

# Space data and information transfer systems — Space link extension (SLE) — Return-all-frames service

ICS 49.140

## National foreword

This British Standard was published by BSI. It is the UK implementation of ISO 22669:2007. It supersedes BS ISO 22669:2003 which is withdrawn.

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

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# INTERNATIONAL STANDARD

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**22669**

Second edition  
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## **Space data and information transfer systems — Space link extension (SLE) — Return-all-frames service**

*Systèmes de transfert des données et informations spatiales —  
Extension de liaisons spatiales (SLE) — Service de retour par tout  
réseau*





## 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.

This second edition cancels and replaces the first edition (ISO 22669:2003), which has been technically revised.

ISO 22669 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 911.1-B-2, 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) — Return-all-frames service

## 1 Scope

This International Standard defines the space link extension (SLE) return-all-frames (RAF) service in conformance with ISO 15396:1998. The RAF service is an SLE transfer service that delivers to a mission user all telemetry frames from one space link physical channel.

This International Standard defines, in an abstract manner, the RAF service in terms of

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

It does not specify

- individual implementations or products;
- the implementation of entities or interfaces within real systems;
- the methods or technologies required to acquire telemetry frames from signals received from a spacecraft;
- the methods or technologies required to provide a suitable environment for communications; or
- the management activities required to schedule, configure, and control the RAF service.

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 911.1-B-2, November 2004, *Space link extension — Return all frames service specification*.

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 911.1-B-2.

*Pages i to v*

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 131.0-B-1, September 2003, is equivalent to ISO 22641:2005.
- [3] Document CCSDS 132.0-B-1, September 2003, is equivalent to ISO 22645:2005.
- [4] Document CCSDS 732.0-B-1, September 2003, is equivalent to ISO 22666:2005.
- [5] Document CCSDS 301.0-B-3, January 2002, is equivalent to ISO 11104:2003.
- [7] ISO/IEC 8824:1998 has been cancelled and replaced by ISO/IEC 8824:2002, *Information technology — Abstract Syntax Notation One (ASN.1)*.

## Page E-1

Add the following information to the reference indicated:

- [E4] Document CCSDS 102.0-B-5, November 2000, is equivalent to ISO 13419:2003.

### 3 Revision of publication CCSDS 911.1-B-2

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 911.1-B-2. 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— RETURN ALL FRAMES SERVICE SPECIFICATION**

CCSDS 911.1-B-2

**Blue Book**

November 2004



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## CCSDS RECOMMENDATION FOR SLE RETURN ALL FRAMES SERVICE

**AUTHORITY**

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

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National Aeronautics and Space Administration  
Washington, DC 20546, USA

## STATEMENT OF INTENT

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

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

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  - The anticipated duration of operational service.
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## CCSDS RECOMMENDATION FOR SLE RETURN ALL FRAMES SERVICE

**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 Return All Frames 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 [2], [3], and [4]) within the framework established by the CCSDS Space Link Extension 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 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.
- United States Geological Survey (USGS)/USA.

## CCSDS RECOMMENDATION FOR SLE RETURN ALL FRAMES SERVICE

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| CCSDS<br>911.1-B-2 | Space Link Extension—<br>Return All Frames Service<br>Specification | November 2004 | Issue 2, Blue Book |

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## 1 INTRODUCTION

### 1.1 PURPOSE OF THIS RECOMMENDATION

The purpose of this Recommendation is to define the Space Link Extension (SLE) Return All Frames (RAF) service in conformance with the SLE Reference Model (reference [1]). The RAF service is an SLE transfer service that delivers to a mission user all telemetry frames from one space link physical channel.

### 1.2 SCOPE

This Recommendation defines, in an abstract manner, the RAF service in terms of:

- a) the operations necessary to provide the 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 acquire telemetry frames from signals received from a spacecraft;
- d) the methods or technologies required to provide a suitable environment for communications; or
- e) the management activities required to schedule, configure, and control the RAF service.

### 1.3 APPLICABILITY

#### 1.3.1 APPLICABILITY OF THIS RECOMMENDATION

This Recommendation provides a basis for the development of real systems that implement the RAF service. Implementation of the RAF service in a real system additionally requires the availability of a communications service to convey invocations and returns of RAF service operations between RAF service users and providers. This Recommendation requires that such a communications service must 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 the application layer in the event of congestion; and
- e) with notification to the application layer in the event that communications between the RAF service user and the RAF service provider are disrupted, possibly resulting in a loss of data.

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

### **1.3.2 LIMITS OF APPLICABILITY**

#### **1.3.2.1 Relationship to Real Systems**

This Recommendation specifies the RAF service that may be provided by an SLE Complex 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.

#### **1.3.2.2 RAF Service and Telemetry Channel Coding**

Telemetry channel coding on the space link is specified by reference [2]. This specification is more restrictive with respect to telemetry channel coding than is reference [2]. In particular, the provision of RAF service requires that Reed-Solomon coding must be present or absent on all frames of a physical channel. RAF service is not supported where there is a concurrent mix, on one physical channel, of some frames with Reed-Solomon coding and some frames without.

### **1.4 RATIONALE**

The goal of this Recommendation is to create a standard for interoperability between the tracking stations or ground data handling systems of various Agencies and the consumers of spacecraft telemetry.

### **1.5 DOCUMENT STRUCTURE**

#### **1.5.1 ORGANIZATION**

This document is organized as follows:

- a) section 1 presents the purpose, scope, applicability and rationale of this Recommendation and lists the definitions, conventions, and references used throughout the Recommendation;

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- b) section 2 provides an overview of the RAF service including a functional description, the service management context, and protocol considerations;
- c) section 3 specifies the operations of the RAF service;
- d) section 4 specifies the dynamic behavior of the RAF service in terms of the state transitions of the RAF service provider;
- e) annex A provides a formal specification of RAF service data types using Abstract Syntax Notation One (ASN.1);
- f) annex B lists all terms used in this Recommendation and identifies where they are defined;
- g) annex C lists all acronyms used within this document;
- h) annex D provides a conformance matrix that defines what capabilities must be provided for an implementation to be considered compliant with this Recommendation;
- i) annex E provides a list of informative references.

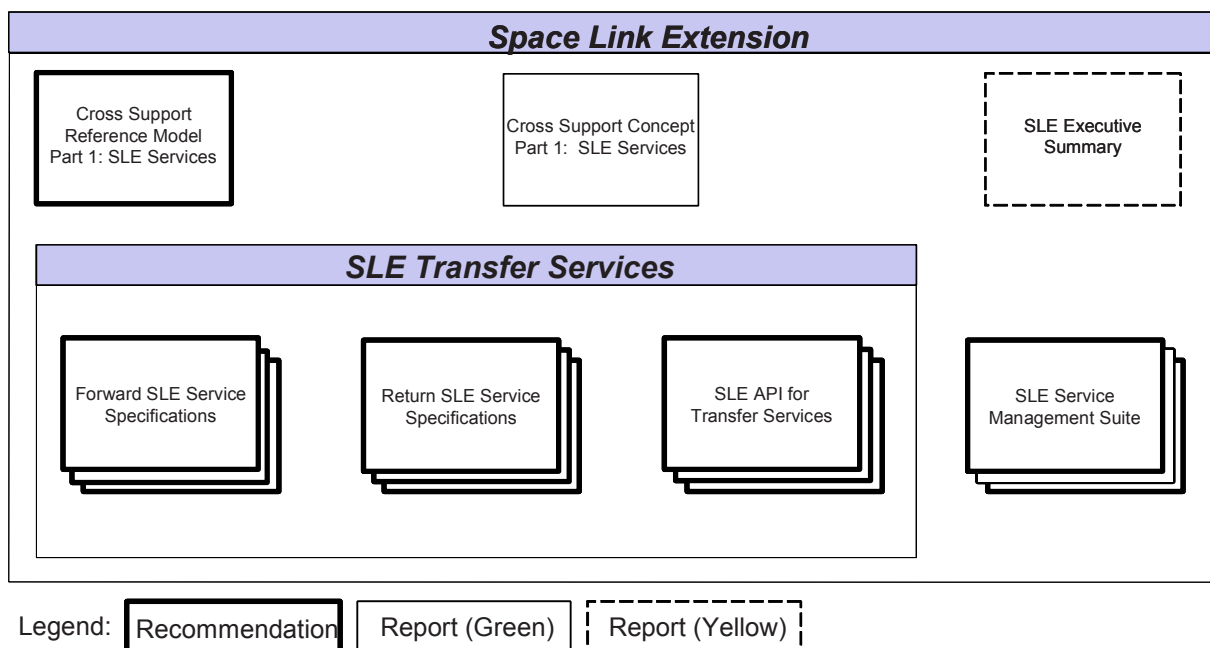
### 1.5.2 SLE SERVICES DOCUMENTATION TREE

This Recommendation is based on the cross support model defined in the SLE Reference Model (reference [1]). It expands upon the concept of an SLE transfer service as an interaction between an SLE Mission User Entity (MUE) and an SLE transfer service provider for the purpose of providing the RAF 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 Domain Services;
- c) Part 3: Ground Communications Services.

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

**Figure 1-1: SLE Services Documentation**

- Cross Support Concept—Part 1: Space Link Extension Services* (reference [E2]): a Report introducing the concepts of cross support and the SLE services;
- Cross Support Reference Model—Part 1: Space Link Extension Services* (reference [1]): a Recommendation that defines the framework and terminology for the specification of SLE services;
- SLE Return Service Specifications*: a set of Recommendations that will provide specification of all return link SLE services (this Recommendation is one of the specifications in that set);
- SLE Forward Service Specifications*: a set of Recommendations that will provide specification of all forward link SLE services;
- SLE Service Management Specifications*: a set of Recommendations that establish the basis of 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 Recommendation makes use of a number of terms defined in reference [6]. The use of those terms in this Recommendation shall be understood in a generic sense; i.e., in the sense

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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) application process;
- e) flow control;
- f) Open Systems Interconnection (OSI);
- g) real system;
- h) 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 RAF service operation invocations and returns. The use of ASN.1 as a descriptive language is intended to support the specification of the abstract RAF 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 RAF service operation invocations and returns.

#### 1.6.1.3 Definitions from TM Synchronization and Channel Coding

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

- a) Attached Sync Marker;
- b) codeblock;
- c) convolutional code;
- d) pseudo-randomization;

- e) Reed-Solomon check symbols;
- f) Reed-Solomon code.

#### **1.6.1.4 Definitions from TM Space Data Link Protocol**

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

- a) Frame Error Control Field (FECF);
- b) TM Transfer Frame.

#### **1.6.1.5 Definitions from AOS Space Data Link Protocol**

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

- a) Cyclic Redundancy Code (CRC);
- b) AOS Transfer Frame;
- c) Frame Error Control Field (FECF).

#### **1.6.1.6 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;
- d) abstract service;
- e) invoker;
- f) Mission Data Operation System (MDOS);
- g) Mission User Entity (MUE);
- h) offline delivery mode;
- i) online delivery mode;
- j) operation;
- k) performer;
- l) physical channel;
- m) return data;

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- n) Return All Frames channel (RAF channel);
- o) Return All Frames service (RAF service);
- p) service agreement;
- q) service provider (provider);
- r) service user (user);
- s) SLE Complex;
- t) SLE Complex Management;
- u) SLE data channel;
- v) SLE Functional Group (SLE-FG);
- w) SLE Protocol Data Unit (SLE-PDU);
- x) SLE Service Data Unit (SLE-SDU);
- y) SLE service package;
- z) SLE System;
- aa) SLE transfer service instance;
- bb) SLE transfer service production;
- cc) SLE transfer service provision;
- dd) SLE Utilization Management;
- ee) space link;
- ff) space link data channel;
- gg) Space Link Data Unit (SL-DU);
- hh) space link session.

### 1.6.1.7 Additional Definitions

#### 1.6.1.7.1 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 the use of an underlying communications service.

#### **1.6.1.7.2 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.

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.

#### **1.6.1.7.3 Confirmed Operation**

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

#### **1.6.1.7.4 Delivery Criteria**

Delivery criteria are rules that determine whether a data unit acquired from the space link by an SLE service provider shall be delivered to a user.

NOTE – For RAF service, the delivery criteria are:

- a) the Earth Receive Time (ERT) of the frame is within the period defined by the start and stop times specified in the RAF-START operation; and
- b) the frame quality of the frame matches the requested frame quality specified in the RAF-START operation.

#### **1.6.1.7.5 Frame Error Control Field**

The Frame Error Control Field (FECF) of a frame is the FECF of a TM Transfer Frame (reference [3]), or the FECF of an AOS Transfer Frame (reference [4]), as applicable.

#### **1.6.1.7.6 Initiator**

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

#### **1.6.1.7.7 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.

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**1.6.1.7.8 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.

**1.6.1.7.9 Performance**

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

**1.6.1.7.10 Port Identifier**

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

NOTE – See 2.6.4.5 for more information.

**1.6.1.7.11 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.

**1.6.1.7.12 Return**

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

**1.6.1.7.13 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.

NOTE – Reaching of the beginning of this period constitutes the event 'start of service instance provision period' (see 4.2.2).

**1.6.1.7.14 Spacecraft Identifier**

The spacecraft identifier (SCID) of a telemetry frame is as defined in reference [3] if the frame is a TM Transfer Frame or as defined in reference [4] if the frame is an AOS Transfer Frame.

#### **1.6.1.7.15 Telemetry Frame**

A (telemetry) frame is a transfer frame TM Transfer Frame (as defined in reference [3]) or a an AOS Transfer Frame (as defined in reference [4]). In case a distinction of the frame versions is necessary, the full term as per references [3] or [4] is used.

#### **1.6.1.7.16 Transfer Frame Version Number**

The Transfer Frame Version Number (TFVN) is either the TFVN as defined in reference [3] or the TFVN as defined in reference [4].

NOTE – The definitions of TFVN given in references [3] and [4] are equivalent. If a CCSDS-compatible telemetry frame is known to contain no errors, the TFVN enables one to distinguish between a TM Transfer Frame and an AOS Transfer Frame.

#### **1.6.1.7.17 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 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 RAF service. The specification of each operation is divided into subsections as described in 1.6.3.1.2 through 1.6.3.1.4.

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**1.6.3.1.2 Purpose Subsection**

The Purpose subsection provides a brief description of the purpose 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 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        |
| 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****1.6.3.2.1 Operation Names**

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

#### 1.6.3.2.2 Parameter Names

In the main text, names of parameters of RAF service operations generally 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, those names are shown in 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 that 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 RAF service providers. States may be referred to by number (e.g., state 2) or by name. State names are always shown in quotation marks (e.g., 'active').

#### 1.6.3.2.5 SLE-PDU Names

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

#### 1.6.3.2.6 Data Type Definitions

Data type definitions for the RAF 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].

## CCSDS RECOMMENDATION FOR SLE RETURN ALL FRAMES SERVICE

## 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.

## NOTE – S

- 1 A list of informative references is provided in annex E.
  - 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 [E3], [E4], and [E5]).
- [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. Washington, D.C.: CCSDS, May 1996.
  - [2] *TM Synchronization and Channel Coding*. Recommendation for Space Data System Standards, CCSDS 131.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.
  - [3] *TM Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 132.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.
  - [4] *AOS Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 732.0-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—Basic Reference Model: The Basic Model*. International Standard, ISO/IEC 7498-1:1994. 2<sup>nd</sup> ed. Geneva: ISO, 1994.
  - [7] *Information Technology—Open Systems Interconnection—Specification of Abstract Syntax Notation One (ASN.1)*. International Standard, ISO/IEC 8824:1998. 2<sup>nd</sup> ed. Geneva: ISO, 1998.

## **2 DESCRIPTION OF THE RETURN ALL FRAMES SERVICE**

### **2.1 OVERVIEW**

The RAF service enables the user of the service to obtain all telemetry frames from one space link physical channel. A telemetry frame is a TM Transfer Frame or an AOS Transfer Frame. A space link physical channel carries one stream of telemetry frames separated by attached sync markers. For delivery to the user, each frame acquired from the space link is encapsulated in a SLE SDU that also carries annotation (i.e., additional information such as the ERT of the frame).

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

- a) establish an association between the user and the provider;
- b) receive annotated telemetry frames;
- c) obtain notifications and reports regarding the status, configuration and performance of the service;
- d) temporarily suspend and later re-start the delivery of telemetry frames;
- e) change the values of certain parameters that affect the behavior of the service; and
- f) release an association.

The provision of RAF service derived from one space link physical channel for access by one service user constitutes one instance of service. The provision of RAF service from one physical channel to multiple service users and the provision of RAF service concurrently to one or more service are permitted but are specified to constitute multiple service instances.

### **2.2 SPACE LINK EXTENSION REFERENCE MODEL**

#### **2.2.1 INTRODUCTION**

The RAF 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. Objects are characterized by their interfaces, which are called abstract ports, and the operations that are made available through those interfaces. One object may provide multiple abstract ports.

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### 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 [6]). 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 that 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.

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 RAF 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 RF channel to the RAF data channel.

Certain configuration parameters are associated with provision of RAF service while others are associated with production. Changes to RAF provision configuration parameters (e.g., quality of service) 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 RAF service operations specified in this Recommendation. Changes to RAF production configuration parameters (e.g., bit rate, frame length, coding type) potentially affect multiple service instances or potentially impact SLE Complex resources; consequently, those parameters may be modified only through service management.

RAF service may be user-initiated (i.e., the user invokes the bind operation) or provider-initiated (i.e., the provider invokes the bind operation). A particular instance of RAF service shall support either user initiation or provider initiation but not both. The form of initiation that applies to a particular service instance is set by service management.

The SLE Reference Model defines two delivery modes: online delivery mode and offline delivery mode. Online delivery mode indicates that the provision of service is generally coincident in time with the space link session, whereas offline delivery mode indicates that the telemetry frames acquired during a space link session are provided to the user some time after the end of the space link session. Within the online delivery mode, the SLE Reference Model defines two quality factors: timeliness and completeness. Within this RAF service specification, the two variants of online delivery are regarded distinct delivery modes: online timely and online complete. Both assume the use of a reliable communications service. They differ in that the timely mode allows for the controlled discarding of telemetry frames at the application layer if it is not possible to deliver those frames within a certain amount of time after they are acquired from the space link (e.g., because of communications service backlog). While the RAF service is defined for the complete online delivery mode, the timely online delivery mode, or the offline delivery mode, any particular instance of RAF service shall support only one of those modes. The delivery mode applicable to a particular service instance is set by service management.

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**2.4 ARCHITECTURE MODEL—FUNCTIONAL VIEW****2.4.1 RETURN SPACE LINK PROCESSING FUNCTIONAL GROUP**

The Return Space Link Processing Functional Group (shown in figure 2-1) is the SLE functional group (SLE-FG) that produces the RAF service and the Return Insert service. The latter service is not addressed by this Recommendation but is defined in reference [1].

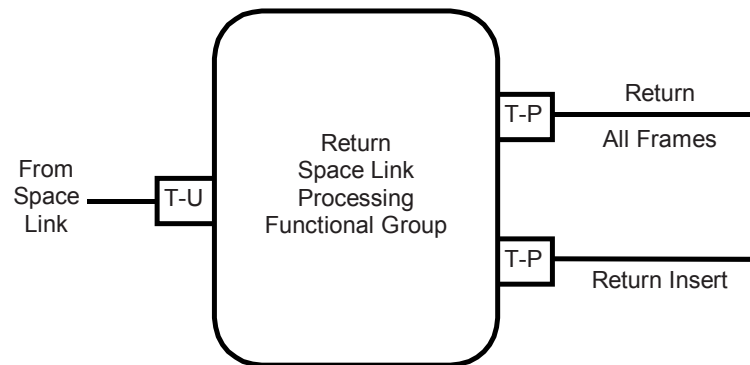


**Figure 2-1: Return Space Link Processing SLE-FG**

As described in reference [1], the Return Space Link Processing Functional Group consumes a space link data channel consisting of a stream of space link data units (SL-DUs). It produces an SLE data channel (viz., an RAF channel) consisting of a stream of SLE service data units (SLE-SDUs) for delivery to users. The SL-DUs are the telemetry frames carried on the space link physical channel. Most SLE-SDUs encapsulate an SL-DU; such SLE-SDUs also carry annotation information associated with that SL-DU (e.g., its ERT). Other SLE-SDUs carry notifications of the occurrences of certain events while the RAF service is being produced (e.g., loss of frame synchronization). More specifically, the Return Space Link Processing Functional Group performs the following functions with respect to RAF service:

- a) utilizes the underlying antenna steering, microwave amplification, and receiver tuning capabilities of the ground element to acquire a radio frequency (RF) carrier channel;
- b) demodulates a physical channel, consisting of a stream of digital symbols, from the RF carrier channel;
- c) synchronizes and recovers telemetry frames from the physical channel;
- d) performs convolutional decoding, removal of pseudo-randomization, error control field decoding, and/or Reed-Solomon or Turbo decoding as applicable (see references [2],[3], and [4]);

## CCSDS RECOMMENDATION FOR SLE RETURN ALL FRAMES SERVICE

- e) annotates each frame to form an RAF SLE-SDU and injects the resulting RAF SLE-SDU into the RAF channel associated with the physical channel from which the frame was extracted;
- f) optionally, stores (and subsequently retrieves) sufficient data to reconstruct the RAF channel for delivery through one or more offline RAF service instances;
- g) makes the RAF channel available to online and offline RAF service instances to enable the provision of RAF service.

The telemetry frames delivered by the RAF service are encapsulated in SLE-SDUs. RAF SLE-SDUs that encapsulate telemetry frames are annotated with information that pertains to that specific frame. The annotation consists of:

- a) the ERT of the frame;
- b) an identifier that indicates the antenna used to acquire the frame;
- c) an indication of whether the frame contains detected, uncorrectable bit errors;
- d) a parameter that characterizes the data link continuity of this frame with respect to the preceding frame on the space link;
- e) an optional octet string that may be used to provide additional, non-standard annotations that are mutually agreed to by the SLE Complex providing the service and the Mission Data Operations System (MDOS) associated with the user of the service.

In the case that an acquired frame is Reed-Solomon encoded and the frame quality is 'good' (i.e., the frame is decoded successfully), then the Reed-Solomon check symbols are removed from the frame prior to its encapsulation into the SLE-SDU. If the frame quality of a Reed-Solomon encoded frame is 'erred' (i.e., the frame is undecodable), then the entire frame, including the Reed-Solomon check symbols, is encapsulated into the SLE-SDU for delivery to the user.

## NOTES

- 1 SLE Return Space Link Processing requires that, at any given time, the coding options must be the same for all frames on a physical channel. This is more restrictive than the constraints imposed by references [2], [3], and [4]. In particular, Reed-Solomon coding must be present or absent on all of the frames of a physical channel. RAF service is not supported where there is a concurrent mix, on one physical channel, of some frames with Reed-Solomon coding and some frames without.
- 2 Acquisition of a frame implies that the attached sync markers preceding and following the frame are identified, exhibit the same data polarity, and delimit the correct number of bits.

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- 3 As defined by this Recommendation, telemetry frames do not include the attached sync marker but are delimited by them.

### 2.4.2 RAF SERVICE PRODUCTION AND PROVISION

One instance of RAF service production (or, one instance of the Return Space Link Processing SLE-FG) may be associated with multiple RAF service instances. RAF production is concerned with the acquisition of frames from the space link and their annotation to form a stream of SLE-SDUs independent of any particular instance of service. In contrast, RAF service provision is concerned with delivering the stream of SLE-SDUs to an RAF service user. Service provision addresses such matters as when service is provided (e.g., service start and stop times), how service is provided (e.g., user-initiated or provider-initiated), and quality of service (e.g., whether frames containing known bit errors are delivered to the user).

The SLE-SDUs generated by RAF service production are delivered to the service user by means of the RAF service operations defined in section 3, which also provide additional functionality to facilitate the provision of RAF service. In turn, the RAF service operations are realized as SLE protocol data units (SLE-PDUs) that are exchanged between the RAF service provider and the RAF service user by means of an underlying communications service. Typically, an SLE-PDU corresponds to the invocation or return of an RAF operation. (Because of the buffering mechanisms described in 3.1.8, there are certain exceptions; for example, multiple RAF-TRANSFER-DATA invocations may be mapped to a single SLE-PDU.) The general relationship between SL-DUs, SLE-SDUs, and SLE-PDUs is illustrated in figure 2-2.

NOTE – SLE-SDUs correspond to the parameters of the RAF-TRANSFER-DATA and RAF-SYNC-NOTIFY operations defined in section 3.

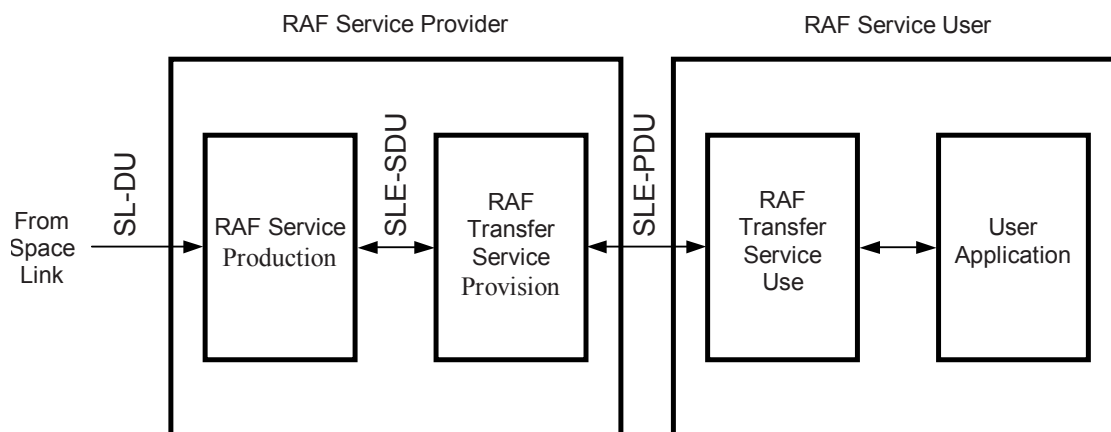


Figure 2-2: RAF Service Production and Provision

For the online delivery mode, production and provision of the RAF service by the provider occur, at least in part, concurrently with the space link session. For the offline delivery mode, service production and provision are detached, with service provision occurring some time after the end of the space link session. In the offline case, data acquired during the space link session are stored for later delivery by an offline service instance.

## 2.5 ARCHITECTURE MODEL—CROSS SUPPORT VIEW

The management and control of the production and provision of SLE transfer services is described in general terms in reference [1]. Figure 2-3 shows an example operational scenario and the related binding of RAF transfer service ports and SLE management ports. This scenario shows an SLE Complex with one Return Space Link Processing SLE-FG instance providing two instances of RAF service to a Mission Data Operations System.

NOTE – Although not shown in this scenario, many other combinations are possible. For example, it is also possible to have several SLE-FG instances, each consuming a different physical channel and each providing one or more instances of service.

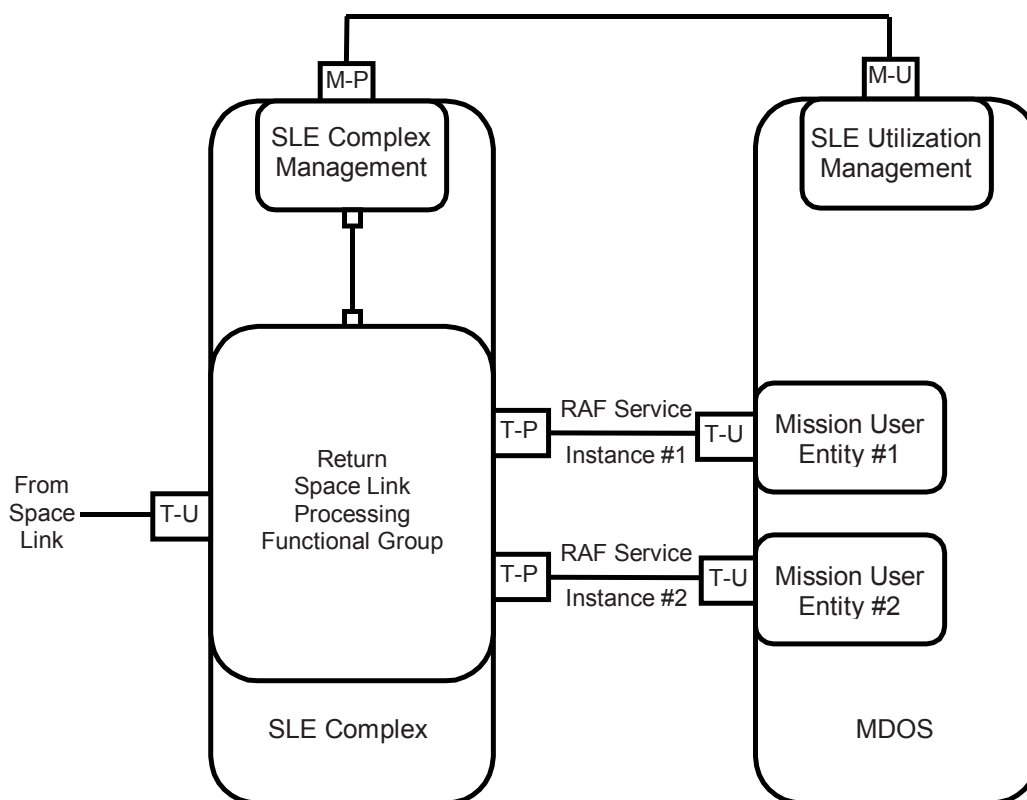


Figure 2-3: Example of the Management and Provision of RAF Service

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## 2.6 FUNCTIONAL DESCRIPTION

### 2.6.1 GENERAL

Subsection 2.6.2 through 2.6.4 describes the RAF 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 mission-dependent parameters required for service production and provision. RAF service production parameters include such things as the frequency of the RF carrier channel, the modulation type, the bit rate, the telemetry channel coding in use, and the scheduled start and stop times of the space link session. RAF service provision parameters include such things as the scheduled start and stop times of the RAF service instance and the delivery mode.

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 RAF service does not depend on any other SLE transfer service. Provision of RAF Transfer service does depend on:

- a) service management for scheduling, resources, and configuration;
- b) the availability of a suitable communications service to enable the exchange of information between the RAF service user and provider; and
- c) the functioning of RAF production resources (e.g., receiver, decoder, frame synchronizer) that acquire frames from the space link.

### 2.6.4 PROTOCOL DESCRIPTION

#### 2.6.4.1 RAF Operations

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

Table 2-1: RAF Operations

| Operation                  | Invoked By       | Purpose                                                                                                            | Confirmed |
|----------------------------|------------------|--------------------------------------------------------------------------------------------------------------------|-----------|
| RAF-BIND                   | User or provider | To establish an association with the peer                                                                          | Yes       |
| RAF-UNBIND                 | User or provider | To release an association previously established by an RAF-BIND operation                                          | Yes       |
| RAF-START                  | User             | To request that the SLE service provider start the delivery of telemetry frames                                    | Yes       |
| RAF-STOP                   | User             | To request that the SLE service provider stop the delivery of telemetry frames                                     | Yes       |
| RAF-TRANSFER-DATA          | Provider         | To transfer a telemetry frame to the SLE service user                                                              | No        |
| RAF-SYNC-NOTIFY            | Provider         | To notify the user of an event affecting production or provision of the RAF service                                | No        |
| RAF-SCHEDULE-STATUS-REPORT | User             | To request that the provider send a status report immediately or periodically or to stop such reporting            | Yes       |
| RAF-STATUS-REPORT          | Provider         | To send a status report to the user                                                                                | No        |
| RAF-GET-PARAMETER          | User             | To ascertain the value of an SLE service parameter (see 3.10.2.5.1)                                                | Yes       |
| RAF-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 RAF service instance is created, the RAF 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 RAF 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 RAF 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, the delivery of telemetry frames (by means of the RAF-TRANSFER-DATA operation) is not permitted. The user may enable the delivery of telemetry frames by means of the appropriate service operation (RAF-

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START); that, in turn, will cause the provider to transition to state 3 ('active') and enable frame delivery.

- c) State 3 ('active'): State 3 is identical to state 2 ('ready') except that all telemetry frames are delivered to the user as they become available. The service continues in this state until the user invokes the RAF-STOP operation to suspend frame delivery and transition back to state 2 (e.g., in response to an 'end of data' notification from the service provider signaling that the space link session has ended and all available frames have been delivered or all RAFs meeting the user selected delivery critery (see 1.6.1.7.4) have been sent).

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

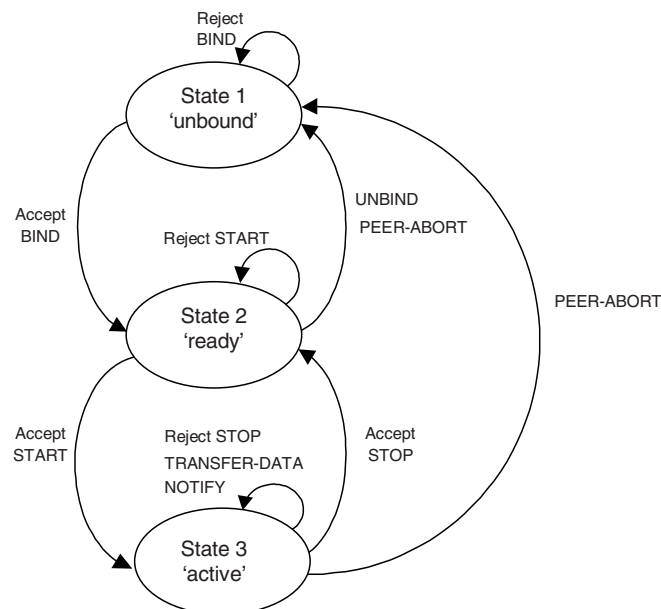


**Figure 2-4: Simplified RAF Service Provider State Transition Diagram**

### 2.6.4.3 Termination of Association

An association is released normally when an RAF-UNBIND operation is invoked by the initiator of the association and performed by the responder. An association may be aborted by either the user or the provider by means of the RAF-PEER-ABORT operation. An association also may be aborted because of certain failures of the communications service; such failures are signaled to the local application by the 'protocol abort' event described in 4.1.5.

#### 2.6.4.4 Effects of Termination

When an association is released or aborted, no further operations shall be invoked by the user or the provider. As a consequence, the delivery of frames stops immediately. The user and provider may re-establish an association via a new RAF-BIND operation if that is consistent with the schedule for the provision of service. However, status information from the prior association is not preserved and is not available to the new association except that:

- a) if the delivery mode is complete online, the contents of the online frame buffer (see 3.1.9) shall be persistent;
- b) if the delivery mode is offline, the contents of the offline frame buffer (see 3.1.9) shall be persistent;
- c) statistics reported by means of the RAF-STATUS-REPORT operation (see 3.9) shall be accumulated for the entire service instance provision period.

#### 2.6.4.5 Technology-specific Aspects

This Recommendation defines the RAF service. Provision of the RAF service in a real system also requires a specification of how the RAF service defined here is mapped to a communications service such that all invocations and returns of RAF 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 RAF 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 operation invocations and returns to protocol data units that can be exchanged by means of the underlying communications service. This Recommendation conceptualizes such a mapping in two parts. First, RAF service operation invocations and returns (defined in section 3) are mapped to SLE-PDUs (defined in annex A). Second, SLE-PDUs are mapped to protocol data units that can be exchanged by means of the underlying communications service. The mapping of RAF service operation invocations and returns to SLE-PDUs is specified by this Recommendation. The mapping of SLE-PDUs to an underlying communications service is intentionally outside the scope of this Recommendation (e.g., so that the RAF 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 RAF service to the underlying communications service. Figure 2-5 illustrates a communications realization of the RAF service that results from such a mapping. The specification of such mappings is the subject of separate CCSDS Recommendations.

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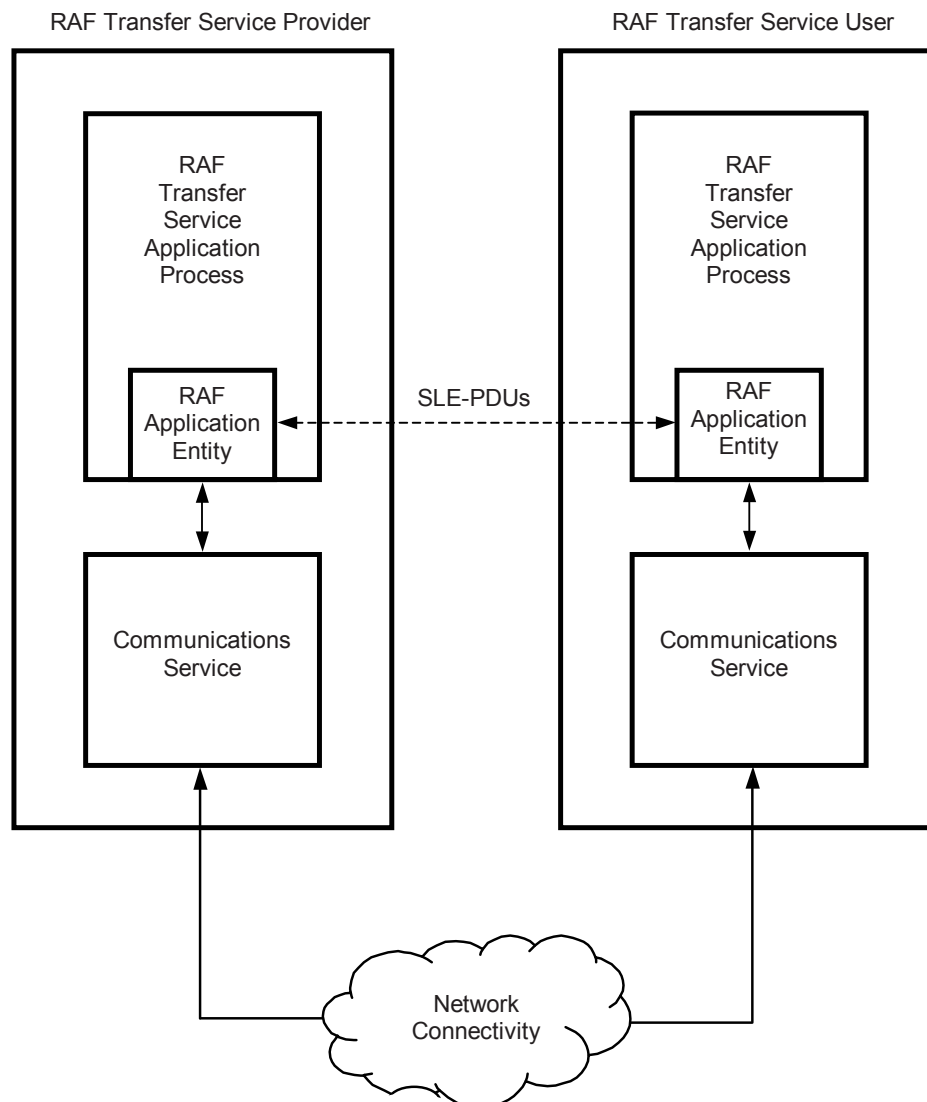


**Figure 2-5: Communications Realization of RAF Service**

The specification of a mapping of the RAF service onto a particular communications service must address such things as:

- a) selection of communication networks to ensure connectivity;
- b) compatible configuration of protocol stacks;
- c) specification of port-identifiers and their translation onto the underlying communications service; and
- d) specification of security related information.

Because the operations of the RAF 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 RAF-BIND and RAF-UNBIND operations as specified in this document are intended to be 'technology neutral'. This neutrality is achieved as described in the following subsections.

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 RAF-BIND operation (initiator). The responder port identifier identifies the endpoint that will perform the RAF-BIND operation (responder). Generally speaking, the information represented by a port identifier consists of:

- a) information needed in order to route data between two real systems over a communications channel or network; and
- b) information needed in order 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 RAF service to the underlying communications service. If the underlying communications service is connection-oriented, then the mapping may specify a one-to-one relationship between SLE associations and communications connections; however, that is not required. For example, two SLE associations involving the same pair of SLE endpoints may share a single connection. In that case, it is the responsibility of the mapping of the RAF service to the underlying communications service to specify how the SLE-PDUs of one association are distinguished from the SLE-PDUs of the other association.

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 RAF-BIND invocation for that association. The initiator needs the information to ensure that the RAF-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 RAF-BIND invocation. The exact means by which the initiator port identifier is provided to

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the responder is technology-specific and must be specified by the mapping of the RAF service to the underlying communications service.

The responder port identifier is included as a parameter of the RAF-BIND operation. Generally speaking, that is unnecessary; it is only necessary that SLE application communicate the information represented by the port identifiers to the underlying communications service. The responder port identifier is provided as a parameter of the RAF-BIND operation to allow for the possibility that the implementation of a gateway might be simplified by the inclusion of this parameter in the RAF-BIND operation.

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

##### 2.6.4.6.1 General

Buffering mechanisms used by the RAF protocol are described in subsections 2.6.4.6.2 and 2.6.4.6.3. They are formally specified by the requirements in 3.1.8 and the state transition matrix in section 4.

##### 2.6.4.6.2 Transfer Buffer

As described in 2.6.4.5, RAF operations (specified in section 3) are mapped to SLE-PDUs (specified in annex A) that are conveyed to the peer SLE entity by means of the underlying communications service. In general, there is a one-to-one mapping between SLE-PDUs and the invocations or returns of RAF operations. However, that is not always the case. In particular, the RAF protocol provides that multiple RAF-TRANSFER-DATA and RAF-SYNC-NOTIFY operations may be mapped to a single SLE-PDU (viz., the SLE-PDU named `RafTransferBuffer` in annex A). In terms of the RAF service, the release of the `RafTransferBuffer` to the communications service provider is equivalent to the near-simultaneous invocation of multiple RAF-TRANSFER-DATA and RAF-SYNC-NOTIFY