BS ISO 22669:2021

BSI Standards Publication

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

Documents
Document Sharing Hub

Full document details: BS ISO 22669:2021

National foreword

This British Standard is the UK implementation of ISO 22669:2021. It supersedes BS ISO 22669:2013, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ACE/68, Space systems and operations.

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

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

© The British Standards Institution 2021
Published by BSI Standards Limited 2021

ISBN 978 0 580 99895 9

ICS 49.140

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2021.

Amendments/corrigenda issued since publication

Date	Text affected

Documents
Document Sharing Hub

Full document details: BS ISO 22669:2021

INTERNATIONAL STANDARD

ISO 22669

Fourth edition
2021-06

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

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

Reference number
ISO 22669:2021(E)

Documents
Document Sharing Hub
© ISO 2021

Full document details: BS ISO 22669:2021

COPYRIGHT PROTECTED DOCUMENT

© ISO 2021

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

© ISO 2021 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO 22669:2021

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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 911.1-B-4, 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 fourth edition cancels and replaces the third edition (ISO 22669:2013), which has been technically revised.

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

— adds clarifications and corrections;

— adds production status annex;

— updates specifications to accommodate recent additions to the CCSDS Recommended Standards for coding and synchronization.

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.

© ISO 2021 – All rights reserved

Documents
Document Sharing Hub
Full document details: BS ISO 22669:2021

CONTENTS

Section Page

1 INTRODUCTION 1-1

1.1 PURPOSE OF THIS RECOMMENDED STANDARD 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 1-5
1.7 REFERENCES 1-13

2 DESCRIPTION OF THE RETURN ALL FRAMES SERVICE 2-1

2.1 OVERVIEW 2-1
2.2 SPACE LINK EXTENSION REFERENCE MODEL 2-1
2.3 SERVICE MANAGEMENT 2-3
2.4 ARCHITECTURE MODEL—FUNCTIONAL VIEW 2-4
2.5 ARCHITECTURE MODEL—CROSS SUPPORT VIEW 2-7
2.6 FUNCTIONAL DESCRIPTION 2-8
2.7 OPERATIONAL SCENARIO 2-17
2.8 SECURITY ASPECTS OF THE SLE RAF TRANSFER SERVICE 2-18

3 RAF SERVICE OPERATIONS 3-1

3.1 GENERAL CONSIDERATIONS 3-1
3.2 RAF-BIND 3-15
3.3 RAF-UNBIND 3-22
3.4 RAF-START 3-26
3.5 RAF-STOP 3-31
3.6 RAF-TRANSFER-DATA 3-33
3.7 RAF-SYNC-NOTIFY 3-38
3.8 RAF-SCHEDULE-STATUS-REPORT 3-41
3.9 RAF-STATUS-REPORT 3-45
3.10 RAF-GET-PARAMETER 3-48
3.11 RAF-PEER-ABORT 3-52

4 RAF PROTOCOL 4-1

4.1 GENERIC PROTOCOL CHARACTERISTICS 4-1
4.2 RAF SERVICE PROVIDER BEHAVIOR 4-4

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

CONTENTS (continued)

Section Page

ANNEX A DATA TYPE DEFINITIONS (NORMATIVE) A-1
ANNEX B PRODUCTION STATUS (NORMATIVE) B-1
ANNEX C CONFORMANCE MATRIX (NORMATIVE) C-1
ANNEX D INDEX TO DEFINITIONS (INFORMATIVE) D-1
ANNEX E ACRONYMS (INFORMATIVE) E-1
ANNEX F INFORMATIVE REFERENCES (INFORMATIVE) F-1

Figure

1-1 SLE Services Documentation 1-4
2-1 Return Space Link Processing SLE-FG 2-4
2-2 RAF Service Production and Provision 2-6
2-3 Example of the Management and Provision of RAF Service 2-7
2-4 Simplified RAF Service Provider State Transition Diagram 2-10
2-5 Communications Realization of RAF Service 2-12
2-6 Buffers and Delivery Modes 2-17
B-1 RAF Production Status Transitions B-1

Table

2-1 RAF Operations 2-9
3-1 Setting of RAF Service Configuration Parameters 3-6
3-2 RAF-BIND Parameters 3-16
3-3 RAF-UNBIND Parameters 3-23
3-4 RAF-START Parameters 3-27
3-5 RAF-STOP Parameters 3-31
3-6 RAF-TRANSFER-DATA Parameters 3-33
3-7 RAF-SYNC-NOTIFY Parameters 3-38
3-8 RAF-SCHEDULE-STATUS-REPORT Parameters 3-42
3-9 RAF-STATUS-REPORT Parameters 3-45
3-10 RAF-GET-PARAMETER Parameters 3-48
3-11 RAF Parameters 3-50
3-12 RAF-PEER-ABORT Parameters 3-52
4-1 Provider Behavior 4-6
4-2 Event Description References 4-13
4-3 Predicate Descriptions 4-13
4-4 Boolean Flags 4-14
4-5 Compound Action Definitions 4-14
B-1 Production Status Changes and Notifications B-2
B-2 Effect of Production Status on Operations B-3
C-1 Conformance Matrix for RAF Service (Operations) C-1
C-2 Conformance Matrix for RAF Service (Other Requirements) C-2

Documents
Document Sharing Hub

© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

1 INTRODUCTION

1.1 PURPOSE OF THIS RECOMMENDED STANDARD

The purpose of this Recommended Standard 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 Recommended Standard 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 RECOMMENDED STANDARD

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

a) in sequence;

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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 Recommended Standard 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 Recommended Standard 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 references [2], [3], and [4]. The provision of RAF service requires, as specified in reference [2], that, at any given time, the coding options must be the same for all frames on a physical channel.

Reference [F5] allowed multiplexing of coded Transfer Frames (encoded with the Reed-Solomon code) with non-coded Transfer Frames on a Physical Channel. This is not allowed anymore by recommendations in force.

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:

Documents
Document Sharing Hub

© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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 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 specifies the relationship of the RAF 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 RAF 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.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

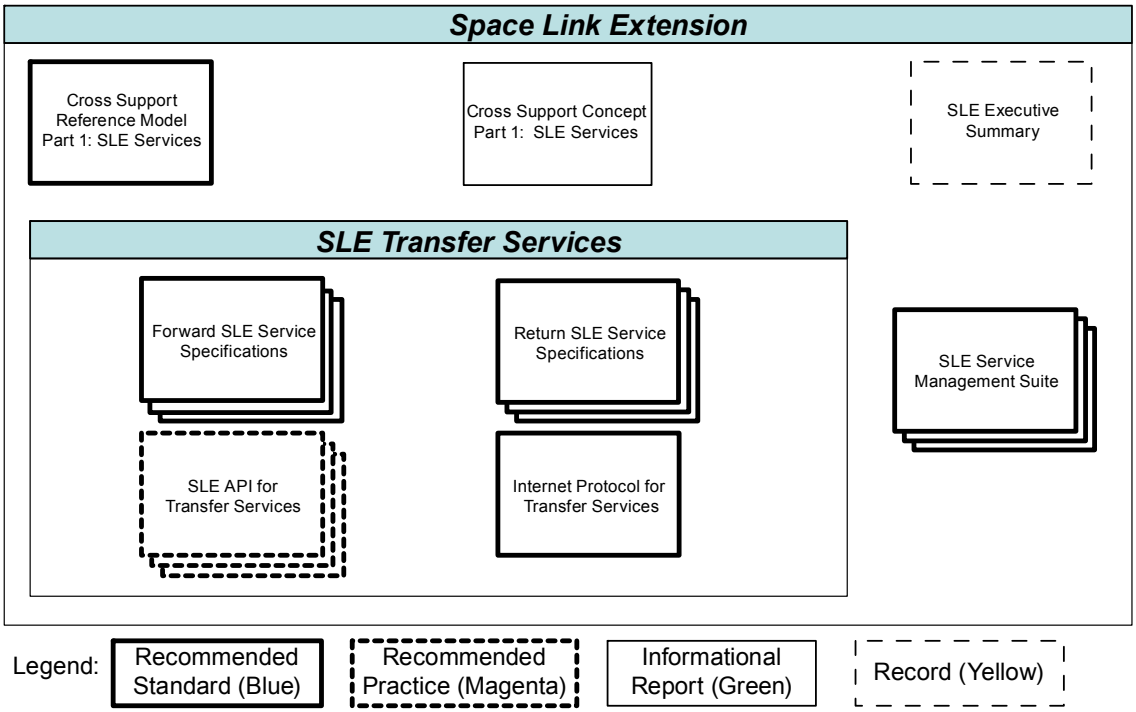

Figure 1-1: SLE Services Documentation

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.

© ISO 2021 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO 22669:2021

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 [8]. 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 [9]:

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 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.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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) codeblock;

c) convolutional code;

d) pseudo-randomization;

e) Reed-Solomon check symbols;

f) Reed-Solomon code;

g) turbo code.

1.6.1.4 Definitions from TM Space Data Link Protocol

This Recommended Standard makes use of the following term defined in reference [5]:

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 [6]:

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 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);

Documents
Document Sharing Hub

© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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) 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 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.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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 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 [5]), or the FECF of an AOS Transfer Frame (reference [6]), as applicable.

Documents
Document Sharing Hub

© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

1.6.1.7.6 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.

1.6.1.7.7 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.

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.

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.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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 [5] if the frame is a TM Transfer Frame or as defined in reference [6] 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 [5]) or an AOS Transfer Frame (as defined in reference [6]). In case a distinction of the frame versions is necessary, the full term as per references [5] or [6] 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 [5] or the TFVN as defined in reference [6].

NOTE – The definitions of TFVN given in references [5] and [6] 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.

Documents
Document Sharing Hub

© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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 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.

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.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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 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 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'.

© ISO 2021 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO 22669:2021

1.6.3.2.4 State Names

This Recommended Standard 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 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], [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 [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.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

[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] *Flexible Advanced Coding and Modulation Scheme for High Rate Telemetry Applications.* Issue 1. Recommendation for Space Data System Standards (Blue Book), CCSDS 131.2-B-1. Washington, D.C.: CCSDS, March 2012.

[4] *CCSDS Space Link Protocols over ETSI DVB-S2 Standard.* Issue 1. Recommendation for Space Data System Standards (Blue Book), CCSDS 131.3-B-1. Washington, D.C.: CCSDS, March 2013.

[5] *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.

[6] *AOS Space Data Link Protocol*. Issue3. Recommendation for Space Data System Standards (Blue Book), CCSDS 732.0-B-3. Washington, D.C.: CCSDS, September 2015.

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

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

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

Documents
Document Sharing Hub

© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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 Recommended Standard 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.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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 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 Recommended Standard, when two objects are involved in provision of a service, the object closer to the space link is considered to be the provider of the service, and the object further from the space link is considered to be the user.

2.2.6 OPERATION

An operation is a procedure or task that one object (the invoker) can request of another (the performer) through a bound port pair. The terms invoker and performer are used to describe the interaction between two objects as the operations that constitute the service occur. One object invokes an operation that is performed by the other. For most services, each object invokes some operations and performs others.

Documents
Document Sharing Hub

© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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 Recommended Standards.

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

a) service provision makes available to the user the operations necessary to obtain the service;

b) service production transforms the 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 Recommended Standard. 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 supports 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 supports only one of those modes. The delivery mode applicable to a particular service instance is set by service management.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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 Recommended Standard but is defined in reference [1].

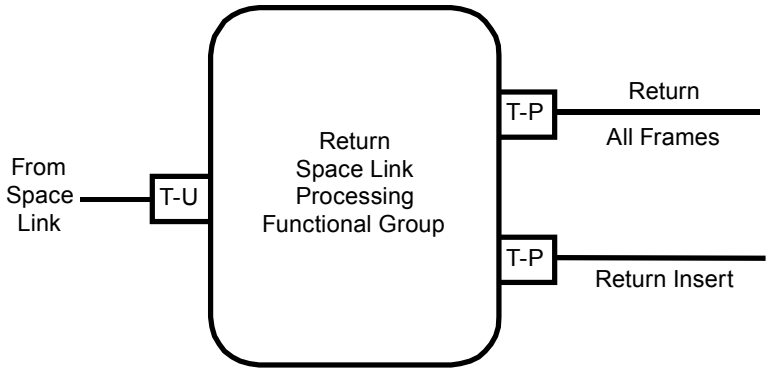

Figure 2-1: Return Space Link Processing SLE-FG

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, Frame Error Control Field decoding, Reed-Solomon, Low-Density Parity-Check (LDPC), or Turbo decoding (see references [2]), Serially Concatenated Convolutional turbo Coding (see reference [3]), and European Telecommunications Standards Institute (ETSI) Digital Video Broadcast – Satellite2 (DVB-S2) Standard (see reference [4]);

© ISO 2021 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO 22669:2021

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 is generated by RAF service production and 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, including the outer encoding of the concatenated coding scheme, 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.

If the acquired frame is not Reed-Solomon encoded and found 'erred' based on the evaluation of the FECF or for the case of LDPC encoding based on checking the validity of the codeword, then the result of the decoding process or, in case of uncoded frames, the frame as acquired, is encapsulated into the SLE-SDU for delivery to the user (see 3.6.2.8).

NOTES

1 SLE Return Space Link Processing and references [2], [3] and require that, at any given time, the coding options and length must be same for all frames on a physical channel.

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.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

3 As defined by this Recommended Standard, 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 3.1.9, 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.

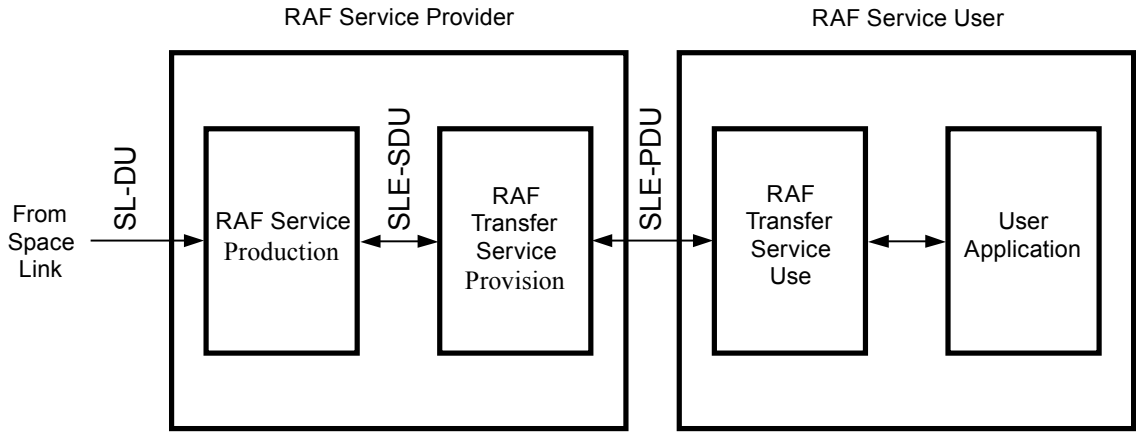

Figure 2-2: RAF Service Production and Provision

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

© ISO 2021 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO 22669:2021

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.

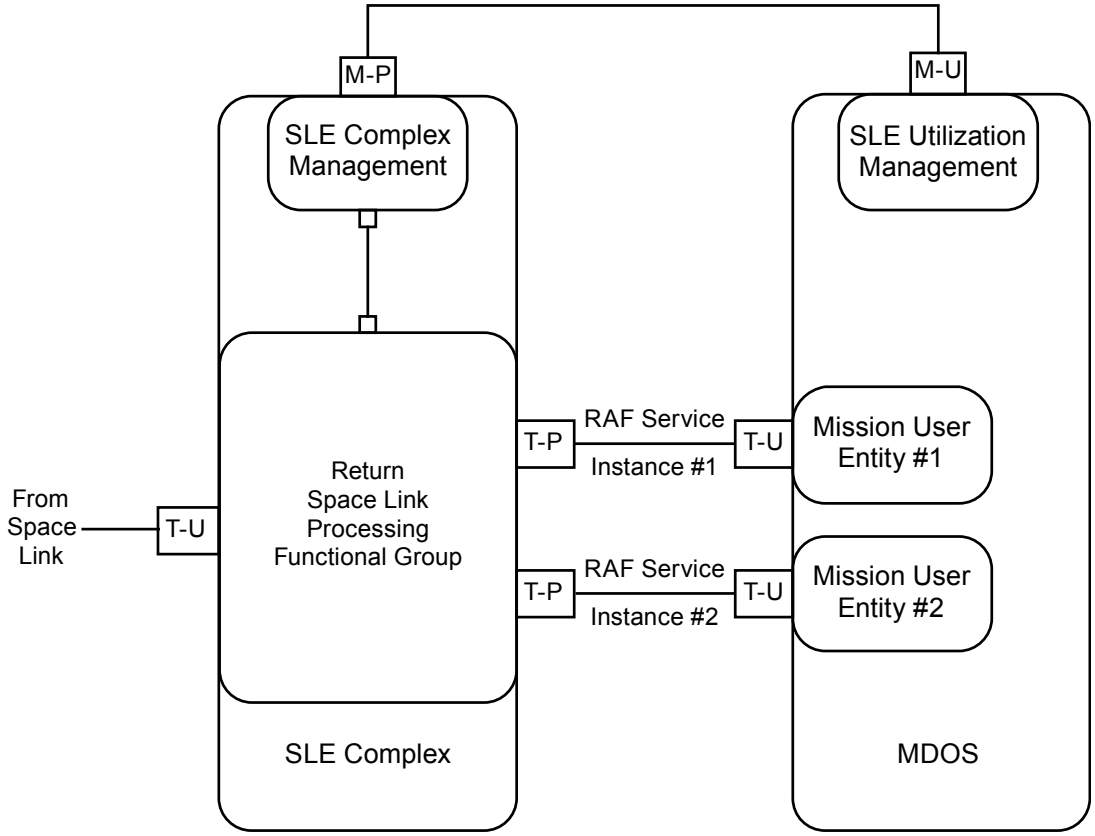

Figure 2-3: Example of the Management and Provision of RAF Service

© ISO 2021 – All rights reserved

Documents Document Sharing Hub

Full document details: BS ISO 22669:2021

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 provision period 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 Recommended Standard provides the detailed specification of these operations.

Documents
Document Sharing Hub

© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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:

a) 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).

b) State 2 (‘ready’): In state 2, an association has been established between the user and the provider, and they may interact by means of the operations described in section 3 of this Recommended Standard. However, 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

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

(RAF-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 criteria (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.

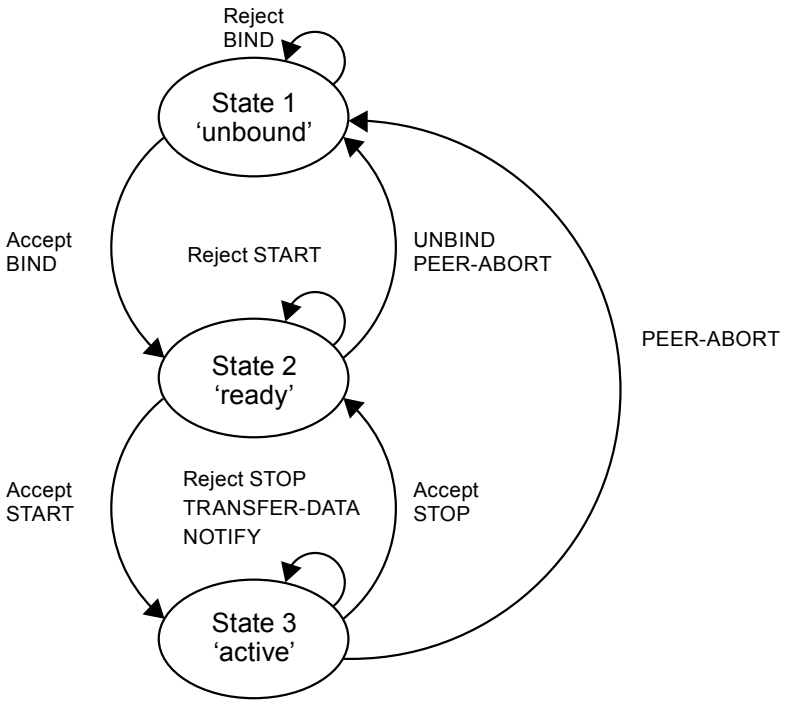

Figure 2-4: Simplified RAF Service Provider State Transition Diagram

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.

© ISO 2021 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO 22669:2021

2.6.4.4 Effects of Termination

When an association is released or aborted, the invocation of further operations by the user or the provider is not permitted. As a consequence, the delivery of frames stops as soon as the RAF-STOP or RAF-PEER-ABORT invocation has been processed by the RAF service provider. 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 content of the online frame buffer (see 3.1.9) is persistent except if in the RAF-UNBIND invocation the `unbind-reason` parameter is set to 'end';

b) if the delivery mode is offline, the content of the offline frame buffer (see 3.1.9) is persistent;

c) statistics reported by means of the RAF-STATUS-REPORT operation (see 3.9) are accumulated for the entire service instance provision period.

2.6.4.5 Technology-specific Aspects

This Recommended Standard 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 Recommended Standard to a specific communications technology, as few assumptions as possible have been made about the characteristics of the underlying communications service (see 1.3.1).

The RAF service interface between the user and the provider is specified in this Recommended Standard in terms of the operations that the service provides. Those operations are realized by mapping the operation invocations and returns to protocol data units that can be exchanged by means of the underlying communications service. This Recommended Standard 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 Recommended Standard. The mapping of SLE-PDUs to an underlying communications service is intentionally outside the scope of this Recommended Standard (e.g., so that the 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 Recommended Standard 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 Recommended Standards.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

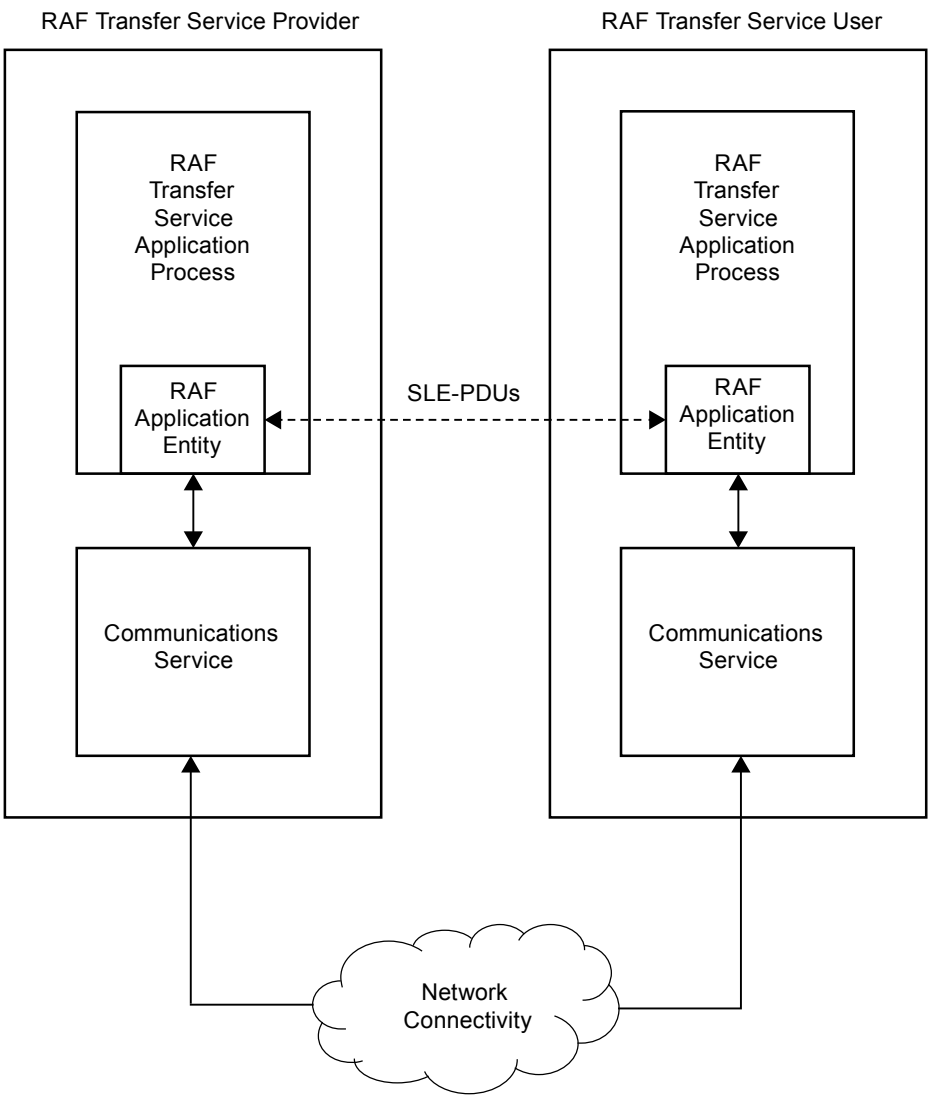

Figure 2-5: Communications Realization of RAF Service

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

© ISO 2021 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO 22669:2021

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.

One possible mapping of the SLE transfer service to the TCP/IP communications service is specified in [F6]. As part of this mapping, also issues such as sizing of TCP buffers in accordance with the bandwidth-delay product of the communication link and ways to manage relative priority of transfer services concurrently using the same connectivity are to be addressed.

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

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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 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 beginning of the service instance provision period, 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 3.1.9 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

© ISO 2021 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO 22669:2021

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 operations. These operations are invoked in the order in which the original annotated telemetry frames and synchronous notifications occur. However, the RAF service provider concatenates them in a buffer, the content of which forms a single RafTransferBuffer SLE-PDU. This SLE-PDU is the service data unit passed to the communications provider.

The primary rationale for this approach is as follows: when the data rate on the space link exceeds the available communications bandwidth or when the ground communication link is congested or unavailable for a period of time, use of the complete online delivery mode may lead to the accumulation of a large backlog of undelivered data, resulting in the delivery of data past the point of usefulness. The timely online delivery mode is an alternative that limits the size of the backlog that is allowed to accumulate by discarding data that cannot be delivered within a certain time. Furthermore, when data is discarded, it is discarded 'in chunks', i.e., as a sufficiently large block of contiguous frames rather than as random frames here and there. In general, this approach maximizes the usefulness of the data that is delivered.

This result is achieved as follows: as the RAF service provider acquires telemetry frames and as events that must be synchronously notified occur, that information is stored in a buffer named the transfer buffer. The size of this buffer is set by service management to achieve the appropriate level of 'chunking' of data; this size corresponds to the maximum-sized RafTransferBuffer SLE-PDU that will be passed to the communications service provider. (This size must also be compatible with the size of the service data units that can be handled by the underlying communications service.) When data is inserted into the transfer buffer, if the transfer buffer was previously empty, a timer, named the release timer, is started. The release timer counts down from an initial time value, named the latency limit, that is set by service management. If the transfer buffer becomes full or if the release timer expires, the entire transfer buffer, in the form of one RafTransferBuffer SLE-PDU, is passed to the communications service provider as one service data unit. If new data needs to be inserted into the transfer buffer, but the transfer buffer is full and cannot be passed to the communications service provider because of congestion of the communications service, then the entire transfer buffer is discarded as one unit. When this happens, the new data is inserted into the newly emptied transfer buffer, along with a synchronous notification that some data was intentionally discarded due to timeliness considerations.

Strictly speaking, the transfer buffer is only required in the case of timely online delivery mode. However, the transfer buffer mechanism has a secondary benefit: it allows for 'tuning' of the size of the service data units that are normally passed to the communications service provider. In some cases, this may contribute to enabling the communications service to operate more efficiently. Thus, the transfer buffer is used in all delivery modes. However,

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

in the case of complete online delivery mode and offline delivery mode, data in the transfer buffer is never discarded. Rather, the contents of the transfer buffer are held until they can be passed to the communications service provider. Any backlog that may accumulate is handled by means of the online frame buffer or offline frame buffer (see 2.6.4.6.3).

2.6.4.6.3 Online Frame Buffer and Offline Frame Buffer

In the case of the timely online delivery mode, the only buffering that occurs is that provided by the transfer buffer. For complete online delivery mode and for offline delivery mode, additional buffering is needed because of the nature of the service. Since the complete online delivery mode is supposed to deliver all data even in the case of extended communications service outages or congestion and since the offline delivery mode is supposed to deliver all data even several days after the space link session, more extensive buffering is required for these modes. This buffering is provided by means of the online frame buffer or the offline frame buffer, respectively. These buffers are relatively large and intended to hold all data (i.e., RAF-TRANSFER-DATA and, in the case of online delivery mode, RAF-SYNC-NOTIFY) for significant periods of time. In the case of complete online delivery mode, the online frame buffer is intended to overcome limitations of the communications service: bandwidth limitations, outages, and congestion. In the case of offline delivery mode, the offline frame buffer is intended to enable data to be delivered hours or days after the completion of the space link session. The exact size of these buffers is set by service management. It is normally expected that the online frame buffer is sufficiently large to hold all data that might be accumulated during one space link session and that the offline frame buffer is sufficiently large to hold all data that might be accumulated during several space link sessions.

NOTE – Synchronous notifications are generally not provided in offline mode, so the data associated with such notifications is not stored in the offline frame buffer.

Figure 2-6 illustrates the differences between timely online delivery mode, complete online deliver mode, and offline delivery mode with respect to the buffers that are used.

Documents
Document Sharing Hub

© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

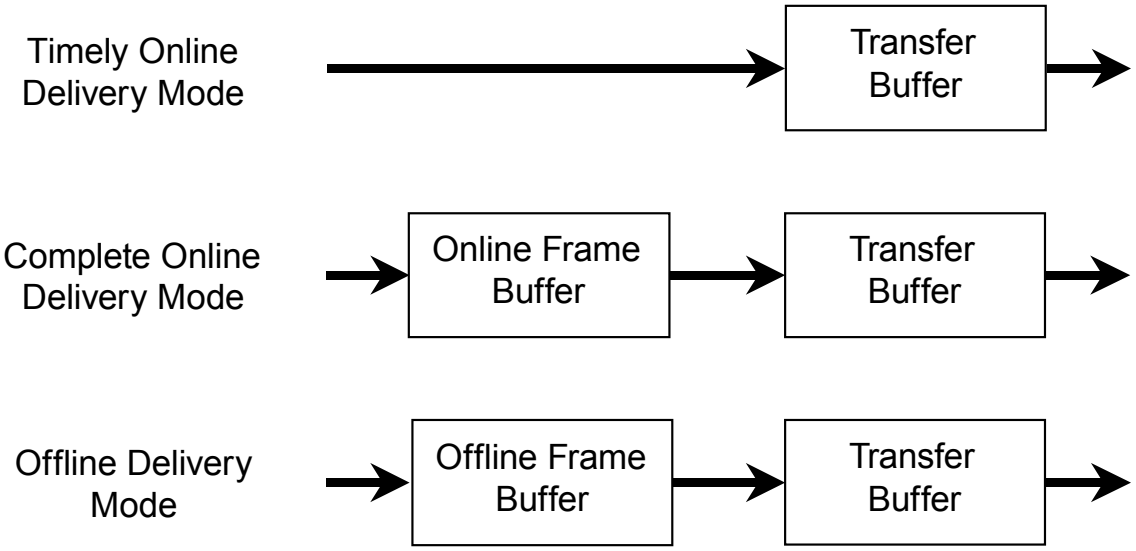

Figure 2-6: Buffers and Delivery Modes

2.7 OPERATIONAL SCENARIO

The following subsections illustrate a typical operational scenario for a user-initiated, online delivery mode RAF service instance:

a) Prior to the actual provision of service, start and stop times for both the space link session and the associated RAF service instance are mutually agreed upon by SLE Complex Management and SLE Utilization Management. Configuration and other information needed to enable the service are also agreed upon.

b) Some time before the scheduled start time of the RAF service instance, the service instance is created by SLE Complex Management. Initially, the service provider is in state 1 ('unbound'). At the scheduled start time of the space link session, the SLE Complex acquires the signal from the spacecraft and initiates the production of RAF service. Typically (but not necessarily) the start time of the service instance provision period 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.

c) The user invokes the RAF-BIND operation to establish an association.

d) The provider transitions from state 1 to state 2 ('ready') and returns a report of the successful completion of the bind operation to the user.

e) The user may now check parameters that control service provision by means of the RAF-GET-PARAMETER operation.

f) If the user is interested in obtaining periodic status reports, the RAF-SCHEDULE-STATUS-REPORT operation may be invoked to configure status reporting.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

g) The user invokes the RAF-START operation to enable data flow.

h) The provider transitions from state 2 to state 3 ('active') and confirms the RAF-START operation to the user. As telemetry frames that meet the delivery criteria established by the user become available, they are delivered to the user by means of RAF-TRANSFER-DATA operations. In addition, notifications may be delivered by means of RAF-SYNC-NOTIFY operations, and requested status reports are delivered by means of RAF-STATUS-REPORT operations.

i) When all available frames are delivered, the provider will invoke the RAF-SYNC-NOTIFY operation to provide an 'end of data' notification. The 'end of data' notification may be triggered, for example, because the space link session ended and all frames have been delivered or because the user specified a value for the `stop-time` parameter when invoking the RAF-START operation.

j) By invoking the RAF-STOP operation the user will cause the provider to transition to state 2 ('ready'). The user may then ask for another set of frames by invoking another RAF-START command or may terminate the association by invoking RAF-UNBIND.

2.8 SECURITY ASPECTS OF THE SLE RAF TRANSFER SERVICE

2.8.1 SECURITY BACKGROUND/INTRODUCTION

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

The SLE RAF transfer service transfers data that originates on a mission spacecraft. As such, the SLE RAF transfer service has custody of the data for only a portion of the end-to-end data path between mission spacecraft and MDOS. 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 space-ground link to the mission spacecraft). End-to-end security must also involve securing the data as it crosses the space-ground link, which can be provided by some combination of securing the mission data itself

Documents
Document Sharing Hub

© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

(e.g., encryption of the mission data within CCSDS space packets) and securing the space-ground link (e.g., encryption of the physical space-ground link). Thus while the SLE RAF 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 RAF 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 RAF 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 RAF 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 RAF transfer service instance without detection.

The SLE RAF 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 RAF 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

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

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 [F2]). 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 invocation 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 RAF transfer service specification defines access control requirements (see 3.1.4), and defines `initiator-identifier` and `responder-identifier` parameters of the service operation invocations and returns that are used to perform SLE transfer service access control. The procedure by which access to SLE transfer services is controlled is described in annex F of the Cross Support Service Green Book (reference [F2]).

2.8.2.5 Availability of Resources

The SLE transfer services are provided via communication networks that have some limit to the resources available to support those SLE transfer services. If these resources can be diverted from their support of the SLE transfer services (in what is commonly known as 'denial of service') then the performance of the SLE transfer services may be curtailed or inhibited. This SLE RAF transfer service specification does not define explicit capabilities to prevent denial of service. Resource availability is expected to be ensured by appropriate capabilities in the underlying communication service. The specific capabilities will be dependent upon the technologies used in the underlying communication service and the security environment in which the transfer service user and provider operate.

2.8.2.6 Auditing

This SLE RAF transfer service specification does not define explicit security auditing requirements or capabilities. Security auditing is expected to be negotiated and implemented bilaterally between the spaceflight mission and the service provider.

Documents
Document Sharing Hub

© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

2.8.3 POTENTIAL THREATS AND ATTACK SCENARIOS

The SLE RAF transfer service depends on unspecified mechanisms operating above the SLE transfer service (between a mission spacecraft application process and its peer application process on the ground), underneath the SLE transfer service in the underlying communication service, or some combination of both, to ensure data privacy (confidentiality). If no such mechanisms are actually implemented, or the mechanisms selected are inadequate or inappropriate to the network environment in which the mission is operating, an attacker could read the spacecraft telemetry data contained in the RAF protocol data units as they traverse the WAN between service user and service provider.

The SLE RAF transfer service constrains the ability of a third party to seize control of an active SLE transfer service instance, but it does not specify mechanisms that would prevent an attacker from intercepting the protocol data units and replacing the contents of the `data` parameter. The prevention of such a replacement attack depends on unspecified mechanisms operating above the SLE transfer service (between a mission spacecraft application process and its peer application process on the ground), underneath the SLE transfer service in the underlying communication service, in bilaterally agreed extra capabilities applied to the SLE transfer service (e.g., encryption of the `data` parameter) or some combination of the three. If no such mechanisms are actually implemented, or the mechanisms selected are inadequate or inappropriate to the network environment in which the mission is operating, an attacker could substitute telemetry data without detection.

If the SLE transfer service authentication capability is not used and if authentication is not ensured by the underlying communication service, attackers may somehow obtain valid `initiator-identifier` values and use them to initiate SLE transfer service instances by which they could gain access to spacecraft telemetry data.

The SLE RAF transfer service depends on unspecified mechanisms operating in the underlying communication service to ensure that the supporting network has sufficient resources to provide sufficient support to legitimate users. If no such mechanisms are actually implemented, or the mechanisms selected are inadequate or inappropriate to the network environment in which the mission is operating, an attacker could prevent legitimate users from receiving telemetry from their spacecraft.

If the provider of SLE RAF transfers service provides no security auditing capabilities, or if a user chooses not to employ auditing capabilities that do exist, then attackers may delay or escape detection while stealing or altering telemetry data.

2.8.4 CONSEQUENCES OF NOT APPLYING SECURITY

The consequences of not applying security to the SLE RAF transfer service are possible degradation and loss of ability to receive telemetry from the spacecraft, or the substitution of altered telemetry data.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021

3 RAF SERVICE OPERATIONS

NOTE – This section (3) specifies the processing of valid SLE-PDUs (i.e., those that are recognized as the invocation or return of an RAF service operation). Subsection 3.1 specifies behaviors that are generally applicable to all operations. Subsections 3.2 through 3.11 specify individual operations. Handling of invalid SLE-PDUs is specified in 4.1.

3.1 GENERAL CONSIDERATIONS

3.1.1 RESULT OF OPERATIONS

3.1.1.1 All confirmed operations shall report on the outcome of the operation in a return, except as specified otherwise in section 4.

3.1.1.2 All returns shall include a `result` parameter that indicates whether the outcome of the operation was successful ('positive result') or unsuccessful ('negative result').

3.1.1.3 In the event of a 'negative result', the return shall also include a `diagnostic` parameter, the value of which is descriptive of the reason for the 'negative result'.

NOTE – Possible values of the `diagnostic` parameter are listed in the description of each operation.

3.1.1.4 A `diagnostic` parameter value of 'other reason' shall be returned only if no other value in the list adequately describes the reason for the 'negative result'.

3.1.2 PARAMETER TYPES

The types of all parameters shall conform to the abstract syntax specified in annex A.

NOTE – Some parameter types in annex A are chosen such that possible future extensions of the range of allowed values of a parameter will not cause a type mismatch. For example, parameters that logically are of the 'enumerated' type may be specified as being of the 'named integer' type.

3.1.3 PARAMETER CHECKING

3.1.3.1 Validity checks shall be performed on the values of parameters associated with an operation.

NOTE – Rules governing the validity of parameter values are included in the specification of individual operations. General reasons for regarding a parameter value as invalid are specified in the subsections 3.1.3.2 through 3.1.3.6.

© ISO 2021 – All rights reserved

Documents
Document Sharing Hub

Full document details: BS ISO 22669:2021

3.1.3.2 A parameter value shall be treated as invalid if it is outside the range or not in the set of values currently permitted by service management for the given parameter.

NOTE – A conforming implementation shall be capable of supporting the full range or set of values as specified in annex A.

3.1.3.3 A parameter value shall be treated as invalid if it is in conflict with the value of another parameter in the same invocation.

NOTE – For example, the value of the `start-time` parameter in an invocation of RAF-START is invalid if it is later than the value of the `stop-time` parameter.

3.1.3.4 If a parameter value is not valid, the operation shall not be performed, and, for confirmed operations, a report of 'negative result' shall be returned to the invoker.

3.1.3.5 Except as noted in 3.2.2.11, checks for invalid parameters or for other conditions that can cause a report of 'negative result' should be performed in the order in which diagnostics are listed in the descriptions of the operations, and the `diagnostic` parameter should be set to the value defined for the first problem found.

3.1.3.6 In the case that an implementation does not adhere to the sequence of checks as specified by the sequence of diagnostics values, such implementation shall specify the sequence in which the checks are actually performed.

3.1.4 ACCESS CONTROL

3.1.4.1 The RAF service shall implement access control based on the identity of the initiator and responder. Access control is performed at two levels:

a) the initiator must be registered at the responder and the responder must be registered at the initiator;

b) the initiator and responder must be authorized for the given service instance.

3.1.4.2 The initiator shall have access to a registry of authorized responders and the responder shall have access to a registry of authorized initiators. These registries shall be maintained by SLE Complex Management and SLE Utilization Management, respectively.

3.1.4.3 Service management shall specify the authorized initiator and responder for each service instance.

3.1.4.4 The initiator and responder shall indicate their identity by setting the parameters `initiator-identifier` and `responder-identifier` in the RAF-BIND operation to the values assigned by service management.

Documents
Document Sharing Hub
© ISO 2021 – All rights reserved

Full document details: BS ISO 22669:2021