

Space data and information transfer systems — Space link extension (SLE) — Forward space packet service

ICS 49.140

National foreword

This British Standard reproduces verbatim ISO 22672:2006 and implements it as the UK national standard.

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

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

Cross-references

The British Standards which implement international publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

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

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the ISO title page, pages ii and iii, a blank page, pages 1 to 194, an inside back cover and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 June 2006

© BSI 2006

ISBN 0 580 48595 1

Amendments issued since publication

Amd. No.	Date	Comments

INTERNATIONAL STANDARD

ISO
22672

First edition
2006-06-01

Space data and information transfer systems — Space link extension (SLE) — Forward space packet service



Reference number
ISO 22672:2006(E)

AVA **Documents**
Document Sharing Hub

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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

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

ISO 22672 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 912.3-B-1, November 2004) 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 — Space link extension (SLE) — Forward space packet service

1 Scope

The Forward Space Packet (FSP) service is a Space Link Extension (SLE) transfer service that enables a mission to send Space Packets to a spacecraft in sequence-controlled or expedited mode. This International Standard defines, in an abstract manner, the FSP service in terms of

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

It does not specify

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

The scope and field of application are furthermore detailed in subclauses 1.1 to 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 912.3-B-1, November 2004, *Space link extension (SLE) — Forward space packet service specification*.

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 912.3-B-1.

Pages i to vi

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

Page 1-13

Add the following information to the reference indicated:

- [1] Document CCSDS 910.4-B-1, May 1996, is equivalent to ISO 15396:1998.
- [2] Document CCSDS 301.0-B-3, January 2002, is equivalent to ISO 11104:2003.
- [3] Document CCSDS 231.0-B-1, September 2003, is equivalent to ISO 22642:2005.
- [4] Document CCSDS 232.0-B-1, September 2003, is equivalent to ISO 22664:2005.
- [5] Document CCSDS 232.1-B-1, September 2003, is equivalent to ISO 22667:2005.
- [6] Document CCSDS 133.0-B-1, September 2003, is equivalent to ISO 22646:2005.
- [7] ISO/IEC 8824:1998 has been cancelled and replaced by ISO/IEC 8824:2002.

Page G-1

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 912.3-B-1

It has been agreed with the Consultative Committee for Space Data Systems that Subcommittee ISO/TC 20/SC 13 will be consulted in the event of any revision or amendment of publication CCSDS 912.3-B-1. To this end, NASA will act as a liaison body between CCSDS and ISO.

Consultative Committee for Space Data Systems

RECOMMENDATION FOR SPACE
DATA SYSTEM STANDARDS

SPACE LINK EXTENSION— FORWARD SPACE PACKET SERVICE SPECIFICATION

CCSDS 912.3-B-1

BLUE BOOK

November 2004



AUTHORITY

Issue:	Blue Book, Issue 1
Date:	November 2004
Location:	Toulouse, France

This document has been approved for publication by the Management Council of the Consultative Committee for Space Data Systems (CCSDS) and represents the consensus technical agreement of the participating CCSDS Member Agencies. The procedure for review and authorization of CCSDS Recommendations is detailed in reference [G1], 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:

CCSDS Secretariat
Program Integration Division (Code M-3)
National Aeronautics and Space Administration
Washington, DC 20546, USA

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

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:

- o Whenever an Agency establishes a CCSDS-related **standard**, this **standard** will be in accord with the relevant **Recommendation**. Establishing such a **standard** does not preclude other provisions that an Agency may develop.
- o Whenever an Agency establishes a CCSDS-related **standard**, the Agency will provide other CCSDS member Agencies 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 **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.

FOREWORD

This document is a technical **Recommendation** for use in developing ground systems for space missions and has been prepared by the **Consultative Committee for Space Data Systems** (CCSDS). The Space Link Extension (SLE) Forward Space Packet (FSP) Service described herein is intended for missions that are cross-supported between Agencies of the CCSDS.

This **Recommendation** specifies a data service that extends certain of the space-to-ground communications services previously defined by CCSDS (references [3], [4], [5], and [6]) within the framework established by the CCSDS SLE Reference Model (reference [1]). It allows implementing organizations within each Agency to proceed with the development of compatible, derived Standards for the ground systems that are within their cognizance. Derived Agency Standards may implement only a subset of the optional features allowed by the **Recommendation** and may incorporate features not addressed by the **Recommendation**.

Through the process of normal evolution, it is expected that expansion, deletion or modification to this document may occur. This **Recommendation** is therefore subject to CCSDS document management and change control procedures, as defined in reference [G1]. 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 ii.

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

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

Member Agencies

- Agenzia Spaziale Italiana (ASI)/Italy.
- British National Space Centre (BNSC)/United Kingdom.
- Canadian Space Agency (CSA)/Canada.
- Centre National d'Etudes Spatiales (CNES)/France.
- Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)/Germany.
- European Space Agency (ESA)/Europe.
- Instituto Nacional de Pesquisas Espaciais (INPE)/Brazil.
- National Aeronautics and Space Administration (NASA)/USA.
- National Space Development Agency of Japan (NASDA)/Japan.
- Russian Space Agency (RSA)/Russian Federation.

Observer Agencies

- Austrian Space Agency (ASA)/Austria.
- Central Research Institute of Machine Building (TsNIIMash)/Russian Federation.
- Centro Tecnico Aeroespacial (CTA)/Brazil.
- Chinese Academy of Space Technology (CAST)/China.
- Commonwealth Scientific and Industrial Research Organization (CSIRO)/Australia.
- Danish Space Research Institute (DSRI)/Denmark.
- European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)/Europe.
- European Telecommunications Satellite Organization (EUTELSAT)/Europe.
- Federal Service of Scientific, Technical & Cultural Affairs (FSST&CA)/Belgium.
- Hellenic National Space Committee (HNSC)/Greece.
- Indian Space Research Organization (ISRO)/India.
- Institute of Space Research (IKI)/Russian Federation.
- KFKI Research Institute for Particle & Nuclear Physics (KFKI)/Hungary.
- MIKOMTEK: CSIR (CSIR)/Republic of South Africa.
- Korea Aerospace Research Institute (KARI)/Korea.
- Ministry of Communications (MOC)/Israel.
- National Institute of Information and Communications Technology (NICT)/Japan.
- National Oceanic & Atmospheric Administration (NOAA)/USA.
- National Space Program Office (NSPO)/Taipei.
- Space and Upper Atmosphere Research Commission (SUPARCO)/Pakistan.
- Swedish Space Corporation (SSC)/Sweden.
- United States Geological Survey (USGS)/USA.

DOCUMENT CONTROL

Document	Title	Date	Status
CCSDS 912.3-B-1	Space Link Extension— Forward Space Packet Service Specification	November 2004	Original Issue

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

CONTENTS

<u>Section</u>	<u>Page</u>
1 INTRODUCTION.....	1-1
1.1 PURPOSE OF THIS RECOMMENDATION.....	1-1
1.2 SCOPE.....	1-1
1.3 APPLICABILITY.....	1-1
1.4 RATIONALE.....	1-2
1.5 DOCUMENT STRUCTURE	1-2
1.6 DEFINITIONS, NOMENCLATURE, AND CONVENTIONS	1-4
1.7 REFERENCES	1-12
2 DESCRIPTION OF THE FORWARD SPACE PACKET SERVICE	2-1
2.1 OVERVIEW	2-1
2.2 SPACE LINK EXTENSION REFERENCE MODEL	2-2
2.3 SERVICE MANAGEMENT	2-3
2.4 ARCHITECTURE MODEL—FUNCTIONAL VIEW	2-4
2.5 ARCHITECTURE MODEL—CROSS SUPPORT VIEW	2-6
2.6 FUNCTIONAL DESCRIPTION.....	2-7
2.7 OPERATIONAL SCENARIO	2-15
2.8 SECURITY ASPECTS OF THE SLE FORWARD SPACE PACKET (FSP) TRANSFER SERVICE	2-16
3 FSP SERVICE OPERATIONS	3-1
3.1 GENERAL CONSIDERATIONS	3-1
3.2 FSP-BIND.....	3-10
3.3 FSP-UNBIND.....	3-16
3.4 FSP-START.....	3-19
3.5 FSP-STOP.....	3-23
3.6 FSP-TRANSFER-DATA.....	3-26
3.7 FSP-ASYNC-NOTIFY	3-36
3.8 FSP-SCHEDULE-STATUS-REPORT	3-50
3.9 FSP-STATUS-REPORT.....	3-54
3.10 FSP-GET-PARAMETER.....	3-61
3.11 FSP-THROW-EVENT	3-66
3.12 FSP-INVOKE-DIRECTIVE.....	3-71
3.13 FSP-PEER-ABORT	3-76

4 FSP PROTOCOL	4-1
4.1 GENERIC PROTOCOL CHARACTERISTICS	4-1
4.2 FSP SERVICE PROVIDER BEHAVIOR	4-4
ANNEX A Data Type Definitions	A-1
ANNEX B FSP Queues and Multiplexing Behaviour Definition	B-1
ANNEX C Production Status	C-1
ANNEX D Index to Definitions	D-1
ANNEX E Acronyms	E-1
ANNEX F Conformance Matrix	F-1
ANNEX G Informative References	G-1
ANNEX H Throw Event Definitions	H-1

Figure

1-1: Space Link Extension (SLE) Services Documentation	1-4
2-1: Forward TC VC Data Insertion SLE-FG	2-4
2-2: FSP Service Production and Provision	2-6
2-3: Example of the Management and Provision of FSP Service	2-7
2-4: Simplified FSP Service Provider State Transition Diagram	2-10
2-5: Communications Realization of FSP Service	2-13
B-1: FSP MAP and TC Frame Multiplexing	B-1
B-2: MAP and VC Multiplexing	B-2
B-3: FSP Queues	B-5
C-1: FSP Production Status Diagram	C-1

Table

2-1: FSP Service Operations	2-8
3-1: Setting of FSP Service Operation Parameters	3-6
3-2: FSP-BIND Parameters	3-11
3-3: FSP-UNBIND Parameters	3-17
3-4: FSP-START Parameters	3-19
3-5: FSP-STOP Parameters	3-23
3-6: FSP-TRANSFER-DATA Parameters	3-27
3-7: FSP-ASYNC-NOTIFY Parameters	3-36
3-8: FSP-SCHEDULE-STATUS-REPORT Parameters	3-50
3-9: FSP-STATUS-REPORT Parameters	3-54
3-10: FSP-GET-PARAMETER Parameters	3-61

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

CONTENTS (CONTINUED)

3-11: FSP Service Parameters.....	3-62
3-12: FSP-THROW-EVENT Parameters	3-67
3-13: FSP-INVOKE-DIRECTIVE Parameters.....	3-71
3-14: FSP-PEER-ABORT Parameters.....	3-76
4-1: Provider Behavior.....	4-6
4-2: Event Description References	4-11
4-3: Predicate Definitions	4-12
4-4: Boolean Flags	4-12
4-5: Compound Action Definitions	4-13
C-1: Production Status Transitions.....	C-2
C-2: Effects of Production Status on Operations.....	C-3
F-1: Conformance Matrix for FSP Service (Operations).....	F-1
F-2: Conformance Matrix for FSP Service (Other Requirements).....	F-2
H-1: Throw Event Examples	H-1

(Blank page)

1 INTRODUCTION

1.1 PURPOSE OF THIS RECOMMENDATION

This Recommendation defines the Forward Space Packet (FSP) service in conformance with the transfer services specified in reference [1], *Cross Support Reference Model—Part 1: SLE Services*. The FSP service is a Space Link Extension (SLE) transfer service that enables a mission to send Space Packets to a spacecraft in sequence-controlled or expedited mode.

1.2 SCOPE

This Recommendation defines, in an abstract manner, the FSP 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 Space Packets 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 FSP service.

NOTE – While the FSP service as described in reference [1] is conceived to handle a variety of packet data structures, this version of the FSP Recommendation is restricted to the handling of Space Packets as defined in reference [6].

1.3 APPLICABILITY

1.3.1 APPLICABILITY OF THIS RECOMMENDATION

This Recommendation provides a basis for the development of real systems that implement the FSP service. Implementation of the FSP service in a real system additionally requires the availability of a communications service to convey invocations and returns of FSP service

operations between FSP service users and providers. This Recommendation requires that such a communications service ensures 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 FSP service user and the FSP service provider are disrupted, possibly resulting in a loss of data.

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

1.3.2 LIMITS OF APPLICABILITY

This Recommendation specifies the FSP 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 Recommendation is to create a standard for interoperability between the tracking stations and/or ground data handling systems of various agencies and the users of forward services.

1.5 DOCUMENT STRUCTURE

1.5.1 ORGANIZATION

This Recommendation is organized as follows:

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

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

- d) section 4 specifies the dynamic behavior of the FSP service in terms of the state transitions of the FSP service provider;
- e) annex A provides a formal specification of FSP service data types, using the Abstract Syntax Notation One (ASN.1);
- f) annex B provides a specification of the multiplexing between concurrent FSP service instances sharing the same TC Virtual Channel (VC) as well as the multiplexing between TC VCs sharing the same physical space link data channel;
- g) annex C presents the FSP production status and its transitions;
- 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 provides a conformance matrix that defines what capabilities must be provided for an implementation to be considered compliant with this Recommendation;
- k) annex G contains a list of informative references;
- l) annex H contains examples of usage of the FSP-THROW-EVENT operation.

1.5.2 SLE SERVICES DOCUMENTATION TREE

This Recommendation 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 an SLE Mission User Entity (MUE) and an SLE Transfer Service provider for the purpose of providing the FSP Transfer Service.

This Recommendation 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.

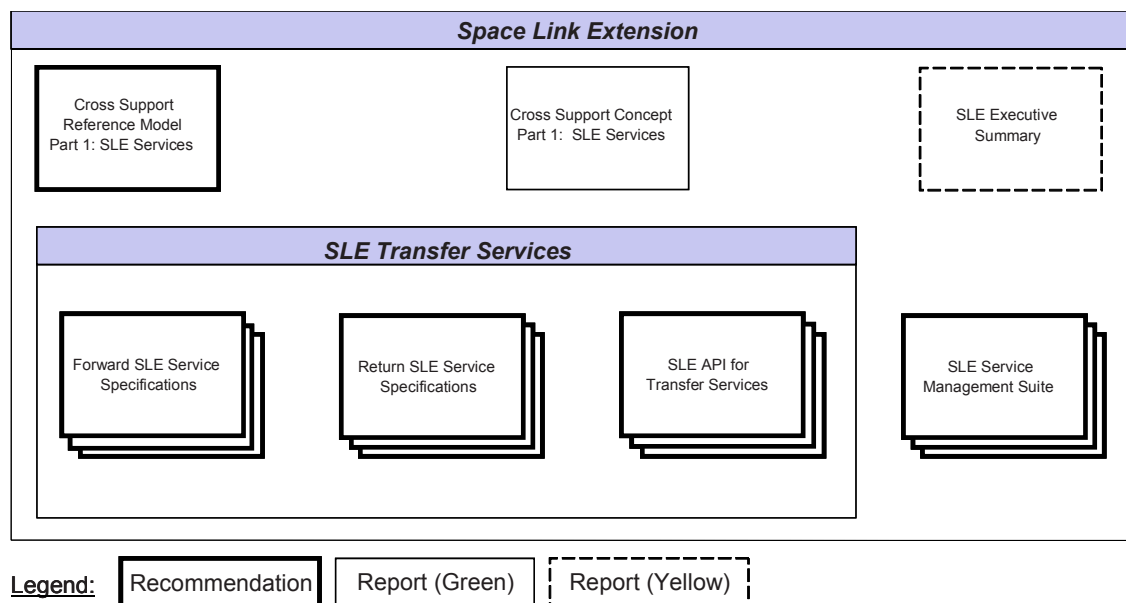


Figure 1-1: Space Link Extension (SLE) Services Documentation

- 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 Recommendation that defines the reference model that provides a common framework and terminology for the specification of SLE services;
- SLE Service Management Specifications*; a set of Recommendations that establish the basis of SLE service management;
- Forward SLE Service Specifications*: a set of Recommendations that will provide specification of all forward link SLE transfer services (this Recommendation is one of the specifications in that set);
- Return SLE Service Specifications*; a set of Recommendations that will provide specification of all return link SLE transfer services.

1.6 DEFINITIONS, NOMENCLATURE, AND CONVENTIONS

1.6.1 DEFINITIONS

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

This Recommendation makes use of a number of terms defined in reference [8]. The use of those terms in this Recommendation shall be understood in a generic sense; i.e., in the sense

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

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 Systems Interconnection (OSI);
- f) real system;
- g) service access point (SAP).

1.6.1.2 Definitions from Abstract Syntax Notation One

This Recommendation makes use of the following terms defined in reference [7]:

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

NOTE – In annex A of this Recommendation, ASN.1 is used for specifying the abstract syntax of the invocations and returns of the operations of the FSP service. The use of ASN.1 as a descriptive language is intended to support the specification of the abstract FSP 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 FSP service.

1.6.1.3 Definitions from TC Synchronization and Channel Coding

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

Communications Link Transmission Unit (CLTU).

1.6.1.4 Definitions from TC Space Data Link Protocol

This Recommendation makes use of the following terms defined in reference [4]:

- a) AD, BD, BC;

- b) Communications Link Control Word (CLCW);
- c) Communications Operation Procedure (COP);
- d) Control Word Type;
- e) Frame Operation Procedure (FOP);
- f) Frame Sequence Number;
- g) Multiplexer Access Point (MAP);
- h) Operational Control Field (OCF);
- i) Segment;
- j) Telecommand Transfer Frame (TC Transfer Frame or TC frame);
- k) Virtual Channel (VC).

1.6.1.5 Definitions from Communications Operation Procedure-1

This Recommendation makes use of the following terms defined in reference [5]:

- a) FOP_Sliding_Window_Width;
- b) Receiver_Frame_Sequence_Number V(R);
- c) Timeout_Type;
- d) Transmitter_Frame_Sequence_Number V(S);
- e) T1_Initial.

1.6.1.6 Definitions from Space Packet Protocol

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

- a) Application Process Identifier (APID);
- b) Space Packet.

1.6.1.7 Definitions from SLE Reference Model

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

- a) abstract binding;
- b) abstract object;
- c) abstract port;

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

- d) abstract service;
- e) Forward Space Packet channel (FSP channel);
- f) Forward Space Packet service (FSP 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;
- 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 System;
- z) SLE transfer service instance;
- aa) SLE transfer service production;
- bb) SLE transfer service provision;
- cc) SLE Utilization Management;
- dd) space link;
- ee) space link data channel;

ff) space link data unit (SL-DU);

gg) space link session.

1.6.1.8 Additional Definitions

For the purposes of this Recommendation, the following definitions also apply.

1.6.1.8.1 Acknowledged (Space Packet)

A Space Packet is said to be acknowledged when evaluation of the CLCWs returned by the space element shows that all TC frames containing parts of the Space Packet reported have been acknowledged by the space element.

NOTE — This status applies only to the sequence-controlled transmission mode (AD). Although a Space Packet is “acknowledged”, packet re-assembly and/or execution may still fail. This can only be determined by examining telemetry.

1.6.1.8.2 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 the use of an underlying communications service.

1.6.1.8.3 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.

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 Recommendation ensures, at least in principle, that it is possible to construct such a gateway.

1.6.1.8.4 Confirmed Operation

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

1.6.1.8.5 Initiator

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

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

1.6.1.8.6 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.

1.6.1.8.7 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 the production or provision of the service.

1.6.1.8.8 Performance

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

1.6.1.8.9 Port Identifier

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

NOTE – See 2.6.4.5 for more information.

1.6.1.8.10 Radiated (Space Packet)

A Space Packet is said to be radiated when, based on the ground equipment monitoring, the FSP production process can assume that all the CLTUs containing parts of the Space Packet reported have been transmitted to the spacecraft.

1.6.1.8.11 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.

1.6.1.8.12 Return

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

1.6.1.8.13 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.

1.6.1.8.14 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 nomenclature applies throughout this Recommendation:

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

1.6.3 CONVENTIONS**1.6.3.1 Specification of Operations****1.6.3.1.1 General**

Section 3 of this Recommendation specifies the operations that constitute the FSP service. The specification of each operation is divided into subsections as follows:

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.

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

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 the 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 Recommendation.

1.6.3.2 Typographic Conventions

Typographic conventions used in this Recommendation are described in the following subsections.

1.6.3.2.1 Operation Names

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

1.6.3.2.2 Parameter Names

In the main text, names of parameters of FSP 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 Recommendation 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 Recommendation.

NOTE – The name of a value does not imply anything about its 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 Recommendation specifies the states of FSP 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., `fspBindInvocation`).

1.6.3.2.6 Data Type Definitions

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

1.6.3.3 Other Conventions

This Recommendation uses the conventions specified in reference [1].

1.7 REFERENCES

The following documents contain provisions that, 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.

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

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 [3], [4], [5], and [6]). 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-1. Blue Book. Issue 1. Pasadena, California, USA: CCSDS, May 1996.
 - [2] *Time Code Formats*. Recommendation for Space Data Systems Standards, CCSDS 301.0-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, January 2002.
 - [3] *TC Synchronization and Channel Coding*. Recommendation for Space Data System Standards, CCSDS 231.0-B-1. Blue Book. Issue 1. CCSDS, September 2003.
 - [4] *TC Space Data Link Protocol*. Recommendation for Space Data Systems Standards, CCSDS 232.0-B-1. Blue Book. Issue 1. CCSDS, September 2003.
 - [5] *Communications Operations Procedure-1*. Recommendation for Space Data System Standards, CCSDS 232.1-B-1. Blue Book. Issue 1. CCSDS, September 2003.
 - [6] *Space Packet Protocol*. Recommendation for Space Data System Standards, CCSDS 133.0-B-1. Blue Book. Issue 1. CCSDS, September 2003.
 - [7] *Information Technology — Open Systems Interconnection — Specification of Abstract Syntax Notation One (ASN.1)*. International Standard, ISO/IEC 8824: 1998. 2nd ed. Geneva: ISO, 1998.
 - [8] *Information Technology—Open Systems Interconnection—Basic Reference Model: The Basic Model*. International Standard, ISO/IEC 7498-1:1994. 2nd ed. Geneva: ISO, 1994.

(Blank page)

2 DESCRIPTION OF THE FORWARD SPACE PACKET SERVICE

2.1 OVERVIEW

The FSP service enables the user of the service to send Space Packets (reference [6]) to a spacecraft. The FSP service user submits Space Packets encapsulated in SLE-SDUs by means of the FSP-TRANSFER-DATA operation.

The FSP service provider checks the Packet Primary Header to determine if the Packet sent by the user complies with the applicable constraints, e.g., that the Packet has an Application Process Identifier (APID) that falls into the set of APIDs the user is authorized to access. The FSP service provider does not otherwise interpret, interrogate, or modify the content of the Packet. Telecommand Packets having valid Packet Primary Header information are transmitted bit for bit as received from the service user.

The FSP service encapsulates Space Packets into TC Transfer Frames (i.e., one or more frames) and passes these to an underlying Forward TC Frame (FTCF) service or equivalent.

The operations defined in section 3 of this Recommendation enable an FSP service user to interact with an FSP service provider to:

- a) establish an association between the user and the provider;
- b) send annotated Space Packets 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 Space Packets;
- e) change the values of certain parameters (such as `transmission-mode`) that affect the behavior of the service; and
- f) release an association.

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

The provision of FSP service for access to one or more TC VCs by one or more MUEs service users is permitted. Each pairing of TC VC and MUE constitutes a separate service instance.

2.2 SPACE LINK EXTENSION REFERENCE MODEL

2.2.1 INTRODUCTION

The FSP 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 [8]). 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.

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

The terms user and provider are used to distinguish the roles of two interacting objects. In this Recommendation, 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 FSP 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 Recommendations.

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 SLE Forward Space Packet channel to the RF channel.

Certain configuration parameters are associated with the provision of FSP service, while others are associated with production (see 2.4.2). Changes to FSP provision configuration parameters (e.g., the frequency at which status reports shall be generated) affect only a single service instance; the values of such parameters are initialized by service management when the service instance is created but may be modified subsequently by the user through FSP operations specified in this Recommendation. Changes to FSP production configuration parameters (e.g., maximum Packet Data Length, VC multiplexing scheme) potentially affect multiple service instances or potentially impact SLE Complex resources and other concurrent service instances; consequently, with one exception outlined below those parameters may be modified only through service management.

For each VC, one service instance can invoke Frame Operation Procedure (FOP) directives, even though FOP directives will in general affect multiple service instances. Some FOP directives also affect the space element and are therefore regarded to be integral part of a telecommand service and not part of the management of such service.

2.4 ARCHITECTURE MODEL—FUNCTIONAL VIEW

2.4.1 FORWARD TC-VC DATA INSERTION FUNCTIONAL GROUP

The Forward TC-VC Data Insertion SLE Functional Group (SLE-FG) shown in figure 2-1 produces the FSP service and the Forward Telecommand Virtual Channel Access (TC VCA) service. The latter service is not addressed by this Recommendation, but is defined in reference [1].

As described in reference [1], the Forward TC VC Data Insertion SLE-FG consumes one or more FSP data channels consisting of a stream of FSP SLE-SDUs and supplies the Forward TC Frame SLE data channel.

NOTE – As defined in reference [1], the production of the FSP service involves three SLE-FGs: the Forward TC Space Link Processing SLE-FG, the Forward Communications Link Transmission Unit (CLTU) Generation SLE-FG, and the Forward TC VC Data Insertion SLE-FG (see figure 2-3).

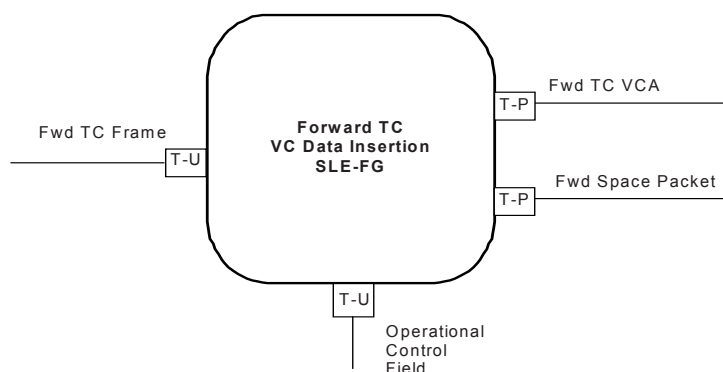


Figure 2-1: Forward TC VC Data Insertion SLE-FG

The Forward TC VC Data Insertion SLE-FG performs the following functions with respect to the FSP service (see references [3], [4], [5], and [6]):

- a) For each FSP service instance, the Forward TC VC Data Insertion SLE-FG consumes one FSP data channel, extracts the Space Packets from the FSP SLE-SDUs in each data channel, blocks or segments the Space Packets into TC frames, and supplies the Forward TC Frame SLE data channel in the form of individual TC frames. The FSP service does not support blocking of TC frames. If the TC frame is to be sent using the sequence-controlled service option of the Communications Operation Procedure (COP), the TC VC Data Insertion SLE-FG sets the Frame Sequence Number and buffers a copy of the TC frame.
- b) The Forward TC VC Data Insertion SLE-FG consumes Operational Control Field (OCF) SLE data channels (Control Word Type 0 only) and extracts the

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

Communications Link Control Words (CLCWs). Based on the values in the CLCW, the Forward TC VC Data Insertion SLE-FG retransmits or deletes buffered TC frames.

- c) The Forward TC VC Data Insertion SLE-FG supplies the Forward TC frame SLE data channels to the Forward CLTU Generation SLE-FG through an online service instance.

In addition to encapsulating the Space Packets, the SLE-SDUs contain control and annotation data that specify production time and other parameters to aid in processing the data. The SLE-SDUs containing Space Packets are described in section 3.6, which defines the FSP-TRANSFER-DATA operation.

2.4.2 FSP SERVICE PRODUCTION AND PROVISION

One instance of FSP service production (or, one instance of the TC-VC Data Insertion SLE FG) may be associated with multiple FSP service instances. FSP **production** is concerned with the extraction of Space Packets from concurrent streams of the SLE-SDUs and their multiplexing onto the space link according to the Space Packet control and annotation information in the SLE-SDU and the configuration set up by service management. This process is independent of any particular instance of service and is specified in detail in annex B. FSP service **provision** is concerned with receiving one stream of SLE-PDUs from an FSP 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 FSP service production are sent by the service user by means of the FSP service operations defined in section 3. These operations also provide additional functionality to facilitate the provision of FSP service, i.e. enabling the exchange of SLE-SDUs across a remote interface. The FSP service operations are realized as SLE protocol data units (SLE-PDUs), which are exchanged between the FSP service provider and the FSP 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. This figure assumes that as in the example shown in figure 2-3 all forward service production is implemented within a single SLE Complex. This may or may not be the case. For instance, one SLE Complex could host the FSP and TC Frame production process and use the Forward CLTU service provided by another SLE Complex. In that case, the latter SLE Complex would generate the SL-DUs while the two SLE Complexes would exchange Forward CLTU SLE-PDUs.

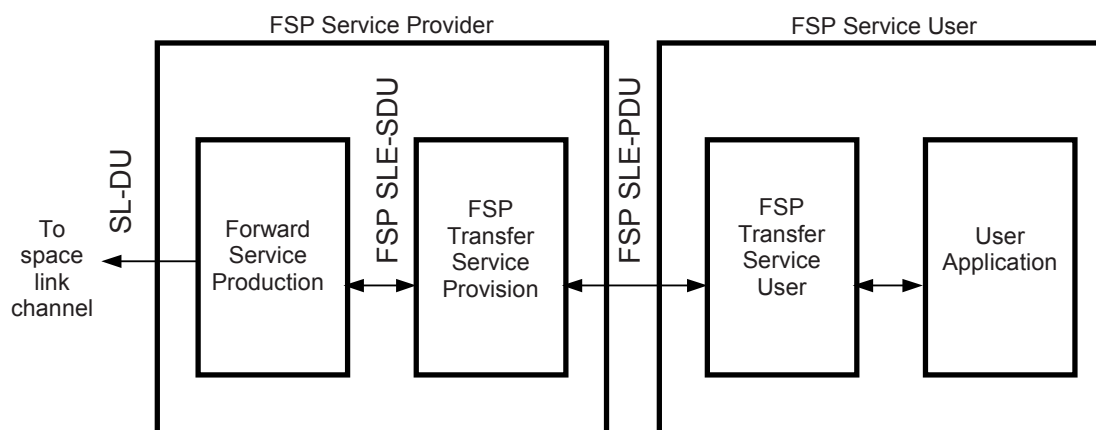


Figure 2-2: FSP Service Production and Provision

Production of the FSP service by the provider occurs during the space link session. It will in general largely overlap with service provisioning. Production status affects the provision of the service, as specified in sections 3 and 4, and reviewed in annex C.

2.5 ARCHITECTURE MODEL—CROSS SUPPORT VIEW

The management and control of the production and provisioning 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 transfer and management ports. This example shows an SLE Complex with one Forward TC VC Data Insertion SLE-FG instance providing two instances of FSP service to MUEs in a Mission Data Operations System (MDOS). The Forward TC VC Data Insertion SLE-FG uses the FTCTF service provided by a Forward CLTU Generation SLE-FG, which in turn uses the Forward CLTU service, provided by a Forward TC Space Link Processing SLE-FG.

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

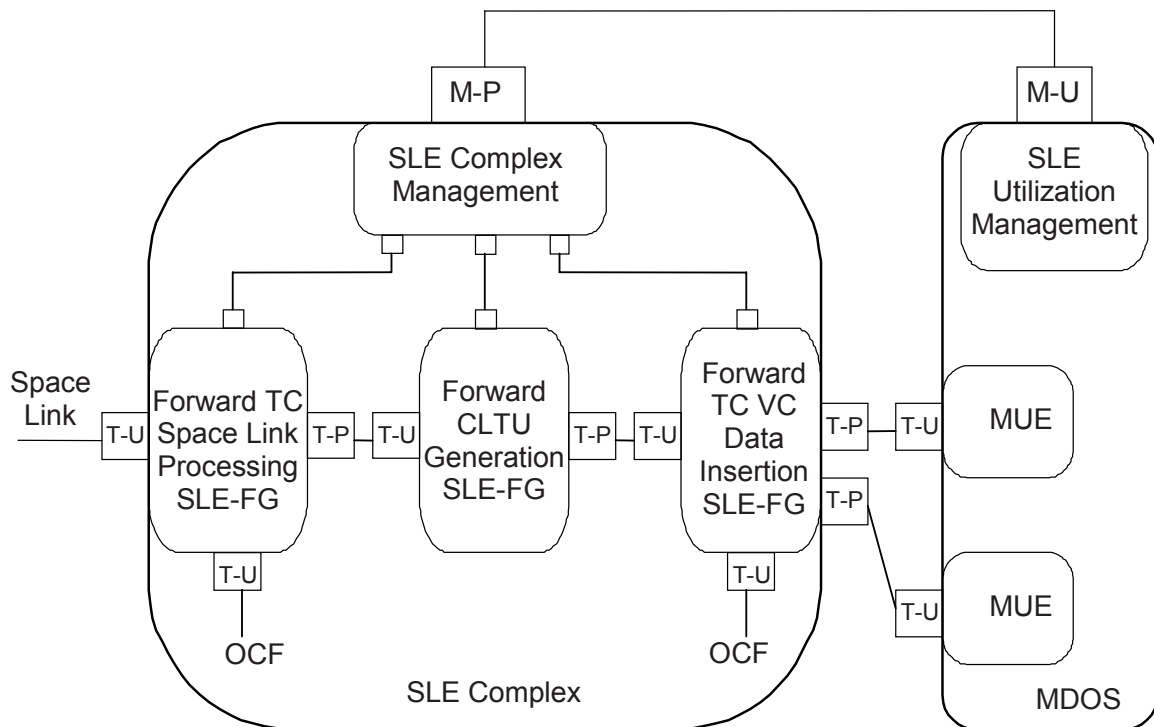


Figure 2-3: Example of the Management and Provision of FSP Service

NOTES

- 1 The FSP service occurs between the MDOS T-U ports and the SLE Complex T-P ports.
- 2 Although not shown in this scenario, many other combinations are possible. For example, it is also possible to have several SLE-FG instances, each supplying a different SLE data channel and each providing one or more instances of service. The different SLE-FGs shown in the scenario may also belong to different SLE Complexes.

2.6 FUNCTIONAL DESCRIPTION

2.6.1 GENERAL

This subsection describes the FSP 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. FSP service production parameters include such things as the TC VC to be used, the multiplexing schemes applicable at TC frame and MAP level, and maximum Packet Data Length and TC Transfer Frame length. Provision parameters include such things as the scheduled start and stop times of the FSP 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 FSP service relies on the following SLE services or their equivalents:

- a) Forward TC Frame;
- b) Forward CLTU.

Provision of FSP service depends on service management for scheduling, resources, and configuration. The schedule for an FSP service instance must be compliant with the schedule of the underlying FTCTF service (or equivalent).

The FSP service also depends on the availability of a suitable communications service to enable the exchange of information between the FSP service user and provider.

2.6.4 PROTOCOL DESCRIPTION

2.6.4.1 FSP Operations

The operations that constitute the FSP service are listed in table 2-1. Section 3 of this Recommendation contains the detailed specification of these operations.

Table 2-1: FSP Service Operations

Operations	Invoked By	Purpose	Con- firmed
FSP-BIND	Initiator (User)	To establish an association with the provider	Yes
FSP-UNBIND	Initiator	To release an association previously	Yes

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

Operations	Invoked By	Purpose	Con- firmed
	(User)	established by an FSP-BIND operation	
FSP-START	User	To request that the SLE service provider prepare to accept FSP-TRANSFER-DATA operations	Yes
FSP-STOP	User	To request that the provider stop service production for the Space Packets associated with this service instance and not yet processed and discard these Space Packets	Yes
FSP-TRANSFER-DATA	User	To transfer a Space Packet to the service provider	Yes
FSP-ASYNC-NOTIFY	Provider	To notify the user of an event affecting production or provision of the FSP service	No
FSP-SCHEDULE-STATUS-REPORT	User	To request that the provider send a status report immediately or periodically, or stop reporting	Yes
FSP-STATUS-REPORT	Provider	To send a status report to the user	No
FSP-GET-PARAMETER	User	To ascertain the value of an SLE service parameter (see tables 3-1 and 3-11)	Yes
FSP-THROW-EVENT	User	To forward an event that requires Complex Management to take the actions defined for this event	Yes
FSP-INVOKE-DIRECTIVE	User	To invoke TC-Directives as specified in reference [5]. TC directives are required to (re-)establish the commanding capability on a given VC	Yes
FSP-PEER-ABORT	User or Provider	To notify the peer that the local SLE application detected an error that requires the association to be terminated	No

2.6.4.2 States of the Service Provider

Once an FSP service instance is created, the FSP service provider is in one of three states, as follows:

- State 1 ('unbound'): In state 1, all resources required to enable the provision of the FSP 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 FSP transfer service provider port is not bound).
- 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 Recommendation. However, sending of Space Packets from the user to the provider (by means of the FSP-TRANSFER-DATA operation) is not permitted. The user may enable the delivery of Space Packets by means of the appropriate service operation (FSP-START), which, in turn, will cause the provider to transition to state 3 ('active').
- State 3 ('active'): State 3 resembles to state 2 ('ready'), except that now the user can send Space Packets. The service continues in this state until the user invokes the FSP-STOP operation to cause the provider to discard any Space Packets belonging to the given service instance and not yet being processed and to transition back to state 2.

A simplified FSP service provider state transition diagram is shown in figure 2-4. A detailed state transition matrix is provided in section 4.2.

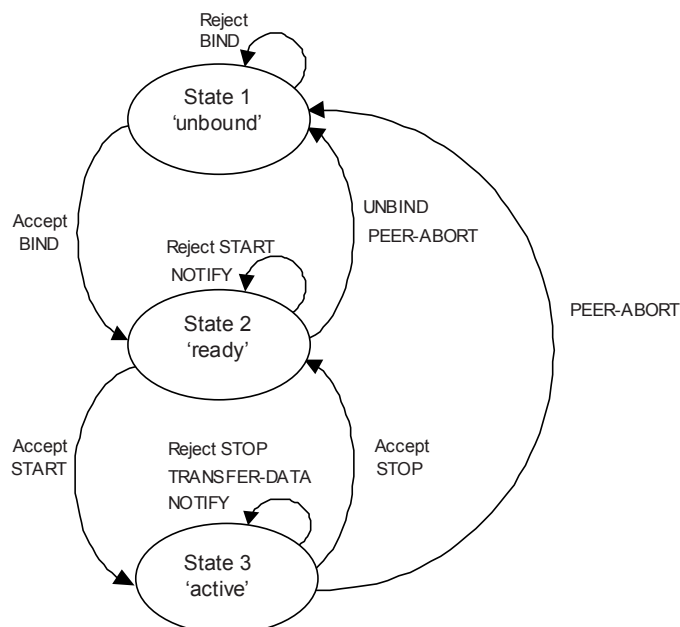


Figure 2-4: Simplified FSP Service Provider State Transition Diagram

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

2.6.4.3 Terminating an Association

An association is released normally when an FSP-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 FSP-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

Following the termination of an association, the provider immediately discards all Space Packets buffered for this service instance except any Space Packet that is already in the production process (see annex B).

When an association is released or aborted, no further operations can be exchanged between the user and the provider. The systems may re-establish an association via a new FSP-BIND operation if that is consistent with the service instance provision period. However, status information from the prior association is not preserved and is not available to the new association except that:

- a) all accounting information, such as number of Space Packets processed, is persistent during the 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;
- c) COP parameters, i.e. parameters that are set by invoking directives (see 3.12), will not be altered.

2.6.4.5 Technology-specific Aspects

This Recommendation defines the FSP service. Provision of the FSP service in a real system also requires a specification of how the FSP service defined here is mapped to a communications service such that all invocations and returns of the FSP service operations can be conveyed between the user and the provider. In order not to restrict the applicability of this Recommendation 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 FSP service interface between the user and the provider is specified in this Recommendation 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

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

can be conveyed by means of the underlying communications service. This Recommendation conceptualizes such mapping in two parts:

- a) FSP 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 FSP service operation invocations and returns to SLE-PDUs is specified by this Recommendation. In the FSP case, an SLE-PDU corresponds to the invocation or return of an FSP operation. Other services may opt to map multiple TRANSFER-DATA invocations to a single SLE-PDU. From the point of view of the provider or user application, the interaction between the user and provider is in terms of operations, but from the point of view of the application entities that implement the FSP protocol, what is exchanged are SLE-PDUs.

The mapping of SLE-PDUs to an underlying communications service is intentionally outside the scope of this Recommendation (e.g., so that the FSP 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 Recommendation but also to an agreed upon specification of the mapping of the FSP service to the underlying communications service. The specification of a mapping of the FSP 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 FSP service that results from such a mapping. The specification of such mappings is the subject of separate CCSDS Recommendations.

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

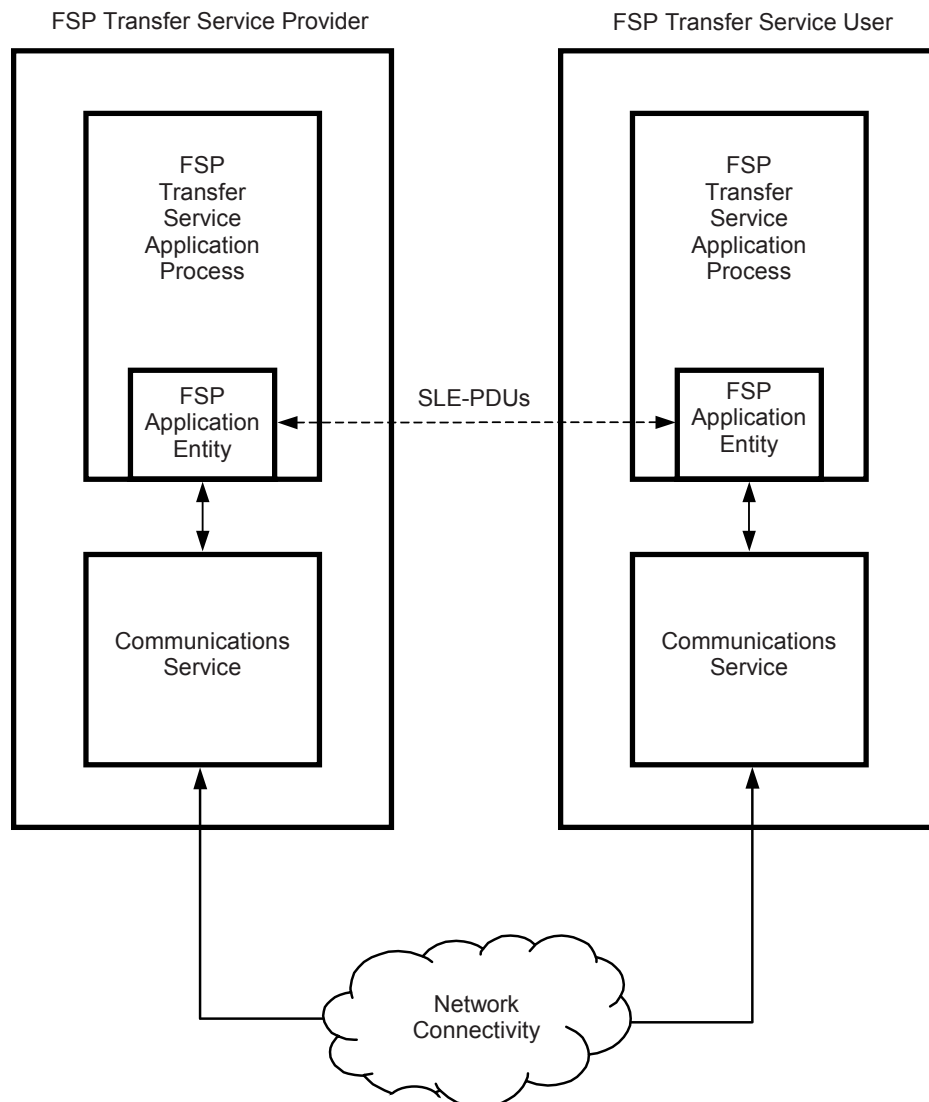


Figure 2-5: Communications Realization of FSP Service

Because the operations of the FSP 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 FSP-BIND and FSP-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 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 FSP-BIND operation (initiator). The responder port identifier identifies the endpoint that will perform the FSP-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 FSP service to the underlying communications service.

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 an FSP-BIND invocation for that association. The initiator needs the information to ensure that the FSP-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 FSP-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 FSP service to the underlying communications service.

The responder port identifier is included as a parameter of the FSP-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 FSP-BIND operation to allow for the possible simplification of the implementation of a gateway.

The information represented by the responder port identifier is technology-specific. In order to define the FSP-BIND operation in a way that is not technology-specific, the `responder-port-identifier` parameter of the FSP-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

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET 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 FSP service buffers the Space Packets for the purpose of multiplexing concurrent FSP data channels in accordance with the applicable multiplexing scheme and for maintaining a steady output stream of TC frames despite variable latency over the ground communications links. Annex B specifies the applicable buffering mechanisms in detail. All Space Packets transfers 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 FSP 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 FSP 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 Complexes involved establish the forward link to the spacecraft and initiate the production of FSP service and, if applicable, of the underlying FTCTF and Forward CLTU services. 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 FSP 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 FSP-BIND operation to establish an association.
- b) The provider monitors the status of the underlying services. If the production status permits, it transitions from state 1 ('unbound') to state 2 ('ready') and returns a report of the successful completion of the bind operation to the user.

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

- c) The provider continuously monitors the production status. When the production status changes and the user might be affected by this change, the provider sends FSP-ASYNC-NOTIFY to the user.
- d) The user may check parameters that control service provision by means of the FSP-GET-PARAMETER operation.
- e) A user interested in obtaining periodic status reports may invoke the FSP-SCHEDULE-STATUS-REPORT operation to configure status reporting.
- f) The user invokes the FSP-START operation to enable the submission of Space Packets.
- g) The provider transitions from state 2 ('ready') to state 3 ('active') and confirms the start operation to the user.
- h) The user next submits a Space Packet by invoking the FSP-TRANSFER-DATA operation. The provider verifies the Packet, and if acceptable, buffers it until the earliest transmission start time specified in the FSP-TRANSFER-DATA invocation is reached. In addition, notifications may be delivered by means of FSP-ASYNC-NOTIFY operations, and requested status reports are delivered by means of FSP-STATUS-REPORT operations.
- i) The user sends additional Space Packets by repeated invocation of FSP-TRANSFER-DATA operations.
- j) The user checks if radiation or acknowledgement of all Space Packets is completed by inspecting the notifications or reports sent by the provider via the FSP-ASYNC-NOTIFY or FSP-STATUS-REPORT operations. If all Space Packets have been radiated or acknowledged, the user will invoke the FSP-STOP operation, which will cause the provider to transition to the 'ready' state.
- k) If the service instance provision period has not expired, the user may initiate the radiation of another set of Space Packets by invoking another FSP-START operation. If there are no more Packets to be uplinked, the user terminates the association by invoking the FSP-UNBIND operation.

2.8 SECURITY ASPECTS OF THE SLE FORWARD SPACE PACKET (FSP) 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

CCSDS RECOMMENDATION FOR SLE FORWARD SPACE PACKET SERVICE

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 Recommendation.

The SLE FSP transfer service transfers data that is destined for a mission spacecraft. As such, the SLE FSP 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 FSP 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 FSP 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 FSP 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 under the SLE transfer service, or some combination of both. For example, mission application processes might apply end-to-end encryption to the contents of the CCSDS space link data units carried as data by the SLE transfer service. Alternatively or in addition, the network connection between the SLE entities might be encrypted to provide data privacy in the underlying communication network.

2.8.2.2 Data Integrity

The SLE FSP service requires that each transferred space packet be accompanied by a sequence number, which must increase monotonically. Failure of a space packet to be accompanied by the expected sequence number causes the space packet to be rejected (see 3.6.2.18.1 d)). This constrains the ability of a third party to inject additional command data into an active FSP transfer service instance.

The SLE FSP transfer service defines and enforces a strict sequence of operations that constrain the ability of a third party to inject operation invocations or returns into the transfer service association between a service user and provider (see 4.2.2). This constrains the ability of a third party to seize control of an active FSP transfer service instance without detection.

The SLE FSP transfer service requires that the underlying communication service transfer data in sequence, completely and with integrity, without duplication, with flow control that notifies the application layer in the event of congestion, and with notification to the application layer in the event that communication between the service user and the service provider is disrupted (see 1.3.1). No specific mechanisms are identified, as they will be an integral part of the underlying communication service.

2.8.2.3 Authentication

This SLE FSP transfer service specification defines authentication requirements (see 3.1.5), and defines `initiator-identifier`, `responder-identifier`, `invoker-credentials`, and `performer-credentials` parameters of the service operation invocations and returns that are used to perform SLE transfer service authentication. The procedure by which SLE transfer service operation invocations and returns are authenticated is described in annex F of the Cross Support Service Green Book (reference [G3]). The SLE transfer service authentication capability can be selectively set to authenticate at one of three levels: authenticate every invocation and return, authenticate only the BIND operation invocation and return, or perform no authentication. Depending upon the inherent authentication available from the underlying communication network, the security environment in which the SLE service user and provider are operating, and the security requirements of the spaceflight mission, the SLE transfer service authentication level can be adapted by choosing the SLE operation invocations and returns that shall be authenticated. Furthermore, the mechanism used for generating and checking the credentials and thus the level of protection against masquerading (simple or strong authentication) can be selected in accordance with the results of a threat analysis.

2.8.2.4 Access Control

This SLE FSP transfer service specification defines access control requirements (see section 3.1.4), and defines `initiator-identifier` and `responder-identifier` parameters of the service operation invocations and returns that are used to perform SLE