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BSI Standards Publication

Space link extension — Cross support transfer service — Monitored data service

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National foreword

This British Standard is the UK implementation of ISO 23104:2020.

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 secretary.

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Published by BSI Standards Limited 2020

ISBN 978 0 580 51551 4

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 29 February 2020.

Amendments/corrigenda issued since publication

Date	Text affected

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INTERNATIONAL STANDARD

ISO 23104

First edition
2020-01

Space link extension — Cross support transfer service — Monitored data service

Reference number
ISO 23104:2020(E)

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This document was prepared by Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 922.1-B-1, April 2017) and drafted in accordance with its editorial rules. It was assigned to Technical Committee ISO/TC 20, *Space vehicles*, Subcommittee SC 13, *Space data and information transfer systems* and adopted under the “fast-track procedure”.

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1 INTRODUCTION

1.1 PURPOSE OF THIS RECOMMENDED STANDARD

This Recommended Standard defines the Monitored Data Cross Support Transfer Service (CSTS), in conformance with the Cross Support Transfer Services Specification Framework Recommended Standard (reference [1]). The Monitored Data CSTS (MD-CSTS) is a service that allows a spaceflight mission to receive cyclic reports on, and to query the current values of, the parameters that are pertinent to Cross Support Services being provided by a Cross Support Complex. The Monitored Data service also allows a spaceflight mission to receive notifications of the occurrence of events of interest associated with the services that are being provided by a Cross Support Complex.

NOTE – The term 'Cross Support Complex', as used throughout this document, corresponds to the Earth Space Link Terminal (ESLT) defined in the Space Communications Cross Support Architecture Description Document (reference [G9]).

1.2 SCOPE

This Recommended Standard defines the Monitored Data service in terms of:

a) the CSTS procedures that constitute the service;

b) the extensions and refinements of the behavior of those CSTS procedures necessary to provide the transfer service;

c) the extensions and refinements of standard CSTS operations associated with each of the procedures;

d) the relationships among the procedures that constitute the service.

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 measure the values of monitored parameters and to detect the occurrence of events of interest;

d) the methods or technologies required for communication;

e) the management activities necessary to schedule, configure, and control the MD-CSTS;

f) the specific parameters that are to be reported and events that are to be notified by the MD-CSTS.

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1.3 APPLICABILITY

1.3.1 GENERAL

The applicability and limits of applicability of Cross Support Transfer Services in general, as described in reference [1], pertain to the Monitored Data service, with the addition of the conditions described in 1.3.2, below.

1.3.2 APPLICABILITY OF THIS RECOMMENDED STANDARD

This Recommended Standard is applicable to the implementation of real systems that monitor provision and production of space communication Cross Support Services for the purposes of generating cyclic status reports, generating notifications of changes in status in real time, and responding to queries of current values of operational parameters.

1.4 RATIONALE

The goal of this Recommended Standard is to create a standard for interoperability for the exchange of cross support service-related status information between the cross support elements of various space Agencies and the users of the Cross Support Services that they provide.

1.5 DOCUMENT ORGANIZATION

Section 2 describes the Monitored Data Cross Support Transfer Service in terms of:

- the role of Service Management with respect to the MD-CSTS;
- the allocation of production and provision of the MD-CSTS to Functional Resources;
- the cross support view of the MD-CSTS;
- the functional description of the production and provision of the service; and
- an operational scenario that illustrates some of the more significant aspects of the service.

Section 3 specifies the composition of the MD-CSTS. The service type identifier is declared, the procedures that constitute the service are identified, and the CSTS state machine that applies to the MD-CSTS is specified. Because the MD-CSTS is composed of procedures that are directly adopted from the CSTS Framework without extension, no further specification of the MD-CSTS is required.

Section 4 specifies the On-Change-Option Cyclic Report procedure, which is an extension and refinement of the Framework Cyclic Report Procedure.

Section 5 specifies the refinements of the Information Query procedure.

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Section 6 specifies the refinements of the Notification procedure.

Section 7 specifies how the procedure configuration parameters are to be set for the MD-CSTS.

Section 8 specifies the Monitored Data Service-specific versions of the service-generic parameter and events that are defined in *Cross Support Transfer Service—Specification Framework* (reference [1]).

Section 9 specifies the refinements of the definitions of Framework parameters, events, and directives for the purposes of making them applicable to the MD-CSTS.

Annex A is the Implementation Conformance Statement Proforma for the MD-CSTS.

Annex B provides the formal specification of the ASN.1 Object Identifiers module for the Monitored Data transfer service.

Annex C provides the formal specification of the ASN.1 Protocol Data Unit module for the On-Change-Option Cyclic Report procedure of the Monitored Data transfer service.

Annex D defines the monitored data production process. In particular, it specifies how monitored data values are to be labeled so that, when transferred by MD-CSTS instances, the sources of the measurements are unambiguous.

Annex E addresses the security, Space Assigned Numbers Authority (SANA), and patent considerations associated with the MD-CSTS.

Annex F describes an example set of monitored parameters, notifiable events, and their associated Functional Resource Types. These examples are modeled on the contents of the SANA Functional Resource Registry (reference [3]).

NOTE – The SANA Functional Resource Registry is the normative repository of all such definitions. The example entries in annex F are included to illustrate the concepts of the use of Functional Resources by the MD service. Any real implementation of the MD service must use the Functional Resource specifications found in the SANA Functional Resource Registry.

Annex G provides the list of informative references.

Annex H lists the acronyms used in this document.

Annex I identifies the specific reference-[1] sections that are cross referenced by the MD-CSTS Recommended Standard, and the sections of the MD-CSTS Recommended Standard that reference each of those sections or subsections in reference [1]. This annex is included for maintainability of this Recommended Standard through future changes in reference [1].

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1.6 CROSS SUPPORT TRANSFER SERVICES DOCUMENTATION

The basic organization of the Cross Support Services documentation and the relationship to the CSTS documentation is shown in figure 1-1.

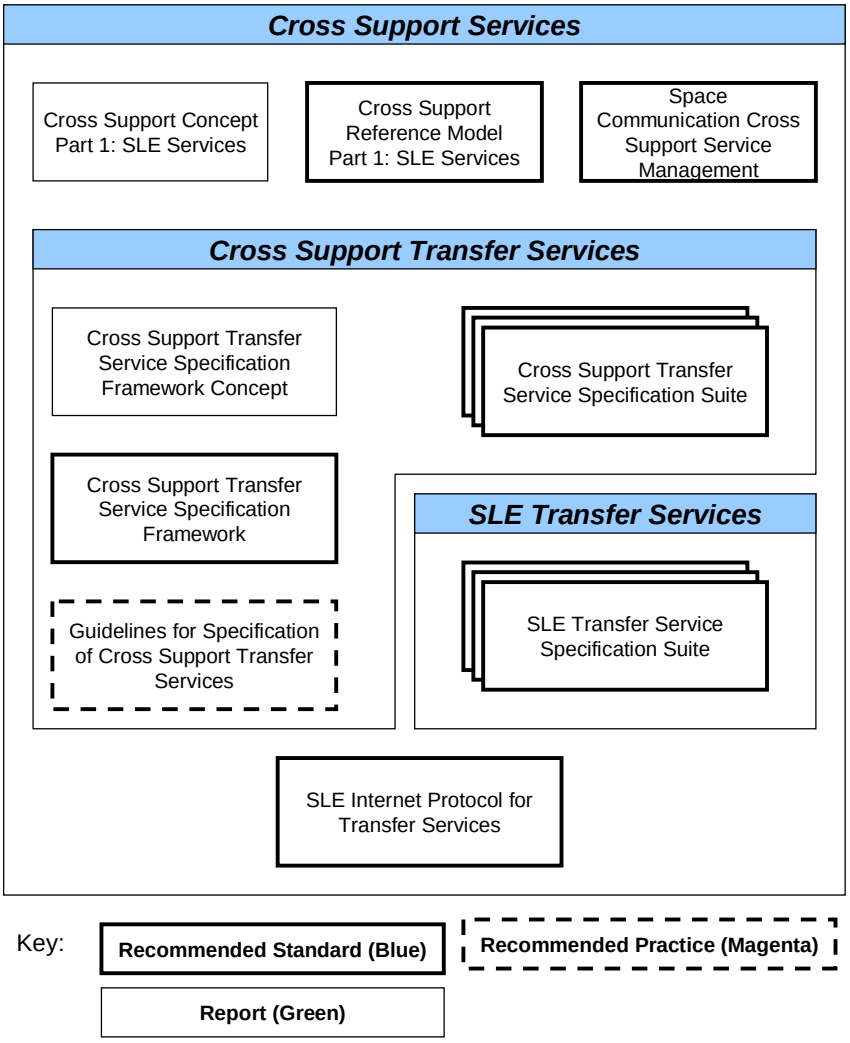

Figure 1-1: Cross Support Services Documentation

The CSTS Documentation is:

a) *Cross Support Concept—Part 1: Space Link Extension Services* (reference [G1]): a Report introducing the concepts of cross support and the Space Link Extension (SLE) services. Many of the concepts for the SLE transfer services have been adopted for the CSTSes (see h) below);

b) *Cross Support Reference Model—Part 1: Space Link Extension Services* (reference [2]): a Recommended Standard that defines the framework and

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terminology for the specification of SLE services. Much of the framework and terminology of this reference model has been adopted or adapted for CSTSes (see 1.7.2 and 2.2).

c) *Space Communication Cross Support Service Management* suite (informative references [G6], [G7], and [G8]): Recommended Standards that specify the Service Management Information Entities that are used to configure and schedule CSTSes;

d) The *SLE Transfer Services* suite: The SLE Transfer Services comprise a set of Cross Support Transfer Services that are used to transfer specific telecommand and telemetry protocol data units. The SLE Transfer Services are closely related to the CSTS suite in that they collectively define the set of operations that are the basis for the CSTS Specification Framework. However, because of history (the SLE Transfer Services were already specified and implemented prior to development of the CSTS Framework) the SLE Transfer Services are separated from CSTSes;

e) *Space Link Extension - Internet Protocol for Transfer Services* (reference [G2]): a Recommended Standard that defines a protocol for transfer of Protocol Data Units (PDUs) defined in the Cross Support Transfer Services. This Recommended Standard was originally developed to support SLE transfer services (hence the title), but it is also applicable to (and specified for) use by Cross Support Transfer Services.

The documents specific to Cross Support Transfer Services are:

f) *Cross Support Transfer Services Specification Framework* (reference [1]): a Recommended Standard that defines basic building blocks for the specification of Cross Support Transfer Service procedures;

g) *Guideline for Specification of Cross-Support Transfer Services*: a Recommended Practice that, when published, will define the guidelines for construction of a Cross Support Transfer Service based on the CSTS Specification Framework;

NOTE – As of the publication of this Recommended Standard, the Guidelines Magenta Book is in-progress. It is not required to understand this Recommended Standard.

h) *Cross Support Transfer Services Specification Framework Concepts* (reference [G3]): A Report that provides tutorial material on the objectives and concepts of the CSTS Specification Framework;

i) *Cross Support Transfer Services* Suite: The set of specifications for actual CSTSes built from the procedures in the CSTS Specification Framework and in accordance with the CSTS Guidelines.

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1.7 DEFINITIONS

1.7.1 TERMS DEFINED IN THE CROSS SUPPORT TRANSFER SERVICES SPECIFICATION FRAMEWORK RECOMMENDED STANDARD (REFERENCE [1])

a) Association Control procedure;

b) Buffered Data Delivery procedure;

c) complete data delivery mode;

d) Cross Support Complex;

e) Cross Support Service production;

f) Cross Support Transfer Service;

g) Event Identifier;

h) Event Label;

i) Event Name;

j) Functional Resource instance;

k) Functional Resource Instance Number;

l) Functional Resource Name;

m) Functional Resource Type;

n) Label List;

o) Label List Set;

p) non-blocking (operation);

q) Parameter Identifier;

r) Parameter Label;

s) Parameter Name;

t) prime procedure instance;

u) procedure configuration parameter;

v) procedure type;

w) procedure instance identifier;

x) Published Identifier;

y) qualified parameter;

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z) secondary procedure instance;

aa) service management parameter;

bb) service-user-responding-timer;

cc) subscription.

1.7.2 TERMS DEFINED IN THE CROSS SUPPORT REFERENCE MODEL (REFERENCE [2])

a) Complex Management (CM) (called *SLE Complex Management* in reference [2]);

b) Mission User Entity (MUE);

c) service agreement (called *SLE Service Agreement* in reference [2]);

d) service package (called *SLE Service Package* in reference [2]);

e) space link session;

f) transfer service production;

g) transfer service provision;

h) Utilization Management (UM);

i) utilization phase (called SLE Service Package Utilization phase in reference [2]).

1.8 NOMENCLATURE

1.8.1 NORMATIVE TEXT

The following conventions apply for the normative specifications in 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.

NOTE – These conventions do not imply constraints on diction in text that is clearly informative in nature.

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1.8.2 INFORMATIVE TEXT

In the normative sections of this document, informative text is set off from the normative specifications either in notes or under one of the following subsection headings:

- Overview;
- Background;
- Rationale;
- Discussion.

1.9 CONVENTIONS

1.9.1 OVERVIEW

The conventions defined in the CSTS Specification Framework Recommended Standard (reference [1]) are applicable to this Monitored Data service specification, with the exception of the representation of Object Identifiers. The conventions for the representation of Object Identifiers in this Recommended Standard are described in 1.9.2.

1.9.2 OBJECT IDENTIFIER REPRESENTATION

1.9.2.1 General

The MD service involves extensive use of Functional Resource Types, procedure types, Functional Resource Names, procedure instance identifiers, Parameter Names, Parameter Identifiers, Event Names, and Event Labels. As specified in reference [1], all of these names are based on Published Identifiers, which are International Organization for Standardization (ISO) Object Identifiers (OIDs). OIDs have the syntax of strings of integers. For purposes of readability, rather than using actual OIDs in the descriptions and examples in this Recommended Standard, the OIDs in these names and identifiers are represented using the following textual notation to represent the OIDs.

1.9.2.2 Functional Resource Type

As specified in reference [1], a Functional Resource Type is a Published Identifier (i.e., an ISO OID). In the descriptions and examples in this Recommended Standard, a Functional Resource Type is represented using the notation *{published identifier descriptor}*, which is a textual description of the Published Identifier. Thus {Antenna} represents the Published Identifier for the Antenna Functional Resource Type.

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1.9.2.3 Procedure Type

As specified in reference [1], a procedure type is an ISO OID that is assigned to a CSTS procedure. In the descriptions and examples in this Recommended Standard, a procedure type is represented using the notation *{object identifier descriptor}*, which is a textual description of the Object Identifier. Thus {Cyclic Report} represents the Object Identifier for the Cyclic Report procedure type.

1.9.2.4 Functional Resource Name

As specified in reference [1], a Functional Resource Name is composed of a Functional Resource Type Published Identifier and an integer Functional Resource Instance Number (FRIN). In the descriptions and examples in this Recommended Standard, a Functional Resource Name is represented using the notation *[{functional resource type published identifier descriptor}: FRIN]*. [{Antenna}: 1] represents the name of the Antenna Functional Resource Type that is assigned FRIN = 1 in the scheduled service package.

1.9.2.5 Procedure Instance Identifier

As specified in reference [1], a procedure instance identifier identifies the specific instance of a procedure in a CSTS. It is composed of a procedure type Published Identifier and a procedure role, which can have one of three values: 'association control' if it is the Association Control procedure of the CSTS; 'prime procedure instance' if it is the prime instance of the procedure of the CSTS; or a positive integer Secondary Procedure Instance Number (SPIN) if it is a secondary procedure instance of the CSTS.

In the descriptions and examples in this Recommended Standard, a procedure instance identifier for an Association Control procedure is represented using the notation *[{procedure type object identifier descriptor}: 'association control']*. [{Association Control}: 'association control'] represents the Procedure Instance Identifier of the Association Control instance of a CSTS.

NOTE – In the case of the Framework Association Control procedure, the Procedure Role appears to be redundant with the procedure type. However, it is possible for a CSTS to extend the Association Control procedure, in which case it would get a separate procedure type, in which case the Procedure Role explicitly identifies the OID as that belonging to an Association Control procedure.

A procedure instance identifier for a prime procedure instance is represented using the notation *[{procedure type object identifier descriptor}: 'prime procedure instance']*. [{Cyclic Report}: 'prime procedure instance'] represents the procedure instance identifier of the Cyclic Report instance that serves as the prime procedure instance of a CSTS.

A procedure instance identifier for a secondary procedure instance is represented using the notation *[{procedure type object identifier descriptor}: SPIN]*. [{Notification}: 1] represents

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the procedure instance identifier of the Notification instance that serves as the first Notification secondary procedure instance of a CSTS.

1.9.2.6 Parameter Name

As specified in reference [1], a Parameter Name can be either the name of a Functional Resource parameter or the name of a CSTS procedure parameter. A Functional Resource Parameter Name is composed of (1) the Functional Resource Name of the Functional Resource instance that reports the parameter, and (2) the Parameter Identifier for the parameter. In the descriptions and examples in this Recommended Standard, a Parameter Name is represented using the notation *[[{functional resource type published identifier descriptor}: FRIN]: {parameter published identifier descriptor}]*. Thus [[{Antenna}: 1]: {`actualAzimuth`}] represents the `actual-azimuth` parameter of the Antenna Functional Resource Type that is assigned FRIN = 1 in the scheduled service package.

A CSTS procedure Parameter Name is composed of (1) the procedure instance identifier of the procedure instance that reports the parameter, and (2) the Parameter Identifier for the parameter. In the descriptions and examples in this Recommended Standard, a CSTS Parameter Name is represented using the notation *[[{procedure type object identifier descriptor}: 'association control' | 'prime procedure instance' | SPIN]: {parameter published identifier descriptor}]*. Thus [[{Cyclic Report}: 'prime procedure instance']: {`pCRnamedLabelLists`}] represents the `named-label-lists` parameter of the prime instance of the Cyclic Report procedure of the CSTS.

1.9.2.7 Event Name

As specified in reference [1], an Event Name can be either the name of a Functional Resource event or the name of a CSTS procedure event. A Functional Resource Event Name is composed of (1) the Functional Resource Name of the Functional Resource instance that reports the event, and (2) the Event Identifier for the event. In the descriptions and examples in this Recommended Standard, an Event Name is represented using the notation *[[{functional resource type published identifier descriptor}: FRIN]: {event published identifier descriptor}]*.

NOTE – As of the publication of this Recommended Standard, there are no procedure events for the three procedures used in the Monitored Data service (Cyclic Report, Information Query, and Notification).

1.9.2.8 Parameter Label

As specified in reference [1], a Parameter Label is composed of (1) the Functional Resource Type that reports the parameter and (2) the Parameter Identifier for the parameter. In the descriptions and examples in this Recommended Standard, a Parameter Label is represented using the notation *[{functional resource type published identifier descriptor}: {parameter*

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published identifier descriptor}]. Thus [{Antenna}: {`actualAzimuth`}] represents the `actual-azimuth` parameter of the Antenna Functional Resource Type.

1.9.2.9 Event Label

As specified in reference [1], an Event Label is composed of (1) the Functional Resource Type that reports the parameter and (2) the Event Identifier for the event. In the descriptions and examples in this Recommended Standard, an Event Label is represented using the notation *[{functional resource type published identifier descriptor}: {event published identifier descriptor}]*.

1.9.2.10 Label List

As specified in reference [1], a Label List is a data structure that specifies the name of a list of Parameter Labels or Events Labels, indicates if the list is the default list, and contains all Parameter Labels or Event Labels represented by that Label List name. In the descriptions and examples in this Recommended Standard, a Label List is represented using the notation:

{ labelListName;
defaultFlag;
<Parameter Label or Event Label>;
.
.
.
<Parameter Label or Event Label>
}

where *<Parameter Label or Event Label>* is as described in 1.9.2.8 or 1.9.2.9.

1.9.2.11 Label List Set

As specified in reference [1], a Label List Set is the set of Label Lists accessible by the user of the given service instance. In the descriptions and examples in this Recommended Standard, a Label List Set is represented using the notation:

{ <Label List>;
.
.
.
<Label List>
}

where *<Label List>* is as described in 1.9.2.10.

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1.10 REFERENCES

[1] *Cross Support Transfer Service—Specification Framework*. Issue 1. Recommendation for Space Data System Standards (Blue Book), CCSDS 921.1-B-1. Washington, D.C.: CCSDS, April 2017.

[2] *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.

[3] "Functional Resources." Space Assigned Numbers Authority. http://sanaregistry.org/r/functional_resources/.

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2 OVERVIEW OF THE MONITORED DATA SERVICE

2.1 SERVICE SUMMARY

The Monitored Data CSTS is a CCSDS Cross Support Transfer Service that during the MD-CSTS service instance provision period provides a user with the capability to:

a) obtain cyclic or on-change reports of the values of monitored parameters of interest;

b) obtain notification of the occurrence of events of interest;

c) query the current values of monitored parameters of interest.

An instance of the Monitored Data service progresses through the following activities:

a) the user binds to the provider to establish a service association;

b) the user selects which monitored parameters are to be reported on-change or cyclically and at which reporting periods, and starts (enables) the reporting of those parameters;

c) the user selects which events are to be notified and enables the transmission of those event notifications (optional);

d) the service provider reports the selected monitored parameter values when they change or at the specified periodicity;

e) the service provider transmits the selected notifications upon occurrence of their associated events (if optional event notification (item c), above) has been invoked by the user),

f) the user queries the current values of monitored parameters (optional);

g) the user stops (disables) periodic reporting and event notification (if optional event notification has been invoked); and

h) the user unbinds from the provider to release the association.

The Monitored Data service delivers only current parameter values: there is no capability in this service to deliver parameter values stored from previous times.

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2.2 FUNCTIONAL DESCRIPTION

2.2.1 GENERAL

As defined in the Cross Support Reference Model: Part 1 (reference [2]), related Cross Support Services are bundled into service packages for the purposes of ensuring that the required relationships among those Cross Support Services are preserved during their production and provision. For example, multiple Cross Support Transfer Services may be related to the operation of the same radio frequency (RF) link, and the return RF link may be related to the forward RF link; all of those transfer services, as well as the RF links themselves, constitute a single service package for the purposes of scheduling. The content and structure of service packages that are compatible with the MD-CSTS will be defined in a future Service Management Recommended Standard (reference [G6]).

A service package may contain multiple instances of the Monitored Data service. Each instance of the Monitored Data service in a service package is capable of reporting all monitored parameters and event notifications for that service package. The example service package used in this section is comprising a forward RF link, two return RF links, multiple SLE transfer service instances, and an instance of the Monitored Data service. The Monitored Data service instance has access to the monitored parameters and event notifications for those RF links and SLE transfer service instances (in addition to the Monitored Data service instance's own monitored parameters and event notifications).

In accordance with reference [2], the functionality associated with a transfer service is partitioned into production and provision of the service. The following subsections describe the production and provision of the Monitored Data service, respectively.

2.2.2 SERVICE PRODUCTION

The production of the Monitored Data service associated with a given service package consists of:

- various space communication and radiometric functions that constitute that service package; and
- a Monitored Data Collection function that collects the monitored parameter measurements and event notifications emitted by those functions in order to make them available to the Monitored Data service instances.

Figure 2-1 is a notional representation of the relationship between the functions of a service package and instances of the Monitored Data service that report on that service package.

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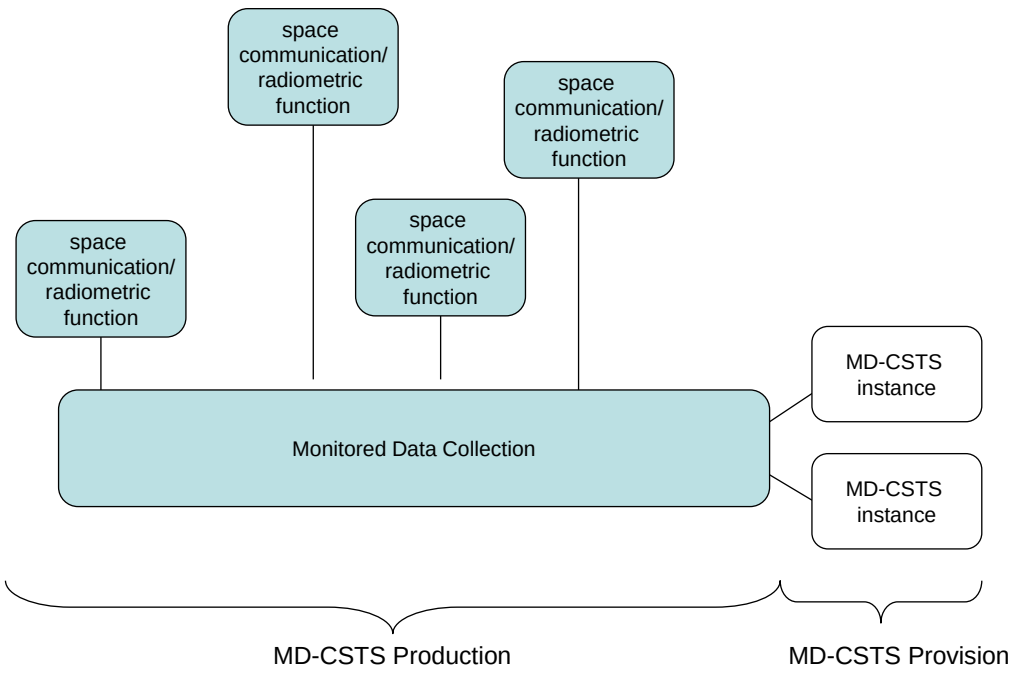

Figure 2-1: Production and Provision of Monitored Data Services (Notional)

In order for the Monitored Data service to represent the monitored parameter values and event notifications of the space communication and radiometric functions in a consistent manner, these functions are represented as standardized *Functional Resources*.

As defined in reference [1], a *Functional Resource Type* is a logical function or related set of functions that provides a space communication capability. A Functional Resource Type may have configuration parameters, monitored parameters, notifiable events, and/or directives associated with it. For the purposes of the Monitored Data CSTS, only the monitored parameters and notifiable events of Functional Resource Types are of interest.

In general, a Functional Resource Type may be instantiated multiple times in the same service package, and therefore it is necessary to distinguish the individual instances of those Functional Resource Types, known as *Functional Resource instances*.

A standard common set of space communication Functional Resource Types and their associated parameters (both configuration and monitored), notifiable events, and directives have been defined by CCSDS and registered with SANA in accordance with the process specified in reference [1]. Annex F identifies an example set of Functional Resource Types and the monitored parameters and notifiable events associated with those Functional Resource Types. These example types, parameters, and events are consistent with the SANA Functional Resource Registry (reference [3]) at the time of publication of this Recommended Standard, but may change over time without annex F being updated. Annex F should therefore be considered informative, and implementers of the MD-CSTS must use the SANA

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Functional Resource Registry as the normative source for definitions of the applicable Functional Resource Types, parameters, and events.

NOTES

1 The operational scenario in 2.5 provides hypothetical examples of Functional Resource Types.

2 Cross Support Complexes that provide the MD-CSTS will be expected to report as many of the standard monitored parameters and notifiable events as possible. Individual Cross Support Complexes may also use the MD-CSTS to report non-standard monitored parameters and event notifications that are available from those Complexes.

The execution of a typical service package is realized through the operation of instances of different types of Functional Resources (e.g., Forward 401 Space Link Carrier Transmission, Return 401 Space Link Carrier Reception) and even multiple instances of the same Functional Resource Type(s) (e.g., a Return Telemetry Synchronization and Channel Decoding Functional Resource instance associated with an X-Band return space link and an instance of that Functional Resource Type associated with an S-Band return space link). Conceptually, instrumentation of the Functional Resources produces the raw measurements that are the basis for the monitored parameter values and the event notifications associated with those Functional Resources.

The MD-CSTS is not constrained to operate with any particular set of Functional Resource Types, but rather can report the monitored parameter values and event notifications for any set of Functional Resources as long as the monitored data and event notifications emitted by those Functional Resources are defined in the SANA Functional Resource Registry.

Functional Resources may occur in different combinations and multiplicities within a service package. For example, a single antenna may be used by both forward and return space links, and more than one return space link may use the same antenna. If Quadrature Phase Shift Keying (QPSK) modulation is used on the carrier, there may be two symbol streams multiplexed onto the single carrier. It is therefore possible that a single service package may have multiple instances of the same types of monitored parameters or notifiable events associated with the different instances of the Functional Resources (e.g., bit synchronizer lock status for a service package that encompasses multiple return symbol streams).

To provide unambiguous identification of each instance of a monitored parameter or notifiable event within the context of the service package, the MD-CSTS uses the Parameter Name of each monitored parameter that is reported and the Event Name of each event that is notified. The Parameter Name of a parameter represents both (a) the type of monitored parameter (e.g., `forward-401-carrier-transmission-actual-carrier-frequency`) and (b) the name of the Functional Resource instance with which the parameter is associated. Similarly, the Event Name of a notifiable event represents both (a) the type of the notifiable event (e.g., ‘`return-telemetry-synchronization-`

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`frame-synchronizer-lock-status-change`') and (b) the name of the Functional Resource instance with which the event is associated.

As specified in the CSTS Specification Framework Recommended Standard (reference [1]):

a) the monitored parameter type component of the Parameter Name is called the Parameter Identifier and has the syntax of a Published Identifier, that is, a special type of Object Identifier on the CCSDS Registration Tree;

b) the notifiable event type component of the Event Name is called the Event Identifier and has the syntax of a Published Identifier;

c) the name of the Functional Resource instance has the syntax of a Functional Resource Name which has two components:

   1) a Functional Resource Type, which has the syntax of a Published Identifier, and

   2) a Functional Resource Instance Number, which is a positive integer.

NOTES

1 The Functional Resource Instance Number is used to differentiate between multiple instances of the same Functional Resource Type that are configured in the same service package. Whereas the Parameter Identifiers, Event Identifiers, and Functional Resource Types are all statically defined, the assignment of Functional Resource Instance Numbers is a dynamic result of the scheduling of service packages, which may contain different combinations and multiplicities of Functional Resource Types.

2 The abstract syntaxes of the Parameter Name, Event Name, Functional Resource Type, Functional Resource Instance Number, and Functional Resource Name are formally specified in reference [1].

The Monitored Data Collection function of MD-CSTS production makes all of the monitored parameters and event notifications available to all instances of MD-CSTS of the service package in conformance with the naming, syntax, type, and units defined in the specification for those monitored parameters and event notifications. In cases where the real implementations of Functional Resources do not present their monitored data measurements and/or event notifications in conformance with the naming, syntax, and/or units required for transfer via the MD-CSTS, the Data Collection function performs the appropriate format conversion.

During the execution of a service package, the production collectively supplies two kinds of data for use in the provision of MD-CSTS instances:

a) the current values of all instances of functional resource monitored parameters that are collected and made available by the Complex for either cyclic or on-change reporting to, or query by, that spaceflight mission; and

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b) functional resource event notifications for all notifiable events that are made available by the Complex for that spaceflight mission.

2.2.3 SERVICE PROVISION

2.2.3.1 General

Multiple instances of the MD-CSTS may exist in the same service package, with each instance providing selected subsets of the functional resource monitored parameter values and event notifications that have been aggregated from the monitored Functional Resources.

Each instance of the Monitored Data service allows the user to subscribe to any of the sets of monitored parameters supported by the Complex and have that set of parameters be cyclically or on-change reported via that service instance. Optionally, each instance of the Monitored Data service allows the user to query the current value of any monitored parameter. Also optionally, each instance of the Monitored Data service allows the user to subscribe to any of the supported set of notifiable events to have those specific events to be notified via that MD-CSTS instance.

NOTE – The capabilities of real implementations of Functional Resources or the Data Collection function of the production affect the freshness and/or accuracy of the data being reported. For example, a particular piece of equipment may output a new measurement value only every 5 seconds. An implementation of the data collection function might hold this value as a constant in the database for the duration of the 5 seconds. In this case, a resulting query that is invoked half-way between samples would return the 2.5-second-old value as the ‘current’ value. Agreements between spaceflight mission and Cross Support Complexes should specify any such timing relationships.

2.2.3.2 Cyclic Reporting of Parameters

The MD-CSTS On-Change-Option Cyclic Report procedure (see section 4) allows the service user to subscribe to a *list of parameters* to be periodically reported, specify the *delivery cycle* (period) for those reports, and specify whether every subscribed parameter value is to be reported at every delivery cycle or only when the parameter value has changed since the previous report. These delivery selections are specified in the START invocation message that activates the On-Change-Option Cyclic Report procedure. Multiple instances of the On-Change-Option Cyclic Report procedure can be active concurrently, each with a different set of subscribed parameters, delivery cycle, and on-change designation, which allows the service user to fine tune the reporting based on relative importance and expected rate of change in the values of the monitored parameters.

The On-Change-Option Cyclic Report procedure is the prime procedure for the MD service. That is, at least one instance of the On-Change-Option Cyclic Report procedure must be active in order for the MD service itself to be considered active.

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Once an On-Change-Option Cyclic Report procedure instance is activated, it reports the values of the subscribed parameters at the specified delivery cycle until a subsequent STOP invocation message for that procedure instance is received.

The list of parameters in the START invocation of the On-Change-Option Cyclic Report procedure may contain:

a) the names of individual monitored parameters that the Cross Support Complex has previously agreed to support, for all instances of all Functional Resources in the service package;

b) the labels of monitored parameter types;

NOTE – Labels provide a form of wildcard selection—when a Parameter Label is used, the values of all instances of that parameter type are reported for all instances of all Functional Resources in the service package.

c) the name of a list of Parameter Labels that has been agreed between the Cross Support Complex and the Mission;

NOTE – Such lists can be used to bundle monitored parameters that are routinely used as a group by the service user. A special case of the Parameter Label List is the *default list*, which is a Parameter Label List that is used by default when MD-CSTS user leaves the list of parameters empty;

d) the name of a specific Functional Resource instance, which is another wildcard selection mechanism, this one causing all parameter values for the named Functional Resource instance to be reported; or

e) the identifier of a Functional Resource Type, yet another wildcard selection mechanism, this one causing all parameter values for all instances of that Functional Resource Type that occur in the service package to be reported.

Optionally (by implementation), the list of parameters may alternatively contain:

a) the names of procedure configuration parameters, in order to receive periodic reports of the values of the configuration parameters of the procedures that constitute the MD service;

b) the identifier of a procedure type, a wildcard selection mechanism that causes the values of all configuration parameters of all instances of the specified procedure type to be reported; or

c) a procedure instance identifier, a wildcard selection mechanism that causes the values of all configuration parameters of the specified procedure instance to be reported.

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NOTE – The configuration parameters of the procedures that constitute the MD service are all static (that is, they do not change during the execution of the MD service). Some of these configuration parameters may be voluminous and cyclic reporting may have adverse operational effects. Therefore cyclic reporting of procedure configuration parameters is optional.

If the list of parameters in the START invocation contains any Parameter Names, Parameter Labels, list names, Functional Resource Types, Functional Resource Names, procedure types, or procedure instance identifiers that are unknown to or not supported by the Cross Support Complex, the START operation fails and a list of the unknown Parameter Names, Labels, etc., is returned to the service user.

At least one instance of the On-Change-Option Cyclic Report procedure is mandatory for all implementations, but each implementation sets the maximum number of instances that can be active during the service instance provision period of the MD-CSTS.

2.2.3.3 Event Notifications

The MD-CSTS Notification procedure (see section 6) allows the service user to subscribe to a *list of events* in the START invocation message that activates the Notification procedure. Once a Notification procedure instance is activated, it will notify the service user of any of the subscribed events that occur between then and the time that a subsequent STOP invocation message for that procedure instance is received.

The START invocation may subscribe to notifiable events by using Events Names, Event Labels, an Event Label List (named or default), a Functional Resource Name, or a Functional Resource Type.

The Notification procedure is optional for MD-CSTS implementations. If an implementation supports the Notification procedure, multiple instances of the Notification procedure can be active concurrently, with each implementation setting the maximum number of instances that can be active during the service instance provision period of the MD-CSTS.

2.2.3.4 Query of Parameters

The Information Query procedure (see section 5) allows the service user to query the current values of functional resource monitored parameters and MD-CSTS procedure configuration parameters. The Information Query procedure consists of a single GET operation that can be used to query the values of different parameters every time that it is invoked.

The GET invocation message can be used to query functional resource parameter values using Functional Resource Parameter Names, Parameter Labels, a Parameter Label List (named or default), a Functional Resource Name, or a Functional Resource Type.

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The GET invocation message can also use procedure configuration Parameter Names, a procedure type, or a procedure instance identifier to query the values of configuration parameter of the procedures that constitute the MD-CSTS instance.

The Information Query procedure is optional for MD-CSTS implementations. Because a single instance of the Information Query procedure can be used to query any of the queriable parameters of the MD-CSTS, the MD-CSTS supports at most one instance of the Information Query procedure during the service instance provision period.

NOTE – The GET operation can be invoked any number of times during the service instance provision period. Furthermore, because the GET operation of the Information Query procedure is non-blocking (as defined in reference [1]), the GET operation can be invoked before the responses to previous invocations are returned.

2.3 SERVICE MANAGEMENT

As defined in the Cross Support Reference Model: Part 1 (reference [2]), related Cross Support Services are bundled into service packages for the purposes of scheduling. Cross Support Service Management both establishes the constraints on the service packages to which a given spaceflight mission must conform (e.g., data rate and frequency ranges, types and numbers of Cross Support Transfer Service instances) and provides the mechanisms for instantiating conformant service packages (e.g., via scheduling).

As described in 2.2, the Monitored Data service uses the Functional Resource representation of the space communication and radiometric functions to report monitored parameter values and event notifications. Functional Resources are also used by Service Management to represent these functions. That is, service packages are expressed in terms of Functional Resource instances, and the initial values of the configuration parameters of those service packages are expressed in terms of the standardized configuration parameters of the respective Functional Resource Types.

With regard to the production and provision of Monitored Data service instances:

a) Cross Support Service Management may establish one or more named lists of Parameter Labels to be used to request groups of monitored parameters to be cyclically reported (and queried if the optional query capability is supported) during the MD-CSTS service instance provision period. One of these lists may be designated the default list of Parameter Labels, which means that it will be applied unless Parameter Names, Parameters Labels, etc., are explicitly requested. As specified in reference [1], each Parameter Label is composed of (1) the Parameter Identifier of that parameter and (2) the Functional Resource Type with which that Parameter Identifier is associated.

b) Cross Support Service Management may (if the Notification procedure is supported by the Complex) establish one or more named lists of Event Labels to be used to request groups of notifiable events to be reported during the MD-CSTS service

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instance provision period. One of these lists may be designated the default list of Event Labels, which means that it will be applied unless Event Names, Event Labels, etc., are explicitly requested. As specified in reference [1], each Event Label is composed of (1) the Event Identifier of that event and (2) the Functional Resource Type with which that Event Identifier is associated.

c) Cross Support Service Management schedules the service packages which specify both the Cross Support Services that are to be monitored and the Monitored Data service instances that transfer the monitored parameters to the users of the Monitored Data service instances.

The means by which Service Management performs these functions is outside the scope of this Recommended Standard.

2.4 CROSS SUPPORT VIEW

Figure 2-2 shows an example configuration of a Cross Support Complex providing instances of Monitored Data service to a Mission Data Operations System (MDOS). In this example, the Functional Resources that are configured to support the service package (and therefore available for monitoring via the MD-CSTS) are the Space Link Extension (SLE) Forward Communications Link Transmission Unit (Forward CLTU) transfer service (reference [G4]), the Functional Resource instances that are associated with F-CLTU production (Antenna, Forward 401 Space Link Carrier Transmission, and Forward TC PLOP, Sync, and Channel Encoding), the SLE Return All Frames transfer service (reference [G5]), and the Functional Resource instances that are associated with Return All Frames production (Antenna, Return 401 Space Link Carrier Reception, and Return Telemetry Synchronization and Channel Decoding).

NOTES

1 ‘401 Space Link’ in the string identifier of the Functional Resource Types indicates that these types are suitable only to model space links that conform to CCSDS 401.0-B-26 (reference [G10]) but not for space links that conform, e.g., to CCSDS 415.1-B-1 (reference [G11]).

2 A given Functional Resource Type may represent several functions of which, depending on the type of input data, only a subset is applicable. The reason for this is twofold: (a) this approach limits the number of Functional Resource Types to a manageable number and (b) permits, where feasible, grouping the functions such that those of one Functional Resource Type correspond to one CCSDS Recommended Standard. The ‘Forward TC PLOP, Sync and Channel Encoding’ Functional Resource Type is one example of this approach. In terms of functions it corresponds to the ‘TC Synchronization and Channel Coding’ book (reference [G12]). It should be noted that, although not obvious from the title of that Recommended Standard, it not only specifies the synchronization mechanism required to delimit CLTUs from each

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other by means of start and tail sequences, but also the Physical Layer Operations Procedure (PLOP) that permits the spacecraft to achieve carrier and symbol lock.

3 In the scenario illustrated in figure 2-2, the input data are readily configured CLTUs including start and tail sequences. The only thing missing in terms of generating the symbol stream that shall modulate the forward carrier is the execution of the Physical Layer Operations Procedure and that is in the depicted scenario the only function of the 'Forward TC PLOP, Sync and Channel Encoding' Functional Resource instance being used. In a different scenario the input data can be TC frames and in that case the coding and synchronization functions would be used in the process of converting incoming TC frames to CLTUs.

The SLE transfer service instances and the production Functional Resources associated with them are not part of the Monitored Data service, but they are monitored through the Monitored data service.

NOTE – For the purposes of this description, the production Functional Resources named above and shown in the figure are generic versions of the Functional Resource Types registered with SANA at the time of publication of this Recommended Standard. The actual names of the Functional Resources are as specified in the SANA Functional Resource Registry (reference [3]).

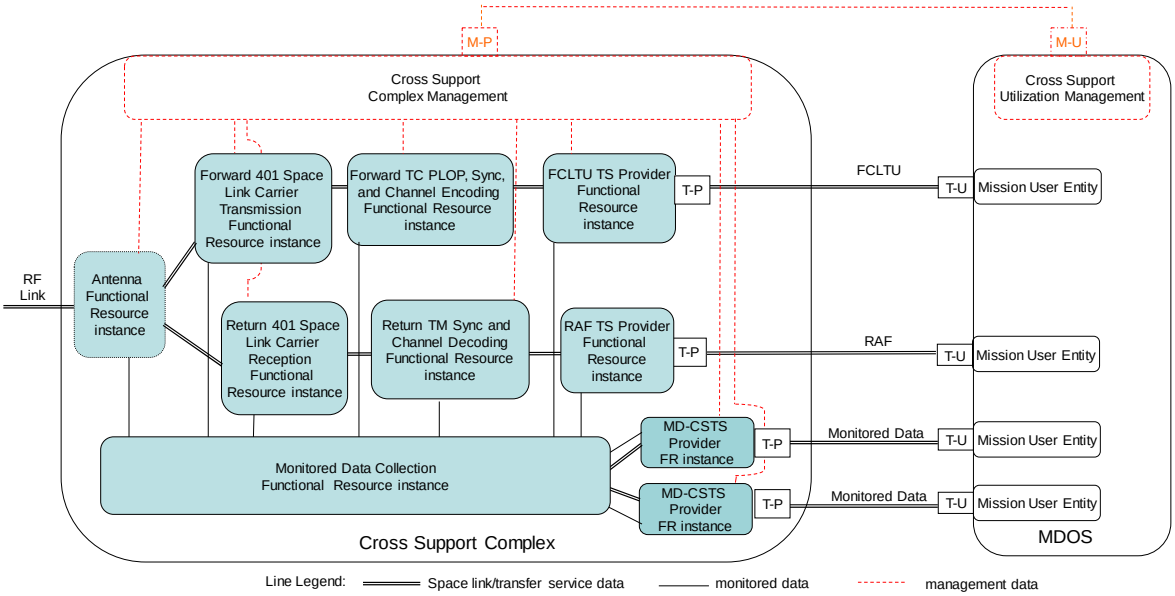

Figure 2-2: Example of the Management and Provision of Monitored Data Service Instances for a Service Package

As shown in figure 2-2, a single service package may include multiple instances of Monitored Data service. All Monitored Data service instances (i.e., all MD-CSTS users) have access to all monitored parameters and notifiable events associated with the service package.

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As also shown in the figure, the MD-CSTS instances and the Monitored Data Collection function are themselves monitored Functional Resources. Any service management parameters or notifiable events associated with the MD-CSTS instances are made available via those MD-CSTS instances in the same way that such information about any Functional Resource instance (including Monitored Data Collection) is made available.

NOTE – According to the Cross Support Reference Model (reference [2]), the responsibility for monitoring the overall state of the execution of a service package is associated with the Utilization Management (UM) role of the MDOS, which is a Service Management role. In this case, a Service Management *function* is being performed, but it is being performed using a CSTS rather than using a management service built upon the Space Communication Cross Support Service Management infrastructure (references [G6], [G7], and [G8]). Although figure 2-2 shows the Mission User Entity (MUE) for the MD-CSTS as being separate from the UM role, it should be understood that in the nominal case the use of the MD-CSTS will be in support of a Service Management responsibility. However, there may be other uses of monitored data that are not linked to UM. For example, the principal investigator for a particular instrument may need to correlate his or her instrument data (returned via the Return All Frames SLE service) with communications service status that is not available via the Return All Frames service. Such a principal investigator could be a user of an MD-CSTS instance and subscribe to the monitored parameters of interest.

2.5 OPERATIONAL SCENARIO

2.5.1 GENERAL

This subsection presents an operational scenario of the MD service. This scenario is written using the Functional Resource Name, Parameter Name, Parameter Label, Event Name, Event Label, procedure type, and procedure instance identifier representation conventions described in 1.9.2.

NOTES

1 The representation conventions in 1.9.2 represent the OID components as text descriptors enclosed in curly braces; e.g., {Association Control} represents the OID assigned as the procedure identifier for the Association Control procedure. The OIDs associated with Functional Resources (Functional Resource Types, Functional Resource Parameter Identifiers, and Functional Resource Event Identifiers) are formally registered with SANA.

2 Annex F identifies the subset of Functional Resources that are used in this operational scenario. For each Functional Resource Type, annex F identifies the OID for that Functional Resource Type, the monitored parameters and notifiable events that are used in this operational scenario. These Functional Resource definitions, parameters, notifiable events, and respective OID assignments are based on the candidate SANA

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Functional Resource Registry that existed as of the time of publication of this Recommended Standard. The normative definitions that are recorded in the SANA Functional Resource Registry at any given time may differ from those in annex F.

3 The OIDs associated with CSTS Framework procedures (procedure types, procedure configuration Parameter Identifiers, and procedure Event Identifiers) are specified in the CSTS Specification Framework Recommended Standard (reference [1]).

The following scenario is success-oriented. That is, no error conditions are addressed.

2.5.2 SERVICE AGREEMENT/SERVICE PLANNING ACTIVITIES

As part of the Service Management activities that establish the relationship between the Xenosat mission and the Multinet Cross Support Complex, UM for Xenosat and Complex Management (CM) for Multinet negotiate the set of Cross Support Services that will be available to the Xenosat mission within the context of the service agreement.

For the purpose of this scenario, the Cross Support Services include a single S-Band forward space link and associated single instance of Forward CLTU SLE transfer service (reference [G4]), an S-Band return space link and associated single instance of Return All Frames SLE transfer service (reference [G5]), and an X-Band return space link and associated single instance of Return All Frames transfer service. Multinet supports both the optional Notification and Information Query procedures of the MD-CSTS standard in addition to the mandatory On-Change-Option Cyclic Report procedure. The service agreement also includes a single instance of the MD-CSTS, which supports four instances of each of the On-Change-Option Cyclic Report and Notification procedures, and one instance of the Information Query procedure.

The Functional Resource instances associated with these Cross Support Services are:

a) two instances of the Antenna Functional Resource Type (see F2), one for X-Band and one for S-Band, with Functional Resource Name ‘[{`antenna`}: 1]’ for the X-Band Antenna and Functional Resource Name ‘[{`antenna`}: 2]’ for the S-Band Antenna;

b) one instance of the Forward 401 Space Link Carrier Transmission Functional Resource Type (see F3), with Functional Resource Name ‘[{`fwd401SpaceLinkCarrierXmit`}: 1]’ for the Forward S-Band;

c) one instance of the Forward TC PLOP, Sync, and Channel Encoding Functional Resource Type (see F4) for the Forward S-Band link, with Functional Resource Name ‘[{`fwdTcPlopSyncAndChnlEncoding`}: 1]’;

d) one instance of the Forward CLTU Transfer Service Provider Functional Resource Type (see F5), with Functional Resource Name ‘[{`fwdCltuTsProvider`}: 1]’;

e) two instances of the Return 401 Space Link Carrier Reception Functional Resource Type (see F6), one for X-Band and one for S-Band, with Functional Resource Name

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‘[{rtn401SpaceLinkCarrierRecpt}: 1]’ for the X-Band Return 401 Space Link Carrier Reception Functional Resource instance and Functional Resource Name ‘[{rtn401SpaceLinkCarrierRecpt}: 2]’ for the S-Band Return 401 Space Link Carrier Reception Functional Resource instance;

NOTE – In this example the data are modulated onto subcarriers that are Bi-Phase Shift Keying (BPSK)-modulated, so that only one symbol stream is carried by each subcarrier.

f) two instances of the Return TM Synchronization and Channel Decoding Functional Resource Type (see F7), one for the X-Band return space link symbol stream and one for the S-Band return space link symbol stream, with Functional Resource Name ‘[{rtnTmSyncAndChnlDecoding}: 1]’ for the X-Band Return TM Synchronization and Channel Decoding Functional Resource instance and Functional Resource Name ‘[{rtnTmSyncAndChnlDecoding}: 2]’ for the S-Band Return TM Synchronization and Channel Decoding Functional Resource instance;

g) two instances of the Return All Frames Transfer Service Provider Functional Resource Type (see F8), one for the X-Band return space link symbol stream and one for the S-Band return space link symbol stream, with Functional Resource Name ‘[{rtnAfTsProvider}: 1]’ for the X-Band Return All Frames Transfer Service Provider Functional Resource instance and Functional Resource Name ‘[{rtnAfTsProvider}: 2]’ for the S-Band Return All Frames Transfer Service Provider Functional Resource instance;

h) one instance of the Monitored Data CSTS Provider Functional Resource Type (see F9) for the service package, with Functional Resource Name ‘[{mdCstsProvider}: 1]’ for the MD-CSTS Provider Functional Resource instance;

i) one instance of the Monitored Data Collection Functional Resource Type (see F10) for the service package, with Functional Resource Name ‘[{mdCollection}: 1]’ for the Monitored Data Collection Functional Resource instance.

Among the Functional Resource monitored parameters collected and made available by the Multinet Complex are:

– the antPointingMode for the Antenna Functional Resource Type, with Parameter Label [{antenna}: {antPointingMode}] (see F2 for the OID values);

– the fwd401CarrierXmitActualCarrierFreq for the Forward 401 Space Link Carrier Transmission FR Type, with Parameter Label [{fwd401SpaceLinkCarrierXmit}: {fwd401CarrierXmitActualCarrierFreq}] (see F3 for the OID values);

– the fwdCltuTsSiState (Forward CLTU Transfer Service Service Instance State) and fwdCltuTsNumberOfCltusRadiated for the Forward CLTU Transfer Service Provider FR Type, with Parameter Labels [{fwdCltuTsProvider}:

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{fwdCltuTsSiState}] and [{fwdCltuTsProvider}: {fwdCltuTsNumberOfCltusRadiated}], respectively (see F5 for the OID values);

– the rtn401CarrierRecptActualFreq, rtn401CarrierRecptSubcarrierLockStat, rtn401CarrierRecptActualSubcarrierFreq, and rtn401CarrierRecptSymbolSyncLockStat for the Return 401 Space Link Carrier Reception FR Type, with Parameter Labels [{rtn401SpaceLinkCarrierRecpt}: {rtn401CarrierRecptActualFreq}], [{rtn401SpaceLinkCarrierRecpt}: {rtn401CarrierRecptSubcarrierLockStat}], [{rtn401SpaceLinkCarrierRecpt}: {rtn401CarrierRecptActualSubcarrierFreq}], and [{rtn401SpaceLinkCarrierRecpt}: {rtn401CarrierRecptSymbolSyncLockStat}] (see F6 for the OID values); and

– the rtnAfSiState and the rtnAfNumberOfFramesDelivered for the Return All Frames Transfer Service Provider FR Type, with Parameter Labels [{rtnAfTsProvider}: {rtnAfSiState}] and [{rtnAfTsProvider}: {rtnAfNumberOfFramesDelivered}], respectively (see F8 for the OID values).

Among the notifiable events made available by the Multinet Complex are:

– rtnTmSyncFrameSyncLockStatChange for the Return TM Synchronization and Channel Decoding FR Type, with Parameter Label [{rtnTmSyncAndChnlDecoding}: {rtnTmSyncFrameSyncLockStatChange}] (see F7 for the OID values);

– mdCstsProdStatChange for the MD CSTS Provider FR Type, with Event Label [{mdCstsProvider}: {mdCstsProdStatChange}] (see F9 for the OID values);

– rtnAfProdStatChange for the Return All Frames Transfer Service (TS) Provider FR Type, with Parameter Label [{rtnAfTsProvider}: {rtnAfProdStatChange}] (see F8 for the OID values); and

– fwdCltuTsProdStatChange for the Forward CLTU TS Provider FR Type, with Parameter Label [{fwdCltuTsProvider}: {fwdCltuTsProdStatChange}] (see F5 for the OID values).

As part of the Service Management activities that establish the relationship between the mission and the Complex, UM and CM negotiate a single monitored Parameter Label List that will serve as the default Label List for both the On-Change-Option Cyclic Report and

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