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Nationales Vorwort

Dieses Dokument (EN 16603-50:2014) wurde vom Technischen Komitee CEN/CLC/TC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat vom DIN (Deutschland) gehalten wird.

Das zuständige deutsche Normungsgremium ist der Arbeitsausschuss NA 131-10-01 AA „Interoperabilität von Informations-, Kommunikations- und Navigationssystemen“ im DIN-Normenausschuss Luft- und Raumfahrt (NL).

Dieses Dokument (EN 16603-50:2014) basiert auf ECSS-E-ST-50C.

Dieses Dokument enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung von EN 16603-50:2014.

Dieses Dokument wurde speziell zur Behandlung von Raumfahrtsystemen erarbeitet und hat daher Vorrang vor jeglicher Europäischer Norm, da es denselben Anwendungsbereich hat, jedoch über einen größeren Geltungsbereich (z. B. Luft- und Raumfahrt) verfügt.

Nationaler Anhang NA (informativ)

Begriffe, Symbole und Abkürzungen

3 Begriffe, Symbole und Abkürzungen

3.1 Begriffe aus anderen Normen

Für die Anwendung dieses Dokuments gelten die Begriffe nach ECSS-S-ST-00-01, insbesondere der folgende Begriff:

Funktion

3.2 Für diese Norm spezifische Begriffe

3.2.1

Kanal

Kombination aus Protokoll und Medium, die einen Ende-zu-Ende-Bitübertragungsschichtdienst bereitstellt

Anmerkung 1 zum Begriff: Dies ist die Übertragung des unstrukturierten Bitstroms von Punkt-zu-Punkt.

3.2.2

Kommunikationsdienst

Dienst, der die Fähigkeit zur Datenbewegung zwischen Nutzern ermöglicht

Anmerkung 1 zum Begriff: Mindestens zwei Nutzer sind bei der Verwendung eines Kommunikationsdienstes beteiligt, einer, der Daten sendet und mindestens ein anderer, der Daten empfängt.

3.2.3

wechselseitige Unterstützung

Verwendung eines Teils der Datensystemressourcen einer Partei durch eine andere Partei, um deren eigenes System zu ergänzen

3.2.4

Entität

aktives Element innerhalb eines Systems

3.2.5

Schnittstelle

Beschreibung der Verbindung zwischen realen oder abstrakten Objekten

3.2.6

isochroner Dienst

Dienst, für die Datenübertragung mit einer festgelegten maximalen Abweichung vom Nennwert einer Ende-zu-Ende-Verzögerung

3.2.7

Protokoll

Satz von Regeln und Formaten (semantisch und syntaktisch), die das Kommunikationsverhalten von Schicht-entitäten bei der Ausführung der Kommunikationsfunktionen bestimmen

3.2.8

Dienst

Fähigkeit einer Schicht und der Schichten darunter (ein Dienstanbieter), die Dienstbenutzern an der Grenze zwischen dem Dienstanbieter und den Dienstbenutzern bereitgestellt wird

Anmerkung 1 zum Begriff: Der Dienst legt das äußere Verhalten des Dienstanbieters fest, unabhängig von den Mechanismen, die zur Bereitstellung dieses Verhaltens verwendet wurden. Schichten, Schichtentitäten und Anwendungs-Dienstelemente sind Beispiele von Komponenten eines Dienstanbieters.

3.2.9

Dienstdateneinheit

Informationsmenge deren Identität bei der Übertragung zwischen gleichrangigen Entitäten in einer gegebenen Schicht erhalten bleibt und die nicht durch die unterstützenden Entitäten in dieser Schicht interpretiert wird

3.2.10

Dienstanbieter

abstrakte Repräsentation der Gesamtheit der Entitäten, die Dienstbenutzern einen Dienst bereitstellen

Anmerkung 1 zum Begriff: Ein Dienstanbieter umfasst Entitäten in der Schicht, in der der Dienst bereitgestellt wird und in den Schichten darunter.

3.2.11

Dienstbenutzer

Entität in einem einzelnen System, die einen Dienst benutzt

Anmerkung 1 zum Begriff: Der Dienstbenutzer benutzt den Dienst mittels einer Sammlung von Dienstelementen, die für den Dienst festgelegt sind.

3.2.12

Simplex

Kommunizieren in einer Richtung von der Datenquelle zur Datensenke

3.2.13

Quelle

Entität, die Dienstdateneinheiten unter Verwendung eines Dienstanbieters sendet

3.2.14

Senke

Entität, die Dienstdateneinheiten von einem Dienstanbieter empfängt

3.2.15

Fernsteuern

Kommunikationsverbindung von Boden zu Weltraum, durch die ein Raumfahrzeug gesteuert wird

3.2.16

Telemetrie

Housekeeping-Daten und Nutzlastdaten

Anmerkung 1 zum Begriff: Housekeeping-Telemetrie wird üblicherweise bei niedriger Rate übertragen, Nutzlastdaten können jedoch bei sehr hoher Rate übertragen werden.

3.2.17

Telemetrieverbindung

Verbindung vom Raumfahrzeug zum Boden, über die im Raumfahrzeug erzeugte Daten an den Boden übermittelt werden

3.2.18

Nutzer

Dienstbenutzer

3.2.19

Benutzeranwendung

Anwendung die Datenverarbeitungssystemdienste verwendet

Anmerkung 1 zum Begriff: Eine Anwendung kann eine Software-Entität oder eine Nicht-Software-Entität sein, die ein Bordsystem regelt.

3.3 Abkürzungen

Für die Anwendung dieses Dokuments gelten die Abkürzungen nach ECSS-ST-00-01 und die folgenden Abkürzungen:

AIT	Baugruppe, Integration und Test (en: assembly, integration, and test)
AR	Abnahme-Review (en: acceptance review)
ARQ	automatische Wiederholungsanfrage (en: automatic repeat request)
BER	Bitfehlerquote (en: bit error rate)
CCITT	Internationaler beratender Ausschuss für den Fernsprech- und Funkdienst (en: Consultative Committee for International Telegraph and Telephone)
CCSDS	Beratender Ausschuss für Raumfahrt-Raumdaten-Systeme (en: Consultative Committee for Space Data Systems)
CDMU	zentrale Datenmanagements-Einheit (en: central data management unit)
CDR	kritisches Design-Review (en: critical design review)
CSAD	Dokument der Kommunikationssystemanalyse (en: communication system analysis document)
CSADD	Dokument zum Entwurf des Aufbaus eines Kommunikationssystems (en: communication system architectural design document)
CSBD	Grundlagendefinition des Kommunikationssystems (en: communication system baseline definition)
CSDDD	Dokument zur Entwicklungsphase des Kommunikationssystems (en: communication system detailed design document)
CSOM	Betriebshandbuch des Kommunikationssystems (en: communication system operations manual)
CSPD	Dokument zum Profil des Kommunikationssystems (en: communication system profile document)
CSRD	Dokument zu den Kommunikationssystemanforderungen (en: communication system requirements document)
CSVP	Prüfplan des Kommunikationssystems (en: communication system verification plan)
DRD	Dokumenten-Anforderungsdefinition (en: document requirements definitions)
EIRP	äquivalente isotrope Strahlungsleistung (en: equivalent isotropically radiated power)
EMV	elektromagnetische Verträglichkeit (en: electromagnetic compatibility, EMC)
ISO	Internationale Organisation für Normung (en: International Organization for Standardization)
ITU	Internationale Fernmeldeunion (en: International Telecommunication Union)
ITU-R	ITU-Funkkommunikation (en: ITU-Radiocommunication)
ITU-RR	ITU-Vollzugsordnung (en: ITU-Radio Regulations)
LEOP	Start und frühe Betriebsphase (en: launch and early operations phase)
MEC	Leitstelle für Experimente bei Raumfahrtmissionen (en: mission experiment centre)
OSI	Kommunikation offener Systeme (en: open system interconnection)
OCC	Betriebskontrollzentrum (en: operational control centre)
PDR	vorläufiges Design-Review (en: preliminary design review)
PFD	Leistungsflussdichte (en: power flux density)
QR	Qualifikations-Review (en: qualification review)
RF	Hochfrequenz, Funkfrequenz (en: radio frequency)
SDU	Dienstdateneinheit (en: service data unit)
SRR	Systemanforderungs-Review (en: system requirements review)
TT&C	Telemetrie, Nachführung und Befehl (en: telemetry, tracking, and command)

— Leerseite —

English version

Space engineering - Communications

Ingénierie spatiale - Communications

Raumfahrttechnik - Kommunikation

This European Standard was approved by CEN on 1 March 2014.

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Foreword

This document (EN 16603-50:2014) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-50:2014) originates from ECSS-E-ST-50C.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2015, and conflicting national standards shall be withdrawn at the latest by March 2015.

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

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This standard specifies requirements for the development of the end-to-end data communication system for spacecraft. Implementation aspects are defined in both ECSS-E-ST-50 Level 3 standards and CCSDS standards.

The complete set of standards to define a complete communication link is project dependent and cannot be specified here. ECSS-E-HB-50 provides some guidance on this aspect, and gives some practical examples.

1

Scope

This Standard specifies the requirements for the development of the end-to-end data communications system for spacecraft.

Specifically, this standard specifies:

- The terminology to be used for space communication systems engineering.
- The activities to be performed as part of the space communication system engineering process, in accordance with the ECSS-E-ST-10 standard.
- Specific requirements on space communication systems in respect of functionality and performance.

The communications links covered by this Standard are the space-to-ground and space-to-space links used during spacecraft operations, and the communications links to the spacecraft used during the assembly, integration and test, and operational phases.

Spacecraft end-to-end communication systems comprise components in three distinct domains, namely the ground network, the space link, and the space network. This Standard covers the components of the space link and space network in detail. However, this Standard only covers those aspects of the ground network that are necessary for the provision of the end-to-end communication services.

NOTE Other aspects of the ground network are covered in ECSS-E-ST-70.

This Standard may be tailored for the specific characteristics and constraints of a space project in conformance with ECSS-S-ST-00.

2

Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revisions of any of these publications, do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system — Glossary of terms

Terms, definitions and abbreviated terms

3.1 Terms defined in other standards

For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply, in particular for the following term:

function

3.2 Terms specific to the present standard

3.2.1 channel

combination of protocol and medium that provides a physical layer service from end-to-end

NOTE This is the transfer of the unstructured bitstream from point-to-point.

3.2.2 communication service

service that provides the capability of moving data between users.

NOTE At least two users are involved when a communication service is used, one sending data and the other(s) receiving data.

3.2.3 cross support

use by one party of part of another party's data system resources to complement its own system

3.2.4 entity

active element within a system

3.2.5 interface

description of the connection between real or abstract objects

3.2.6 isochronous service

service providing for the transfer of data with a defined maximum deviation from a nominal delay from end to end

3.2.7 protocol

set of rules and formats (semantic and syntactic) that determine the communication behaviour of layer entities in the performance of communication functions

3.2.8 service

capability of a layer, and the layers beneath it (a service-provider), that is provided to service-users at the boundary between the service-provider and the service-users

NOTE The service defines the external behaviour of the service-provider, independent of the mechanisms used to provide that behaviour. Layers, layer entities, and application-service-elements are examples of components of a service-provider.

3.2.9 service data unit

amount of information whose identity is preserved when transferred between peer entities in a given layer and which is not interpreted by the supporting entities in that layer

3.2.10 service-provider

abstract representation of the totality of those entities which provide a service to service-users

NOTE A service provider includes entities in the layer at which the service is provided, and in the layers beneath it.

3.2.11 service-user

entity in a single system that makes use of a service

NOTE The service-user makes use of the service through a collection of service primitives defined for the service.

3.2.12 simplex

communicating in one direction from data source to data sink

3.2.13 source

entity that sends service-data-units, using a service provider

3.2.14 sink

entity that receives service-data-units from a service provider

3.2.15 telecommand

communication link from ground to space by which a spacecraft is commanded

3.2.16 telemetry

housekeeping data and payload data

NOTE Housekeeping telemetry is usually transmitted at low rate, but payload data can be transmitted at a very high rate.

3.2.17 telemetry link

link from spacecraft to ground over which data generated on the spacecraft is provided to ground

3.2.18 user

service-user

3.2.19 user application

application that makes use of data handling system services

NOTE An application can be a software entity or a non-software entity which is controlling an onboard system.

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-ST-00-01 and the following apply:

Abbreviation	Meaning
AIT	assembly, integration, and test
AR	acceptance review
ARQ	automatic repeat request
BER	bit error rate
CCITT	Consultative Committee for International Telegraph and Telephone
CCSDS	Consultative Committee for Space Data Systems
CDMU	central data management unit
CDR	critical design review
CSAD	communication system analysis document
CSADD	communication system architectural design document
CSBD	communication system baseline definition
CSDDD	communication system detailed design document
CSOM	communication system operations manual
CSPD	communication system profile document
CSRD	communication system requirements document
CSVP	communication system verification plan
DRD	document requirements definitions
EIRP	equivalent isotropically radiated power
EMC	electromagnetic compatibility
ISO	International Organization for Standardization

ITU	International Telecommunication Union
ITU-R	ITU – Radiocommunication
ITU-RR	ITU – Radio Regulations
LEOP	launch and early operations phase
MEC	mission experiment centre
OSI	open system interconnection
OCC	operational control centre
PDR	preliminary design review
PFD	power flux density
QR	qualification review
RF	radio frequency
SDU	service data unit
SRR	system requirements review
TT&C	telemetry, tracking and command

4

Space communications engineering principles

4.1 Context

Space communications engineering is concerned with the provision of end-to-end communication services to and from spacecraft. Communication links are generally between the spacecraft and ground. However, this Standard also addresses spacecraft-to-spacecraft links, e.g. in spacecraft constellations, and can be applied to links between spacecraft and landed elements such as orbiter-lander or orbiter-lander-rover configurations.

End-to-end communication is used both to control the operation of the spacecraft, and to transfer data, such as payload data. However, the requirements on the communications system for controlling the spacecraft differ from those for payload data transfer. For control operations, the communication system objective is to provide guaranteed delivery of commands in the order of transmission. Commands can be repeated, but not lost. By contrast, the requirement for payload data transfers is to transfer as much data as possible. Some loss of data may be acceptable, and delivery order is generally unimportant, provided the data can be reconstituted.

In addition to the end-to-end transfer of commands and data, some additional services are provided across space communication links, such as time correlation and ranging. Time correlation is used to accurately relate the local time maintained at each end of the communication link in order to determine the absolute time relationship between events. Ranging is used to determine the distance to the spacecraft, e.g. between a ground station antenna and the spacecraft, or between two spacecraft, and is used for orbit determination.

The goals of standardization for space communication systems are:

- to ensure efficient use of the RF spectrum allocated to the space infrastructure in a non-interfering manner;
- to ensure that the RF links to and from the spacecraft can be used for orbit determination and ranging;
- to ensure reliable and error free end-to-end communication between ground stations and the spacecraft;
- to enable the use of the same ground segment infrastructure by different spacecraft;

- to ensure that standard communication interfaces are provided to the spacecraft payloads and experiments in order to simplify the spacecraft development process;
- to enable cross support between agencies.

Cross support can be beneficial for many reasons, including:

- Technical: to attain additional network coverage or to conduct some programmatic endeavour, such as very long baseline interferometry measurements.
- Economic: to avoid the expense of duplicate implementation, especially to meet some short term requirement.
- Emergency: to increase mission support over that normally planned.
- Research: to avoid the cost and time delay of repeating investigations or re-flying an experiment and to obtain unique data acquired in the past and held by another agency.

These arguments were apparent as long ago as the early 1970s. For this reason, the Consultative Committee for Space Data Systems (CCSDS) was established to standardize space link protocols. Where appropriate, this ECSS Standard calls up CCSDS recommendations directly.

Space communication engineering involves many different disciplines. The physical layers of wireless communications links are the preserve of RF or optical specialists, and wired links are the speciality of analogue electronics engineers. The electronic components that implement the communication services are designed and implemented by analogue and digital electronics engineers, and the design of the protocols used in the provision of services is entrusted to protocol experts. In many cases, the higher level services and protocols are implemented in software by specialized software engineers. Other ECSS Standards which are applicable to this discipline are called up within this Standard.

4.2 Overall space communication

Figure 4-1 shows an example of a configuration for a space communication system.

NOTE This configuration includes a space-to-space link between two flight elements.

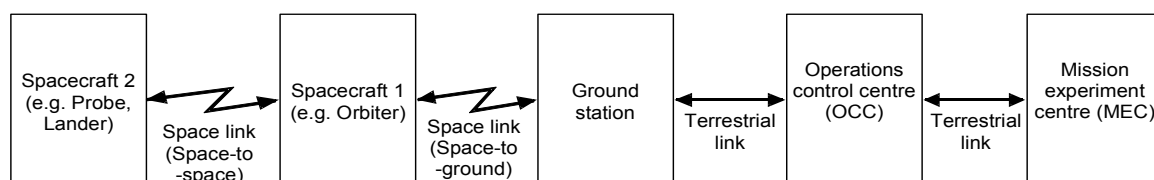


Figure 4-1: Example configuration of a space communication system

The overall data communication requirement is to transfer data to and from any element of the space system in accordance with the mission requirements.

The elements of a space communication system are described in the following paragraphs. In a real space communication system, the number and type of elements actually present can vary. For example, in complex missions, there can be several spacecraft, and multiple ground stations. In other missions, a single spacecraft can be controlled from a single operation control centre, without a mission experiment centre.

The space communication system elements are:

- a spacecraft linked to the ground via a space link (space-to-ground). This can also be linked to other spacecraft, landers, and probes via space-to-space (proximity) links;
- other spacecraft, landers, and probes linked only with the main spacecraft via proximity links;
- a ground station that forms the terrestrial end of the space-to-ground space link, and is connected to the operational control centre via a terrestrial link;
- an operational control centre (OCC), connected to the ground station via a terrestrial link. The OCC is used to control the spacecraft;
- a dedicated mission experiment centre (MEC) connected to the operations control centre. Mission payloads and experiments are operated from the MEC.

Each element includes a data handling system, which provides three main communication functions:

- managing data communication interfaces internal to the element (internal links);
- managing data communication interfaces with external links (i.e. space links and terrestrial links to other elements);
- performing data processing for the transfer between internal and external links.

The data handling for transferring data from a sending element to a receiving element of the space communication system via an external link consists of:

- For the down-link data stream:
 - At sender side
 - Acquisition of data from subsystems.
 - Processing and formatting of the data stream for transmission to the ground via the external link as telemetry.
 - Forwarding of the data stream via the external link.
 - At receiver side
 - Acquisition of the data stream from the sender via the external link.

- De-formatting and processing for delivery to receiver internal elements (e.g. space system user for a link between ground station and OCC) and for transfer to the next element via an external link (e.g. transfer from ground station to OCC).
 - Delivery of data to receiver internal elements (e.g. space system user).
- For the up-link data stream:
 - At sender side
 - Acquisition of data from space system user.
 - Processing and formatting of the data stream for transmission to the spacecraft via the external link as telecommand.
 - Forwarding of the data stream via the external link.
 - At receiver side
 - Acquisition of the data stream from the sender via the external link.
 - De-formatting and processing for delivery to receiver internal elements (e.g. spacecraft subsystems for a link between ground station and spacecraft) and for transfer to the next element via an external link.
 - Delivery of data to receiver internal elements (e.g. commands to spacecraft subsystems).

The type of data to be transmitted can be telemetry, files, video, and digital voice for the down-link, and telecommands, files, video, and digital voice for the up-link.

For each type of data transmission, protocols defined by CCSDS or other standardization bodies may be used. Figure 4-2 shows some of the CCSDS and internet protocols that can be used over the space-to-ground space link. This figure illustrates five of the seven ISO reference model layers defined in ISO 7498 (the session and presentation are not shown).

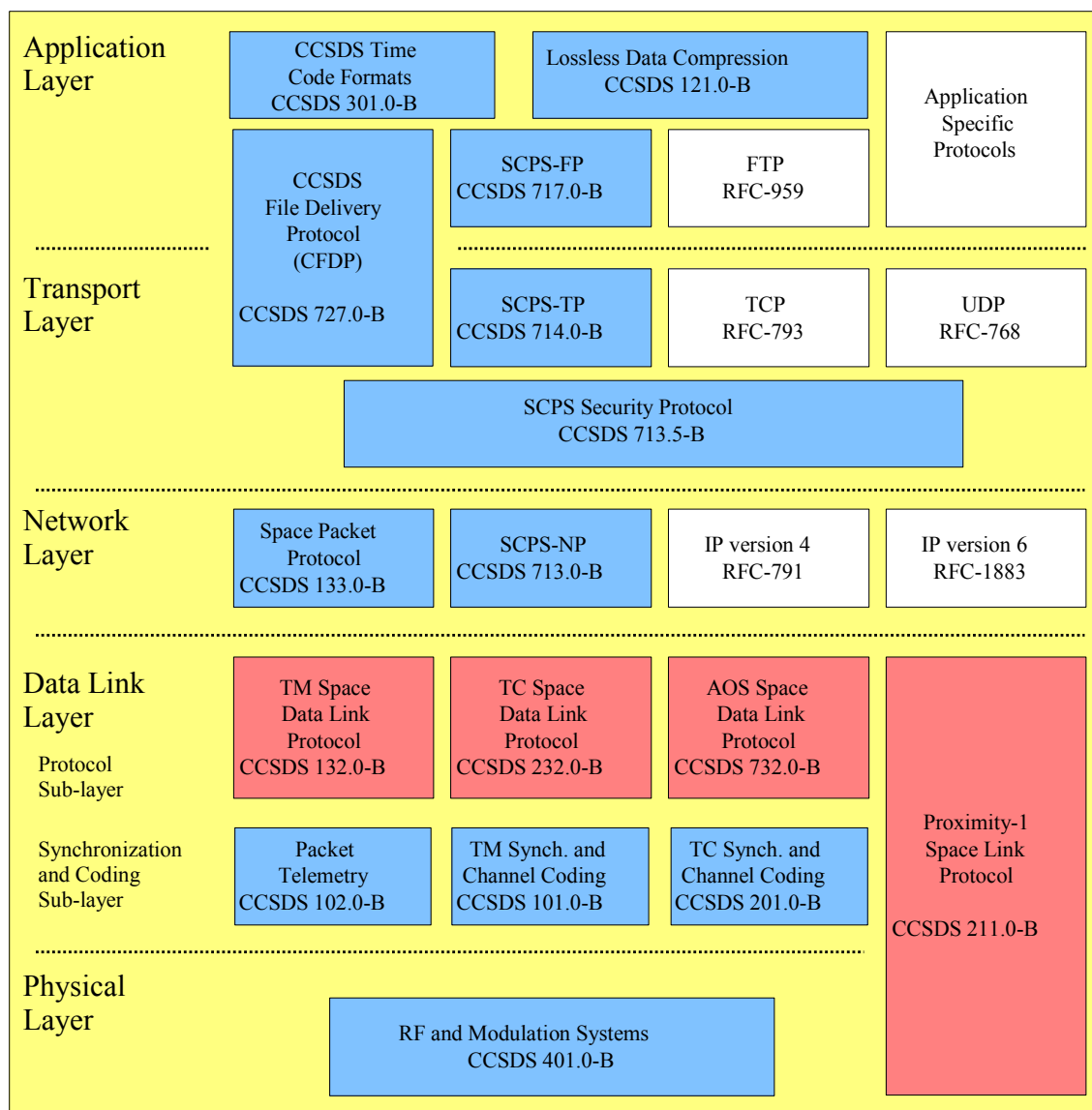


Figure 4-2: CCSDS and Internet space link protocols

4.3 Space communication domains

4.3.1 Overview

A space communication system comprises three distinct domains that each have markedly different characteristics. The three domains are

- the space network,
- the space link, and
- the ground network.

These domains are illustrated in Figure 4-3.

4.3.2 Space network

The space network comprises all of the nodes in the flight segment of a spacecraft mission. These nodes can all be on a single spacecraft, or can be distributed among several spacecraft, for example in a constellation. The space network therefore includes both intra-spacecraft and inter-spacecraft links.

The type of network medium and topologies of the space network are highly varied, often being based on proprietary protocols. The emphasis of this Standard in this case is on the definition of appropriate user and transfer layer services that maintain freedom of choice in the sub-network layers, while also moving towards harmonization and better definition of the subnet layers.

Except in very rare circumstances, the space network cannot be maintained or upgraded during a mission. Usually, the technology used to implement the space network is conservative, and reflects the state-of-the-art years before launch. This severely constrains the performance available when compared with the ground network.

An increasing number of missions involve a space segment consisting of more than one element, e.g. constellations of spacecraft, or planetary missions consisting of an orbiter and lander, or orbiter-lander-rover. This Standard regards all of these elements as comprising the space network. These missions change the nature of the space network by including inherently unreliable wireless links and introducing the potential for a variable network topology.

4.3.3 Space link

The space link is essentially a point-to-point wireless link between a ground station and a spacecraft. This link is inherently unreliable, and the emphasis of this Standard here is on the achievement of reliable data transfer services. Users concerned only with the exchange of data, either onboard or on ground, do not generally use the space link services directly, accessing these services instead through their local ground or onboard subnets. However, users concerned with the operation and control of the spacecraft can access space link services for a number of reasons, including routine operations such as ranging, orbital position determination, and emergency operations such as low level commanding.

Equipment at the terrestrial end of the space link is essentially unconstrained in terms of power, mass, and volume requirements. By contrast, equipment at the onboard end of the space link is severely constrained in these respects. This limits the bandwidth that can be achieved, especially in the return (space-to-ground) direction.

The medium through which the space link signal propagates can interfere with or distort the signal, and the very high relative velocity of some spacecraft introduces severe Doppler effects. The movement of the spacecraft relative to its ground station makes the signal propagation path characteristics highly variable. The combination of these factors imposes on the space link to be capable of operating reliably over a very wide range of conditions, and to tolerate very high bit error rates (BER).

For bi-directional communications, the space link comprises at least two physical channels, one for forward (ground-to-space) and one for return