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Space data and information transfer systems — Space link extension (SLE) — Forward communications link transmission unit (CLTU) service

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National foreword

This British Standard is the UK implementation of ISO 22671:2011. It supersedes BS ISO 22671:2007 which is withdrawn.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.

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Amendments issued since publication

Date	Text affected
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**Space data and information transfer
systems — Space link extension (SLE) —
Forward communications link
transmission unit (CLTU) service**

*Systèmes de transfert des informations et données spatiales —
Extension de liaisons spatiales (SLE) — Service de l'unité de
transmission pour la liaison d'envoi de télécommande (CLTU)*





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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 22671 was prepared by the Consultative Committee for Space Data Systems (CCSDS) as CCSDS 912.1-B-3, July 2010 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*.

This third edition cancels and replaces the second edition (ISO 22671:2007), which has been technically revised.

Space data and information transfer systems — Space link extension (SLE) — Forward communications link transmission unit (CLTU) service

1 Scope

1.1 This International Standard defines the Communications Link Transmission Unit (CLTU) service in conformance with the transfer services specified in CCSDS 910.4-B-2 (equivalent to ISO 15396). The Forward CLTU service is a Space Link Extension (SLE) transfer service that enables a mission to send Communications Link Transmission Units (CLTUs) to a spacecraft.

1.2 This International Standard defines, in an abstract manner, the Forward CLTU service in terms of

- a) the operations necessary to provide the transfer service,
- b) the parameter data associated with each operation,
- c) the behaviors that result from the invocation of each operation, and
- d) the relationship between, and the valid sequence of, the operations and resulting behaviors.

1.3 It does not specify

- a) individual implementations or products,
- b) the implementation of entities or interfaces within real systems,
- c) the methods or technologies required to radiate data to a spacecraft and to acquire telemetry frames from the signals received from that spacecraft for extraction of the Operational Control Field,
- d) the methods or technologies required for communications, or
- e) the management activities necessary to schedule, configure, and control the Forward CLTU service.

1.4 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 912.1-B-3, July 2010, *Space link extension — Forward CLTU service specification*.

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 912.1-B-3.

Pages i to vi

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

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Add the following information to the reference indicated:

- [1] Document CCSDS 910.4-B-2, October 2005, is equivalent to ISO 15396:2007.
- [2] Document CCSDS 231.0-B-1, September 2003, is equivalent to ISO 22642:2005.
- [3] Document CCSDS 232.0-B-1, September 2003, is equivalent to ISO 22664:2005.
- [4] Document CCSDS 232.1-B-1, September 2003, is equivalent to ISO 22667:2005.
- [5] Document CCSDS 301.0-B-3, January 2002, is equivalent to ISO 11104:2003.
- [6] ISO/IEC 8824-1:2002 has been cancelled and withdrawn. It has been replaced by ISO/IEC 8824-1:2008, *Information technology — Abstract Syntax Notation One (ASN.1): Specification of basic notation*.

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Add the following information to the reference indicated:

- [G4] Document CCSDS 201.0-B-3, June 2000, is equivalent to ISO 12171:2002.
- [G5] Document CCSDS 202.0-B-3, June 2001, is equivalent to ISO 12172:2003.
- [G6] Document CCSDS 202.1-B-2, June 2001, is equivalent to ISO 12173:2003.
- [G7] Document CCSDS 203.0-B-2, June 2001, is equivalent to ISO 12174:2003.

3 Revision of publication CCSDS 912.1-B-3

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 912.1-B-3. To this end, NASA will act as a liaison body between CCSDS and ISO.



Recommendation for Space Data System Standards

SPACE LINK EXTENSION— FORWARD CLTU SERVICE SPECIFICATION

RECOMMENDED STANDARD

CCSDS 912.1-B-3

BLUE BOOK
July 2010

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CCSDS RECOMMENDED STANDARD FOR SLE FCLTU SERVICE

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

This document is published and maintained by:

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NASA Headquarters
Washington, DC 20546-0001, USA

CCSDS RECOMMENDED STANDARD FOR SLE FCLTU SERVICE

STATEMENT OF INTENT

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

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

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

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

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

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FOREWORD

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

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

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

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- Swedish Space Corporation (SSC)/Sweden.

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- United States Geological Survey (USGS)/USA.

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DOCUMENT CONTROL

Document	Title	Date	Status
CCSDS 912.1-B-1	Space Link Extension—Forward CLTU Service Specification	April 2002	Original issue, superseded
CCSDS 912.1-B-2	Space Link Extension—Forward CLTU Service Specification	November 2004	Issue 2, superseded
CCSDS 912.1-B-3	Space Link Extension—Forward CLTU Service Specification, Recommended Standard, Issue 3	July 2010	Current issue: – corrects/clarifies/ updates text and adds the option of picosecond resolution to the earth-receive- time parameter

NOTE – Substantive changes from the previous issue are indicated by change bars in the inside margin.

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1 INTRODUCTION

1.1 PURPOSE OF THIS RECOMMENDED STANDARD

This Recommended Standard defines the Communications Link Transmission Unit (CLTU) service in conformance with the transfer services specified in reference [1], *Cross Support Reference Model—Part 1: SLE Services*. The Forward CLTU service is a Space Link Extension (SLE) transfer service that enables a mission to send Communications Link Transmission Units (CLTUs) to a spacecraft.

1.2 SCOPE

This Recommended Standard defines, in an abstract manner, the Forward CLTU service in terms of:

- a) the operations necessary to provide the transfer service;
- b) the parameter data associated with each operation;
- c) the behaviors that result from the invocation of each operation; and
- d) the relationship between, and the valid sequence of, the operations and resulting behaviors.

It does not specify:

- a) individual implementations or products;
- b) the implementation of entities or interfaces within real systems;
- c) the methods or technologies required to radiate data to a spacecraft and to acquire telemetry frames from the signals received from that spacecraft for extraction of the Operational Control Field;
- d) the methods or technologies required for communications; or
- e) the management activities necessary to schedule, configure, and control the Forward CLTU service.

1.3 APPLICABILITY

1.3.1 APPLICABILITY OF THIS RECOMMENDED STANDARD

This Recommended Standard provides a basis for the development of real systems that implement the Forward CLTU service. Implementation of the Forward CLTU service in a real system additionally requires the availability of a communications service to convey invocations and returns of Forward CLTU service operations between service users and

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providers. This Recommended Standard requires that such a communications service ensure that invocations and returns of operations are transferred:

- a) in sequence;
- b) completely and with integrity;
- c) without duplication;
- d) with flow control that notifies backpressure to the application layer in the event of congestion; and
- e) with notification to the application layer in the event that communications between the Forward CLTU service user and the Forward CLTU service provider are disrupted, possibly resulting in a loss of data.

It is the specific intent of this Recommended Standard to define the Forward CLTU service in a manner that is independent of any particular communications services, protocols, or technologies.

1.3.2 LIMITS OF APPLICABILITY

This Recommended Standard specifies the Forward CLTU service that may be provided by an SLE System for inter-Agency cross support. It is neither a specification of, nor a design for, real systems that may be implemented for the control and monitoring of existing or future missions.

1.4 RATIONALE

The goal of this Recommended Standard is to create a standard for interoperability between the tracking stations or ground data handling systems of various agencies and the users of forward services.

1.5 DOCUMENT STRUCTURE

1.5.1 DOCUMENT ORGANIZATION

This Recommended Standard is organized as follows:

- a) section 1 provides purpose, scope, applicability, and rationale of this Recommended Standard and lists definitions, nomenclature, conventions, and references used throughout the Recommended Standard;
- b) section 2 presents an overview of the Forward CLTU service including a functional description, the service management context, and protocol considerations;
- c) section 3 specifies the operations of the Forward CLTU service;

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- d) section 4 specifies the dynamic behavior of the Forward CLTU service in terms of the state transitions of the Forward CLTU service provider;
- e) annex A is a formal specification of Forward CLTU service data types, using the Abstract Syntax Notation One (ASN.1);
- f) annex B explains the relationship of the Forward CLTU service provisioning on the production status and its dependency on the status of the forward space link channel.
- g) annex C provides a conformance matrix that defines what capabilities must be provided for an implementation to be considered compliant with this Recommended Standard;
- h) annex D lists all terms used in this document and identifies where they are defined;
- i) annex E lists all acronyms used within this document;
- j) annex F contains examples of usage of the CLTU-THROW-EVENT operation;
- k) annex G contains a list of informative references.

1.5.2 SLE SERVICES DOCUMENTATION TREE

This Recommended Standard is based on the architectural model for cross support defined in reference [1]. It expands upon the concept of an SLE transfer service as interactions between SLE Mission User Entities (MUEs) and an SLE transfer service provider for the purpose of providing the Forward CLTU transfer service.

This Recommended Standard is part of a suite of documents specifying the SLE Services. The SLE Services constitute one of the three types of Cross Support Services:

- a) Part 1: SLE Services;
- b) Part 2: Ground Communications Services;
- c) Part 3: Ground Domain Services.

The basic organization of the SLE services documentation is shown in figure 1-1. The documents are described in the following paragraphs.

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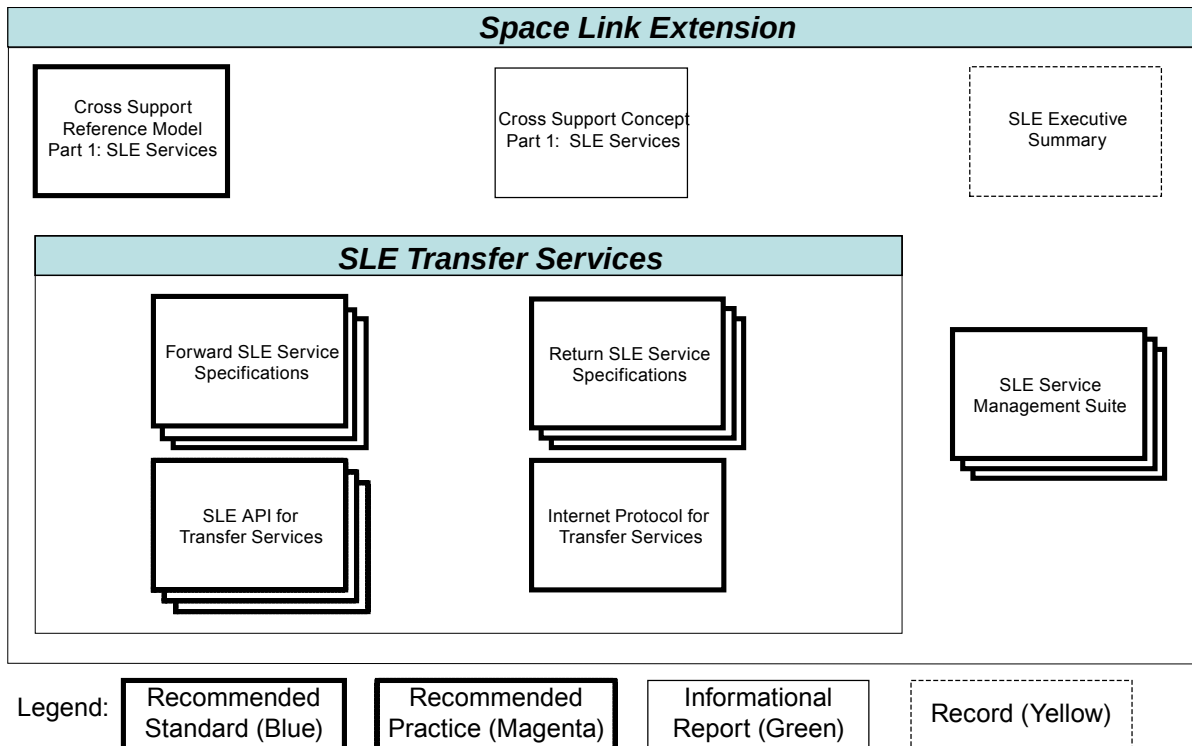


Figure 1-1: SLE Services Documentation

- Cross Support Concept – Part 1: Space Link Extension Services* (reference [G3]): a Report introducing the concepts of cross support and SLE services;
- Cross Support Reference Model—Part 1: Space Link Extension Services* (reference [1]): a Recommended Standard that defines the framework and terminology for the specification of SLE services;
- Return SLE Transfer Service Specifications*: a set of Recommended Standards that will provide specification of all return link SLE transfer services.
- Forward SLE Transfer Service Specifications*: a set of Recommended Standards that will provide specification of all forward link SLE transfer services (this Recommended Standard is one of the specifications in that set);
- SLE API for Transfer Services Specifications*: a set of Recommended Practices that provide specifications of an Application Program Interface; a set of Recommended Standards that provide specifications of an Application Program Interface and a mapping to TCP/IP as underlying communications service for SLE services;
- Internet Protocol for Transfer Services*: defines a protocol for transfer of SLE Protocol Data Units using TCP/IP as underlying communications service for SLE services;

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- g) *SLE Service Management Specification Suite*: a set of Recommended Standards that establish the basis for SLE service management.

1.6 DEFINITIONS, NOMENCLATURE, AND CONVENTIONS

1.6.1 DEFINITIONS

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

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

- a) abstract syntax;
- b) application entity;
- c) application layer;
- d) flow control;
- e) Open System Interconnection (OSI);
- f) real system;
- g) service access point (SAP).

1.6.1.2 Definitions from Abstract Syntax Notation One

This Recommended Standard makes use of the following terms defined in reference [6]:

- a) Abstract Syntax Notation One (ASN.1);
- b) object identifier;
- c) (data) type;
- d) (data) value.

NOTE – In annex A of this Recommended Standard, ASN.1 is used for specifying the abstract syntax of the invocations and returns of the operations of the Forward CLTU service. The use of ASN.1 as a descriptive language is intended to support the specification of the abstract Forward CLTU service; it is not intended to constrain implementations. In particular, there is no requirement for implementations to employ ASN.1 encoding rules. ASN.1 is simply a convenient tool for formally describing the abstract syntax of the invocations and returns of the Forward CLTU service.

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1.6.1.3 Definitions from TC Synchronization and Channel Coding

This Recommended Standard makes use of the following terms defined in reference [2]:

- a) acquisition sequence;
- b) Communications Link Transmission Unit (CLTU);
- c) Carrier Modulation Mode (CMM);
- d) idle sequence;
- e) Physical Layer operations procedure (PLOP).

1.6.1.4 Definitions from TC Space Data Link Protocol

This Recommended Standard makes use of the following term defined in reference [3]:

Communications Link Control Word (CLCW).

1.6.1.5 Definitions from SLE Reference Model

This Recommended Standard makes use of the following terms defined in reference [1]:

- a) abstract binding;
- b) abstract object;
- c) abstract port;
- d) abstract service;
- e) CLTU channel;
- f) Forward CLTU service;
- g) invoker;
- h) Mission Data Operation System (MDOS);
- i) Mission User Entity (MUE);
- j) offline delivery mode;
- k) online delivery mode;
- l) operation;
- m) performer;
- n) physical channel;

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- o) service agreement;
- p) service provider (provider);
- q) service user (user);
- r) SLE Complex;
- s) SLE Complex Management;
- t) SLE data channel;
- u) SLE functional group (SLE-FG);
- v) SLE protocol data unit (SLE-PDU);
- w) SLE service data unit (SLE-SDU);
- x) SLE service package;
- y) SLE transfer service instance;
- z) SLE transfer service production;
- aa) SLE transfer service provision;
- bb) SLE Utilization Management;
- cc) space link;
- dd) space link data channel;
- ee) space link data unit (SL-DU);
- ff) space link session.

1.6.1.6 Additional Definitions

For the purposes of this Recommended Standard, the following definitions also apply.

1.6.1.6.1 Association

An association is a cooperative relationship between an SLE service-providing application entity and an SLE service-using application entity. An association is formed by the exchange of SLE protocol data units through use of an underlying communications service.

1.6.1.6.2 Communications Service

A communications service is a capability that enables an SLE service-providing application entity and an SLE service-using application entity to exchange information.

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NOTE – If an SLE service user and an SLE service provider are implemented using different communications services, then interoperability between them is possible only by means of a suitable gateway. Adherence to this Recommended Standard ensures, at least in principle, that it is possible to construct such a gateway.

1.6.1.6.3 Confirmed Operation

A confirmed operation is an operation that requires the performer to return a report of its outcome to the invoker.

1.6.1.6.4 Initiator

The initiator is the object that issues the request to bind to another object (the responder).

NOTE – In other words, the initiator is always the invoker of the request to bind to another object. Therefore, in the context of the request to bind, the terms ‘initiator’ and ‘invoker’ refer to the same object and are synonyms.

1.6.1.6.5 Invocation

The invocation of an operation is the making of a request by an object (the invoker) to another object (the performer) to carry out the operation.

1.6.1.6.6 Parameter

A parameter of an operation is data that may accompany the operation’s invocation or return.

NOTE – The term parameter is also used to refer to mission-dependent configuration information used in production or provision of the service.

1.6.1.6.7 Performance

The performance of an operation is the carrying out of the operation by an object (the performer).

1.6.1.6.8 Port Identifier

A port identifier identifies a source or a destination in a communications system.

NOTE – See 2.6.4.6 for more information.

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1.6.1.6.9 Responder

The responder is the object that receives a request to bind and completes the binding (if possible) with the initiator in order for a service association to exist between the two objects.

NOTE – In other words, the responder is always the performer of the binding. Therefore, in the context of binding, the terms ‘responder’ and ‘performer’ refer to the same object and are synonyms.

1.6.1.6.10 Return

The return of an operation is a report, from the performer to the invoker, of the outcome of the performance of the operation.

1.6.1.6.11 Service Instance Provision Period

A service instance provision period is the time during which a service instance (i.e., the capability to transfer one or more SLE data channels of a given type) is scheduled to be provided.

1.6.1.6.12 Unconfirmed Operation

An unconfirmed operation is an operation that does not require a report of its outcome to be returned to the invoker by the performer.

1.6.2 NOMENCLATURE

The following conventions apply throughout this Recommended Standard:

- a) the words ‘shall’ and ‘must’ imply a binding and verifiable specification;
- b) the word ‘should’ implies an optional, but desirable, specification;
- c) the word ‘may’ implies an optional specification;
- d) the words ‘is’, ‘are’, and ‘will’ imply statements of fact.

1.6.3 CONVENTIONS

1.6.3.1 Specification of Operations

1.6.3.1.1 General

Section 3 of this Recommended Standard specifies the operations that constitute the Forward CLTU service. The specification of each operation is divided into subsections as follows:

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1.6.3.1.2 Purpose Subsection

The Purpose subsection briefly describes the purpose and functioning of the operation. Additionally, it indicates whether the operation may be invoked by the user, provider, or both; whether the operation is confirmed or unconfirmed; and whether there are any constraints on when the operation may be invoked.

1.6.3.1.3 Invocation, Return, and Parameters Subsection

The Invocation, Return, and Parameters subsection describes the parameters associated with each operation, including their semantics. A table accompanying the description of each operation lists all parameters associated with the operation and, for both the invocation and return, whether the parameter is always present, always absent, or conditionally present.

For parameters that are conditionally present, the parameter description specifies the conditions for the presence or absence of the parameter. The condition is generally based on the value of another parameter in the same invocation or return; for example, in return of an operation, the `diagnostic` parameter is present if and only if the value of the `result` parameter is 'negative result'. For a conditional parameter in a return, the condition may be based on the value of a parameter in the corresponding invocation.

In the table, the following convention is used to indicate whether a parameter is always present, always absent, or conditionally present:

M	always present (mandatory)
C	conditionally present
Blank	always absent

NOTE – Even though a parameter may be characterized as always present, its description may specify that its value is permitted to be 'null' or 'unused' or the like.

1.6.3.1.4 Effects Subsection

The Effects subsection describes the effects an operation has on the invoker, the performer, the association between them, or any combination thereof. The details of how those effects occur or the mechanisms used are outside the scope of this Recommended Standard.

1.6.3.2 Typographic Conventions

Typographic conventions used in this Recommended Standard are described in the following subsections.

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1.6.3.2.1 Operation Names

Names of Forward CLTU service operations appear in uppercase and begin with the characters 'CLTU-' (e.g., CLTU-TRANSFER-DATA).

1.6.3.2.2 Parameter Names

In the main text, names of parameters of Forward CLTU service operations appear in lowercase and are typeset in a fixed-width font (e.g., `responder-port-identifier`). In annex A, the corresponding name is formed by omitting any hyphens contained in the name and using mixed-case (e.g., `responderPortIdentifier`).

1.6.3.2.3 Value Names

The values of many parameters discussed in this Recommended Standard are represented by names. In the main text, these names are shown in single quotation marks (e.g., 'no such service instance'). The corresponding name in annex A is formed by omitting any hyphens or white space contained in the name and using mixed-case (e.g., `noSuchServiceInstance`). The actual value associated with the name is constrained by the type of the parameter taking on this value. Parameter types are specified in annex A of this Recommended Standard.

NOTE – The name of a value does not imply anything about type. For example, the value 'no such service instance' has the appearance of a character string but might be assigned to a parameter whose type is integer.

1.6.3.2.4 State Names

This Recommended Standard specifies the states of Forward CLTU service providers. States may be referred to by number (e.g., state 3) or by name. State names are always shown in single quotation marks (e.g., 'active').

1.6.3.2.5 SLE-PDU Names

The names of SLE-PDUs appear in mixed-case (e.g., `cltuBindInvocation`).

1.6.3.2.6 Data Type Definitions

Data type definitions for the Forward CLTU service are presented in annex A in the form of a set of ASN.1 modules. Regardless of the conventions used elsewhere in this Recommended Standard, the text of the ASN.1 modules is typeset entirely in a fixed-width font.

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1.6.3.3 Other Conventions

This Recommended Standard uses the conventions specified in reference [1].

1.7 REFERENCES

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

NOTES

- 1 A list of informative references is provided in annex G.
- 2 This document takes advantage of the harmonized terminology introduced by restructured documentation of the space link protocols (references [2], [3], and [4]). From an interoperability point of view, they do not introduce any incompatibilities with respect to the original set of space link protocol documents (references [G4], [G5], [G6], and [G7]).

- [1] *Cross Support Reference Model—Part 1: Space Link Extension Services*. Recommendation for Space Data System Standards, CCSDS 910.4-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, October 2005.
- [2] *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.
- [3] *TC Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 232.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.
- [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] *Time Code Formats*. Recommendation for Space Data System Standards, CCSDS 301.0-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, January 2002.
- [6] *Information Technology—Open Systems Interconnection—Specification of Abstract Syntax Notation One (ASN.1)*. International Standard, ISO/IEC 8824-1:2002. 3rd ed. Geneva: ISO, 2002

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- [7] *Information Technology—Open Systems Interconnection—Basic Reference Model: The Basic Model*. International Standard, ISO/IEC 7498-1:1994. 2nd ed. Geneva: ISO, 1994.

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2 DESCRIPTION OF THE FORWARD CLTU SERVICE

2.1 OVERVIEW

The Forward CLTU service enables the user of the service to send Communications Link Transmission Units (CLTUs) to a spacecraft via an established forward space link channel. A forward space link channel is a physical channel carrying an asynchronous stream of CLTUs (reference [1]).

The service user submits CLTUs, encapsulated in Space Link Extension (SLE) Service Data Units (SLE-SDUs), by means of the CLTU-TRANSFER-DATA operation. Production of the Forward CLTU service by the provider entails processing the CLTUs transferred by the user through the necessary transformations to modulate the Radio Frequency (RF) carrier channel providing uplink communications with the spacecraft.

The Forward CLTU service transmits the CLTUs in the order in which they are submitted by the service user. The provider may perform checks to determine if the CLTU complies with applicable constraints, e.g., that the length of the CLTU is within the maximum size set by service management. However, the provider does not interpret, interrogate, or modify the contents of a CLTU. CLTUs are transmitted bit for bit as received from the service user.

CLTUs may or may not conform to the format defined in reference [2]. The Forward CLTU service may be used to uplink any octet-aligned bit pattern.

The operations defined in section 3 of this Recommended Standard enable a single Forward CLTU service user to interact with a Forward CLTU service provider to:

- a) establish an association between the user and the provider;
- b) send annotated CLTUs to the provider;
- c) obtain notifications and reports regarding status, configuration, and performance of the service;
- d) temporarily stop and later re-start the sending of CLTUs;
- e) release an association.

The Sequence Controlled (AD) and Expedited (BD) Services, as defined in the Communications Operation Procedures (COP) Recommended Standard (reference [3]) are accomplished by higher layer SLE services.

The Forward CLTU service is provided only in the online delivery mode, as defined in reference [1]. The offline delivery mode is the subject of further study.

The provision of Forward CLTU service for access to one physical channel by one service user constitutes one instance of service. Only a single service instance of the Forward CLTU service may exist per physical channel at a time.

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2.2 SPACE LINK EXTENSION REFERENCE MODEL

2.2.1 INTRODUCTION

The Forward CLTU service is specified within the framework defined by the SLE Reference Model (reference [1]). The following subsections summarize selected concepts from the SLE reference model.

2.2.2 ABSTRACT OBJECT

An abstract object is a functional entity that interacts with other abstract objects. Objects are of different types, which determine their function and behavior. An object is characterized by its interfaces (one or more), which are called abstract ports, and the operations that are made available through those interfaces.

2.2.3 ABSTRACT SERVICE

An abstract service is the capability provided by a set of operations that an abstract object exposes at one or more of its abstract ports.

NOTE – The concept of an abstract service is to be distinguished from the concept of an (N)-service as defined in the OSI Basic Reference Model (reference [7]). The definition of (N)-service is in terms of the capability provided by one layer in the OSI architecture to the layer above it. The definition of abstract service is in terms of the capability provided by one abstract object to another abstract object. In a cross support scenario, where one Agency is providing an SLE service to another Agency, the object that provides the service typically is associated with one Agency, and the object that uses the service typically is associated with the other Agency.

2.2.4 ABSTRACT BINDING

When two abstract ports have an association established between them, they are said to be bound. The act of establishing such an association is called abstract binding. One object (the initiator) invokes a bind operation which is accepted (or rejected) by another object (the responder).

2.2.5 SERVICE USER/PROVIDER

An object that offers a service to another by means of one or more of its ports is called a service provider (provider). The other object is called a service user (user). An object may be a provider of some services and a user of others.

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The terms user and provider are used to distinguish the roles of two interacting objects. In this Recommended Standard, when two objects are involved in provision of a service, the object closer to the space link is considered to be the provider of the service, and the object further from the space link is considered to be the user.

2.2.6 OPERATION

An operation is a procedure or task that one object (the invoker) can request of another (the performer) through a bound port pair.

The terms invoker and performer are used to describe the interaction between two objects as the operations that constitute the service occur. One object invokes an operation that is performed by the other. For most services, each object invokes some operations and performs others.

2.3 SERVICE MANAGEMENT

SLE service management determines the number and schedule of Forward CLTU service instances to be provided, the resources required to enable those service instances, and the initial configuration of all service instances and their supporting resources. SLE service management is the subject of separate CCSDS Recommended Standards.

The SLE Reference Model (reference [1]) distinguishes between service provision and service production:

- a) service provision makes available to the user the operations necessary to obtain the service;
- b) service production transforms the Forward CLTU data channel to the RF carrier channel.

Certain configuration parameters are associated with provision of Forward CLTU service while others are associated with production. Configuration parameters that are associated with the production, such as bit rate and modulation index, can potentially impact SLE Complex resources. Consequently, only service management may modify production configuration parameter values. The Forward CLTU service user may modify some provision configuration parameters through operations specified in this Recommended Standard.

2.4 ARCHITECTURE MODEL – FUNCTIONAL VIEW

2.4.1 FORWARD TC SPACE LINK PROCESSING SLE FUNCTIONAL GROUP

The Forward Telecommand (TC) Space Link Processing SLE Functional Group (SLE-FG) (shown in figure 2-1) produces the Forward CLTU service.

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As described in reference [1], the Forward TC Space Link Processing SLE-FG consumes one CLTU data channel consisting of a stream of CLTU SLE-SDUs. The SLE-SDUs that encapsulate the CLTUs contain control and annotation data that specify radiation time and other parameters to aid in processing the data (see 3.6). The Forward TC Space Link Processing SLE-FG uses these data to extract the CLTUs and inject them into the asynchronous physical channel.

NOTE – Per physical forward channel, only a single instance of the Forward CLTU service is supported at any point in time.

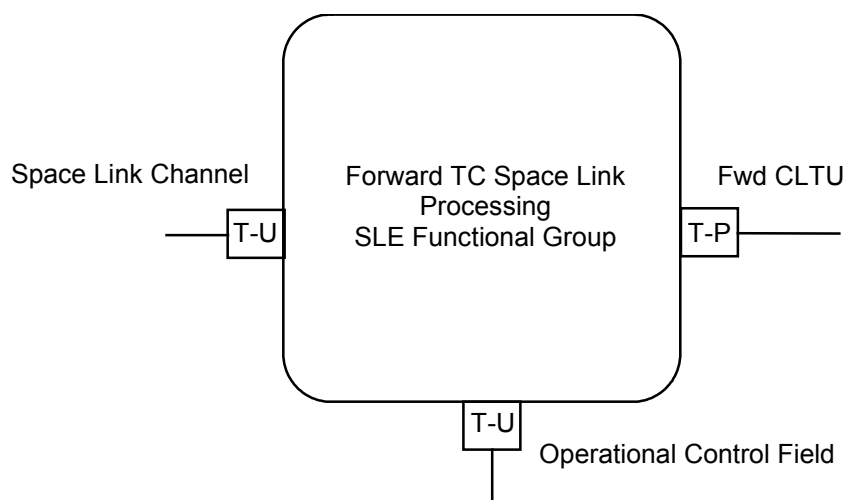


Figure 2-1: Forward TC Space Link Processing SLE-FG

The Forward TC Space Link Processing SLE-FG performs the following functions with respect to the Forward CLTU service:

- a) consumes one CLTU data channel and extracts CLTUs encapsulated in SLE Service Data Units (SLE-SDUs);
- b) consumes one Operational Control Field (OCF) data channel and extracts the Communications Link Control Words (CLCWs). Based on the values in the CLCWs, the Forward CLTU service determines whether the physical channel is available;

NOTE – CLCWs may be ignored, as an option set by Service Management. See 3.1.9 and table 3-11.

- c) performs the following:
 - 1) generates the acquisition sequence and idle sequence on the physical channel in accordance with the PLOP in effect;
 - 2) utilizes the underlying antenna steering capabilities provided by the ground element;

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- 3) modulates the CLTUs as a stream of bits on the ground-to-space RF channel; and
- 4) radiates the signal to the spacecraft.

2.4.2 FORWARD CLTU SERVICE PRODUCTION AND PROVISION

Forward CLTU **production** is concerned with radiating CLTUs extracted from a stream of SLE-SDUs according to the CLTU control and annotation information in the SLE-SDU and according to the configuration set up by service management. Forward CLTU service **provision** is concerned with receiving a stream of SLE-SDUs from a Forward CLTU service user. Service provision addresses such matters as when service is provided (e.g., service start and stop times), and how service is provided (e.g., which events are notified to the user).

The SLE-SDUs consumed by the Forward CLTU service are sent by the service user by means of the Forward CLTU service operations defined in section 3. These operations also provide additional functionality to facilitate the provision of service, i.e., enabling the exchange of SLE-SDUs across a remote interface. The service operations are realized as SLE protocol data units (SLE-PDUs) which are exchanged between the Forward CLTU service provider and the Forward CLTU service user by means of an underlying communications service. The general relationship between SL-DUs, SLE-SDUs, and SLE-PDUs is illustrated in figure 2-2.

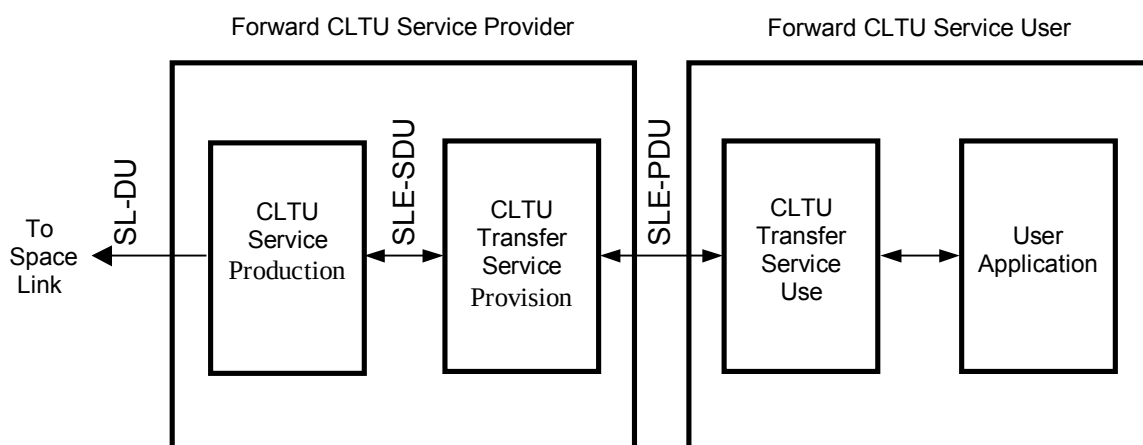


Figure 2-2: Forward CLTU Service Production and Provision

Production of the Forward CLTU service by the provider occurs during the space link session; in general, service production will largely overlap with service provision. Production status affects the provision of the service, as specified in sections 3 and 4, and reviewed in annex B.

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2.5 ARCHITECTURE MODEL – CROSS-SUPPORT VIEW

The management and control of the production and provision of the SLE transfer services is described in general terms in reference [1]. Figure 2-3 shows an example operational scenario and the related binding of the Forward CLTU transfer service ports and SLE management ports. This example shows an SLE Complex with one Forward Space Link Processing SLE-FG instance; it is providing one instance of Forward CLTU service to a Mission Data Operations System (MDOS). As this figure shows, only a single Mission User Entity can use the Forward CLTU service provided by a single Forward Space Link Processing SLE-FG.

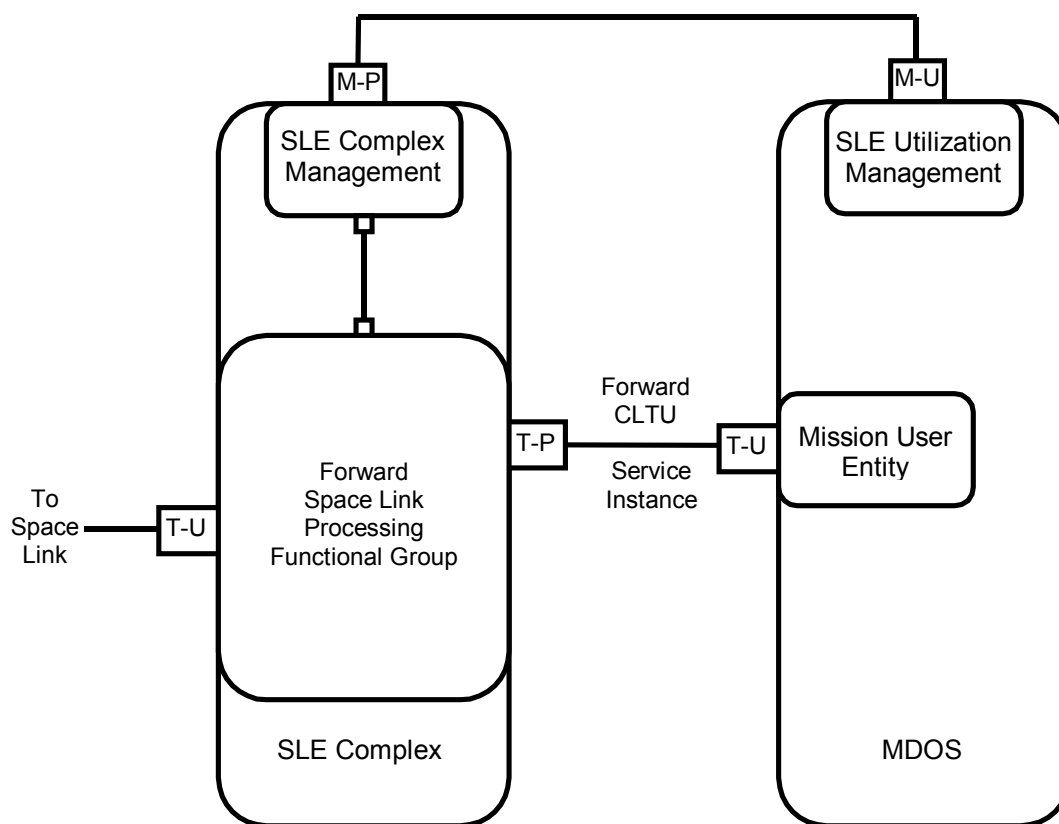


Figure 2-3: Example of Management and Provision of Forward CLTU Service

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2.6 FUNCTIONAL DESCRIPTION

2.6.1 GENERAL

This subsection describes the Forward CLTU service with respect to scheduling, configuration, underlying services, provider states and protocol considerations.

2.6.2 SCHEDULING AND CONFIGURATION

SLE Utilization Management negotiates with SLE Complex Management to establish mutually agreed upon SLE service packages. Among other things, SLE service packages specify what service instances are to be provided, when those services are to be provided, and what resources are needed to enable those services.

Service packages also specify the initial values of the mission-dependent parameters required for service production and provision. Forward CLTU service production parameters include such things as bit rate, modulation index, and subcarrier frequency. Provision parameters include such things as scheduled start and stop times of the Forward CLTU service instance.

Service production is guaranteed to occur only as needed to support service packages that have been scheduled and mutually agreed upon by SLE Complex Management and SLE Utilization Management. Service provision occurs only within the bounds of the agreed upon schedule of service instances and only during those periods when there is an association between the service provider and the service user.

2.6.3 UNDERLYING SERVICES

The CLTU service does not depend on any other SLE transfer service. Provision of the CLTU Transfer service does depend on:

- a) service management for scheduling, resources, and configuration; the schedule for a Forward CLTU service instance must be compliant with the schedule of the underlying equipment such as antennas, etc. The Forward CLTU service relies on service management actions for establishment of the space link, management of the PLOP and, when possible, recovery from production interruption;
- b) the availability of a suitable communications service to enable the exchange of information between the CLTU service user and provider; and
- c) the functioning of CLTU production resources (e.g., modulator(s), up-converter) to produce the forward physical channel.

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2.6.4 PROTOCOL DESCRIPTION

2.6.4.1 CLTU Operations

The operations that constitute the Forward CLTU service are listed in table 2-1. Section 3 of this Recommended Standard contains the detailed specification of these operations.

Table 2-1: Forward CLTU Service Operations

Service Operation	Invoked By	Purpose	Con- firmed
CLTU-BIND	Initiator (User)	To establish an association with the provider	Yes
CLTU-UNBIND	Initiator (User)	To release an association previously established by a CLTU-BIND operation	Yes
CLTU-START	User	To request that the SLE service provider prepare to accept CLTU-TRANSFER-DATA operations	Yes
CLTU-STOP	User	To request that the SLE service provider stop service provision and production.	Yes
CLTU-TRANSFER-DATA	User	To transfer a CLTU to the service provider	Yes
CLTU-ASYNC-NOTIFY	Provider	To notify the user of an event affecting production or provision of the Forward CLTU service	No
CLTU-SCHEDULE-STATUS-REPORT	User	To request that the provider send a status report immediately or periodically, or stop reporting	Yes
CLTU-STATUS-REPORT	Provider	To send a status report to the user	No
CLTU-GET-PARAMETER	User	To ascertain the value of an SLE service parameter (see table 3-11)	Yes
CLTU-THROW-EVENT	User	To forward an event that requires Complex Management to take the actions defined for this event	Yes
CLTU-PEER-ABORT	User or Provider	To notify the peer system that the local system detected an error that requires the association to be terminated	No

2.6.4.2 States of the Service Provider

Once a Forward CLTU service instance is created, the Forward CLTU service provider is in one of three states, as follows:

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- a) State 1 ('unbound'): In state 1, all resources required to enable the provision of the Forward CLTU service have been allocated, and all objects required to provide the service have been instantiated. However, no association yet exists between the user and the provider (i.e., the Forward CLTU transfer service provider port is not bound).
- b) State 2 ('ready'): In state 2, an association has been established between the user and the provider, and they may interact by means of the operations described in section 3 of this Recommended Standard. However, sending of CLTUs from the user to the provider (by means of the CLTU-TRANSFER-DATA operation) is not permitted. The user may enable the delivery of CLTUs by means of the appropriate service operation (CLTU-START), which, in turn, will cause the provider to transition to state 3 ('active').
- c) State 3 ('active'): State 3 resembles state 2 ('ready'), except that now the user can send CLTUs and the provider is enabled to radiate CLTUs to the spacecraft. The service continues in this state until the user invokes the CLTU-STOP operation to cause the provider to suspend transmission of CLTUs and transition back to state 2.

A simplified state transition diagram for the Forward CLTU service provider is shown in figure 2-4. A detailed state transition matrix is provided in 4.2.

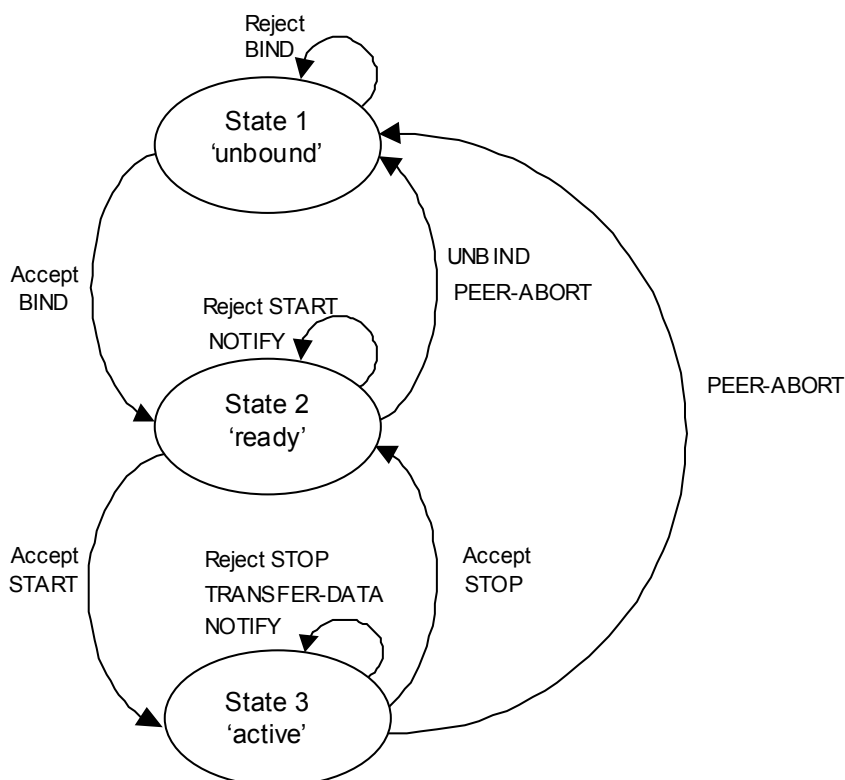


Figure 2-4: Simplified Forward CLTU Service Provider State Transition Diagram

2.6.4.3 Terminating an Association

An association is released normally when a CLTU-UNBIND is issued by the user (the initiator of the association) and accepted by the provider (the responder). An association may be aborted by either the user or the provider by means of the CLTU-PEER-ABORT operation. An association may also be aborted because of a failure in the underlying communications system. Such failures are signaled to the local application entity by the 'protocol abort' event described in 4.1.5.

2.6.4.4 Effects of Association Termination

The production of CLTUs stops immediately following the termination of an association, except for a CLTU in the process of being radiated. Any buffered CLTUs are discarded. The only exception to this occurs when the association is terminated due to a protocol abort, and the protocol-abort-mode option has been set to 'continue'; in this case, production of CLTUs continues, and buffered CLTUs are not discarded.

When an association is terminated, no further operations can be exchanged between the user and the provider. The systems may re-establish an association via a new CLTU-BIND operation, if that is consistent with the schedule for provision of service. Status information is not preserved after an association terminates and is not available to the new association with the following exceptions:

- a) statistics reported by means of the CLTU-STATUS-REPORT operation, such as the number of CLTUs processed (see 3.9), shall be accumulated for the entire service instance provision period;
- b) parameters that serve to relate notifications on an activity to operations that triggered this activity will not be altered when the association is released or aborted.

2.6.4.5 Technology-specific Aspects—Interoperability and the Underlying Communications Service

This Recommended Standard defines the Forward CLTU service. Provision of the Forward CLTU service in a real system also requires a specification of how the service is mapped to a communications service, such that all invocations and returns of the Forward CLTU service operations can be conveyed between the user and the provider. In order not to restrict the applicability of this Recommended Standard to a specific communications technology, as few assumptions as possible have been made about the characteristics of the underlying communications service (see 1.3.1).

The service interface between the user and the provider is specified in this Recommended Standard in terms of the operations that the service provides. Those operations are realized by mapping the service operation invocations and returns to protocol data units that can be

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conveyed by means of the underlying communications service. This Recommended Standard conceptualizes such mapping in two parts:

- a) Forward CLTU service operation invocations and returns (defined in section 3) are mapped to SLE-PDUs (defined in annex A);
- b) SLE-PDUs are mapped to protocol data units that can be conveyed by means of the underlying communications service.

The mapping of Forward CLTU service operation invocations and returns to SLE-PDUs is specified by this Recommended Standard. The mapping of SLE-PDUs to an underlying communications service is intentionally outside the scope of this Recommended Standard (e.g., so that the Forward CLTU service may be mapped to more than one communications technology). In order to achieve interoperability, the user and provider must conform not only to this Recommended Standard but also to an agreed upon specification of the mapping of the Forward CLTU service to the underlying communications service. The specification of a mapping of the Forward CLTU service onto a particular communications service must address such points as:

- a) selection of communications network(s) to ensure connectivity;
- b) compatible configuration of protocol stacks (e.g., timeout values);
- c) specification of port-identifiers, and their translation onto the communications technology;
- d) specification of security related information.

Figure 2-5 illustrates a communications realization of the Forward CLTU service that results from such a mapping. The specification of such mappings is the subject of separate CCSDS Recommended Standards.

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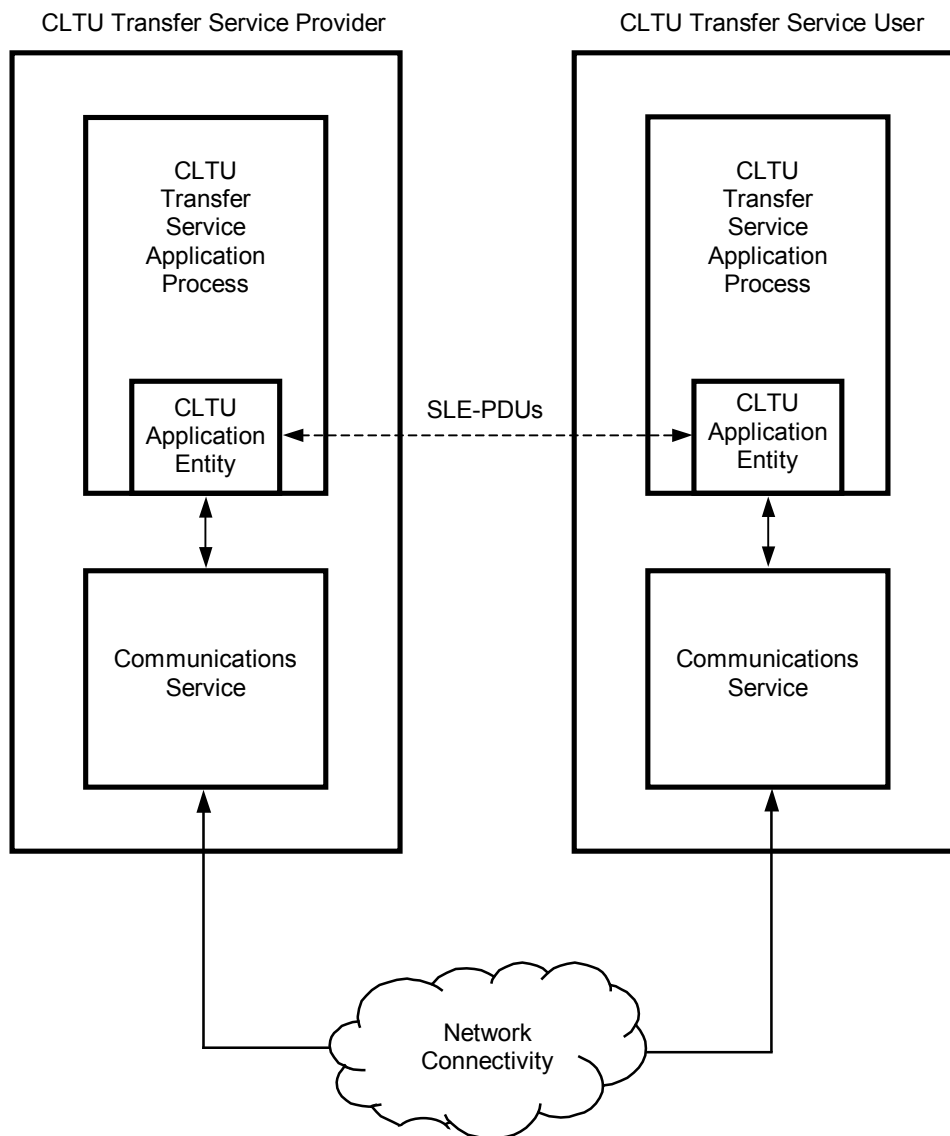


Figure 2-5: Communications Realization of Forward CLTU Service

Because the operations of the Forward CLTU service are relatively simple, once an association is in place between the service user and the service provider, the technology specific elements involved in the exchange of SLE-PDUs are generally minor. However, the way an association is established (i.e., the binding) tends to vary significantly depending on the communications technology in use. Nonetheless, the CLTU-BIND and CLTU-UNBIND operations as specified in this document are intended to be ‘technology neutral’. This neutrality is achieved as described in the following paragraphs.

For purposes of the communications mapping, the endpoints of an SLE association are identified by port identifiers, namely, an ‘initiator port identifier’ and a ‘responder port

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identifier'. The port identifiers represent all the technology-specific addressing information needed to establish communications between the user and provider and to route SLE-PDUs between them. The initiator port identifier identifies the endpoint that will invoke the CLTU-BIND operation (initiator). The responder port identifier identifies the endpoint that will perform the CLTU-BIND operation (responder). Generally speaking, the information represented by a port identifier consists of:

- a) information needed to route data between two real systems over a communications channel or network; and
- b) information needed to route data within a real system to a particular application entity.

For example, the information represented by a port identifier might be the combination of an Internet Protocol (IP) network address and a Transmission Control Protocol (TCP) port number or the combination of an OSI network address and an associated set of service access points (SAPs).

The exact relationship between SLE port identifiers and communications ports provided by the underlying communications service must be specified by the mapping of the Forward CLTU service to the underlying communications service.

One possible mapping of the SLE transfer service to the TCP/IP communications service is specified in [G8]. As part of this mapping, also issues such as sizing of TCP buffers in accordance with the bandwidth-delay product of the communication link and ways to manage relative priority of transfer services concurrently using the same connectivity are to be addressed.

In order for an SLE association to be established, SLE Complex Management and SLE Utilization Management must agree beforehand on the responder port identifier for the association. The responder needs the information represented by the responder port identifier to ensure that resources are allocated to recognize and respond to a CLTU-BIND invocation for that association. The initiator needs the information to ensure that the CLTU-BIND invocation will be communicated to the appropriate responder.

In general, it is not necessary for SLE Complex Management and SLE Utilization Management to agree beforehand on the initiator port identifier for the association. Rather, the initiator should communicate that information to the responder in conjunction with the CLTU-BIND invocation. The exact means by which the initiator port identifier is provided to the responder is technology-specific and must be specified by the mapping of the Forward CLTU service to the underlying communications service.

The responder port identifier is included as a parameter of the CLTU-BIND operation. While it is only necessary that the SLE application entity communicate the information represented by the port identifiers to the underlying communications service, the responder port identifier is provided as a parameter of the CLTU-BIND operation to allow for the possible simplification of the implementation of a gateway.

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The information represented by the responder port identifier is technology-specific. In order to define the CLTU-BIND operation in a way that is not technology-specific, the `responder-port-identifier` parameter of the CLTU-BIND operation is defined to be a logical name. A logical name is an arbitrary identifier that has an appropriately chosen and agreed upon translation to technology-specific information. Prior to the start time of a service instance, SLE Complex Management and SLE Utilization must mutually agree upon the value of the responder port identifier (and its translation) applicable to that service instance. The actual process of translating logical names to technology-specific information is considered a local matter. The translation methodology may rely on simple techniques such as look-up tables or may use more elaborate mechanisms such as naming or directory services.

The above discussion describes the case that both the user and provider applications are implemented using the same communications service. It is possible to achieve interoperability even if the user and provider use different communications services. However, in that case interoperability requires the use of an appropriate gateway.

2.6.4.6 Buffering

The Forward CLTU service buffers the CLTUs for the primary purpose of maintaining radiation of a steady stream of CLTUs despite variable latency over the ground communications channel. All transfers of CLTUs from the service user to the service provider must occur within the scheduled service instance provision period.

2.7 OPERATIONAL SCENARIO

Prior to the actual provision of service, start and stop times for both the space link session and the associated Forward CLTU service instance are negotiated between SLE Complex Management and SLE Utilization Management. Configuration and other information needed to enable the service are also agreed.

Some time before the scheduled start time of the Forward CLTU service instance, the service instance is created by SLE Complex Management. Initially, the service provider is in state 1 ('unbound'). At the scheduled start time of the space link session, the SLE Complex establishes the forward link to the spacecraft and initiates the production of Forward CLTU service. Typically (but not necessarily) the start time of the service instance will precede by a small margin the start time of the space link session to allow the user to bind to the service before the start of the space link session.

The following illustrates a typical sequence of operations between the user and the provider of the Forward CLTU service. A complete definition of the operations is found in section 3; the formal specification of provider behavior is presented in section 4.

- a) The user invokes the CLTU-BIND operation to establish an association.

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- b) The provider, when configured to monitor uplink status by examining the No RF Available and/or No Bit Lock flags returned from the spacecraft in the Communications Link Control Word (CLCW), performs the necessary operations to receive the Operational Control Field (OCF) as provided by the Return Frame Processing SLE-FG.
- c) The provider monitors equipment readiness, the status of the physical channel and (when configured to do so) the uplink status. When production status changes to 'operational' the provider sends CLTU-ASYNC-NOTIFY to the user.

NOTE – Modulation of the uplink signal with acquisition sequence and idle sequence, in accordance with the PLOP in effect, is under the control of service management.

- d) The user sends CLTU-START, and the provider transitions to state 3, 'active'.
- e) The user sends a CLTU-TRANSFER-DATA operation to the provider. The provider verifies the invocation, and if acceptable, buffers the CLTU until the specified **earliest-radiation-time** is reached.
- f) Additional CLTUs may be sent by the user and buffered.

NOTE – The user may perform steps, d), e) and f), invoking CLTU-START and CLTU-TRANSFER-DATA, before the production status becomes operational as described in step c).

- g) At the time specified for start of radiation, if production status is operational, the first CLTU is injected into the physical channel and modulated onto the RF carrier. The signal is radiated to the spacecraft. If no start time was specified in the CLTU-TRANSFER-DATA operation, the CLTU is radiated as soon as received, or whenever the production status becomes operational, if that is later.
- h) Successive CLTUs are processed in similar fashion after the delay period (if any) specified in the preceding CLTU is satisfied.
- i) The user transfers the last CLTU to the provider.
- j) The provider completes processing the buffered CLTUs. When the provider's CLTU buffer is empty, it sends CLTU-ASYNC-NOTIFY to inform the user.
- k) The user sends CLTU-STOP and the provider transitions to state 2, 'ready'.
- l) The user performs CLTU-UNBIND to release the association.

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2.8 SECURITY ASPECTS OF THE SLE FORWARD CLTU TRANSFER SERVICE

2.8.1 SECURITY BACKGROUND/INTRODUCTION

The SLE transfer services explicitly provide authentication and access control. Additional security capabilities, if required, are levied on the underlying communication services that support the SLE transfer services. The SLE transfer services are defined as layered application services operating over underlying communication services that must meet certain requirements but which are otherwise unspecified. Selection of the underlying communication services over which real SLE implementations connect is based on the requirements of the communicating parties and/or the availability of CCSDS-standard communication technology profiles and proxy specifications. Different underlying communication technology profiles are intended to address not only different performance requirements but also different security requirements. Missions and service providers are expected to select from these technology profiles to acquire the performance and security capabilities appropriate to the mission. Specification of the various underlying communication technologies, and in particular their associated security provisions, are outside the scope of this Recommended Standard.

The SLE Forward CLTU transfer service transfers data that is destined for a mission spacecraft. As such, the SLE Forward CLTU transfer service has custody of the data for only a portion of the end-to-end data path between MDOS and mission spacecraft. Consequently the ability of an SLE transfer service to secure the transfer of mission spacecraft data is limited to that portion of the end-to-end path that is provided by the SLE transfer service (i.e., the terrestrial link between the MDOS and the ground termination of the ground-space link to the mission spacecraft). End-to-end security must also involve securing the data as it crosses the ground-space link, which can be provided by some combination of securing the mission data itself (e.g., encryption of the mission data within CCSDS space packets) and securing the ground-space link (e.g., encryption of the physical ground-space link). Thus while the SLE Forward CLTU transfer service plays a role in the end-to-end security of the data path, it does not control and cannot ensure that end-to-end security. This component perspective is reflected in the security provisions of the SLE transfer services.

2.8.2 STATEMENTS OF SECURITY CONCERNS

This section identifies SLE Forward CLTU transfer service support for capabilities that responds to these security concerns in the areas of data privacy, data integrity, authentication, access control, availability of resources, and auditing.

2.8.2.1 Data Privacy (also known as Confidentiality)

This SLE Forward CLTU transfer service specification does not define explicit data privacy requirements or capabilities to ensure data privacy. Data privacy is expected to be ensured outside of the SLE transfer service layer, by the mission application processes that communicate over the SLE transfer service, in the underlying communication service that lies