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

Systèmes de transfert des informations et données spatiales — Extension de liaisons spatiales (SLE) — Service de réseau pour liaison retour

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted (see www.iso.org/directives).

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This document was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 911.2-B-3, August 2016) and was adopted (without modifications) by Technical Committee ISO/TC 20, *Space vehicles,* Subcommittee SC 13, *Space data and information transfer systems*.

This third edition cancels and replaces the second edition (ISO 22670:2013), which has been technically revised.

The main changes compared to the previous edition are as follows:

— adds clarifications and corrections;

— adds production status annex.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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1 INTRODUCTION

1.1 PURPOSE OF THIS RECOMMENDED STANDARD

The purpose of this Recommended Standard is to define the Space Link Extension (SLE) Return Channel Frames (RCF) service in conformance with the SLE Reference Model (reference [1]). The RCF service is an SLE transfer service that delivers to a mission user all telemetry frames from one master channel or one virtual channel.

NOTE – Reference [1] defines the Return Master Channel Frames (Rtn MC Frames) service and the Return Virtual Channel Frames (Rtn VC Frames) service as two distinct services. Subsequent study has indicated that it is preferable to define one service that provides the functionality of both. The RCF service defined here does just that. It is anticipated that a future issue of reference [1] will take the same approach, deleting the Rtn MC Frames and Rtn VC Frames services and replacing them with the RCF service.

1.2 SCOPE

This Recommended Standard defines, in an abstract manner, the RCF 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 RCF service.

1.3 APPLICABILITY

1.3.1 APPLICABILITY OF THIS RECOMMENDED STANDARD

This Recommended Standard provides a basis for the development of real systems that implement the RCF service. Implementation of the RCF service in a real system additionally requires the availability of a communications service to convey invocations and returns of RCF service operations between RCF service users and providers. This Recommended Standard 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 RCF service user and the RCF service provider are disrupted, possibly resulting in a loss of data.

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

1.3.2 LIMITS OF APPLICABILITY

This Recommended Standard specifies the RCF 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.

1.4 RATIONALE

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

1.5 DOCUMENT STRUCTURE

1.5.1 ORGANIZATION

This document is organized as follows:

a) section 0 presents the purpose, scope, applicability and rationale of this Recommended Standard and lists the definitions, conventions, and references used throughout the Recommended Standard;

b) section 2 provides an overview of the RCF service including a functional description, the service management context, and protocol considerations;

c) section 3 specifies the operations of the RCF service;

d) section 4 specifies the dynamic behavior of the RCF service in terms of the state transitions of the RCF service provider;

e) annex A provides a formal specification of RCF service data types using Abstract Syntax Notation One (ASN.1);

f) annex B specifies the relationship of the RCF service provision to the production status;

g) annex C provides a conformance matrix that defines what capabilities must be provided for an implementation to be considered compliant with this Recommended Standard;

h) annex D lists all terms used in this Recommended Standard and identifies where they are defined;

i) annex E lists all acronyms used within this document;

j) annex F provides a list of informative references.

1.5.2 SLE SERVICES DOCUMENTATION TREE

This Recommended Standard 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 RCF transfer service.

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

a) Part 1: SLE Services;

b) Part 2: Ground 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.

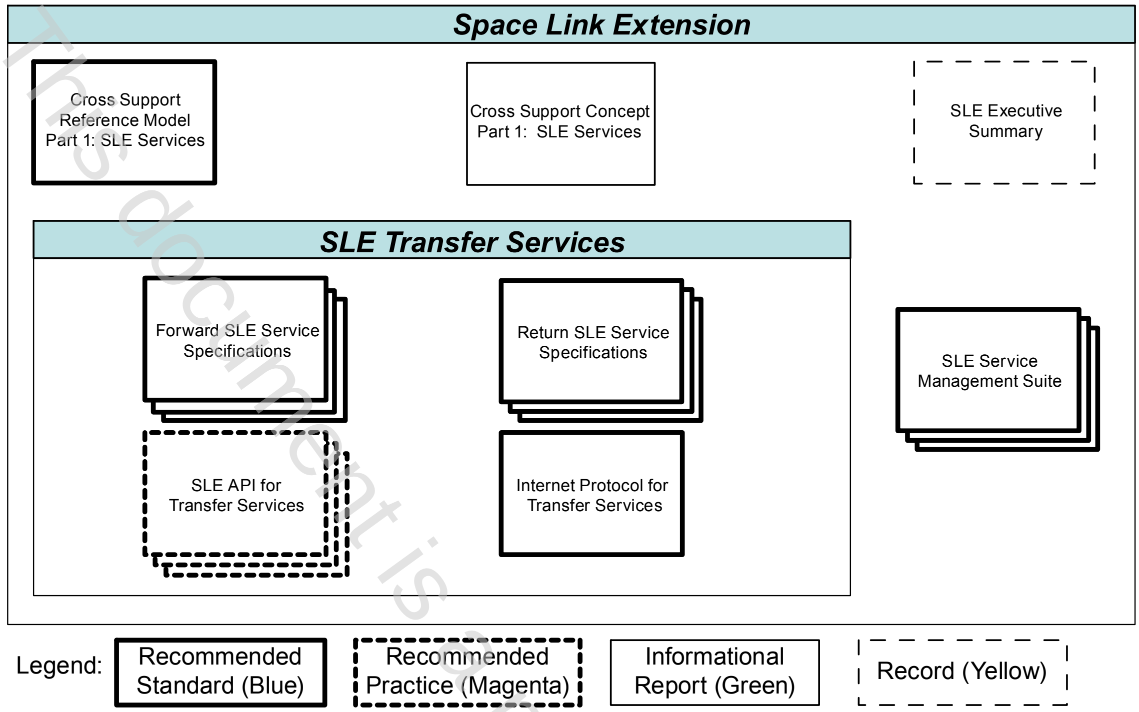

Figure 1-1: SLE Services Documentation

a) *Cross Support Concept—Part 1: Space Link Extension Services* (reference [F2]): a Report introducing the concepts of cross support and the SLE services;

b) *Cross Support Reference Model—Part 1: Space Link Extension Services* (reference [1]): a Recommended Standard that defines the framework and terminology for the specification of SLE services;

c) *SLE Return Service Specifications*: a set of Recommended Standards that will provide specification of all return link SLE services (this Recommended Standard is one of the specifications in that set);

d) *SLE Forward Service Specifications*: a set of Recommended Standards that will provide specification of all forward link SLE services;

e) *SLE API for Transfer Services Specifications:* a set of Recommended Practices that provide specifications of an Application Program Interface; a set of Recommended Standards that provide specifications of an Application Program Interface and a mapping to TCP/IP as underlying communications service for SLE services;

f) *Internet Protocol for Transfer Services:* defines a protocol for transfer of SLE Protocol Data Units using TCP/IP as underlying communications service for SLE services;

g) *SLE Service Management Specifications*: a set of Recommended Standards 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 Recommended Standard makes use of a number of terms defined in reference [6]. The use of those terms in this Recommended Standard shall be understood in a generic sense, i.e., in the sense that those terms are generally applicable to technologies that provide for the exchange of information between real systems. Those terms are:

a) abstract syntax;

b) application entity;

c) application layer;

d) 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 Recommended Standard 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 Recommended Standard, ASN.1 is used for specifying the abstract syntax of RCF service operation invocations and returns. The use of ASN.1 as a descriptive language is intended to support the specification of the abstract RCF 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 RCF service operation invocations and returns.

1.6.1.3 Definitions from TM Synchronization and Channel Coding

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

a) Attached Sync Marker;

b) Reed-Solomon check symbols;

c) Reed-Solomon code.

1.6.1.4 Definitions from TM Space Data Link Protocol

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

a) AOS Transfer Frame;

b) Frame Error Control Field (FECF);

1.6.1.6 Definitions from SLE Reference Model

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

a) abstract binding;

b) abstract object;

c) abstract port;

d) abstract service;

e) 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;

n) Return All Frames channel (RAF channel);

o) Return All Frames service (RAF service);

p) Return Master Channel Frame Service (MC service)

q) Return Virtual Channel Frame Service (VC Frame service)

r) service agreement;

s) service provider (provider);

t) service user (user);

u) SLE Complex;

v) SLE Complex Management;

w) SLE data channel;

x) SLE Functional Group (SLE-FG);

y) SLE Protocol Data Unit (SLE-PDU);

z) SLE Service Data Unit (SLE-SDU);

aa) SLE service package;

bb) SLE transfer service instance;

cc) SLE transfer service production;

dd) SLE transfer service provision;

ee) SLE Utilization Management;

ff) space link;

gg) space link data channel;

hh) Space Link Data Unit (SL-DU);

ii) 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 Recommended Standard 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 RCF 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 RCF-START operation;

b) the spacecraft identifier (SCID) of the frame matches the SCID of the global VCID specified in the RCF-START operation; and

c) the Virtual Channel Identifier (VCID) of the frame matches the VCID of the global VCID specified in the RCF-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 Frame Version Number

The frame version number is either the transfer frame version number (reference [3]) or the version number in the AOS transfer frame primary header (reference [4]).

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

1.6.1.7.7 Initiator

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

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

1.6.1.7.8 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.

1.6.1.7.9 Master Channel

The sequence of all telemetry frames with the same Transfer Frame Version Number (TFVN) and the same SCID on the same physical channel constitutes a master channel.

NOTE – Depending on the TFVN, the definition of SCID is as given in either reference [3] or reference [4].

1.6.1.7.10 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.

1.6.1.7.11 Performance

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

1.6.1.7.12 Port Identifier

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

NOTE – See 2.6.4.5 for more information.

1.6.1.7.13 Responder

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

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

1.6.1.7.14 Return

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

1.6.1.7.15 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).

1.6.1.7.16 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.

1.6.1.7.17 Telemetry Frame

A telemetry frame is a TM Transfer Frame (as defined in reference [3]) or 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.

1.6.1.7.18 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.

1.6.1.7.19 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.

1.6.1.7.20 Virtual Channel

All telemetry frames with the same TFVN, the same SCID, and the same virtual channel identifier (VCID) on the same physical channel constitute a virtual channel.

1.6.1.7.21 Virtual Channel Identifier

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

1.6.2 NOMENCLATURE

The following conventions apply throughout this Recommended Standard:

a) the words ‘shall’ and ‘must’ imply a binding and verifiable specification;

b) the word ‘should’ implies an optional, but desirable, specification;

c) the word ‘may’ implies an optional specification;

d) the words ‘is’, ‘are’, and ‘will’ imply statements of fact.

1.6.3 CONVENTIONS

1.6.3.1 Specification of Operations

1.6.3.1.1 General

Section 3 of this Recommended Standard specifies the operations that constitute the RCF service. The specification of each operation is divided into subsections as described in 1.6.3.1.2 through 1.6.3.1.4.

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 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 Recommended Standard.

1.6.3.2 Typographic Conventions

1.6.3.2.1 Operation Names

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

1.6.3.2.2 Parameter Names

In the main text, names of parameters of RCF 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 Recommended Standard 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 Recommended Standard.

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 Recommended Standard specifies the states of RCF 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., rcfBindInvocation).

1.6.3.2.6 Data Type Definitions

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

1.6.3.3 Other Conventions

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

1.7 REFERENCES

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

NOTES

1 A list of informative references is provided in annex F.

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 [F3], [F4], and [F5]).

[1] *Cross Support Reference Model—Part 1: Space Link Extension Services*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 910.4-B-2. Washington, D.C.: CCSDS, October 2005.

[2] *TM Synchronization and Channel Coding*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 131.0-B-2. Washington, D.C.: CCSDS, August 2011.

[3] *TM Space Data Link Protocol*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 132.0-B-2. Washington, D.C.: CCSDS, September 2015.

[4] *AOS Space Data Link Protocol*. Issue 3. Recommendation for Space Data System Standards (Blue Book), CCSDS 732.0-B-3. Washington, D.C.: CCSDS, September 2015.

[5] *Time Code Formats*. Issue 4. Recommendation for Space Data System Standards (Blue Book), CCSDS 301.0-B-4. Washington, D.C.: CCSDS, November 2010.

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

[7] *Information Technology—Abstract Syntax Notation One (ASN.1): Specification of Basic Notation*. 4th ed. International Standard, ISO/IEC 8824-1:2008. Geneva: ISO, 2008.