-3 Proximity Link Control Word Fields.....	C-7

Table

3-1 U-Frame Data Field Construction Rules	3-4
3-2 Segment Header Sequence Flags.....	3-8
3-3 Fixed-Length Supervisory Protocol Data Unit.....	3-11
3-4 Variable-Length Supervisory Protocol Data Unit	3-14
6-1 Proximity-1 Data Services Operations Roadmap	6-1
6-2 States Independent of the DUPLEX Variable	6-2
6-3 States When DUPLEX = Full.....	6-3
6-4 States When DUPLEX = Half	6-5
6-5 States When DUPLEX = Simplex (receive or transmit)	6-6
6-6 Proximity-1 Control Variable Initialization Table.....	6-18
6-7 Full Duplex Session Establishment/Data Services State Transition Table.....	6-20
6-8 Full Duplex Communication Change State Table	6-21
6-9 Full Duplex Session Termination State Table	6-22
6-10 Half Duplex Session Establishment and Data Services.....	6-23
6-11 Half Duplex Communication Change State Table	6-26
6-12 Half Duplex Session Termination State Table	6-27
6-13 Simplex State Transition Table.....	6-28
6-14 Data Source Selection for Output Bit Stream with TRANSMIT = <i>on</i> and MODULATION = <i>on</i>	6-30

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

1 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to provide a Recommendation for Space Data System Standards in the area of Proximity space links. Proximity space links are defined to be short-range, bi-directional, fixed or mobile radio links, generally used to communicate among probes, landers, rovers, orbiting constellations, and orbiting relays. These links are characterized by short time delays, moderate (not weak) signals, and short, independent sessions.

1.2 SCOPE

This Recommendation defines the Data Link layer (framing, media access, data services, and input-output sublayers). The specifications for the protocol data units, framing, media access control, expedited and sequenced controlled data transfer, timing service, i/o control as well as the procedures for establishing and terminating a session between a caller and responder are defined in this document. The Coding and Synchronization sublayer is defined in the separate CCSDS recommendation entitled, *Proximity-1 Space Link Protocol—Coding and Synchronization Sublayer*; see reference [8]. The Physical layer is defined in the separate CCSDS recommendation entitled, *Proximity-1 Space Link Protocol—Physical Layer*; see reference [9].

This Recommendation does not specify a) individual implementations or products, b) 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. It applies also to internal Agency links where no cross-support is required. It includes specification of the services and protocols for inter-Agency cross support. It is neither a specification of, nor a design for, 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. Concept and rationale behind the decisions that formed the basis for Proximity-1 will be documented in the CCSDS Proximity-1 Space Link Green Book, which is under development.

1.5 CONVENTIONS AND DEFINITIONS

1.5.1 DEFINITIONS

1.5.1.1 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 as follows:

- a) connection;
- b) Data Link layer;
- c) entity;
- d) physical layer;
- e) protocol control information;
- f) Protocol Data Unit (PDU);
- g) real system;
- h) segmenting;
- i) service;
- j) Service Access Point (SAP);
- k) SAP address;
- l) Service Data Unit (SDU).

1.5.1.2 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.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

asynchronous channel: a data channel where the symbol data are modulated onto the channel only for the period of the message. The message must be preceded by an acquisition sequence to achieve symbol synchronization. Bit synchronization must be reacquired on every message. A hailing channel is an example of an asynchronous channel.

asynchronous data link: a data link consisting of a sequence of variable-length Proximity Link Transmission Units (PLTUs), which are not necessarily concatenated. Two types of asynchronous data links are:

1) Asynchronous Data Link over an Asynchronous Channel

Hailing provides an example of an asynchronous data link over an asynchronous channel. An important issue is resynchronization between successive hails. Idle is provided for the reacquisition process.

2) Asynchronous Data Link over a Synchronous Channel

Data service provides an example of an asynchronous data link over a synchronous channel. Once the link is established via hailing, communication transitions to a synchronous channel and maintains the link in this configuration until the session is interrupted or ends. If the physical layer does not receive data from the data link layer, it provides idle to maintain a synchronous channel.

caller and responder: A **caller transceiver** is the initiator of the link establishment process and manager of negotiation (if required) of the session. A **responder transceiver** typically receives link establishment parameters from the caller. The caller initiates communication between itself and a responder on a pre-arranged communications channel with predefined controlling parameters. As necessary, the caller and responder may negotiate the controlling parameters for the session (at some level between fully controlled and completely adaptive).

COP-P: Communication Operations Procedure for Proximity links (COP-P). The COP-P includes both the FARM-P and FOP-P of the caller and responder unit.

FARM-P: Frame Acceptance and Reporting Mechanism for Proximity links, for Sequence Controlled service carried out within the receiver in the Proximity-1 link.

FOP-P: Frame Operation Procedure for Proximity links for ordering the output frames for Sequence Controlled service carried out in the transmitter in the Proximity-1 link.

forward link: that portion of a Proximity space link in which the caller transmits and the responder receives (typically a command link).

hailing: the persistent activity used to establish a Proximity link by a caller to a responder in either full or half duplex. It does not apply to simplex operations.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

hailing channel: the forward and return frequency pairs that a caller and responder use to establish physical link communications.

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

PCID: The Physical Channel ID is used to distinguish between Proximity Link Control Words (PLCWs) received on a single receive channel in support of two independent transmitting channels.

P-frame: a Version-3 Transfer Frame that contains only self-identified and self-delimited supervisory protocol data units; compare U-frame.

physical channel: The RF channel upon which the stream of bits is transferred over a space link in a single direction.

PLCW: Proximity Link Control Word. The PLCW is the protocol data unit for reporting Sequence Controlled service status via the return link from the responder back to the caller.

PLTU: The Proximity Link Transmission Unit is the data unit composed of the Attached Synchronization Marker, the Version-3 Transfer Frame, and the attached Cyclic Redundancy Check (CRC)-32.

Protocol object: directives, PLCWs, or status reports contained within an SPDU.

Proximity link: short-range, bi-directional, fixed or mobile radio links, generally used to communicate among probes, landers, rovers, orbiting constellations, and orbiting relays. These links are characterized by short time delays, moderate (not weak) signals, and short, independent sessions.

pseudo packet ID: the temporary packet ID assigned by the protocol to a user's packet within the segmentation process.

resynchronization (COP-P): process in which sender and receiver nodes readjust their sequence controlled frame numbers via the SET V(R) activity.

return link: that portion of a Proximity space link in which the responder transmits and the caller receives (typically a telemetry link).

Routing ID: identifier that uniquely identifies a user's packet through the segmentation process. It consists of a PCID, Port ID, and pseudo packet ID.

Sent queue (Sent Frame queue): contains sequence controlled frames that have been sent but not yet acknowledged by the receiver.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

session: a continuous dialog between two communicating Proximity link transceivers. It consists of three distinct operational phases: session establishment, data services, and session termination.

space link: a communications link between transmitting and receiving entities, at least one of which is in space.

SPDU: Supervisory Protocol Data Unit. Used by the local transceiver to either control or report status to the remote partnered transceiver. Consists of one or more directives, reports, or PLCWs.

synchronous channel: a data channel where the symbol data are continuously modulated onto the channel at a fixed data rate. If the data link fails to provide frames (data or fill), it is the responsibility of the physical layer to provide the continuous bit stream.

U-frame: a Version-3 Transfer Frame that contains user data information; compare P-frame.

vehicle controller: the entity (e.g., spacecraft control computer) which receives the notifications defined in annex E and potentially acts upon them.

Version-3 Transfer Frame: a Proximity-1 transfer frame.

1.5.2 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.

1.5.3 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', as shown in figure 1-1.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

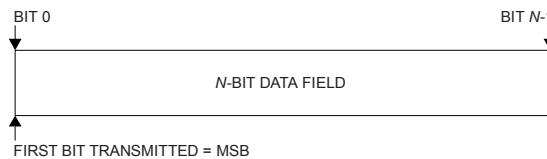


Figure 1-1: Bit Numbering Convention

In accordance with standard data-communications practice, data fields are often grouped into 8-bit ‘words’ that conform to the above convention. Throughout this Recommendation, such an 8-bit word is called an ‘octet’.

The numbering for octets within a data structure begins with zero. Octet zero is the first octet to be transmitted.

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

Throughout this Recommendation, directive, parameter, variable, and signal names are presented with all upper-case characters; data-field and MIB-parameter names are presented with initial capitalization; values and state names are presented with predominantly lower-case characters, and are italicized.

1.6 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] *Communications Operation Procedure-1*. Recommendation for Space Data System Standards, CCSDS 232.1-B-1. Blue Book. Issue 1. CCSDS, September 2003.
- [3] *TC Space Data Link Protocol*. Recommendation for Space Data Systems Standards, CCSDS 232.0-B-1. Blue Book. Issue 1. CCSDS, September 2003.
- [4] *TM Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 132.0-B-1. Blue Book. Issue 1. CCSDS, September 2003.
- [5] *TM Synchronization and Channel Coding*. Recommendation for Space Data System Standards, CCSDS 131.0-B-1. Blue Book. Issue 1. CCSDS, September 2003.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

- [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.
- [7] *Time Code Formats*. Recommendation for Space Data System Standards, CCSDS 301.0-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, January 2002.
- [8] *Proximity-1 Space Link Protocol: Coding and Synchronization Sublayer*. Recommendation for Space Data System Standards, CCSDS 211.2-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, April 2003.
- [9] *Proximity-1 Space Link Protocol—Physical Layer*. Recommendation for Space Data System Standards, CCSDS 211.1-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, March 2006.

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CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

2 OVERVIEW

2.1 CONCEPT OF PROXIMITY-1

2.1.1 LAYERED MODEL

Proximity-1 is a bi-directional Space Link layer protocol to be used by space missions. It consists of a Physical layer (reference [9]), a Coding and Synchronization sublayer (reference [8]) and a Data Link layer. This protocol has been designed to meet the requirements of space missions for efficient transfer of space data over various types and characteristics of Proximity space links. On the send side, the Data Link layer is responsible for providing data to be transmitted by the Coding and Synchronization sublayer and Physical layer. The operation of the transmitter is state-driven. On the receive side, the Data Link layer accepts the serial data output from the receiver and processes the protocol data units received. It accepts directives both from the local vehicle controller and across the Proximity link to control its operations. Once the receiver is turned on, its operation is modeless. It accepts and processes all valid local and remote directives and received service data units.

The layered model consists of two layers (Physical and Data Link) and has five component sublayers within the Data Link layer:

- a) Physical Layer
 - 1) On the send side:
 - i) provides an Output Bit Clock to the Coding & Synchronization sublayer in order to receive the Output Bitstream;
 - ii) provides status i.e., Carrier_Acquired and Bit_In_Lock_Status signals to the Media Access Control sublayer.
 - 2) On the receive side: Provides the Received Bit Clock/Data to the Coding & Synchronization sublayer.
- b) Coding and Synchronization Sublayer. The C&S sublayer includes PLTU delimiting and verification procedures. In addition this sublayer performs as follows:
 - 1) On the send side:
 - i) includes pre-pending Version-3 frames with the required Attached Synchronization Marker (ASM);
 - ii) includes addition of CRC-32 to PLTUs.
 - 2) On both the send and receive sides: Captures the value of the clock used for time correlation process.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

- c) **Frame Sublayer.** The Frame sublayer includes frame validation procedures, such as transfer frame header checks, and supervisory data processing for supervisory frames. In addition, this sublayer performs as follows:
 - 1) On the send side:
 - i) encapsulates the Input/Output (I/O) sublayer–provided User Data (SDUs) into Version-3 frames;
 - ii) prioritizes and multiplexes the frames for output via the C&S sublayer to the Physical layer for transmission across the link.
 - 2) On the receive side:
 - i) accepts delimited and verified frames from the C&S sublayer;
 - ii) delivers supervisory protocol data units (reports, directives) to the MAC sublayer;
 - iii) passes the user data to the Data Services sublayer;
 - iv) performs a subset of validation checks to ensure that the received data should be further processed.
- d) **Medium Access Control Sublayer.** The Medium Access Control (MAC) sublayer defines how a session is established, maintained (and how characteristics are modified, e.g., data rate changes), and terminated for point-to-point communications between Proximity entities. This sublayer builds upon the Physical and Data Link layer functionality. The MAC controls the operational state of the Data Link and Physical layers. It accepts and processes Supervisory Protocol Data Units (SPDUs) and provides the various control signals that dictate the operational state. In addition this sublayer:
 - 1) decodes the directives from the local vehicle’s controller (e.g., spacecraft control computer);
 - 2) decodes the directives received via the remote transceiver (extracting and processing SPDUs from the Frame Data Field);
 - 3) stores and distributes the Management Information Base (MIB) parameters (implementation-specific) and status variables;
 - 4) maintains and distributes the state control variables (MODE, TRANSMIT, DUPLEX, see figure 2-1);
 - 5) provides status information to the local vehicle controller.
- e) **Data Services Sublayer.** The Data Services sublayer defines the Frame Acceptance and Reporting Mechanism for Proximity links (FARM-P) (receive side) and the Frame Operations Procedures for Proximity links (FOP-P) (send side) associated with

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

- the Expedited and Sequence Controlled data services including how the FOP-P and FARM-P (COP-P) operate in the Sequence Controlled service.
- f) Input/Output Sublayer. The Input/Output (I/O) interface sublayer provides the interface between the transceiver and the on-board data system and their applications. In addition, this sublayer performs as follows:
- 1) On the receive side:
 - i) accepts received U-frames;
 - ii) extracts the SDUs from U-frames;
 - iii) provides required packet aggregation services;
 - iv) routes SDUs to data service users via the specified Port ID.
 - 2) On the send side: accepts local user-provided SDUs and associated routing and control information (SCID, PCID, Source-or-Destination ID, QOS, Port ID):
 - i) aggregates these SDUs as required to form U-frame data fields;
 - ii) provides required packet segmentation services;
 - iii) delivers these U-frame data fields to the Data Services sublayer;
 - iv) delivers acknowledgements to spacecraft vehicle controller for SDUs delivered via Sequence Controlled service.

The interactions of the Proximity-1 layers and associated data and control flows are shown in figure 2-1.

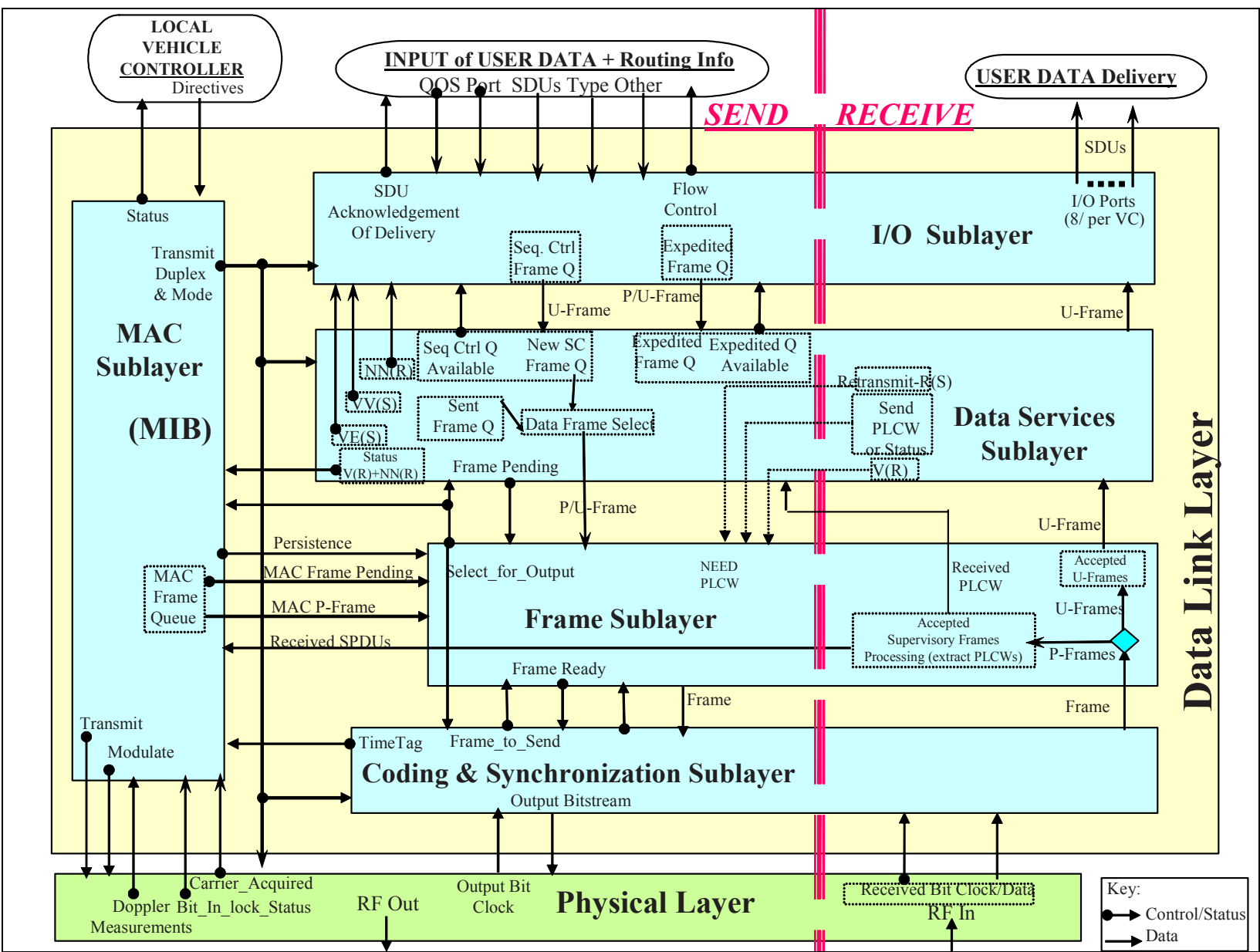


Figure 2-1: Proximity-1 Layered Protocol Model

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

2.1.2 PROTOCOL-UNIQUE FEATURES

The Proximity-1 protocol controls and manages data interchange across the communications link. This Data Link layer protocol provides the capability to send user data, control reports, and control directives between the transceiver units. The directives are used for selection of communications frequencies, data rates, modulation, coding, and link directionality (full duplex, half duplex, and simplex). The Data Link layer provides for the transfer of both packets and user-defined data units. All of these units can be transferred using either an Expedited or a Sequence Controlled (reliable) service supportive of applications involving remote space vehicles.

State tables and diagrams describe the actions the protocol takes when responding to events during full duplex, half duplex, and simplex operations. See section 6, Data Services Operations, and Section 7, Communication Operations Procedure for Proximity Links (COP-P).

The terms ‘transfer frame’ and ‘frame’ in this text refer to the Version-3 Transfer Frame. Each transfer frame contains a header, which provides protocol control information for processing the Transfer Frame Data field. This data field contains either:

- a) Service Data Units (SDUs), i.e., user data for delivery to applications within the receiving node;
- b) Supervisory Protocol Data Units (SPDUs):
 - 1) protocol directives:
 - i) for configuring and controlling the protocol processor at the receiving node,
 - ii) for the establishment, maintenance, and termination of a communications session;
 - 2) protocol reports:
 - i) for reporting the configuration and status of the transmitting node,
 - ii) for reporting the status of a Sequence Controlled data transfer operating in the opposite direction, i.e., PLCW.

The list of protocol directives and reports is extended for use in controlling and reporting status for the Physical layer process when the Data Link layer and Physical layers are collocated.

2.1.3 PLTU TYPE

The PLTU is flexibly sized to fit its variable-length data content (e.g., variable-length frame containing variable-length packets). This PLTU is intended for use on links characterized by short time delays, moderate (not weak) signals, and short, independent sessions. These link characteristics determine the type of ASM (24-bit), its associated bit error tolerance for

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

synchronization, and coding (32-bit Cyclic Redundancy Check) employed for the PLTUs. Symbol and bit synchronization is maintained in the data channel by the insertion of an idle sequence between PLTUs, and these variable-length PLTUs are only inserted into the data link when a physical connection has been achieved. The data field of a variable-length frame can contain an integer number of unsegmented packets, a single packet segment, or a collection of user-provided octets. See figure 3-1 and reference [8] for the definition of this PLTU.

2.1.4 ADDRESSING

A triad of addressing capabilities is incorporated for specific functionality within the link. The Spacecraft Identifier (SCID) identifies the source or destination of transfer frames transported in the link connection based upon the Source-or-Destination Identifier. The Physical Channel Identifier (PCID) provides two independently multiplexed channels, each capable of supporting both the Sequence Controlled and Expedited services. The Port ID provides the means to route user data internally (at the transceiver's output interface) to specific logical ports, such as applications or transport processes, or to physical ports, such as on-board buses or physical connections (including hardware command decoders).

2.1.5 PROTOCOL DESCRIPTION

The Proximity-1 protocol is described in terms of:

- a) the services provided to the users (transfer of SDUs);
- b) the Protocol Data Units (PDUs);
- c) the protocol directives and reports (SPDUs described in 3.2.8);
- d) the procedures performed by the protocol as described in the state tables.

This protocol specification also defines the requirements for the underlying services provided by the lower layers.

2.2 OVERVIEW OF SERVICES

2.2.1 COMMON FEATURES OF SERVICES

Proximity-1 provides users with data transfer services known as Space Data Link Proximity-1 services. The point at which a service is provided by a protocol entity to a user is called a Service Access Point (SAP). For each Physical Channel (PC), there are two receiving SAPs (one for Sequence Controlled service, and the other for Expedited service) through which input data (SDUs) are received (presumably from the spacecraft vehicle controller). There are also eight output SAPs (port addresses) through which received telemetered data are distributed to the on-board data systems and their applications.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

2.2.2 SERVICE TYPES

2.2.2.1 General

The Proximity-1 protocol provides data and timing services. Data services are of two types: the first accepts and delivers packets, while the second accepts and delivers user-defined data. The timing service provides time tagging upon ingress/egress of selected PLTUs. See 5.1 for details on the Proximity-1 Timing Service.

2.2.2.2 CCSDS Packet Delivery Service

The packet delivery service provides for the transfer of packets (CCSDS source packets, Space Communications Protocol Specification (SCPS)—Network Protocol (SCPS-NP) packets, IPv4 packets, and encapsulation packets—see reference [4]) across the Proximity space link. The packets are multiplexed into transfer frames (when they are smaller than the maximum frame data field size allowed in the link), or they are segmented before being inserted into transfer frames and then reassembled into packets for delivery (when they are greater than the maximum frame data field size allowed in the asynchronous link). In this service the delivery process makes use of the Port ID to identify the specific physical or logical port through which the packet is to be routed.

2.2.2.3 User Defined Data Delivery Service

The user defined data delivery service provides for the transfer of a single user's collection of octets (format unknown to the protocol) via the Port ID specified in the Transfer Frame Header. The service does not utilize any information from the Frame Data field. The user data will be placed in one or more frames as required based upon the size of the received data. In this service the delivery process makes use of the Port ID to identify the specific physical port through which the octets are to be routed.

2.2.2.4 Timing Service

Timing services are required for Proximity operations in order to provide time (spacecraft clock) correlation data among communicating units and time-derived ranging measurements. See 5.1.

2.2.3 SERVICE QUALITIES

2.2.3.1 General

The Proximity-1 data services protocol provides two grades of service (Sequence Controlled and Expedited) that determine how reliably SDUs supplied by the sending user are delivered to the receiving user. The controlling procedure is called COP-P and consists of a Frame Operations Procedure for Proximity links (FOP-P), used on the sending side of the service, and a Frame Acceptance and Reporting Mechanism for Proximity links (FARM-P), used on the receiving side of the service.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

Each of these two service grades is accessed through its own SAP. For each SDU, the user must additionally specify the output port through which the data are to be delivered by the receiving transceiver and the type of data units provided. Packetized data units that are larger than the maximum frame size in asynchronous frames can be transferred only by using the segmentation process, utilizing either the Sequence Controlled service or the Expedited service.

2.2.3.2 Sequence Controlled Service

The Sequence Controlled service ensures that data are reliably transferred across the space link and delivered in order, without gaps, errors, or duplications within a single communication session without COP-P resynchronization during the session (see 4.3.2). This service is based on a 'go-back-n' type of Automatic Repeat Queuing (ARQ) procedure that utilizes sequence-control mechanisms of both sending and receiving ends and a standard report (PLCW) returned from the receiving end to the sending end.

Sequence Controlled SDUs supplied by a sending user at the Sequence Controlled SAP are inserted into transfer frames as required and transmitted on a Physical Channel (PC) initially in the order in which they are presented at the SAP. SDUs are passed to the receiving user via the identified port. The retransmission mechanism ensures with a high probability of success that:

- a) no SDU is lost;
- b) no SDU is duplicated;
- c) no SDU is delivered out of sequence.

2.2.3.3 Expedited Service

The Expedited service is nominally used with upper-layer protocols that provide their own retransmission features, or in exceptional operational circumstances such as during spacecraft recovery operations.

Expedited SDUs supplied by the sending user are transmitted without ARQ. At the sending end, Expedited SDUs are transmitted on specified PCs independently of the Sequence Controlled SDUs waiting to be transmitted on the same PC. At the receiving end, the SDUs are passed to the receiving user via the identified port. Note that Expedited SDUs may be sent once or multiple times, but they are not sent again as a result of a request for retransmission. If such a request occurs it is performed outside the purview of the protocol.

There is no guarantee that all Expedited SDUs will be delivered to the receiving user. Expedited service delivers only complete SDUs to the user.

NOTE – In Expedited service the capability is provided to deliver portions of user-defined data units that are greater than the maximum frame size allowed for the link.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

3 PROTOCOL DATA UNITS

3.1 CONTEXT OF THE VERSION-3 TRANSFER FRAME

See figure 3-1 for the Proximity-1 protocol data unit context diagram.

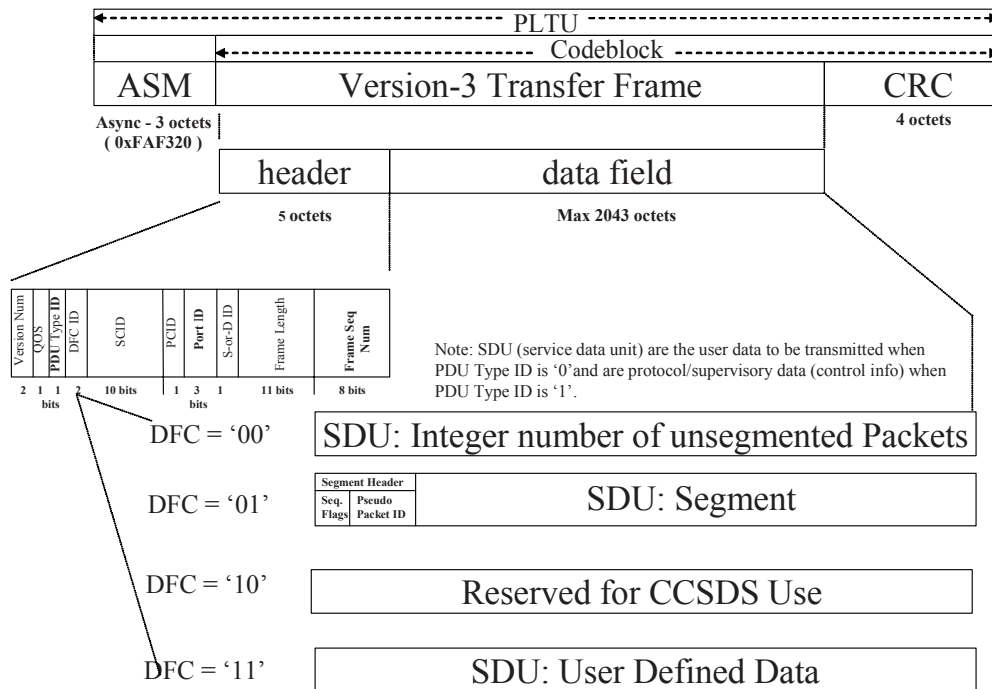


Figure 3-1: Proximity-1 Protocol Data Unit Context Diagram

3.2 VERSION-3 TRANSFER FRAME

3.2.1 VERSION-3 TRANSFER FRAME STRUCTURE

A Version-3 Transfer Frame shall encompass the following fields, positioned contiguously, in the following sequence:

- Transfer Frame Header (five octets, mandatory);
- Transfer Frame Data Field (up to 2043 octets).

NOTES

- 1 The Version-3 Transfer Frame is the PDU transmitted from the sending end to the receiving end by Proximity-1.
- 2 The maximum transfer frame length allowed by a particular spacecraft or ground implementation on a particular PC may be less than the maximum specified here.
- 3 The composition of the Version-3 Transfer Frame is shown in figure 3-2.

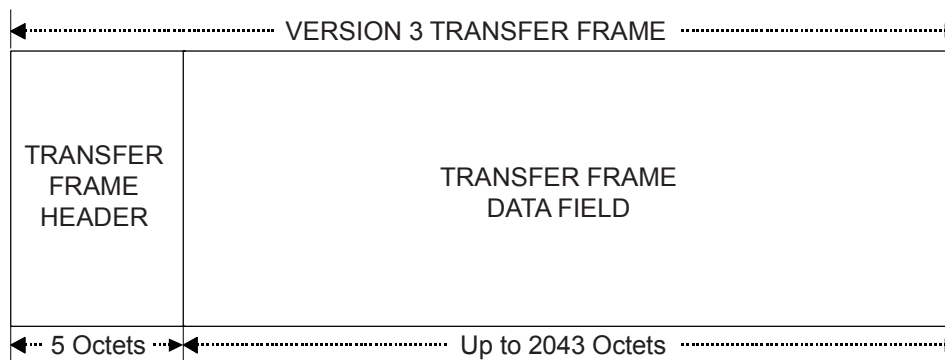


Figure 3-2: Version-3 Transfer Frame

3.2.2 TRANSFER FRAME HEADER

3.2.2.1 Summary of Header Fields

The Transfer Frame Header is mandatory and shall consist of ten mandatory fields, positioned contiguously, in the following sequence:

- a) Transfer Frame Version Number (2 bits);
- b) Quality of Service (QOS) Indicator (1 bit);
- c) Protocol Data Unit (PDU) Type ID (1 bit);
- d) Data Field Construction Identifier (DFC ID) (2 bits);
- e) Spacecraft Identifier (SCID—see reference [6]) (10 bits);
- f) Physical Channel Identifier (PCID) (1 bit);
- g) Port ID (3 bits);
- h) Source-or-Destination Identifier (1 bit);
- i) Frame Length (11 bits);
- j) Frame Sequence Number (interpretation is QOS dependent) (8 bits).

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

NOTE – The format of the Transfer Frame Header is shown in figure 3-3.

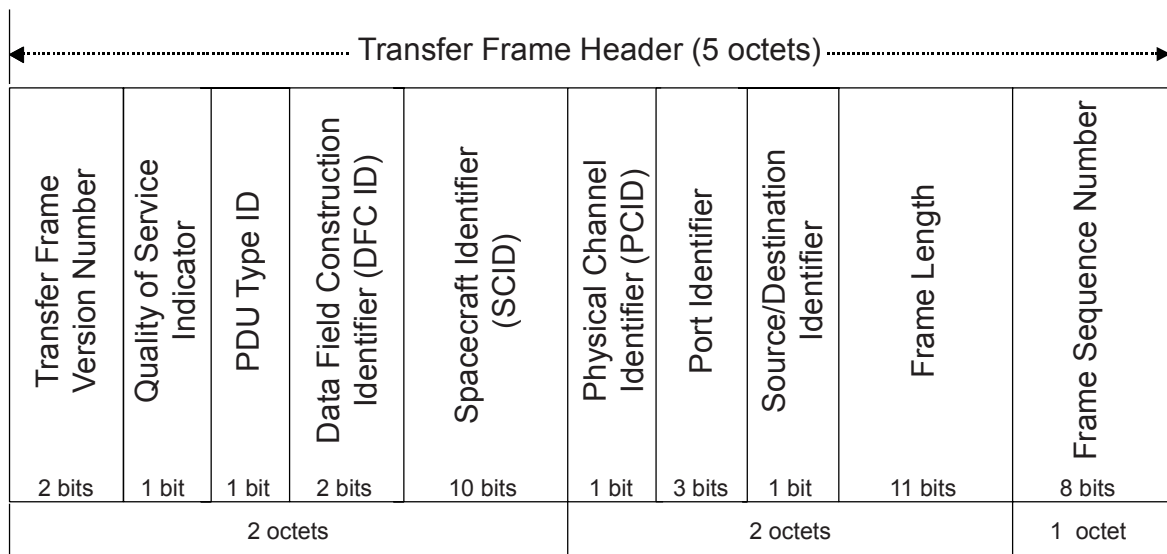


Figure 3-3: Transfer Frame Header

3.2.2.2 Transfer Frame Version Number

3.2.2.2.1 Bits 0–1 of the Transfer Frame Header shall contain the Transfer Frame Version Number.

3.2.2.2.2 The Transfer Frame Version Number field shall contain the binary value ‘10’.

NOTE – This Recommendation defines the Version-3 Transfer Frame. For other transfer frames defined by CCSDS for use with other protocols, see references [3] and [4].

3.2.2.3 Quality of Service Indicator

3.2.2.3.1 Bit 2 of the Transfer Frame Header shall contain the QOS Indicator.

3.2.2.3.2 The single-bit QOS Indicator shall control the application of Frame Acceptance Checks by the receiving end.

- Setting this Indicator to ‘0’ specifies that this transfer frame is a Sequence Controlled transfer frame, and acceptance of this transfer frame by the receiving end shall be subject to the Frame Acceptance Checks, which provide the ‘reliable’ Sequence Controlled service.
- Setting this indicator to ‘1’ specifies that this transfer frame is an Expedited transfer frame, and the Frame Acceptance Checks used for Sequence Controlled service by the receiving end shall be bypassed.

3.2.2.4 PDU Type ID

3.2.2.4.1 Bit 3 of the Transfer Frame Header shall contain the PDU Type ID.

3.2.2.4.2 The PDU Type ID shall be used to specify whether the Transfer Frame Data field is conveying protocol supervisory data or user data information.

- a) Setting the PDU Type ID to '0' indicates that the Transfer Frame Data field contains user data information.
- b) Setting the PDU Type ID to '1' indicates that the Transfer Frame Data field contains supervisory protocol data, i.e., control information, used for controlling operations of the Proximity-1 protocol processor. See 3.2.8 for an explanation of when this PDU type must be used.

3.2.2.5 Data Field Construction ID

3.2.2.5.1 Bits 4–5 of the Transfer Frame Header shall contain the Data Field Construction ID (DFC ID).

3.2.2.5.2 The DFC ID shall signal the data field construction rules used to build the U-Frame Data field.

3.2.2.5.3 The four frame data field construction rules are defined in table 3-1.

Table 3-1: U-Frame Data Field Construction Rules

DFC ID	PLTU Type	Frame Data Field Content	Subsection
'00'	Asynchronous	Packets (integer number of unsegmented packets)	3.2.4
'01'	Asynchronous	Segment Data (a complete or segmented packet)	3.2.5
'10'	Reserved for future CCSDS definition.	Reserved for future CCSDS definition.	3.2.6
'11'	Asynchronous	User-defined Data	3.2.7

3.2.2.6 Spacecraft Identifier (SCID)

3.2.2.6.1 Bits 6–15 of the Transfer Frame Header shall contain the SCID.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

3.2.2.6.2 The 10-bit SCID shall provide the identification of the spacecraft that is either the source or the destination of the data contained in the transfer frame.

NOTE – See Source-or-Destination Identifier for the definition of the value of the SCID.

3.2.2.7 Physical Channel Identifier (PCID)

3.2.2.7.1 Bit 16 of the Transfer Frame Header shall contain the PCID.

3.2.2.7.2 The PCID shall be used to identify the transmitter (FOP-P Protocol Unit, see 7.1) within a spacecraft:

- a) setting the PCID to '0' indicates PCID 0;
- b) setting the PCID to '1' indicates PCID 1.

3.2.2.8 Port ID

3.2.2.8.1 Bits 17–19 of the Transfer Frame Header shall contain the Port ID.

3.2.2.8.2 The Port ID shall be used to address different physical or logical connection ports to which user data are to be routed.

NOTE – There are eight Port IDs (i.e., 0 through 7).

3.2.2.8.3 Port IDs shall be independent of physical channel assignment.

EXAMPLE – A Port ID could designate that the contents of the Frame Data field should be delivered via the addressed physical data port (e.g., a port to a spacecraft bus), or to a defined process within the connected command and data handling system.

3.2.2.9 Source-or-Destination Identifier

3.2.2.9.1 Bit 20 of the Transfer Frame Header shall contain the Source-or-Destination Identifier.

3.2.2.9.2 The Source-or-Destination Identifier shall identify the link node to which the value in the SCID field applies:

- a) a setting of '0' shall indicate that:
 - 1) the SCID refers to the **source** of the transfer frame,
 - 2) the test of the SCID shall be included in the Frame sublayer only when Test_Source is *true*;

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

b) a setting of '1' shall indicate that:

- 1) the SCID refers to the **destination** of the transfer frame,
- 2) the test of the SCID shall be included in the frame sublayer.

3.2.2.9.3 When the Source-or-Destination ID is set to '0', i.e., *source*, the value of the SCID shall be contained in the MIB parameter, Local_Spacecraft_ID.

NOTE – Assignment procedures for SCIDs in Proximity-1 Transfer Frames are controlled by reference [6].

3.2.2.9.4 When the Source-or-Destination ID is set to '1', i.e., *destination*, the value of the SCID shall be contained in the MIB parameter, Remote_Spacecraft_ID.

3.2.2.10 Frame Length

3.2.2.10.1 Bits 21–31 of the Transfer Frame Header shall contain the frame length.

3.2.2.10.2 This 11-bit field shall contain a length count C , which equals one fewer than the total number of octets in the transfer frame.

- a) the count shall be measured from the first octet of the Transfer Frame Header to the last octet of the Transfer Frame Data field;
- b) the length count C is expressed as: $C = (\text{total number of octets in the transfer frame}) - 1$.

NOTE – The size of the Frame Length field limits the maximum length of a transfer frame to 2048 octets ($C = 2047$). The minimum length is 5 octets ($C = 4$).

3.2.2.11 Frame Sequence Number (Sequence Controlled or Expedited)

3.2.2.11.1 Bits 32–39 of the Transfer Frame Header shall contain the Frame Sequence Number (FSN).

3.2.2.11.2 The FSN shall increment monotonically and independently for the set of frames within a PC that are associated with the Sequence Controlled service (QOS Indicator set to '0'). In this case, the FSN is called the Sequence_Controlled_FSN (SEQ_CTRL_FSN).

3.2.2.11.3 The FSN shall increment monotonically for the set of frames for a given PC that are associated with the Expedited Data Service (QOS Indicator set to '1'). In this case, the FSN is called the Expedited_FSN (EXP_FSN).

NOTES

- 1 The FSN (controlled within the Data Services sublayer) for each service is initialized to '0' by the SET INITIALIZE MODE directive (see 6.3.6.1.2).

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

- 2 The SEQ_CTRL_FSN enables the Sequence Controlled process to number sequentially and then check the sequence of incoming Sequence Controlled transfer frames.
- 3 The EXP_FSN is not used in the frame validation process but is required for correlations associated with timing services.
- 4 The FSN is PC-dependent for both the Sequence Controlled and Expedited services.

3.2.3 TRANSFER FRAME DATA FIELD

The Transfer Frame Data field shall:

- a) follow, without gap, the Transfer Frame Header;
- b) be of variable length;
- c) contain from zero octets up to 2043 octets (maximum frame length of 2048 less five octets for the frame header);
- d) contain either an integer number of octets of data corresponding to one or more SDUs, or an integer number of octets of protocol information.

NOTE – These octets may contain an SDU and other data fields based upon the DFC ID. See figure 3-4.

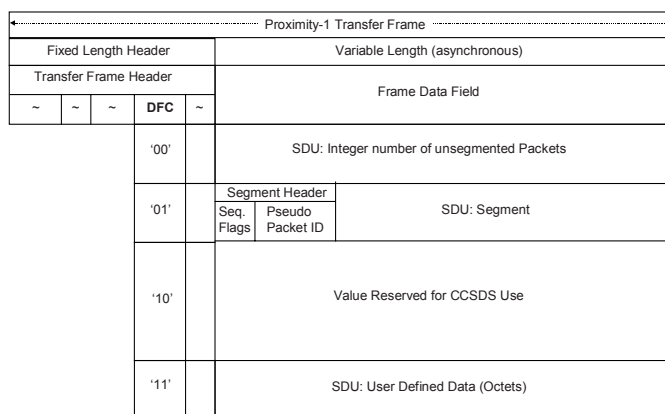


Figure 3-4: Proximity-1 Transfer Frame Data Field Structure

3.2.4 PACKETS

3.2.4.1 When the DFC ID field contains the binary value '00' (pertaining to asynchronous PLTUs), the Frame Data field shall consist of an integer number of packets each designated to the same Port ID (see figure 3-4).

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

3.2.4.2 The first bit of the Frame Data field shall be the first bit of a packet header.

3.2.5 SEGMENT DATA UNITS

3.2.5.1 When the DFC ID field contains the binary value '01' (pertaining to asynchronous PLTUs), the Frame Data field contains a Segment Data Unit consisting of an eight-bit segment header followed by a segment of a packet (see figure 3-4).

3.2.5.2 The contents of the segment header and segment data field shall be as follows:

- a) bits 0 and 1 of the segment header compose the sequence flag, which shall identify the position of the segment relative to the packet of which the segment is a part as specified in table 3-2;
- b) the remaining six bits compose an identifier field, the pseudo packet identifier, which shall adaptively be used to associate all the segments of a packet data unit;
- c) segments must be placed into the data link in the proper order:
 - 1) segments of the same packet must be sent in frames of the same PCID and Port ID,
 - 2) segments from another packet may be interspersed but only in frames containing a different PCID or Port ID.

Table 3-2: Segment Header Sequence Flags

Sequence Flags	Interpretation
'01'	first segment
'00'	continuing segment
'10'	last segment
'11'	no segmentation (i.e., contains the entire packet)

3.2.5.3 Prior to delivery to the user, the Data Link layer shall re-assemble all the segments using the same Routing ID, i.e., using the same PCID, Port ID, and pseudo packet ID, into a packet.

NOTE – See 1.5.1.3 for the definitions of Routing ID and pseudo packet ID.

3.2.5.4 Only complete packets shall be sent on to the user.

3.2.5.5 The accumulated packet shall be discarded and this event shall be logged into the session accountability report whenever any of the following errors occur:

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

- a) the packet length field does not agree with the number of bytes received and aggregated from the segments;
- b) the first segment received for a Routing ID is not the start segment of the data unit;
- c) the last segment for a Routing ID is not received before the starting segment of a new packet is received.

3.2.6 CCSDS RESERVED FIELD

The binary value '10' for the DFC ID field is reserved by CCSDS and shall not be used.

3.2.7 USER-DEFINED DATA

When the DFC ID field contains the binary value '11', the Frame Data field shall consist of User Defined Data (see figure 3-4).

3.2.8 SUPERVISORY PDU (SPDU)

NOTE – The protocol data units discussed in this subsection are used by the local transceiver either for local control within the transceiver, or for reporting status to and controlling the remote transceiver acting as the communication partner over the Proximity space link.

3.2.8.1 General

3.2.8.1.1 SPDUs are of either fixed or variable length based upon the value of the SPDU format ID. Currently there is only one fixed-length SPDU defined, i.e., PLCW. Variable-length SPDUs provide the capability for concatenating and multiplexing protocol objects, i.e., directives, status reports, and PLCWs. Note that the positions of the individual fields within the fixed-length PLCW differ from those of the variable-length PLCW. Each SPDU Type is further described in tables 3-3 and 3-4.

3.2.8.1.2 SPDUs can be transmitted using only the expedited QOS (QOS = '1').

3.2.8.1.3 SPDUs are all self-identifying and self-delimiting. Only variable-length SPDUs further decompose into specific types of supervisory directives, reports, or PLCWs. See annex A for the detailed specification of variable-length SPDUs.

3.2.8.2 Overview of SPDU Formats

3.2.8.2.1 Fixed-length SPDUs consist of an SPDU Format ID, SPDU Type Identifier, and a Supervisory Data field. Variable-length SPDUs consist of an SPDU Format ID, SPDU Type Identifier, length of SPDU field, and a Supervisory Data field.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

3.2.8.2.2 For fixed-length SPDUs these fields are defined and are positioned contiguously, in the following sequence as:

- a) SPDU Header (two bits) consisting of:
 - 1) SPDU Format ID (one bit),
 - 2) SPDU Type Identifier (one bit);
- b) Supervisory Data field (14 bits) consisting of either the data field of a fixed-length PLCW or the data field of a CCSDS reserved SPDU.

3.2.8.2.3 For variable-length SPDUs, these fields are defined and are positioned contiguously, in the following sequence as:

- a) SPDU Header (one octet) consisting of:
 - 1) SPDU Format ID (one bit),
 - 2) SPDU Type Identifier (three bits),
 - 3) Data Field Length (four bits) (this represents the actual number of octets in the data field of the SPDU);

NOTE – Data Field Length is not a ‘length minus one’ field.

- b) Supervisory Data field (variable length, i.e., 0 to 15 octets) consisting of one or more supervisory directives, status reports, or PLCWs of the same SPDU type.

CCSDS RECOMMENDED STANDARD FOR PROXIMITY-1 SPACE DATA LINK PROTOCOL

Table 3-3: Fixed-Length Supervisory Protocol Data Unit

Fixed-Length SPDU (16 bits)	SPDU Header (2 bits)		SPDU Data Field (14 bits)
	SPDU Format ID (Bit 0)	SPDU Type Identifier (Bit 1)	(contains 1 protocol object, i.e., directive or report or PLCW) (Bits 2 through 15)
Type F1	‘1’	‘0’	Fixed Length PLCW (See 3.2.8.3.2)
Type F2	‘1’	‘1’	Reserved for CCSDS Use

3.2.8.3 Fixed-Length SPDU**3.2.8.3.1 General**

A ‘1’ in the SPDU Format ID field identifies a 16-bit fixed-length SPDU. This format provides for only two fixed SPDUs, which are differentiated by the SPDU Type Identifier field. A ‘zero’ in bit 1 identifies the SPDU as a PLCW, while an SPDU identified by a ‘one’ in bit 1 is reserved for future CCSDS specification.

3.2.8.3.2 Type F1 SPDU: Proximity Link Control Word (PLCW)**3.2.8.3.2.1 General**

3.2.8.3.2.1.1 The Proximity Link Control Word (PLCW) shall consist of seven fields, positioned contiguously in the following sequence (described from least significant bit, bit 15, to most significant bit, bit 0):

- Report Value (eight bits);
- Expedited Frame Counter (three bits);
- Reserved Spare (one bit);
- PCID (one bit);
- Retransmit Flag (one bit);
- SPDU Type Identifier (one bit);
- SPDU Format ID (one bit).

3.2.8.3.2.1.2 The PLCW shall be transmitted using the Expedited QOS.