The Consultative Committee for Space Data Systems

Technical Note Concerning Space Data System Standards

FUNCTIONAL RESOURCES FOR CROSS SUPPORT SERVICES

DRAFT TECHNICAL NOTE

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DOCUMENT CONTROL

Document	Title and Issue	Date	Status
CSSA-CSS_FRs-TN-0.1	Functional Resources in Cross Support Services, Issue 0.1	April 2013	first draft. Integrates FR material from multiple sources.
CSSA 1-TN-0.2	Functional Resources in Cross Support Services, Issue 0.2	May 2013	- Combines All Frames Reception with Return Sync and Decoding - Changes cardinality of symbol streams per subcarrier. - Changes Section to be a description of additional Function Resource Concepts, deletes the concept of Functional Resources Class. - Includes a new section 3, which describes Space Communication Cross Support Functional Groups. - Defines the FR Types needed for IOAG SC1 services, organized by Functional Group (section 4). - Includes a new section 5 that describes service templates and service profiles.

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Section Page

1 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

This report documents the concept of Functional Resources and their use in cross support services.

1.2 BACKGROUND

The CCSDS Cross Support Reference Model (CSRM) for SLE Services [1] organizes the functionality associated with producing and providing SLE transfer services into *functional groups*. The significance of the functional groups is now largely historic. At the time that the CSRM was first published, it was anticipated that production and provision of SLE transfer services might be *staged* (that is, distributed) across multiple processing facilities. The functional groups combined sets of logically-related TT&C and SLE-related functions into atomic groupings, each of which was required to be implemented within a single facility. These logical groupings, or more correctly the interfaces between them, defined the natural demarcation points for SLE transfer services. Each functional group includes the *provision* of one or more SLE transfer service types and the processing required to *produce* that (those) service(s) (with respect to the data exchanged across the interface at the opposite end of the functional group).

The primary purpose of the CSRM functional groups was to provide the context for the definition of the SLE transfer services. However, the CSRM functional group definitions do not provide a sufficient level of information from which configuration parameters, monitored parameters, and notifiable events can be defined for the production of cross support services. Specifically, a single instance of a CSRM functional group can have multiple instances of the same management parameters or contain multiple sources of the same monitored parameter and notifiable event types. For example, in the CSRM Return Space Link Processing functional group QPSK modulation of the RF link can result in two separate return symbol streams. In such cases the (hypothetical) event notification “frame sync lock dropped” must be reported with respect to the specific symbol stream, but CSRM functional groups do not provide the granularity to identify individual symbol streams.

Functional Resources provide that necessary granularity. Fundamental to the concept of Functional Resources is that each one represents a cohesive, atomic set of space communication functionality with which can be associated single instances of management parameters, monitored parameters, real-time control parameters, and event notifications.

Functional Resources are not the physical resources (e.g., transmitters and receivers) that comprise real systems. Rather, they represent the functions or capabilities that are provided by those physical resources. A Functional Resource may be realized by several physical entities that work cooperatively to perform that function. Alternatively, for some types of functional resources, a single physical resource may be designed such that it instantiates several functional resources.

The Functional Resource concept was originally developed as a way to provide unique qualifiers for monitored parameter names in cases where multiple instances of those parameters could be reported simultaneously through the Monitored Data CSTS (MD-CSTS). A strawman set of Functional Resource Types was developed for the MD-CSTS (see reference [10]). The strawman Functional Resource Types were subsequently used (with modifications) to generate a proposed standard set of monitored parameters for each functional resource type.

The concept has subsequently been adopted as a core concept of the *CSTS Specification Framework* (CSTS SFW) (see reference [4]), with standard parameter names being defined as having a functional resource identifier component. The CSTS SFW also defines a registration subtree for functional resource type Object Identifiers (OIDs) under the CCSDS registration tree. The technical note "Operational Scenario Implementation" (reference [11]) applied the functional resource type and monitored parameter OID structure to the proposed standard set of monitored parameters. Besides monitored parameters, the Functional Resource registration tree defined in the CSTS SFW is used to register OIDs for *notifiable events* and *directives* associated with each Functional Resource Type. *Notifiable events* are also reported by the MD-CSTS. A *directive* is a control action that is invoked in real time. The directives are intended for use by a future Service Control CSTS.

The Functional Resource concept has been adopted as the method for organizing the management information associated with the services to be managed via the in-progress Extensible Space Communication Cross Support Service Management standard (see the *Extensible Space Communication Cross Support Service Management Concept* Green Book, reference [12]).

1.3 SCOPE

The scope of this technical note is limited to the functional resources that are associated with what are called *Earth Space Link Terminals* (ESLTs) in the SCCS Architecture (reference [13]). As its name implies, an ESLT provides an Earth-side termination of a space-ground link to a user platform (spacecraft, rover, etc.). A typical ESLT is a ground stations, but in the case of a relay satellite system such as the NASA Space Network, the ESLT represents the functionality of both the ground terminal *and* the relay satellite.

1.4 DOCUMENT ORGANIZATION

This report contains material that was previously contained in the draft *Extensible Space Communication Cross Support Service Management – Concept* Green Book and the technical notes "Functional Resources in Service Management and Service Package Execution" and "Functional Resources for IOAG Service Catalog #1 Services." This report expands on some of the material taken from those sources.

Section 2 describes concepts of Functional Resources.

Section 3 describes the concept and derivation of Space Communication Cross Support Functional Groups and identifies the Functional Groups that are present in IOAG Service Catalog #1 services.

Section 4 identifies the functional resource types that are used to compose the services called out in the Interagency Operations Advisory Group (IOAG) Service Catalogs #1 (reference [9]). For each functional resource type (FR Type), the Functional Resource Type Object Identifier (if available) is given, the relationship of the FR Type to functions and procedures of CCSDS Recommended Standards is identified, and the mapping of the FR Type to its Cross Support Reference Model [1] Functional Group is given (if applicable). The FR Types in section 4 are organized according to the Functional Groups to which they belong.

Section 5 describes the concepts of *service templates* and *service profiles*, and how they are composed of Functional Groups.

Section 6 identifies the FR Types that are present in each of the IOAG Service Catalog #1 services. For each IOAG service, the Functional Groups are identified along with the Functional Resource Types.

Section 7 describes the use of Functional Resources in Service Management and the Execution of Service Packages. For this draft version of this Report, section 7 is mostly a cut-and-paste from the technical note of the same name, which was prepared in late 2013. That is, the table and figure numbers have not been changed, and any recent name changes of FR Types have not been reflected. As time, resources, and interest allow, these will be cleaned up.

1.5 DEFINITIONS

TBS.

1.6 REFERENCES

The following documents are referenced in this Report. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this Report 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 documents.

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

[2] *Space Link Extension—Return All Frames Service Specification*. Recommendation for Space Data System Standards, CCSDS 911.1-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, January 2010.

[3] *Space Link Extension—Return Channel Frames Service Specification*. Recommendation for Space Data System Standards, CCSDS 911.2-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, January 2010.

[4] *Cross Support Transfer Service - Specification Framework*, Draft Recommended Standard, CCSDS 921.1-R-2-draft. March 2013.

[5] *TC Synchronization and Channel Coding*. Recommendation for Space Data System Standards, CCSDS 231.0-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, September 2010.

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

[7] <RUFT>

[8] <TD-CSTS>

[9] <IOAG Service Catalog #1>

[10] *Monitored Data Cross Support Transfer Service*. Draft Recommended Standard. CCSDS 922.1-W-0.12. February 2013.

[11] Doat, Yves, "Operational Scenario Implementation", CSTSWG technical note. 20 May 2012.

[12] *Extensible Space Communication Cross Support Service Management Concept*. Draft Informational Report. (no number. Draft 0.20). February 2013.

[13] *Space Communications Cross Support Architecture Description Document*. Report Concerning Space Data System Standards, CCSDS 901.0-G-1. Green Book. Issue 1. Washington, D.C.: CCSDS, forthcoming.

[14] *Space Communication Cross Support - Service Management – Service Specification*. Recommendation for Space Data System Standards, CCSDS 910.11-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2009

[15] *Framework for Extensible Space Communication Cross Support Service Management*. Future Recommended Standard.

[16] <IOAG SC #2>

[17] *TC Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 232.0-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, September 2010.

[18] *AOS Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 732.0-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, July 2006.

[19] *TM Space Data Link Protocol*. Recommendation for Space Data System Standards, CCSDS 132.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.

[20] *Space Packet Protocol*. Recommendation for Space Data System Standards, CCSDS 133.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.

[21] *Communications Operation Procedure-1*. Recommendation for Space Data System Standards, CCSDS 232.1-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.

[22] *Space Packet Protocol*. Recommendation for Space Data System Standards, CCSDS 133.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2003.

[23] <Encapsulation Service>

For possible future use

Space Communications Cross Support Architecture Requirements Document. Recommendation for Space Data System Practices, CCSDS 901.1-M-1. Magenta Book. Issue 1. Washington, D.C.: CCSDS, forthcoming.

[2-1] *Space Communications Cross Support—Service Management—Operations Concept*. Report Concerning Space Data System Standards, CCSDS 910.14-G-1. Green Book. Issue 1. Washington, D.C.: CCSDS, May 2011.

[2-2] *Radio Frequency and Modulation Systems—Part 1: Earth Stations and Spacecraft*. Recommendation for Space Data System Standards, CCSDS 401.0-B-21. Blue Book. Issue 21. Washington, D.C.: CCSDS, July 2011.

September 2003.

[2-3] *Space Link Extension—Forward CLTU Service Specification*. Recommendation for Space Data System Standards, CCSDS 912.1-B-3. Blue Book. Issue 3. Washington, D.C.: CCSDS, July 2010.

[2-4]*Space Link Extension—Return Operational Control Fields Service Specification*. Recommendation for Space Data System Standards, CCSDS 911.5-B-2. Blue Book. Issue 1. Washington, D.C.: CCSDS, January 2010.

. [2-5] *Space Link Extension—Forward Space Packet Service Specification* Recommendation for Space Data System Standards, CCSDS 912.3-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, July 2010.

[2-6] *Cross Support Concept—Part 1: Space Link Extension Services*. Report Concerning Space Data System Standards, CCSDS 910.3-G-3. Green Book. Issue 3. Washington, D.C.: CCSDS, March 2006.

Orbit Data Messages. Recommendation for Space Data System Standards, CCSDS 502.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2004.

[7] *XML Specification for Navigation Data Messages*. Draft Recommendation for Space Data System Standards, CCSDS 505.0-R-1. Red Book. Issue 1. Washington, D.C.: CCSDS, November 2005.

[8] "CCSDS-910.11-B-1_XML_schemas." http://public.ccsds.org/publications/archive/CCSDS-910.11-B-1_XML_schemas.zip.

[9] *XML Encryption Syntax and Processing*. http://www.w3.org/TR/xmlenc-core/

[10] *XML Digital Signature Syntax and Processing*. http://www.w3.org/TR/xmldsig-core/

[11] *XML Key Management Specification*. http://www.w3.org/TR/xkms2/

2 CONCEPTS OF FUNCTIONAL RESOURCES

Functional Resources are the *externally observable* abstract representations of the functionality needed to provide space communication and navigation services, defined at a level of granularity sufficient to specify the configuration parameters, monitored parameters, and notifiable events associated with that functionality. The externally observable qualifier is important – if a processing function does not need to be independently configured, cannot be independently reconfigured (via real-time control directives), or does not have unique monitored parameters or notifiable events, then it does not have a Functional Resource to represent it. Note that only one of these facets needs to be present in order for a function to need to be represented by a Functional Resource.

Figure 2-1 depicts a generic Functional Resource Type and its notional interfaces.

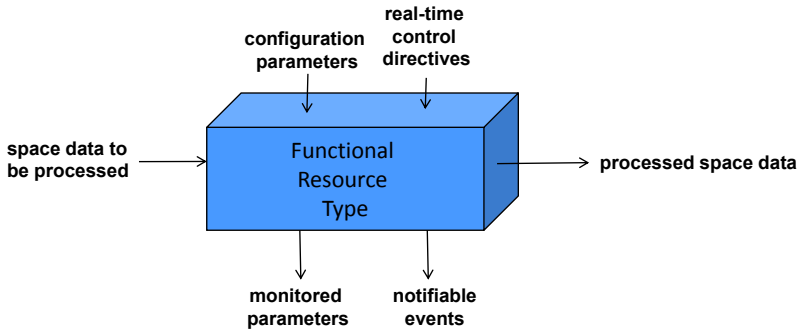

Figure 2-1: Notional Interfaces of the Generic Functional Resource Type

The horizontal interfaces represent the flow of the space data through an instance of the FR Type – the "function" of the FR Type is the process that it performs on this data. An FR instance is configured via the setting of the configuration parameters for its FR Type. When the FR instance is active, it emits measurements of whatever monitored parameters are defined for that FR Type. The FR instance also emits event notifications if any of the notifiable events that are defined for its FR Type occur. Finally, the behavior of an FR instance may be modified via the real-time control directives that are defined for its FR Type (if any).

For the IOAG Service Catalog #1 services performed by an Earth Space Link Terminal (which is the current scope of Extensible SCCS-SM), the composite functionality includes the transmission/reception of the signal on the space link with the mission spacecraft, the channel synchronization and coding/decoding of the data on that space link, the execution of the space link protocols, and the provision of the cross support services by which the User missions submit data destined for their spacecraft and receive data from their spacecraft. This functionality nominally conforms to the specifications provided by CCSDS Recommended Standards for space link modulation (references XXX), synchronization and channel coding (references [5] and [6]), space data link protocols (references [17] - [22]), terrestrial cross

support services e.g., (references [2], [3], and [10]), and space internetworking services (references WWW).

The services provided in a Service Package can contain multiple instances of *Functional Resource Types* (FR Types). Indeed, it is because multiple instances of the same atomic functionality can occur in the same Service Package that the notion of Functional Resource was created. Each FR Type is assigned an ISO object identifier (OID). The FR Type OID is used to construct unique identifiers for functional resource instances and for the monitored parameters, configuration parameters, notifiable events, and real-time control directives that those functional resources expose for Service Management purposes. A *Functional Resource instance* is identified by the combination of the Functional Resource Type with a Functional Resource Instance Number (see the *Functional Resources for Cross Support Services* Tech Note/Yellow Book/Green Book? for additional details).

3 SPACE COMMUNICATION CROSS SUPPORT FUNCTIONAL GROUPS

Functional Resource Types represent specific space communication technologies and specific terrestrial cross support services. As space communication technologies evolve and new terrestrial cross support services are added over time, the FR Types that are used to represent them may need to be augmented or replaced by different FR Types. In cases where multiple FR Types are closely bound to a particular space communication technology (e.g., space link signal modulation), the replacement/addition of such a technology could involve the replacement/addition of multiple FR Types. Similarly, a terrestrial cross support service may need multiple FR Types to represent to total functionality associated with that cross support service. For example, a return offline SLE transfer services has an FR Type for the service provision functions of the SLE service, and also an FR Type for the offline buffer that stores the data for subsequent retrieval by the SLE service provider.

In order to accommodate the bundling of related FR Types for the purposes of substitution and extensibility, the concept of Functional Groups is re-defined for Extensible SCCS-SM.

The Functional Groups (FGs) that are used for Extensible SCCS-SM are evolved from the CSRM FGs, but they differ from them in three significant respects:

1. Whereas the primary purpose of the CSRM FGs is to accommodate the staging of cross support services across multiple Provider CSSSes, the primary purpose of this set of FGs is to group technologically-related Functional Resources so that those Functional Resources can be updated or replaced as the technologies evolve. This difference in purpose results in differences in the FGs in which the various functions are combined.
2. The CSRM FGs mix both space link (e.g., modulation, coding, and space data link protocols) and terrestrial cross support service (e.g., SLE transfer services, CSTSes, and the future IOAG Forward and Return File services) functionality within the same FG. In contrast, the new set of FGs separates the functionality associated with the space link and the functionality associated with terrestrial cross support services into different FGs.
3. Unlike the CSRM FGs, which mix abstract functionality with specific technologies (e.g., AOS-specific FGs vs. Telecommand-specific FGs), the new FGs are defined in terms of an abstract layered model of the interface across a space link and of the services used to make that space link accessible to terrestrial users.

In order to differentiate these new Functional Groups from the CSRM FGs, they are referred to as *SCCS Functional Groups*.

Organizing the SCCS FGs around space communication technology-related groupings that can be substituted or added is important for Extensible SCCS-SM because such groupings identify the *extensibility points* for SCCS-SM information entities. This topic is addressed in greater detail in 5.

Basing the SCCS FGs on a purely abstract layered model of space communication functionality ensures that any new space communication technology can be introduced into and supported by ESCCS-SM as long as it conforms to the minimal functional and interface definitions for the corresponding FG. The abstract layered model has the following components:

a. The aperture, which is the physical interface to the space medium. On the "ground side", the aperture receives and/or transmits a modulated signal.
b. The physical channel, which transfers a stream of bits through the aperture across the physical medium (in this case, space). The space physical channel has traditionally been provided at radio frequencies using RF modulation techniques, but the use of optical physical channels is expected to increase.

   NOTE - In any realization of a space link, the technology used by the aperture must be compatible with the technology used by the physical channel. However, the possibility for multiple aperture technologies being applicable to the same physical channel technology (e.g., phased array vs. single antenna for an RF space link) justifies treating apertures separately from physical channels for the purposes of SCCS FG definition.

c. Channel synchronization and coding, which consists of the error coding, randomization, and synchronization functions that are performed to convert space data link transfer frames to the bit streams that are transferred across the space physical channel, and vice versa.
d. Space data link protocols that insert/extract space-optimized protocol data units (PDUs) into/from space data link transfer frames and in some cases control the flow of those transfer frames across the space link.
e. Terrestrial cross support services that allow remote user mission entities to interface with the ESLT for the purpose of exchanging data with their respective spacecraft via the space links provided by the ESLT. These services include SLE Transfer Services, CSTSes, and application-level services that transform and/or store data on the way to or from the mission spacecraft.
f. Internetworking protocols that provide end-to-end connectivity across multiple kinds of data links, including space links.

   NOTE - Space Internetworking is part of IOAG Service Catalog #2 capabilities.

Figure 3-1 depicts the set of SCCS FGs for the ESLT, and the possible data flows through them. As illustrated in the figure, many combinations of FGs are possible, although most services will each use only a single flow through the FGs.

NOTE - The possible flows shown in figure 3-1 are the service data flows through these FGs. They do not include the flows by which the Functional Resources within these FGs are configured and controlled in real time and by which the Functional Resources report monitored parameter values and event notifications. Such data flows can be considered to occur in a separate management plane.

Comment [JP1]: I've gone back and forth about whether to call out Data Storage as a separate FG. Functionally, the nature of storage and where it "plugs in" ion intimately tied to the terrestrial cross support service with which it is associated. Also, it becomes esthetically ugly in the diagram, because of the spaghetti of cross-connects. For this pass data storage is considered part of the terrestrial cross support service (or in the DTN case, as part of the Internetworking FG) with which it is associated and therefore included in the Terrestrial Cross Support Service FG. We can consider the ramifications of this in the near future.

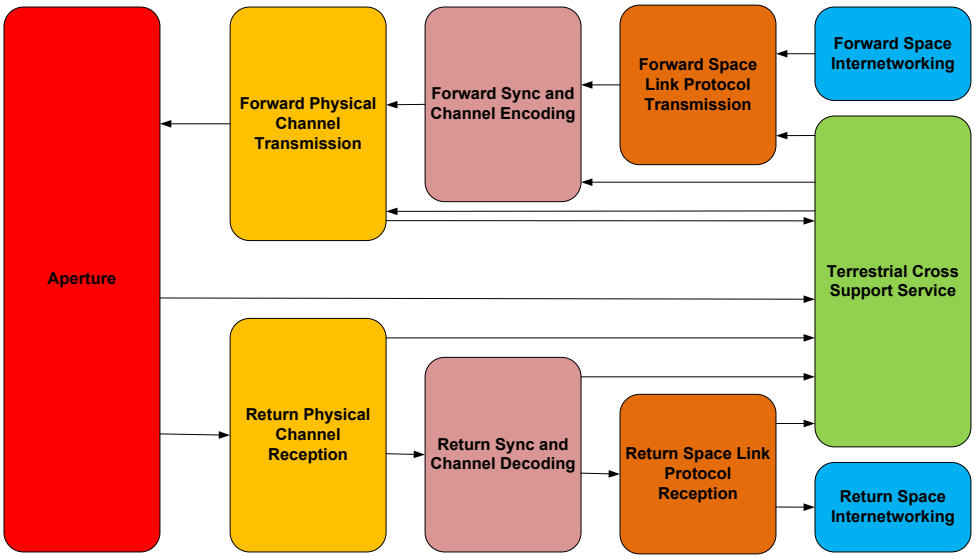

Figure 3-1: SCCS Functional Groups for Earth-Space Link Terminals

The Aperture FG represents the general class of apertures through which forward space link signals are transmitted, and return space link signals are received. Some apertures can be used by multiple forward and/or return space links simultaneously, although specific types may be limited in directionality and/or number of simultaneous links.

The Forward Physical Channel Transmission and Return Physical Channel Reception FGs represent the Radio Frequency (RF) Modulation and (future) Optical Modulation aspects of space link services.

The Forward Synchronization and Channel Encoding and Return Synchronization and Channel Decoding FGs represent the coding/decoding and synchronization aspects of space link services.

The Forward Space link Protocol Transmission and Return Space Link Reception FGs represent the space link protocol processing that is performed on data transmitted across the space link.

The Terrestrial Cross Support Service FG represents the various cross support services that are used to transfer data across terrestrial networks between a spaceflight Mission ground facility and an ESLT. These services include SLE transfer services, Cross Support Transfer Services, as well as services that transfer and operate on files of space data.

The Forward Space Internetworking and Return Space Internetworking FGs represent functions performed to transfer internetwork data across the space link as part of an end-to-end internetwork data transfer. IOAG Service Catalog #1 does not include internetwork

services – those are covered by Service Catalog #2. These FGs are included in the set of ESLT FGs for completeness.

Because the SCCS FGs are abstract, they do not have specific management parameters, monitored parameters, notifiable events and real-time control parameters. An SCCS FG must be *specialized* for a given technology before an appropriate set of parameters and notifiable events can be defined. For each specialization of the FG, a set of Functional Resource Types is defined for that specialization. The specialization of the FG also defines the relationships among the component FR Types, and which of those FR Types implement the extension point interfaces of the FG.

Figure 3-2 illustrates the relationships between the CSRM Return Space Link Processing FG, the specialized SCCS FGs that collectively perform its functions, the FR Types that comprise those specialized SCCS FGs, and instances of those FR Types. Note that the figure does not illustrate all possible FR Types that comprise the FGs, only those that perform the functions that were allocated to the original CSRM Return Space Link Processing FG.

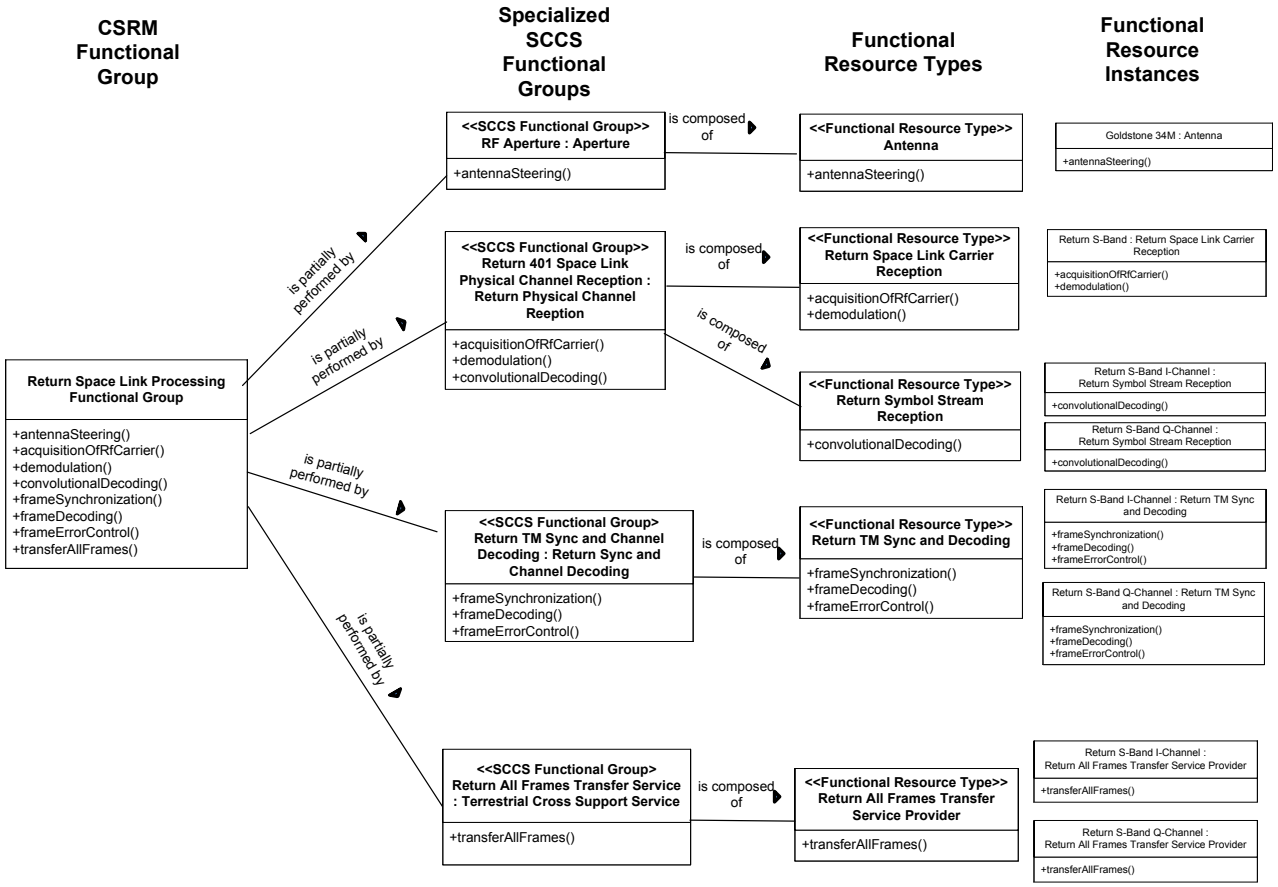

Figure 3-2: Relationships among CSRM Functional Group, SCCSM Functional Groups, Functional Resource Types, and Functional Resource Instances

4 FUNCTIONAL RESOURCE TYPES FOR ESLT FUNCTIONAL GROUPS

This section describes the Functional Resource Types that are performed by ESLTs. Primarily, these Functional Resource Types are the ones that are performed in providing of IOAG Service Catalog 1 services. However, several other FR Types – corresponding to IOAG Service Catalog 2 services and another future service – are also described to illustrate how future capabilities can be accommodated.

Figure 4-1 depicts the Functional Resource Types for specializations of the Functional Groups identified in.3. The FR Types in the diagram are color-coded to identify the major category of the FGs to which they belong. The future FR Types that correspond to non-IOAG Service Catalog 1 services are indicated by dashed boxes.

In this section, the Functional Resource Types are organized by the specialized FGs to which they belong. Section 6 describes each IOAG Service Catalog 1 service in terms of its component functional resource types. For each Functional Resource Type, the corresponding Functional Resource Type Object Identifier is listed and the pertinent CCSDS Recommended Standard is identified. If applicable, the associated Functional Group from the Cross Support Reference Model is also identified.

The Functional Resource Type OIDs are registered under the crossSupportFunctionalities branch of the CCSDS Object Identifier Tree, whch is specified in [4] as:

```
{ iso  identified-organization(3) standards-producing-
organization(112)  ccsds(4) css(4)  crossSupportResources(2)
crossSupportFunctionalities(1)}
```

4.1 APERTURE FUNCTIONAL GROUP

4.1.1 RF APERTURE SPECIALIZATION OF THE APERTURE FUNCTIONAL GROUP

The RF Aperture specialization of the Aperture FG consists of the Antenna FR Type.

4.1.1.1 Antenna

The OID of the Antenna type is {crossSupportFunctionalities antenna (1)}.

One antenna can be used by multiple forward and/or return space links simultaneously. The Antenna FR Type also encompasses the tracking receiver used to lock onto the RF signal for the purposes of autotracking.

With respect to the Cross Support Reference Model, the Antenna functions are performed by the Return Space Link Process, Forward AOS Space Link Processing, and Forward TC Space Link Processing Functional Groups.

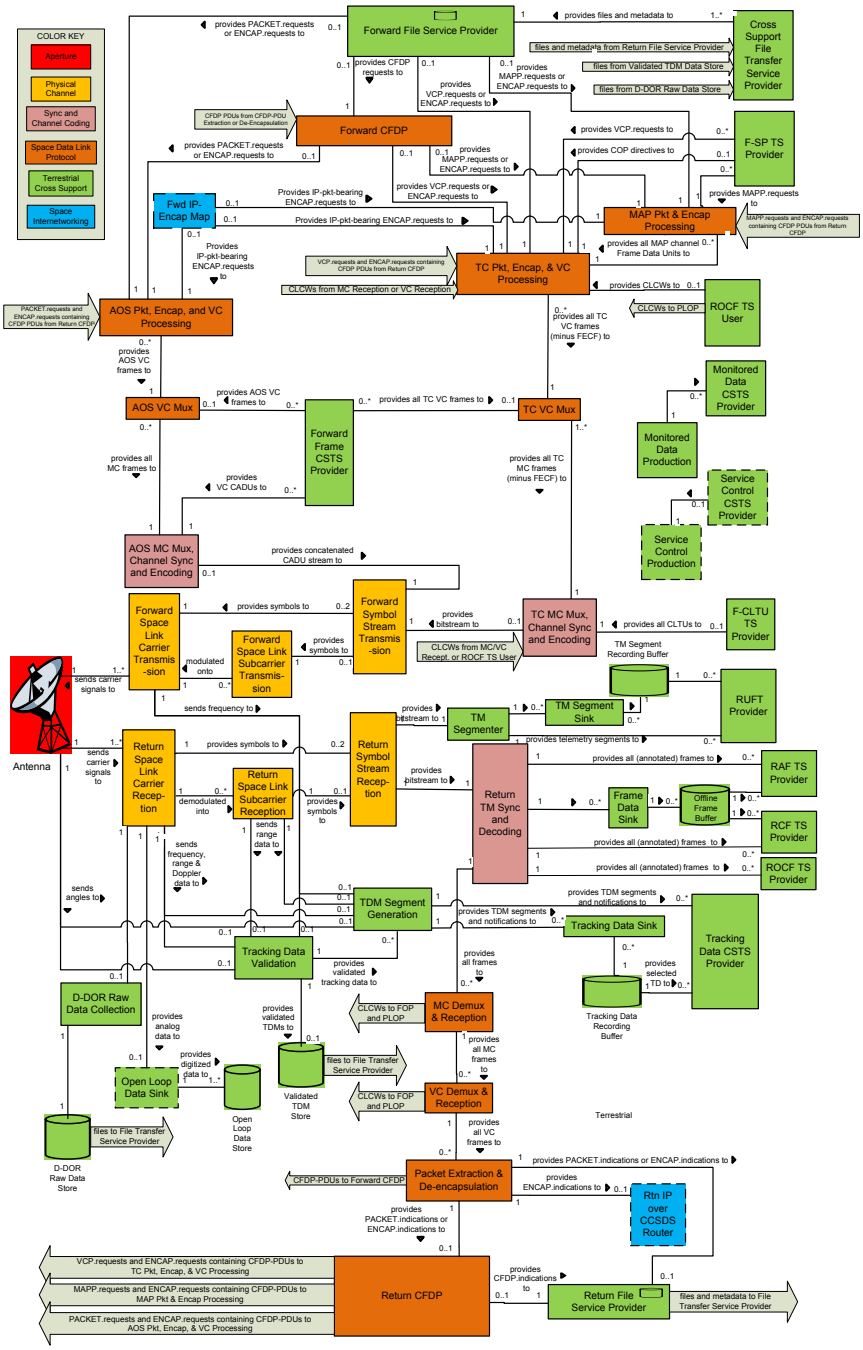

Figure 4-1: Functional Resource Types for IOAG Service Catalog 1

4.2 FORWARD PHYSICAL CHANNEL FUNCTIONAL GROUP

4.2.1 CCSDS 401 SPECIALIZATION OF THE FORWARD PHYSICAL CHANNEL FUNCTIONAL GROUP

The FR Types that compose the CCSDS 401 specialization of the Forward Physical Channel Transmission FG are:

a) Forward Space Link Carrier Transmission;

b) Forward Space Link Subcarrier Transmission;

c) Forward Link Ranging;

d) Forward Symbol Stream Transmission.

4.2.1.1 Forward Space Link carrier Transmission

The OID of the Forward Space Link Carrier Transmission FR Type is {crossSupportFunctionalities fwdSpaceLinkCarrierTransmission (2)}.

[Author's Note – a description of how this relates to the relevant CCSDS standards is still needed].

With respect to the Cross Support Reference Model, the Forward Space Link Carrier Transmission functions are performed by the Forward AOS Space Link Processing and Forward TC Space Link Processing Functional Groups.

4.2.1.2 Forward Space Link Subcarrier Transmission

The OID of the Forward Space Link Subcarrier Transmission FR Type is {crossSupportFunctionalities fwdSpaceLinkCarrierTransmission (3)}.

[Author's Note – a description of how this relates to the relevant CCSDS standards is still needed].

With respect to the Cross Support Reference Model, the Forward Space Link Carrier Transmission functions are performed by the Forward AOS Space Link Processing and Forward TC Space Link Processing Functional Groups.

4.2.1.3 Forward Link ranging

The OID of the Forward Link Ranging FR Type is

{crossSupportFunctionalities fwdLinkRanging (4)}.

NOTE – The author of this technical note does not have a good understanding of this functional resource type, how it relates to the carrier and/or subcarrier, and whether its parameters can be allocated instead to some combination of the carrier or subcarrier. It is not included in the current version of figure 3-1.

With respect to the Cross Support Reference Model, the Forward Link Ranging functions are performed by the Forward AOS Space Link Processing and Forward TC Space Link Processing Functional Groups.

4.2.1.4 Forward Symbol Stream Transmission

The OID of the Forward Symbol Stream Transmission FR Type is {crossSupportFunctionalities fwdSymbolStreamTransmission (5)}.

[Author's Note – a description of how this relates to the relevant CCSDS standards is still needed].

The Forward Symbol Stream Transmission functional resource type also implements optional convolutional encoding, which is formally defined in TM Synchronization and Channel Coding [6].

With respect to the Cross Support Reference Model, the Forward Symbol Stream Transmission functions are performed by the Forward AOS Space Link Processing and Forward TC Space Link Processing Functional Groups.

4.3 FORWARD SYNCHRONIZATION AND CHANNEL ENCODING FG

4.3.1 TC SYNC AND CHANNEL ENCODING SPECIALIZATION OF THE FORWARD SYNCHRONIZATION AND CHANNEL ENCODING FG

The TC Sync and Channel Encoding specialization of the Forward Sync and Channel Encoding FG consists of the TC MC Multiplexing, Channel Synchronization and Encoding FR Type.

4.3.1.1 TC MC Multiplexing, Channel Synchronization, and Encoding

There is currently no separate FR Type OID assigned to the TC MC Multiplexing, Channel Synchronization and Encoding FR Type. However, its monitored parameters are currently listed as being available via the Forward CLTU Transfer Service (TS) Provider and Forward Space Packet TS Provider FR Types.

The TC MC Multiplexing, Channel Synchronization and Encoding FR Type corresponds to the following functions:

a) the Physical Layer Operations Procedure (PLOP) as specified in the TC Synchronization and Channel Coding Recommended Standard. With respect to the Cross Support Reference Model, the PLOP is performed by the Forward TC Space Link Processing Functional Group;
b) the (optional) frame randomization, BCH encoding, and CLTU generation functions specified in the TC Synchronization and Channel Coding Recommended Standard. With respect to the Cross Support Reference Model, these functions are performed by the Forward CLTU Generation Functional Group; and

c) the All Frames Generation frame error control function and the Master Channel (MC) Multiplexing function of the TC Space Data Link Protocol Recommended Standard. With respect to the Cross Support Reference Model, these functions are performed by the Forward TC VC Data Insertion Functional Group.

NOTE - It may also be possible to further combine the functionality of the TC VC Multiplexing FR Type into the TC MC Multiplexing, Channel Synchronization and Encoding FR Type, resulting in a TC Global VC (GVC) Multiplexing, Channel Synchronization and Encoding FR Type. This would be possible if the same multiplexing scheme can be applied across all VCs of all MCs in the same All Frames channel. The separation of MC and VC Multiplexing functions in the TC Space Data Link Protocol Recommended Standard allows the theoretical possibility of applying different multiplexing schemes to the VCs of different MCs, and still a different multiplexing scheme to the MCs being multiplexed into the All Frames channel. If this flexibility is not necessary, then the aforementioned combination can occur.

4.3.2 AOS FORWARD SYNC AND CHANNEL ENCODING SPECIALIZATION OF THE FORWARD SYNCHRONIZATION AND CHANNEL ENCODING FG

The AOS Forward Sync and Channel Encoding specialization of the Forward Sync and Channel Encoding FG consists of the AOS MC Multiplexing, Channel Synchronization and Encoding FR Type.

4.3.2.1 AOS MC Multiplexing, Channel Synchronization and Encoding FR Type

There is currently no separate FR Type OID assigned to the AOS MC Multiplexing, Channel Synchronization and Encoding FR Type.

The AOS MC Multiplexing, Channel Synchronization and Encoding FR Type corresponds to the following functions:

a) the multiplexing and idle data unit insertion that is nominally specified in the AOS Space Data Link Recommended Standard to be performed on transfer frames. In the IOAG service set, these functions are performed on already-coded and synch-markered channel access data units (CADUs) instead, in order to provide the CADU mode of the Forward Frames CSTS. The resultant waveform on the space link carrier is the same as that produced by conformance to the AOS Space Data Link Protocol and TM Synchronization and Channel Coding Recommended Standards. With respect to the Cross Support Reference Model, these functions are performed by the Forward AOS Space Link Processing Functional Group;
b) the (optional) frame randomization, block (Reed Solomon, Turbo, or LDPC) encoding, and frame synchronization marker attachment functions specified in the TM Synchronization and Channel Coding Recommended Standard. With respect to the Cross Support Reference Model, these functions are performed by the Forward AOS Space Link Processing Functional Group;

c) the All Frames Generation frame error control function and the MC Multiplexing function of the AOS Space Data Link Protocol Recommended Standard. With respect to the Cross Support Reference Model, these functions are performed by the Forward AOS VC Data Insertion Functional Group.

NOTES

1 It may also be possible to further combine the functionality of the TM VC Multiplexing FR Type into the AOS MC Multiplexing, Channel Synchronization and Encoding FR Type, resulting in a AOS Global VC (GVC) Multiplexing, Channel Synchronization and Encoding FR Type. This would be possible if the same multiplexing scheme can be applied across all VCs of all MCs in the same All Frames channel. The separation of MC and VC Multiplexing functions in the AOS Space Data Link Protocol Recommended Standard allows the theoretical possibility of applying different multiplexing schemes to the VCs of different MCs, and still a different multiplexing scheme to the MCs being multiplexed into the All Frames channel. If this flexibility is not necessary, then the aforementioned combination can occur.

2 The AOS All Frames Generation represented by the AOS MC Multiplexing, Channel Synchronization and Encoding FR Type is also the insertion point for Insert service data units. If the Insert SLE transfer service (or an equivalent CSTS) were ever to be implemented, its functionality would be added to the AOS MC Multiplexing and Error Control Functional Resource Type.

4.4 FORWARD SPACE LINK PROTOCOL FG

4.4.1 TC SPACE LINK PROTOCOL SPECIALIZATION OF THE FORWARD SPACE LINK PROTOCOL FG

The FR Types that compose the TC Space Link Protocol specialization of the Forward Space Link Protocol FG are:

a) TC Virtual Channel (VC) Multiplexing;

b) TC Packetization, Encapsulation, and VC Processing;

c) Multiplexer Access Point (MAP) Packet and Encapsulation Processing;

d) Forward CCSDS File Transfer Protocol (CFDP) over TC.

4.4.1.1 TC Virtual Channel (VC) Multiplexing

There is currently no separate FR Type OID assigned to the TC Virtual Channel (VC) Multiplexing FR Type. However, its monitored parameters are currently listed as being available via the Forward Space Packet TS Provider FR Type.

The TC VC Multiplexing FR Type corresponds to the Virtual Channel Multiplexing function of the TC Space Data Link Protocol Recommended Standard. With respect to the Cross

Support Reference Model, the TC VC Multiplexing FR Type and the corresponding Virtual Channel Multiplexing function are performed by the Forward TC VC Data Insertion SLE Functional Group.

NOTE - See the NOTE in ???.

4.4.1.2 TC Packetization, Encapsulation, and VC Processing

There is currently no separate FR Type OID assigned to the TC Packetization, Encapsulation, and VC Processing FR Type. However, its monitored parameters are currently listed as being available via the Forward Space Packet TS Provider FR Type.

The TC Packetization, Encapsulation, and VC Processing FR Type corresponds to the following functions:

a) the Virtual Channel Generation function of the TC Space Data Link Protocol Recommended Standard and the Frame Operation Procedure-1 (FOP-1) of the Communications Operation Procedure-1 Recommended Standard;
b) the VC Packet Processing function of the TC Space Data Link Protocol Recommended Standard;
c) the MAP Multiplexing function of the TC Space Data Link Protocol Recommended Standard; and
d) the Encapsulation function of the Encapsulation Recommended Standard. In this FR Type, the encapsulation occurs directly into TC VCs.

With respect to the Cross Support Reference Model, these functions are performed by the Forward TC VC Data Insertion SLE Functional Group, except for the Encapsulation function, which is outside the scope of the Cross Support Reference Model.

4.4.1.3 Multiplexer Access Point (MAP) Packet and Encapsulation Processing

There is currently no separate FR Type OID assigned to the TC Packetization, Encapsulation, and VC Processing FR Type. However, its monitored parameters are currently listed as being available via the Forward Space Packet TS Provider FR Type.

The Multiplexer Access Point (MAP) Packet and Encapsulation Processing FR Type corresponds to the following functions:

a) the MAP Packet Processing function of the TC Space Data Link Protocol Recommended Standard. With respect to the Cross Support Reference Model, this function is performed by the Forward TC VC Data Insertion SLE Functional Group; and
b) the Encapsulation function of the Encapsulation Recommended Standard. In this FR Type, the encapsulation occurs into MAP packets. The Encapsulation function is outside the scope of the Cross Support Reference Model.

4.4.1.4 Forward CFDP over TC

There is currently no FR Type OID assigned to the Forward CFDP over TC FR Type.

The Forward CFDP over TC FR Type corresponds to the Sending Entity Core Delivery procedures of the CFDP Recommended Standard. CFDP is outside the scope of the Cross Support Reference Model.

4.4.2 FORWARD AOS SPACE LINK PROTOCOL SPECIALIZATION OF THE FORWARD SPACE LINK PROTOCOL FG

The FR Types that compose the Forward AOS Space Link Protocol specialization of the Forward Space Link Protocol FG are:

a) AOS VC Multiplexing;

b) AOS Packetization, Encapsulation, and VC Processing;

c) Forward CFDP over AOS.

4.4.2.1 AOS VC Multiplexing

There is currently no FR Type OID assigned to the AOS VC Multiplexing FR Type.

The AOS VC Multiplexing FR Type corresponds to the Virtual Channel Multiplexing function of the AOS Space Data Link Protocol Recommended Standard. With respect to the Cross Support Reference Model, this function is performed by the Forward AOS VC Data Insertion SLE Functional Group.

Comment [JP2]: Or in the SL Processing FG? Check also for TC.

NOTE - See the NOTE in ???.

4.4.2.2 AOS Packetization, Encapsulation, and VC Processing

There is currently no FR Type OID assigned to the AOS Packetization, Encapsulation, and VC Processing FR Type.

The AOS Packetization, Encapsulation, and VC Processing FR Type corresponds to the following functions:

a) the Virtual Channel Generation function of the AOS Space Data Link Protocol Recommended Standard:
b) the Packet Processing function of the AOS Space Data Link Protocol Recommended Standard;
c) the Encapsulation function of the Encapsulation Recommended Standard. In this FR Type, the encapsulation occurs into AOS VCs.

With respect to the Cross Support Reference Model, these functions are performed by the Forward AOS VC Data Insertion SLE Functional Group, except for the Encapsulation function, which is outside the scope of the Cross Support Reference Model.

4.4.2.3 Forward CFDP over AOS

There is currently no FR Type OID assigned to the Forward CFDP over AOS FR Type.

The Forward CFDP over AOS FR Type corresponds to the Sending Entity Core Delivery procedures of the CFDP Recommended Standard. CFDP is outside the scope of the Cross Support Reference Model.

4.5 RETURN PHYSICAL CHANNEL RECEPTION FG

4.5.1 CCSDS 401 SPECIALIZATIONOF THE RETURN PHYSICAL CHANNEL RECEPTION FG

The FR Types that compose the CCSDS 401 specialization of the Return Physical Channel Reception FG are:

a) Return Space Link Carrier Reception;

b) Return Space Link Subcarrier Reception;

c) Return Symbol Stream Reception.

4.5.1.1 Return Space Link carrier Reception

The OID of the Return Space Link Carrier Reception FR Type is {crossSupportFunctionalities rtnSpaceLinkCarrierReception (8)}.

[Author's Note – a description of how this relates to the relevant CCSDS standards is still needed].

NOTE - This FR Type includes the range and Doppler extraction functionality (and therefor the associated monitored parameters) currently assigned to the Range and Doppler Extraction FR Type ({crossSupportFunctionalities (12)}) in the current Candidate Monitored Parameters spreadsheet.

With respect to the Cross Support Reference Model, the Return Space Link Carrier Reception functions are performed by the Return Space Link Processing Functional Group.

4.5.1.2 Return Space Link Subcarrier Reception

The OID of the Return Space Link Subcarrier Reception FR Type is {crossSupportFunctionalities rtnSpaceLinkSubcarrierReception (9)}.

[Author's Note – a description of how this relates to the relevant CCSDS standards is still needed].

With respect to the Cross Support Reference Model, the Return Space Link Subcarrier Reception functions are performed by the Return Space Link Processing Functional Group.

4.5.1.3 Return Symbol Stream Reception

The OID of the Return Symbol Stream Reception FR Type is {crossSupportFunctionalities rtnSymbolStreamReception (10)}.

[Author's Note – a description of how this relates to the relevant CCSDS standards is still needed].

The Return Symbol Stream also implements optional convolutional decoding, which is formally defined in TM Synchronization and Channel Coding [6].

With respect to the Cross Support Reference Model, the Return Space Link Subcarrier Reception functions are performed by the Return Space Link Processing Functional Group.

4.6 RETURN SYNCHRONIZATION AND CHANNEL DECODING FG

4.6.1 RETURN TM SYNCHRONIZATION AND CHANNEL DECODING SPECIALIZATION OF THE RETURN SYNCHRONIZATION AND CHANNEL DECODING FG

The Return TM Sychronization and Channel Decoding specialization of the Return Sychronization and Channel Decoding FG consists of the Return TM Synchronization and Decoding FR Type.

4.6.1.1 Return TM Synchronization and Decoding

The OID of the Return TM Synchronization and Decoding FR Type is {crossSupportFunctionalities rtnSynchAndDecode (11)}.

The Return TM Synchronization and Decoding FR Type corresponds to the frame synchronization, optional frame de-randomization, and block decoding (Reed Solomon, Turbo, or LDPC) functions specified in the TM Synchronization and Channel Coding Recommended Standard. It also includes the Frame Error Control functions specified in the TM Space Data Link Protocol and AOS Space Data Link Protocol Recommended Standards and the Frame Header Error Control function specified in the AOS Space Data Link Protocol Recommended Standard.

With respect to the Cross Support Reference Model, the functions corresponding to the Return Synchronization and Decoding FR Type are performed by the Return Space Link Processing Functional Group.

4.7 RETURN SPACE LINK PROTOCOL FG

4.7.1 RETURN TM/AOS SPACE LINK PROTOCOL SPECIALIZATION OF THE RETURN SPACE LINK PROTOCOL FG

The FR Types that compose the Return TM/AOS Space Link Protocol specialization of the Return TM/AOS Space Link Protocol FG are:

a) MC Demultiplexing and Reception;

b) VC Demultiplexing and Reception;

c) Packet Extraction and De-encapsulation;

d) Return CFDP.

4.7.1.1 MC Demultiplexing and Reception

There is currently no FR Type OID assigned to the MC Demultiplexing and Reception FR Type.

The MC Demultiplexing and Reception FR Type corresponds to the MC Demultiplexing and All Frames Reception functions of the TM Space Data Link Protocol and AOS Space Data Link Protocol Recommended Standards. With respect to the Cross Support Reference Model, these functions are performed by the Return Frame Processing Functional Group.

NOTE - AOS Space Data Link Protocol Recommended Standard does not include the MC Reception function.

4.7.1.2 VC Demultiplexing and Reception

There is currently no FR Type OID assigned to the VC Demultiplexing and Reception FR Type.

The VC Demultiplexing and Reception FR Type corresponds to the VC Demultiplexing and VC Reception functions of the TM Space Data Link Protocol and AOS Space Data Link Protocol Recommended Standards. With respect to the Cross Support Reference Model, functions are performed by the Return Frame Processing Functional Group.

4.7.1.3 Packet Extraction and De-encapsulation

There is currently no FR Type OID assigned to the Packet Extraction and De-encapsulation FR Type.

The Packet Extraction and De-encapsulation FR Type corresponds to the Packet Extraction function of the TM Space Data Link Protocol and AOS Space Data Link Protocol Recommended Standards and the De-encapsulation function of the Encapsulation Service Recommended Standard. With respect to the Cross Support Reference Model, the Packet Extraction function is performed by the Return Frame Data Extraction Functional Group, and the De-encapsulation function is outside the scope of the Cross Support Reference Model, (although logically it could be added to the Return Frame Data Extraction Functional Group).

4.7.1.4 Return CFDP

There is currently no FR Type OID assigned to the Return CFDP FR Type.

The Return CFDP FR Type corresponds to the Receiving Entity Core Delivery procedures of the CFDP Recommended Standard. The CFDP Receiving Entity Core Delivery procedures and the Return CFDP FR Type are outside the scope of the Cross Support Reference Model.

4.8 TERRESTRIAL CROSS SUPPORT SERVICE FG

4.8.1 SLE FORWARD SPACE PACKET SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The SLE Forward Space Packet (F-SP) specialization of the Terrestrial Cross Support Service FG consists of the F-SP Transfer Service Provider FR Type.

4.8.1.1 F-SP Transfer Service Provider

The OID of the FSP TS Provider FR Type is {crossSupportFunctionalities fspTsProvider (7)}.

The FSP TS Provider FR Type corresponds to the functions specified in the SLE Forward Space Packet Service Specification Recommended Standard.

With respect to the Cross Support Reference Model, the functions corresponding to the FSP TS Provider FR Type are performed by the Forward TC VC Data Insertion Functional Group.

4.8.2 SLE FORWARD CLTU SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The SLE Forward CLTU specialization of the Terrestrial Cross Support Service FG consists of the F-CLTU Transfer Service Provider FR Type.

4.8.2.1 F-CLTU Transfer Service Provider

The OID of the FCLTU TS Provider FR Type is {crossSupportFunctionalities fcltuTsProvider (6)}.

The FCLTU TS Provider FR Type corresponds to the functions specified in the SLE Forward CLTU Service Specification Recommended Standard.

With respect to the Cross Support Reference Model, the functions corresponding to the FCLTU TS Provider FR Type are performed by the Forward TC Space Link Processing Functional Group.

4.8.3 SERVICE CONTROL CSTS SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The FR Types that compose the Return All Frames (RAF) specialization of the Terrestrial Cross Support Service FG are:

a) Service Control CSTS Provider FR Type;
b) Service Control Production.

4.8.3.1 Service Control CSTS Provider

The OID of the Service Control CSTS Provider FR Type is {crossSupportFunctionalities scCstsProvider (20)}.

The Service Control CSTS Provider FR Type corresponds to the functions to be specified in a future Service Control CSTS Specification Recommended Standard.

The Service Control CSTS Provider FR Type and the Service Control CSTS are outside the scope of the Cross Support Reference Model.

4.8.3.2 Service Control Production

There is currently no FR Type OID assigned to the Service Control Production FR Type.

Service Control Production constitutes the production functions associated with the Service Control CSTS.

The Service Control Production FR Type corresponds to the Service Control Production functions to be defined in the future Service Control CSTS Recommended Standard.

The Service Control Production FR Type and the Service Control Production functions are outside the scope of the Cross Support Reference Model.

4.8.4 FORWARD FRAMES CSTS SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The Forward Frames CSTS specialization of the Terrestrial Cross Support Service FG consists of the Forward Frames CSTS Provider FR Type.

4.8.4.1 Forward Frames CSTS Provider

There is currently no FR Type OID assigned to the Forward Frames CSTS Provider FR Type.

The Forward Frames CSTS Provider FR Type corresponds to the functions to be specified in a future Forward Frames CSTS Specification Recommended Standard.

The Forward Frames CSTS Provider FR Type and the Forward Frames CSTS are outside the scope of the Cross Support Reference Model.

4.8.5 CROSS SUPPORT FILE TRANSFER SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The Cross Support File Transfer specialization of the Terrestrial Cross Support Service FG consists of the Cross Support File Transfer Provider FR Type.

NOTE - As of the writing of this Technical Note, the Cross Support File Transfer Service has not been defined, but it is assumed to be bidirectional (forward and return).

4.8.5.1 Cross Support File Transfer Provider

There is currently no FR Type OID assigned to the Cross Support File Transfer Service Provider FR Type.

The Cross Support File Transfer Provider) FR Type corresponds to the functions to be specified in a future Cross Support File Transfer Specification Recommended Standard.

The Cross Support File Transfer Service Provider FR Type and the Cross Support File Transfer service are outside the scope of the Cross Support Reference Model.

4.8.6 FORWARD FILE SERVICE SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The Forward File Service specialization of the Terrestrial Cross Support Service FG consists of the Forward File Service Provider FR Type.

4.8.6.1 Forward File Service Provider

There is currently no FR Type OID assigned to the Forward File Service Provider FR Type.

The Forward File Service Provider FR Type corresponds to the functions to be specified in a future Forward File Service Specification Recommended Standard.

The Forward File Service Provider FR Type and the Forward File service are outside the scope of the Cross Support Reference Model.

4.8.7 SLE RETURN ALL FRAMES SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The FR Types that compose the Return All Frames (RAF) specialization of the Terrestrial Cross Support Service FG are:

a) RAF TS Provider;
b) Frame Data Sink;
c) Offline Frame Buffer.

Comment [JP3]: The data sinks may disappear.

4.8.7.1 RAF TS Provider

The OID of the RAF TS Provider FR Type is

{crossSupportFunctionalities rafTsProvider (13)}.

The RAF TS Provider FR Type corresponds to the functions specified in the SLE Return All Frames Service Specification Recommended Standard.

With respect to the Cross Support Reference Model, the functions corresponding to the RAF TS Provider FR Type are performed by the Return Space Link Processing Functional Group.

4.8.7.2 Frame Data Sink

The OID of the Frame Data Sink FR Type is

{crossSupportFunctionalities frameDataSink (22)}.

The Frame Data Sink FR Type comprises the functions performed during the Space Link Session to ensure that return transfer frames are recorded in a specific instance of the Offline Frame Buffer type. The Frame Data Sink FR Type corresponds to the Frame Data Sink managed object defined in the Space Communication Cross Support Service Management Service Specification Recommended Standard.

With respect to the Cross Support Reference Model, the functions corresponding to the Frame Data Sink FR Type are performed by the Return Space Link Processing Functional Group.

4.8.7.3 Offline Frame Buffer

There is currently no FR Type OID assigned to the Offline Frame Buffer FR Type.

The Offline Frame Buffer is a repository of return transfer frames that are subsequently retrieved by offline (SLE) transfer service instances that carry transfer frames or space link data units that have been transferred across the space link within those transfer frames.

The Offline Frame Buffer FR Type corresponds to the Offline Frame Buffer production entities defined in the SLE RAF, RCF, and ROCF Service Specification Recommended Standard.

With respect to the Cross Support Reference Model, the functions corresponding to the Offline Frame Buffer FR Type are performed by the Return Space Link Processing Functional Group.

NOTE - The Offline Frame Buffer for a given symbol stream may be shared by multiple offline RAF TS and/or Return Channel Frame TS service instances.

4.8.8 SLE RETURN CHANNEL FRAMES SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The FR Types that compose the Return Channel Frames (RCF) specialization of the Terrestrial Cross Support Service FG are:

a) RCF TS Provider;
b) Frame Data Sink;
c) Offline Frame Buffer.

Comment [JP4]: The data sinks may disappear.

NOTE - The Offline Frame Buffer for a given symbol stream may be shared by multiple offline RAF TS and/or RCF TS service instances.

4.8.8.1 RCF TS Provider

The OID of the RCF TS Provider FR Type is

{crossSupportFunctionalities rcfTsProvider (14)}.

The RCF TS Provider FR Type corresponds to the functions specified in the SLE Return Channel Frames Service Specification Recommended Standard.

With respect to the Cross Support Reference Model, the functions corresponding to the RCF TS Provider FR Type are performed by the Return Frame Processing Functional Group.

4.8.8.2 Frame Data Sink

See 4.8.7.2.

4.8.8.3 Offline Frame Buffer

See 4.8.7.3.

4.8.9 SLE RETURN OPERATIONAL CONTROL FIELDS SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The Return Operational Control Fields (ROCF) specialization of the Terrestrial Cross Support Service FG consists of the ROCF Transfer Service Provider.

4.8.9.1 ROCF Transfer Service Provider

The OID of the ROCF TS Provider FR Type is

{crossSupportFunctionalities rcfTsProvider (15)}.

The ROCF TS Provider FR Type corresponds to the functions specified in the SLE Return Operational Control Fields Service Specification Recommended Standard.

With respect to the Cross Support Reference Model, the functions corresponding to the ROCF TS Provider FR Type are performed by the Return Frame Processing Functional Group.

4.8.10 RETURN UNFRAMED TELEMETRY SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The FR Types that compose the Return Unframed Telemetry (RUFT) specialization of the Terrestrial Cross Support Service FG are:

a) RUFT CSTS Provider;
b) Telemetry Segmenter;
c) Telemetry Segment Sink;
d) Telemetry Segment Recording Buffer.

Comment [JP5]: TM Segmenter may disappear if no independent parameters or events are exposed that cannot be attributed to other FG Types.

Comment [JP6]: TM Segment Sink may disappear if no independent parameters or events are exposed that cannot be attributed to other FG Types.

4.8.10.1 RUFT CSTS Provider

There is currently no FR Type OID assigned to the Forward File Provider FR Type.

The RUFT CSTS Provider FR Type corresponds to the functions to be specified in the future RUFT CSTS Recommended Standard.

The RUFT CSTS Provider FR Type and the RUFT CSTS were not included in the Cross Support Reference Model, but logically they belong to the Return Space Link Processing Functional Group.

4.8.10.2 Telemetry Segmenter

Comment [JP7]: TM Segmenter may disappear if no independent parameters or events are exposed that cannot be attributed to other FG Types.

NOTE - An alternative formulation would be to cast the TM Segmenter as a Return Sync and Coding type, but (at least for now) that class should be restricted to functions that trigger on the data content of the data stream. By definition, RUFT delivers data streams that have no recognizable data structure (or, more accurately, data streams for which no data structure is used to demarcate the segments to be delivered).

There is currently no FR Type OID assigned to the Telemetry Segmenter FR Type.

The Telemetry Segmenter constitutes the production functions associated with segmenting unframed telemetry streams for delivery via real-time and complete RUFT CSTS instances.

The Telemetry Segmenter FR Type corresponds to the Telemetry Segmenter production function to be defined in the future RUFT CSTS Recommended Standard.

The Telemetry Segmenter FR Type and the Telemetry Segmenter production functions are outside the scope of the Cross Support Reference Model.

4.8.10.3 Telemetry Segment Sink

Comment [JP8]: TM Segment Sink may disappear if no independent parameters or events are exposed that cannot be attributed to other FG Types.

There is currently no FR Type OID assigned to the Telemetry Segment Sink FR Type.

The Telemetry Segment Sink constitutes the functions performed during the Space Link Session to ensure that unframed telemetry data segments [7] are recorded in a specific instance of the Telemetry Segment Recorded Buffer type.

The Telemetry Segment Sink FR Type corresponds to the Telemetry Segment Sink managed object to be defined in a future version of the Extensible Space Communication Cross Support Service Management Service Specification Recommended Standard.

The Telemetry Segment Sink is outside the scope of the Cross Support Reference Model, although logically it would be performed by the Return Space Link Processing Functional Group.

4.8.10.4 Telemetry Segment Recording Buffer

There is currently no FR Type OID assigned to the Telemetry Segment Recording Buffer FR Type.

The Telemetry Segment Recording Buffer is a repository of unframed data segments that are subsequently retrieved by complete RUFT CSTS instances.

The Telemetry Segment Recording Buffer FR Type corresponds to the Recording Buffer production entity to be defined in the future RUFT CSTS Recommended Standard.

The TM Segment Recording Buffer is outside the scope of the Cross Support Reference Model.

4.8.11 REAL-TIME RADIO METRIC DATA SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

NOTE - The real-time radio metric data service may also be used to deliver tracking data after the conclusion of the pass. However, the tracking data measurements will have been sampled at a defined rate.

The FR Types that compose the Real-Time Radio Metric Data specialization of the Terrestrial Cross Support Service FG are:

a) Tracking Data CSTS Provider;
b) TDM Segment Generation;
c) Tracking Data Sink;
d) Tracking Data Recording Buffer.

Comment [JP9]: TDM Segment Generation may disappear if no independent parameters or events are exposed that cannot be attributed to other FG Types.

Comment [JP10]: Tracking Data Sink may disappear if no independent parameters or events are exposed that cannot be attributed to other FG Types.

4.8.11.1 Tracking Data CSTS Provider

The OID of the Tracking Data CSTS Provider FR Type is

{crossSupportFunctionalities tdCstsProvider (19)}.

The Tracking Data CSTS Provider FR Type corresponds to the functions specified in the draft Tracking Data CSTS Recommended Standard.

The Tracking Data CSTS Provider FR Type and the Tracking Data CSTS are outside the scope of the Cross Support Reference Model.

4.8.11.2 TDM Segment Generation

There is currently no FR Type OID assigned to the TDM Segment Generation FR Type.

TDM Segment Generation constitutes the production functions associated with collecting angle measurements from the antenna, Doppler measurements from the return space link carrier, and range measurements from the return space link carrier, subcarrier, or symbol stream (depending in the ranging technology employed), and generating Tracking Data Message (TDM) segments containing those measurements.

The TDM Segment Generation FR Type corresponds to the TDM Segment Generation production functions defined in the draft Tracking Data CSTS Recommended Standard.

The TDM Segment Generation FR Type and the TDM Segment Generation production functions are outside the scope of the Cross Support Reference Model.

4.8.11.3 Tracking Data Sink

There is currently no FR Type OID assigned to the Tracking Data Sink FR Type.

The Tracking Data Sink constitutes the functions performed during the Space Link Session to ensure that tracking data segments [8] are recorded in a specific instance of the Tracking Data Recording Buffer type.

The Tracking Data Sink FR Type corresponds to the Tracking Data Sink managed object to be defined in a future version of the Extensible Space Communication Cross Support Service Management Service Specification Recommended Standard.

The Tracking Data Sink FR Type and the Tracking Data Sink managed object are outside the scope of the Cross Support Reference Model.

4.8.11.4 Tracking Data Recording Buffer

There is currently no FR Type OID assigned to the Tracking Data Recording Buffer FR Type.

The Tracking Data Recording Buffer is a repository of tracking data segments that are subsequently retrieved by Complete Tracking Data CSTS Provider instances

Comment [JP11]: TDM Segment Generation may disappear if no independent parameters or events are exposed that cannot be attributed to other FG Types.

The Tracking Data Recording Buffer FR Type corresponds to the Recording Buffer production entity defined in the Draft Tracking Data CSTS Recommended Standard.

The Tracking Data Recording Buffer FR Type and the Tracking Data Recording Buffer are outside the scope of the Cross Support Reference Model.

4.8.12 VALIDATED RADIO METRIC DATA SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The FR Types that compose the Validated Radio Metric Data specialization of the Terrestrial Cross Support Service FG are:

a) Tracking Data Validation
b) Validated TDM Store.

NOTE - The Validated Radio Metric Data specialization supports the delivery of validated radio metric data via file transfer when used with the Cross Support File Transfer Service Provider FR Type. It also supports the delivery of real-time validated tracking data when used with the Tracking Data CSTS Provider FR Type.

Comment [JP12]: Tracking Data Validation may disappear if no independent parameters or events are exposed that cannot be attributed to other FG Types..

4.8.12.1 Tracking Data Validation

Comment [JP13]: Tracking Data Validation may disappear if no independent parameters or events are exposed that cannot be attributed to other FG Types..

There is currently no FR Type OID assigned to the Tracking Data Validation FR Type.

Tracking Data Validation constitutes the production functions associated with validating raw tracking data prior to using it to generate Tracking Data Messages (TDMs) that are either transferred via the Tracking Data CSTS or stored for subsequent retrieval using the Cross Support File Transfer Service. .

There appears to be no standard definition or specification for "validated" tracking data.

The Tracking Data Validation FR Type and the Tracking Data Validation production functions are outside the scope of the Cross Support Reference Model.

4.8.12.2 Validated TDM Store

There is currently no FR Type OID assigned to the Validated TDM Store FR Type.

The Validated TDM Store constitutes a repository of validated TDMs.

The Validated TDM Store FR Type will presumably correspond to a Validated TDM Store production function to be defined in the future Validated Data Radio Metric Service Recommended Standard.

The Validated TDM Store FR Type and the Validated TDM Store production functions are outside the scope of the Cross Support Reference Model.

4.8.13 DELTA DIFFERENTIAL ONE-WAY RANGING SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The FR Types that compose the Delta Differential One-way Ranging (Delta DOR) specialization of the Terrestrial Cross Support Service FG are:

a) D-DOR Raw Data Collection;
b) D-DOR Raw Data Store.

NOTE - The D-DOR specialization supports the delivery of raw D-DOR data sets via file transfer. The full capability to delivery raw D-DOR data sets also includes Cross Support File Transfer Service Provider FR Type.

Comment [JP14]: D-DOR Raw Data Collection may disappear if no independent parameters or events are exposed that cannot be attributed to other FG Types

4.8.13.1 D-DOR Raw Data Collection

There is currently no FR Type OID assigned to the D-DOR Raw Data Collection FR Type.

D-DOR Raw Data Collection constitutes the production functions associated with collecting the .D-DOR raw data samples and organizing them in a format suitable for subsequent exchange and processing.

[Author's Note – Need to find out if there is a standard specification for this.]

The D-DOR Raw Data Collection FR Type and the D-DOR Raw Data Collection production functions are outside the scope of the Cross Support Reference Model.

4.8.13.2 D-DOR Raw Data Store

There is currently no FR Type OID assigned to the D-DOR Raw Data Store FR Type.

The D-DOR Raw Data Store constitutes the repository of D-DOR raw data samples that have been organized them in a format suitable for subsequent exchange and processing.

[Author's Note – Need to find out if there is a standard specification for this.]

The D-DOR Raw Data Store FR Type and the D-DOR Raw Data Store production functions are outside the scope of the Cross Support Reference Model.

4.8.14 MONITORED DATA SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The FR Types that compose the Monitored Data specialization of the Terrestrial Cross Support Service FG are:

a) Monitored Data CSTS Provider;
b) Monitored Data Production

Comment [JP15]: Monitored Data Production may disappear if no independent parameters or events are exposed that cannot be attributed to other FG Types

4.8.14.1 Monitored Data CSTS Provider

The OID of the Monitored Data CSTS Provider FR Type is

{crossSupportFunctionalities mdCstsProvider (17)}.

The Monitored Data CSTS Provider FR Type corresponds to the functions specified in the draft Monitored CSTS Recommended Standard.

The Monitored Data CSTS Provider FR Type and the Monitored Data CSTS are outside the scope of the Cross Support Reference Model.

4.8.14.2 Monitored Data Production

Comment [JP16]: Monitored Data Production may disappear if no independent parameters or events are exposed that cannot be attributed to other FG Types

There is currently no FR Type OID assigned to the Monitored Data Production FR Type.

Monitored Data Production constitutes the Data Collection production functions associated with collecting periodically-sampled monitored data values, receiving event notifications, and retrieving the current values of the Functional Resources that are operating during a Space Link Session.

The Monitored Data Production FR Type corresponds to the Data Collection production function identified in the draft Monitored Data CSTS Recommended Standard.

The Monitored Data Production FR Type and the TDM Data Collection production functions are outside the scope of the Cross Support Reference Model.

4.8.15 RETURN FILE SERVICE PROVIDER SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The Return File Service specialization of the Terrestrial Cross Support Service FG consists of the Return File Service Provider FR Type.

4.8.15.1 Return File Service Provider

There is currently no FR Type OID assigned to the Return File Service Provider FR Type.

The Return File Service Provider FR Type corresponds to the functions to be specified in a future Return File Service Specification Recommended Standard.

The Return File Service Provider FR Type and the Forward File service are outside the scope of the Cross Support Reference Model.

4.8.16 SLE ROCF TRANSFER SERVICE USER SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

The SLE ROCF Transfer Service User specialization of the Terrestrial Cross Support Service FG consists of the SLE ROCF Transfer Service User FR Type.

4.8.16.1 SLE ROCF Transfer Service User

There is currently no FR Type OID assigned to the SLE ROCF Transfer Service User FR Type.

This FR Type is used to get CLCWs from a different ESLT, e.g., for three way tracking and communication activities.

The SLE ROCF TS User FR Type corresponds to the user functions implied by the SLE Return Operational Control Fields Service Specification Recommended Standard.

With respect to the Cross Support Reference Model, the functions corresponding to the SLE ROCF TS User FR Type are performed by the Forward TC Space Link Processing Functional Group.

4.8.17 OPEN LOOP RECORDING SPECIALIZATION OF THE TERRESTRIAL CROSS SUPPORT SERVICE FG

NOTE - The Open Loop Recording specialization is intended to serve as a placeholder for what Wolfgang Hell has labeled “open loop recording”. There is apparently some overlap with D-DOR that needs to be further explored, but for the time being these FG Types will be kept in the model.

The FR Types that compose the Monitored Data specialization of the Terrestrial Cross Support Service FG are:

a) Open Loop Data Sink;

b) Open Loop Data Store.

4.8.17.1 Open Loop Data Sink

There is currently no FR Type OID assigned to the Open Loop Data Sink FR Type.

The Open Loop Data Sink constitutes the functions performed during the Space Link Session to ensure that open loop data are recorded in a specific instance of the Open Loop Data Store type.

The Open Loop Data Sink FR Type corresponds to the Open Loop Data Sink managed object to be defined in a future version of the Extensible Space Communication Cross Support Service Management Service Specification Recommended Standard.

The Open Loop Data Sink FR Type and the Open Loop Data Sink production functions are outside the scope of the Cross Support Reference Model.

4.8.17.2 Open Loop Data Store

There is currently no FR Type OID assigned to the Open Loop Data Store **FR Type.**

The Open Loop Data Store is a repository of open loop data.

[Author's Note – Need to find out if there is a standard specification for this.]

The Open Loop Data Store FR Type and the Open Loop Data Store production functions are outside the scope of the Cross Support Reference Model.

4.9 FORWARD SPACE INTERNETWORKING FUNCTIONAL GROUP

The Forward Space Internetworking FG will support IOAG Service Catalog 2 (reference [16]). An early, Agency-specific implementation of Internet Protocol (IP) over CCSDS is represented by the Forward IP over CCSDS specialization of the Forward Space Internetworking FG.

4.9.1 FORWARD IP OVER CCSDS SPECIALIZATION OF THE FORWARD SPACE INTERNETWORKING FUNCTIONAL GROUP

The Forward IP over CCSDS specialization of the Forward Space Internetworking FG consists of the Forward IP-VC Map FR Type.

4.9.1.1 Forward IP-VC Map

There is currently no FR Type OID assigned to the Forward IP-VC Map FR Type. However, given that it is (at least so far) an NASA-unique FR Type, it could be registered under the {crossSupportResources agenciesFunctionalities (2)} node of the registration tree.

The Forward IP-VC Map constitutes the functions of identifying which IP addresses are to be routed to which virtual channels

This FR Type corresponds to the IP Encapsulation over CCSDS service that is provided by the NASA Space Network Ground Segment Sustainment (SGSS) project.

4.10 RETURN SPACE INTERNETWORKING FUNCTIONAL GROUP

The Return Space Internetworking FG will support IOAG Service Catalog 2 (reference [16]). An early, Agency-specific implementation of Internet Protocol (IP) over CCSDS is represented by the Return IP over CCSDS specialization of the Return Space Internetworking FG.

4.10.1 RETURN IP OVER CCSDS SPECIALIZATION OF THE RETURN SPACE INTERNETWORKING FUNCTIONAL GROUP

The Return IP over CCSDS specialization of the Return Space Internetworking FG consists of the Return IP over CCSDS Extractor/Router FR Type.

4.10.1.1.1 Return IP over CCSDS Extractor/Router

There is currently no FR Type OID assigned to the Return IP over CCSDS Extractor/Router FR Type. However, given that it is (at least so far) an NASA-unique FR Type, it could be registered under the {crossSupportResources agenciesFunctionalities (2)} node of the registration tree.

The Return IP over CCSDS Extractor/Router constitutes the function of identifying which VCs bear IP traffic that needs to be extracted and routed to the Internet.

This FR Type corresponds to the IP Encapsulation over CCSDS service that is provided by the NASA Space Network Ground Segment Sustainment (SGSS) project.

5 FUNCTIONAL RESOURCES AND SCCS FUNCTIONAL GROUPS IN SERVICE TEMPLATES AND SERVICE PROFILES

Functional Resources and SCCS FGs are used to represent the data delivery services and radio metric services that are performed by ESLTs on behalf of User missions. The terms *data delivery service* and *radio metric service* are adopted from IOAG Service Catalog #1 [9]. A *forward data delivery service* comprises the space link and terrestrial link functions that receive data from the User of that data delivery service, process the data, and modulate the data on a carrier that is radiated to the target User Space Node. A *return data delivery service* comprises the space link and terrestrial link functions that receive a carrier signal from the User Space Node, demodulate the carrier, process the data, and transfer the data to the User of that data delivery service. A *radio metric service* comprises the space link and terrestrial link functions that receive a carrier signal from a User Space Node, derive radio metric measurements from the carrier, process the radio metric data, and transfer the radio metric data to the User of that radio metric service.

Forward data delivery, return data delivery, and radio metric are not specific services but rather *service groups*. Specific services in these groups are formed by specific combinations of space link and terrestrial cross support functionality. Corresponding to each of these service groups is a *service template* that is formed by a particular configuration of SCCS FGs.

NOTE - The term *service group* is the IOAG term for the collection of services. It should not be confused with *functional group*.

In addition to the three IOAG service groups (forward data delivery, return data delivery, and radio metric), the IOAG Service Catalogs recognize a category of *service management functions*.

5.1 FORWARD DATA DELIVERY SERVICE TEMPLATE

The service template for forward data delivery services comprises the Aperture FG, the Forward Physical Channel Transmission FG, the Forward Sync and Channel Encoding FG, the Forward Space Link Protocol Transmission FG, the Terrestrial Cross Support Service FG, and the Forward Space Internetworking FG. The forward data delivery service template is illustrated in figure 3-6. Each specific forward frame delivery service will involve some, but most likely not all, of the FGs in the template. For example, forward Delay Tolerant Networking (DTN) involves the Forward Space Internetworking FG, Aperture FG, and all FGs between. A non-networked forward data delivery service involves the Terrestrial Cross Support Service FG and Aperture FG, but the specific combination of intermediate FGs depends on the nature of the data delivery service.

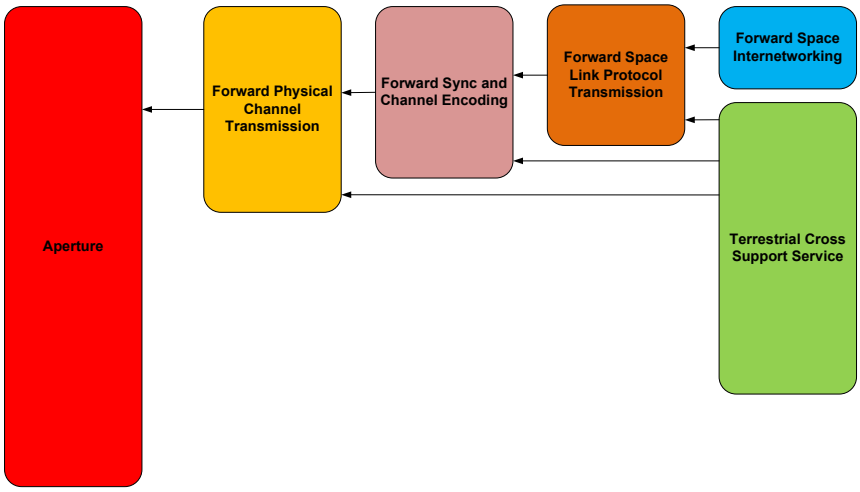

Figure 3-6: Forward Data Delivery Service Template

In order to ensure that different specializations of FGs can interoperate at least at a minimal level, the definition of each FG (except Terrestrial Cross Support Service) includes the specification of primary interfaces through which the FG consumes data and/or supplies data as appropriate to the FG. For the FGs used in the forward data delivery service template, these primary interfaces are as follows:

1. Aperture: consumes a forward carrier signal.
2. Forward Physical Channel Transmission: consumes a bitstream, supplies a forward carrier signal to an Aperture specialization.
3. Forward Sync and Channel Encoding: consumes delimited data units, supplies a bitstream to a Forward Physical Channel Transmission specialization.
4. Forward Space Link Protocol Transmission: consumes addressed packets, supplies delimited space link frames to a Forward Sync and Channel Encoding specialization.
5. Forward Space Internetworking: consumes internetwork packets, supplies addressed packets to a Forward Space Link Protocol Transmission specialization.

NOTES

1 The “space link frames” mentioned above do not necessarily conform to any of the existing CCSDS transfer frame specifications. The specific characteristics of the frames depend on the details of the space link protocol represented by the FG specialization, but generically a space link frame carries data and whatever identification is necessary to identify that data for purpose of transferring the data across a single space link.

2 The “addressed packets” mentioned above do not necessarily conform to any of the existing CCSDS space packet or encapsulation packet specifications. The specific characteristics of the addressed packets+ depend on the details of the

space link protocol represented by the FG specialization, but generically an addressed packet carries data and whatever identification is necessary to identify that data for purpose of transferring the data to its final destination node. The addressing information may be a combination of data that is contained in the packet itself and data appended to the packet for purposes of routing the packet through the space link.

In addition of the primary interfaces, specializations of FGs listed above may support one or more secondary consumer interfaces. The nature of these secondary consumer interfaces will depend on the technologies employed by the specializations of the FGs.

The Terrestrial Cross Support Service FG is an exception to the requirement for a primary interface (a primary supplier interface in the case of forward delivery services). At least in concept, a Terrestrial Cross Support Service specialization could supply data to any one (or more) of the primary or secondary consumer interfaces of the Forward Physical Channel Transmission FG, the Forward Sync and Channel Encoding FG, or the Forward Space Link Protocol Transmission FG.

5.2 RETURN DATA DELIVERY SERVICE TEMPLATE

The service template for return data delivery services comprises the Aperture FG, the Return Physical Channel Reception FG, the Return Sync and Channel Decoding FG, the Return Space Link Protocol Reception FG, the Terrestrial Cross Support Service FG, and the Return Space Internetworking FG. The return data delivery service template is illustrated in figure 3-7. As with the forward data delivery services, each specific return frame delivery service will involve some, but most likely not all, of the FGs in the template.

For the FGs used in the return data delivery service template, the primary interfaces are as follows:

1. Aperture: supplies a return carrier signal.
2. Return Physical Channel Reception: consumes a return carrier signal, supplies a bitstream.
3. Return Sync and Channel Decoding: consumes a bitstream, supplies delimited data units.
4. Return Space Link Protocol Reception: consumes delimited space link frames, supplies addressed packets.
5. Return Space Internetworking: consumes internetwork packets, supplies internetwork packets.

5.3 RADIO METRIC SERVICE TEMPLATE

The service template for radio metric services comprises the Aperture FG, Forward Physical Channel Transmission FG, the Return Physical Channel Reception FG, and the Terrestrial Cross Support Service FG. The radio metric service template is illustrated in figure 3-8.

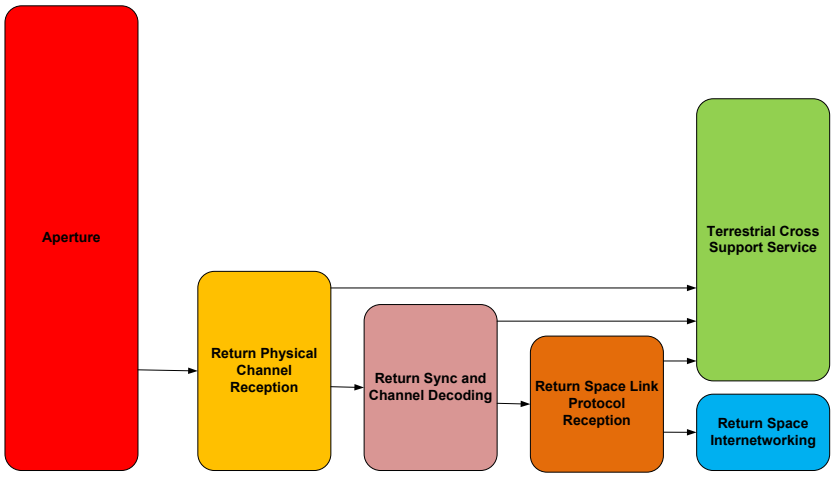

Figure 3-7: Return Data Delivery Service Template

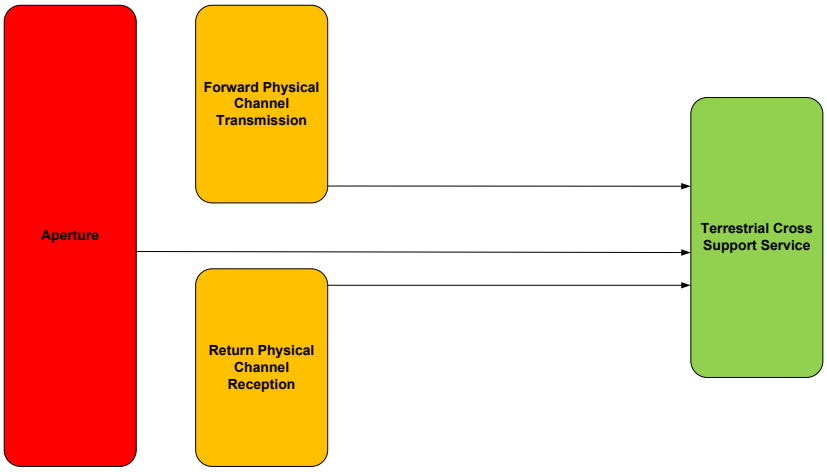

Figure 3-8: Radio Metric Service Template

Unlike the forward and return data delivery service templates, there are no primary interfaces that must be supported by the FGs that comprise the template. The only FG that consumes data from the Aperture, Forward Physical Channel Transmission, and Return Physical Channel Reception FGs is the Terrestrial Cross Support Service FG. The radio metric specializations of Terrestrial Cross Support Service can be defined to consume whatever

radio metric data are supplied by the specializations of the Aperture, Forward Physical Channel Transmission, and the Return Physical Channel Reception FGs that are being used.

5.4 SERVICE MANAGEMENT FUNCTIONS

Service management functions are distinguished from "services" in that they don't involve the direct transfer and/or processing of space communication and navigation data. Instead, they involve the exchange of data used to configure, control, and monitor the space communication and navigation services. Some service management functions themselves have Functional Resource Types that represent the processes associated with the exchange of management data between Utilization Management and Provision Management.

Service management functions are implicitly connected to all Functional Resource instances in a Service Package. As such, they do not have to be explicitly connected to any other FGs. Service management functions FR Types belong to the Terrestrial Cross Support Service FG. The service management function "template" therefore consists of the Terrestrial Cross Support Services FG.

6 COMPOSITION OF IOAG SERVICE CATALOG 1 SERVICES BY FUNCTIONAL RESOURCE TYPES

6.1 GENERAL

IOAG Service Catalog 1 focusses on the services provided by an ESLT (see reference [13]).

The organization of this section follows that of IOAG Service Catalog #1: Forward Data Delivery Services, Return Data Delivery Services, Radiometric Services, and Service Management Functions.

6.2 FORWARD DATA DELIVERY SERVICES

The IOAG Service Catalog #1 forward data delivery services are:

a) Forward CLTU;
b) Forward Space Packet;
c) Forward Synchronous Encoded Frame;
d) Forward File.

6.2.1 FORWARD CLTU

Figure 6-1 illustrates the Functional Resource types that comprise the Forward CLTU Forward Data Delivery service. The non-dashed boxes represent the FR Types involved in the transfer of the CLTUs themselves. The dashed boxes represent the FR Types that perform related functions that are necessary to the complete production and provision of the service. In this case, the dashed boxes represent the FR Types involved in acquiring the CLCWs that contain the RF availability and bit lock flags that may be used to determine the production status of the FCLTU service.

6.2.2 FORWARD SPACE PACKET

Figure 6-2 illustrates the Functional Resource types that comprise the Forward Space Packet Forward Data Delivery service. As with the FCLTU service, the dashed boxes represent the FR Types involved in acquiring the CLCWs that contain not only the RF availability and bit lock flags that may be used to determine the production status of the PLOP, but also the COP-related information.

6.2.3 FORWARD SYNCHRONOUS ENCODED FRAME

Figure 6-3 illustrates the Functional Resource types that comprise the Forward Frames Forward Data Delivery service, which includes the functionality of the Forward Synchronous Encoded Frame service.

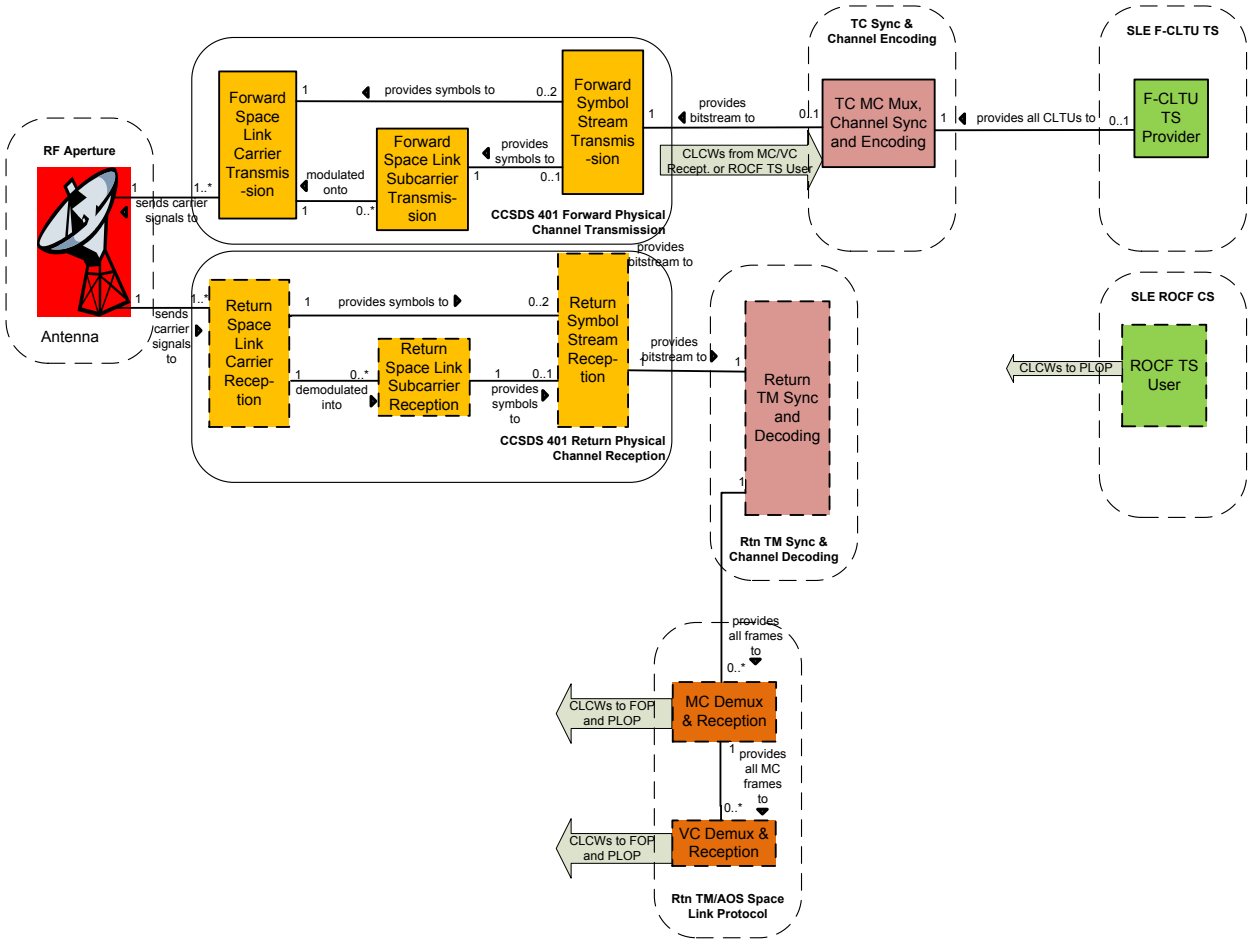

Figure 6-1. Functional Resource Types of the Forward CLTU Forward Data Delivery Service

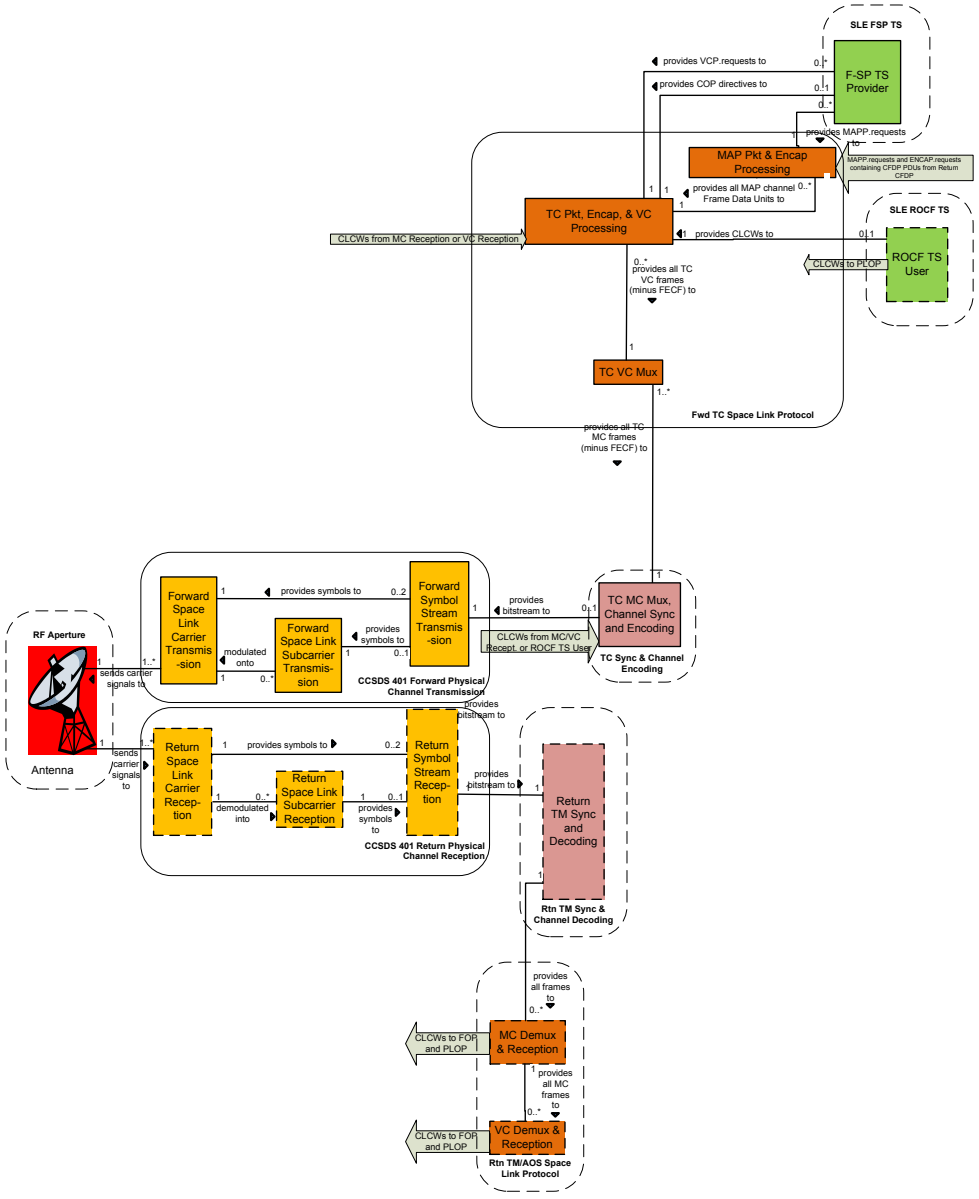

Figure 6-2. Functional Resource Types of the Forward Space Packet Forward Data Delivery Service

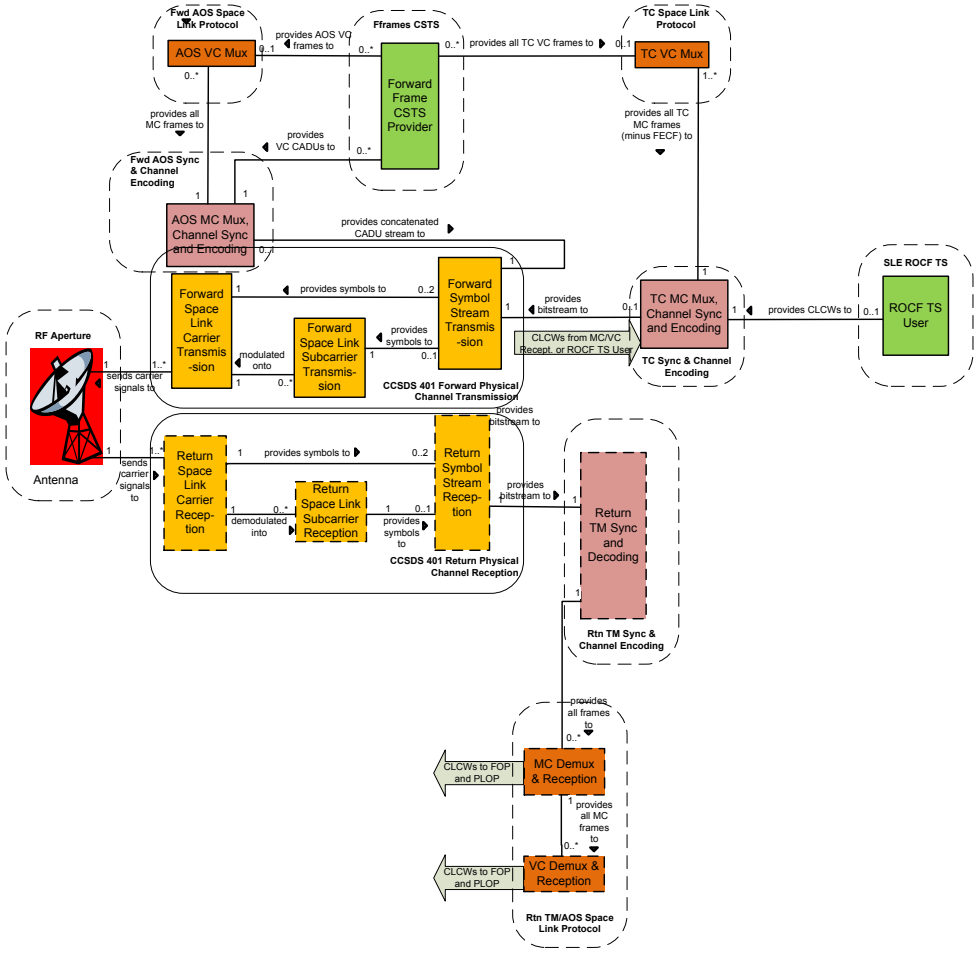

Figure 6-3. Functional Resource Types of the Forward Frames Forward Data Delivery Service

NOTES

1 IOAG SC #1 calls for a Forward Synchronous Encoded Frame (FSEF) service. However, the FSEF service is a subset of the Forward Frames (FF) service which is included in IOAG SC #2. As a practical consideration CCSDS is currently planning to develop only the FF service.

6.2.4 FORWARD FILE

The Forward File service is a new service which is supposed to rely on two as-yet-undefined "CSTS" services. As such, the definition of this service is very ambiguous and subject to further definition and elaboration.

Figure 6-4 illustrates the Functional Resource types that comprise the Forward File service as currently understood by the author of this technical note.

The complexity of this set of FR Types comes from the IOAG SC#1 definition[1] of the Forward File service:

> This Service enables a mission to send the contents of a file to a spacecraft by allowing a Control Center to provide a Ground Tracking Asset with files for uplink. Within Catalog #1, usage of this service is limited to a spacecraft directly reachable from a Ground Tracking Asset (i.e. single hop space link) … . It relies on the following Space Link Interface Standards and Ground Link Interface Standards.
>
> - CSTS Forward File Service [CFFS] over CSTS Transfer File Service [CFXS]
> - Space Packet Protocol [SPP]
> - Encapsulation Service [ENC]
> - CCSDS File Delivery Protocol [CFDP]
> - AOS Space Data Link Protocol [AOS]
> - TC Space Data Link Protocol [TC-DLP][2]
> - TM Synchronization and Channel Coding [TM-S&C]
> - TC Synchronization and Channel Coding [TC-S&C]
> - Radio Frequency and Modulation [RFM] limited to modules for "Earth-to-Space Radio Frequency (Forward Link)" and "Telecommand (Forward Link)"
>
> Remark - The two CSTS File Services listed above are "to be written". It is assumed that a generic transfer file service allowing to transfer files between two units, i.e. [CFXS], will be available and - on top of this generic service – more "specialized" file services will allow requesting the dedicated processing for the file being transferred. Therefore, it is expected that the CSTS Forward File Service will allow the Control Center to inform whether the file contains
>
> - a collection of Space Packets,
> - a collection of Encapsulation Packets, or
> - a file to be processed into CFDP PDUS to be embedded either in Space Packets or Encapsulation Packets.

[1] This definition has been modified to include material that was merely referenced in the original IOAG SC#1 definition.

[2] The IOAG SC#1 definition of the Forward File service does not contain the TC Space Data Link Protocol in its list of component Space Link Interface Standards. However, the inclusion of the TC Synchronization and Channel Coding standard and the mention of "TC Frames" in the final paragraph of the quote implies that the Forward Frames service was intended to run over the TC stack as well as the Forward AOS stack.

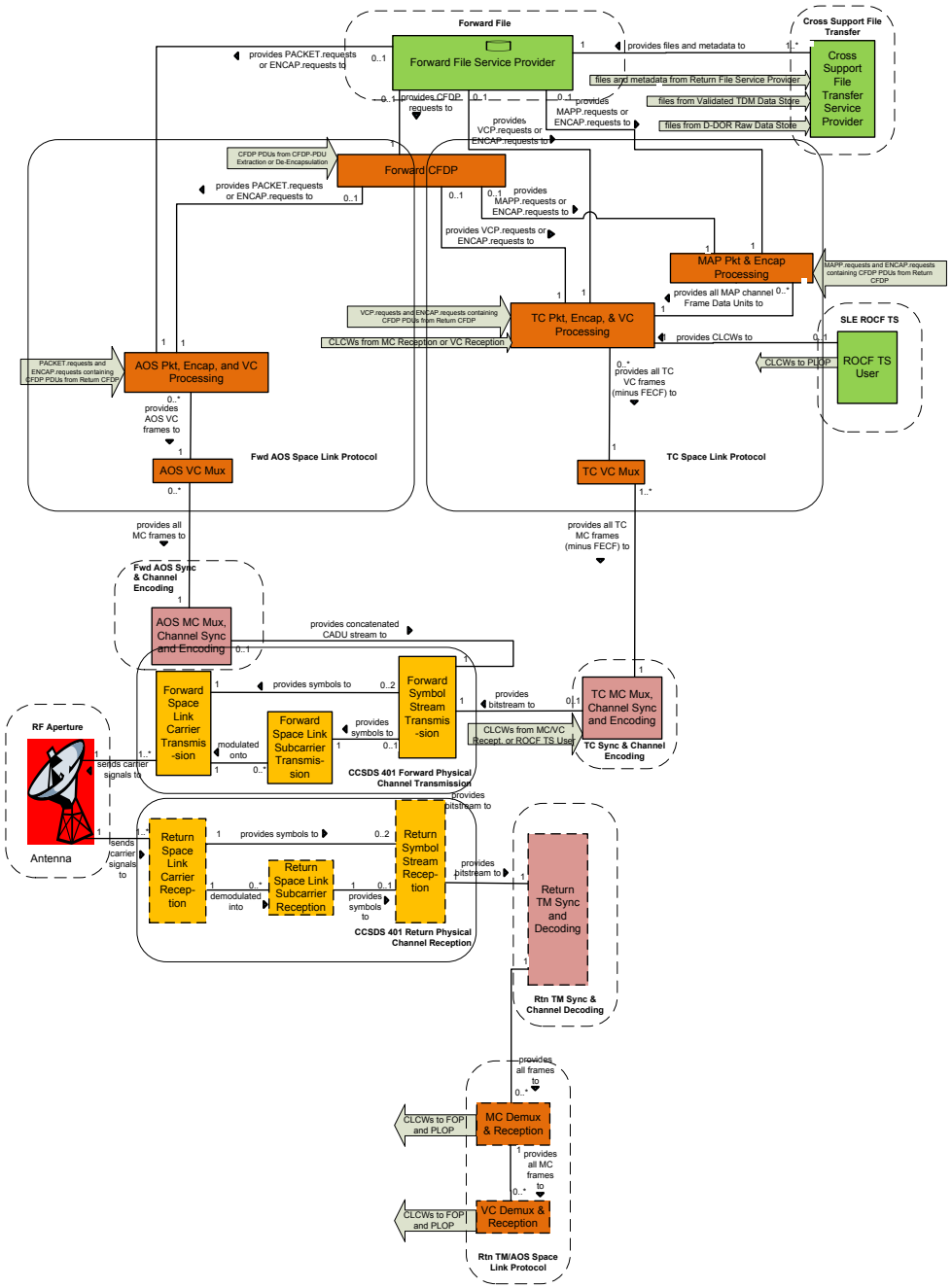

Figure 6-4. Functional Resource Types of the Forward File Forward Data Delivery Service

Additionally the CSTS Forward File Service will allow the Control Center to state how the Space/Encapsulation Packets shall be forwarded to the spacecraft either within TC Frames or AOS Frames.

The possible combinations of protocol stacks raise questions regarding the possible redundancy of reliability (i.e., retransmission) capabilities in the TC path through the stack. Specifically, should the Forward File service include the retransmission capabilities of both CFDP and COP concurrently, or should one be used (and if so, which one)?

Another question is the degree to which the Forward File Service Provider functional resource (acting as the CFDP User) should have standard algorithms defined for determining which control directives to send when, vs. having all control specified in the metadata that accompanies to file to be transferred.

Finally, there is in development a CFDP Over Encapsulation Service Recommended Standard, but there does not seem to be a similar specification for CFDP directly over Space Packet. If CFDP over Space Packet is removed as an option, this would change (and simplify) the set of FR Types associated with the Forward File service.

6.3 RETURN DATA DELIVERY SERVICES

The IOAG Service Catalog #1 return data delivery services are:

a) Return All Frames;
b) Return Channel Frames;
c) Return Operational Control Fields;
d) Return Unframed Telemetry; and
e) Return File.

6.3.1 RETURN ALL FRAMES

Figure 6-5 illustrates the Functional Resource types that comprise the Return All Frames Return Data Delivery service.

6.3.2 RETURN CHANNEL FRAMES

Figure 6-6 illustrates the Functional Resource types that comprise the Return Channel Frames Return Data Delivery service.

NOTE - The RCF service demultiplexes a virtual channel or a master channel from a return all frames channel and delivers the frames of that channel to the RCF service user. This demultiplexing functionality is technically part of the Space Data Link Protocol, but for the SLE RCF transfer service it is performed by each RCF transfer service instance.

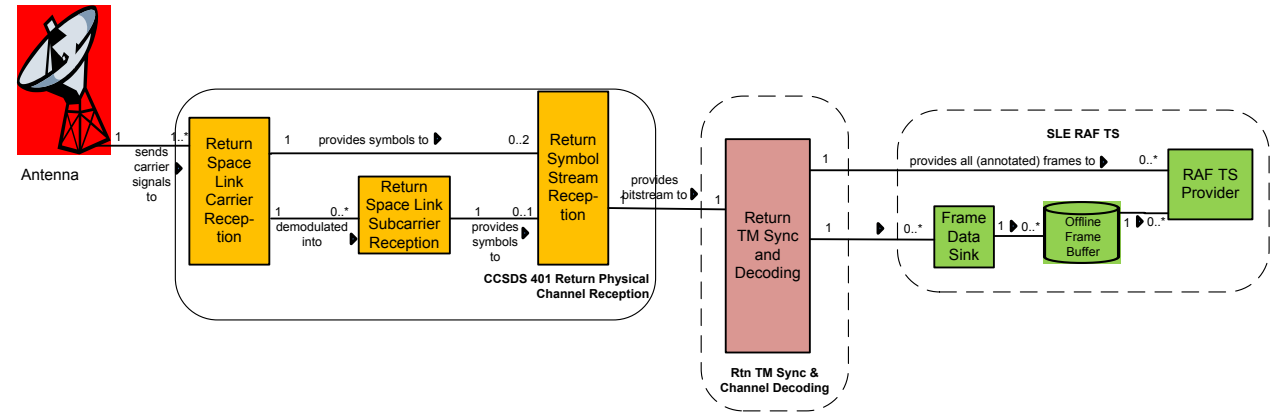

Figure 6-5. Functional Resource Types of the Return All Frames Return Data Delivery Service

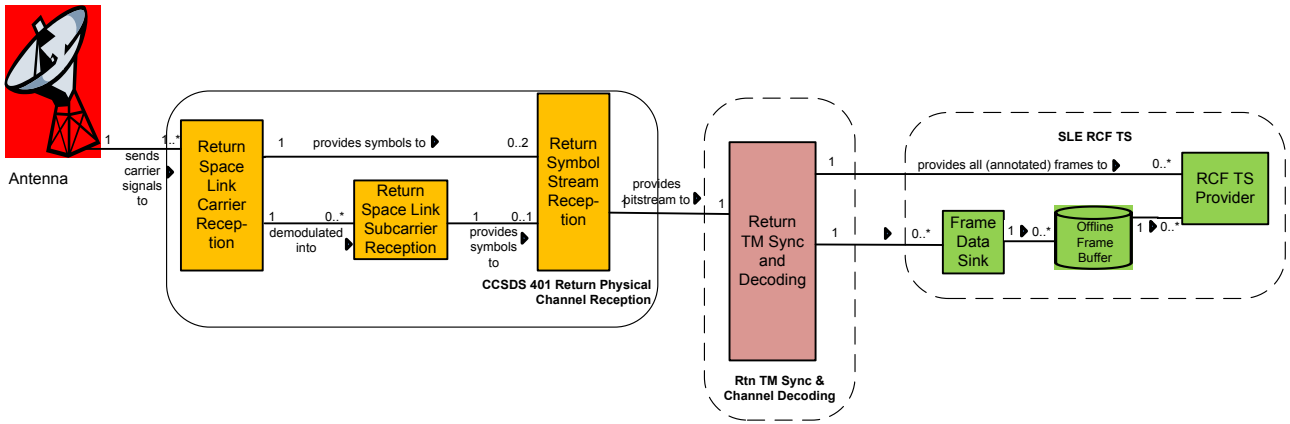

Figure 6-6. Functional Resource Types of the Return Channel Frames Return Data Delivery Service

6.3.3 RETURN OPERATIONAL CONTROL FIELD

Figure 6-7 illustrates the Functional Resource types that comprise the Return Channel Frames Return Data Delivery service.

NOTE - The ROCF service extracts Operational Control Fields (OCFs) from a return all frames channel and delivers those OCFs to the ROCF service user. This OCF extraction functionality is technically part of the Space Data Link Protocol, but for the SLE ROCF transfer service it is performed by each ROCF transfer service instance.

6.3.4 RETURN UNFRAMED TELEMETRY

Figure 6-8 illustrates the Functional Resource types that comprise the Return Unframed Telemetry Return Data Delivery service.

NOTE – The Segmenter is shown as being derived from the Production Class, but it could alternatively be defined and a type of Synchronization and Channel Decoding algorithm.

6.3.5 RETURN FILE SERVICE

The Return File service is a new service which is supposed to rely on two as-yet-undefined "CSTS" services. As with the Forward File service (see 6.2.4), the definition of this service is very ambiguous and subject to further definition and elaboration.

Figure 6-9 illustrates the Functional Resource types that comprise the Return File service as currently understood by the author of this technical note.

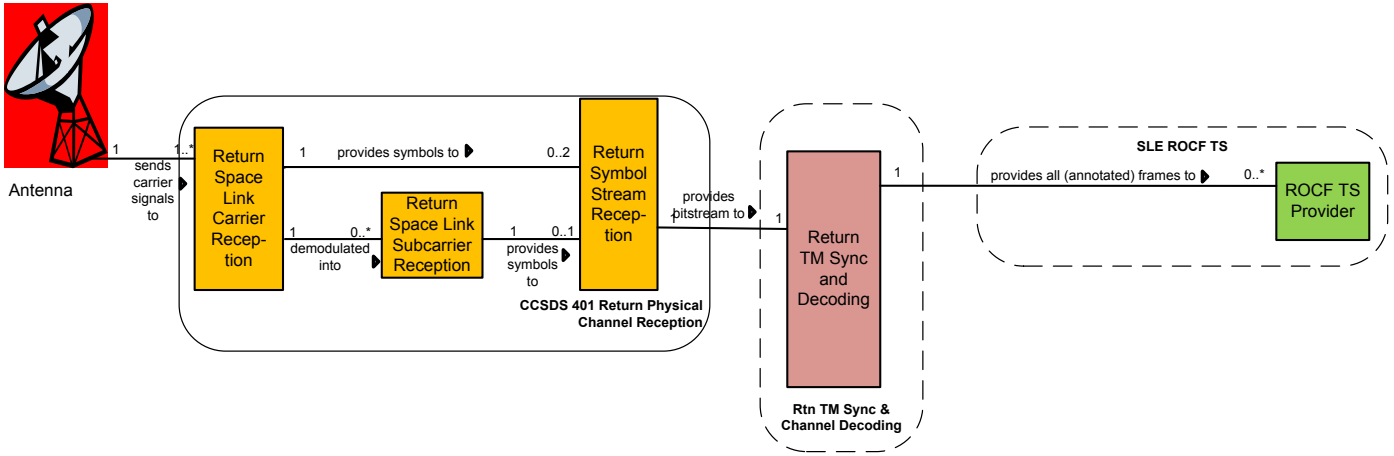

Figure 6-7. Functional Resource Types of the Return Channel Frames Return Data Delivery Service

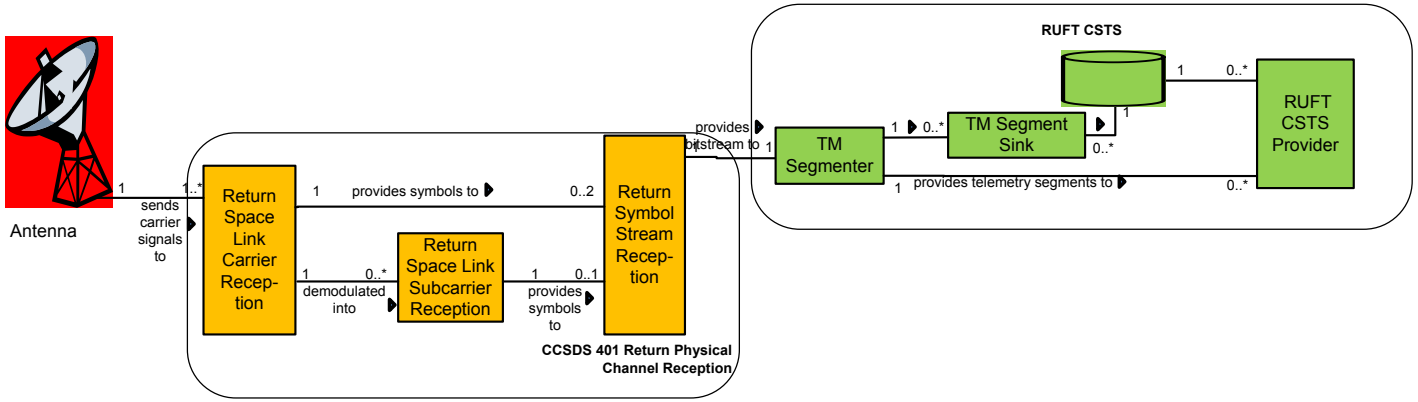

Figure 6-8. Functional Resource Types of the Return Unframed Telemetry Return Data Delivery Service

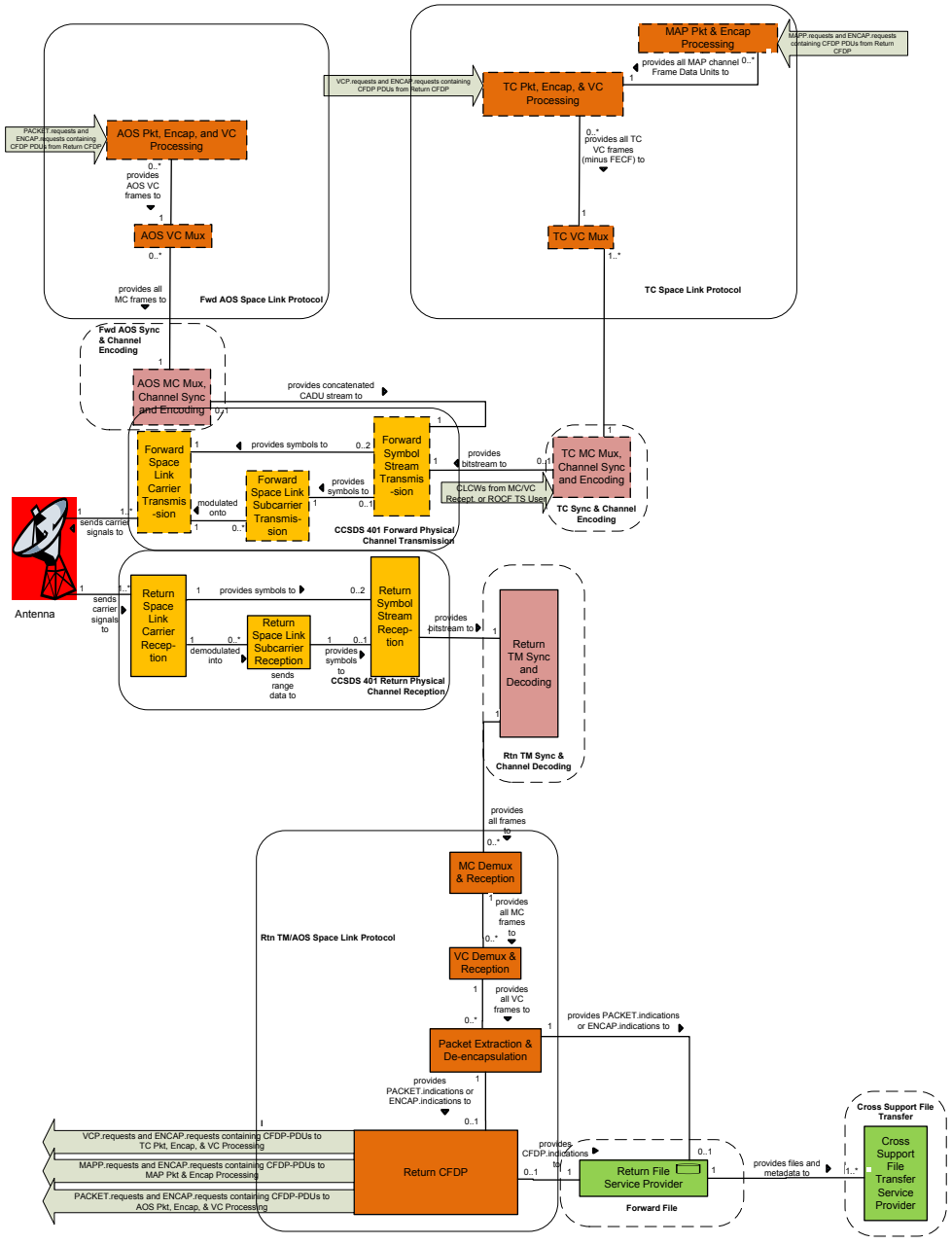

Figure 6-9. Functional Resource Types of the Return File Return Data Delivery Service

6.4 RADIO METRIC SERVICES

The IOAG Service Catalog #1 Radio Metric services are:

a) Validated Data Radio Metric;
b) Raw Data Radio Metric; and
c) Delta DOR.

6.4.1 VALIDATED DATA RADIO METRIC

IOAG SC#1 defines the Validated Data Radiometric service as:

> This Service enables a Control Center to receive the data involved in orbit computation as received and validated by a Ground Tracking Asset. Validated data include traditional and Pseudo-Noise ranging results as well as correlated Delta-DOR data. Such data are provided to a Control Center within files assembled by the Ground Tracking Asset. This Service relies on the following Space Link Interface Standards and Ground Link Interface Standards.
>
> - Radio Frequency and Modulation [RFM] limited to module for "Radio Metric"
> - Pseudo-Noise (PN) Ranging Systems [PNR]
> - Delta-Differential One Way Ranging (Delta-DOR) Operations [DDORO]
> - CSTS Offline Radio Metric Service [CORS] over
> - CSTS Transfer File Service [CFXS]
>
> Remark - The two CSTS File Services listed above are "to be written". It is assumed that a generic transfer file service allowing to transfer files between two units, i.e. [CFXS], will be available and - on top of this generic service – more "specialized" file services will allow requesting the dedicated processing for the file being transferred. In this case, it is expected that the CSTS Offline Radio Metric Service will allow the Ground Tracking Asset to inform the Control Center about applied processing and file contents (i.e. Tracking Data Messages (TDM) according to the [TDM] standard specifying a format for use in exchanging spacecraft tracking data).

Figure 6-10 illustrates the Functional Resource types that comprise the Validated Data Radio Metric service as currently understood by the author of this technical note.

Note that while the IOAG Service Catalog #1 description of the Validated Data Radio Metric service limits its data delivery to the user to file transfer, the service as illustrated in figure 4-10 allows the possibility of delivery via the Tracking Data CSTS. Whether this alternative delivery mechanism is viable is a matter for further analysis and definition.

6.4.2 RAW DATA RADIO METRIC

Figure 6-11 illustrates the Functional Resource types that comprise the Raw Data Radio Metric service.

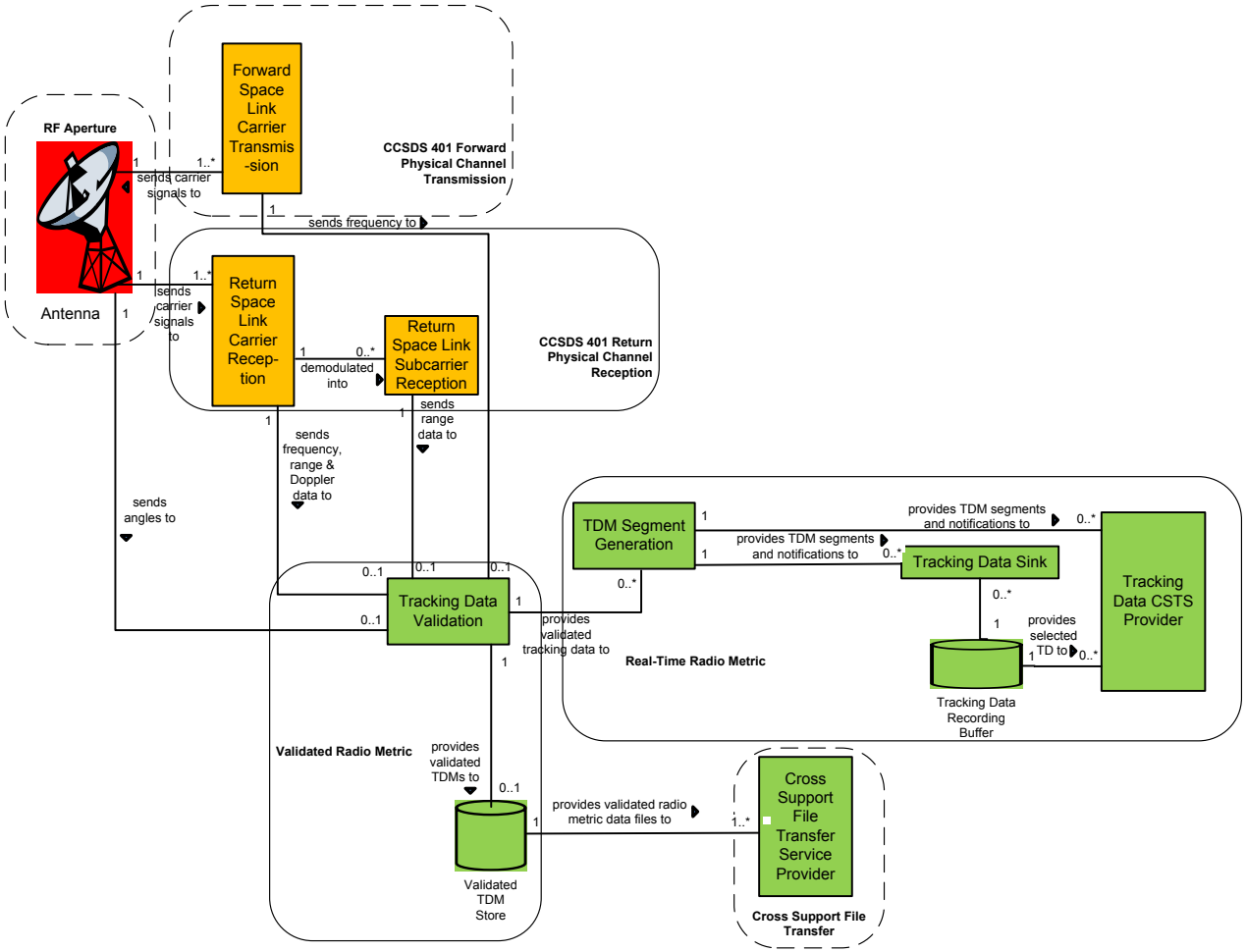

Figure 6-10. Functional Resource Types of the Validated Data Radio Metric Service

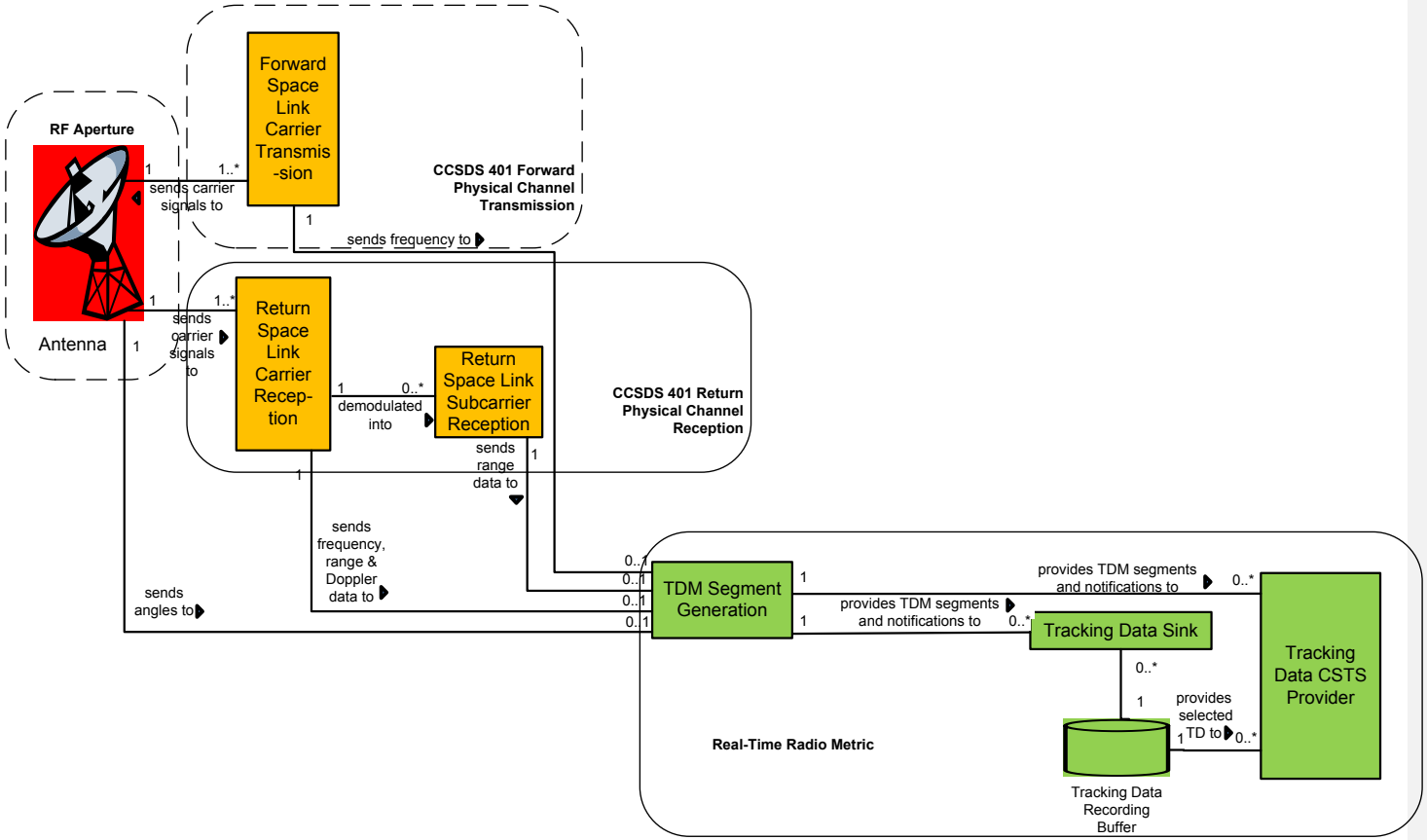

Figure 6-11. Functional Resource Types of the Raw Data Radio Metric Service

6.4.3 DELTA DOR

IOAG SC#1 defines the Delta DOR service as:

> This Service enables a Control Center to receive Delta-DOR raw data10 acquired by a Ground Tracking Asset. Such data are provided to a Control Center within files assembled by the Ground Tracking Asset. It relies on the following Space Link Interface Standards and Ground Link Interface Standards.
>
> - Radio Frequency and Modulation [RFM]
> - Delta-Differential One Way Ranging (Delta-DOR) Operations [DDORO]
> - CSTS D-DOR Data Service [DDORS] over
> - CSTS Transfer File Service [CFXS]
>
> Remark - The [DDORO] Recommended Practice is undergoing review before official CCSDS publication. The CSTS D-DOR Data Service is “to be written”. It is assumed that a generic transfer file service allowing to transfer files between two units, i.e. [CFXS], will be available and - on top of this generic service – more “specialized” file services will allow requesting the dedicated processing for the file being transferred. In this case, it is assumed that the CSTS D-DOR Data Service [DDORS] will implement delivery of newly defined D-DOR “raw data” transfer according to [DDRXF].

Figure 6-12 illustrates the Functional Resource types that comprise the Validated Data Radio Metric service as currently understood by the author of this technical note.

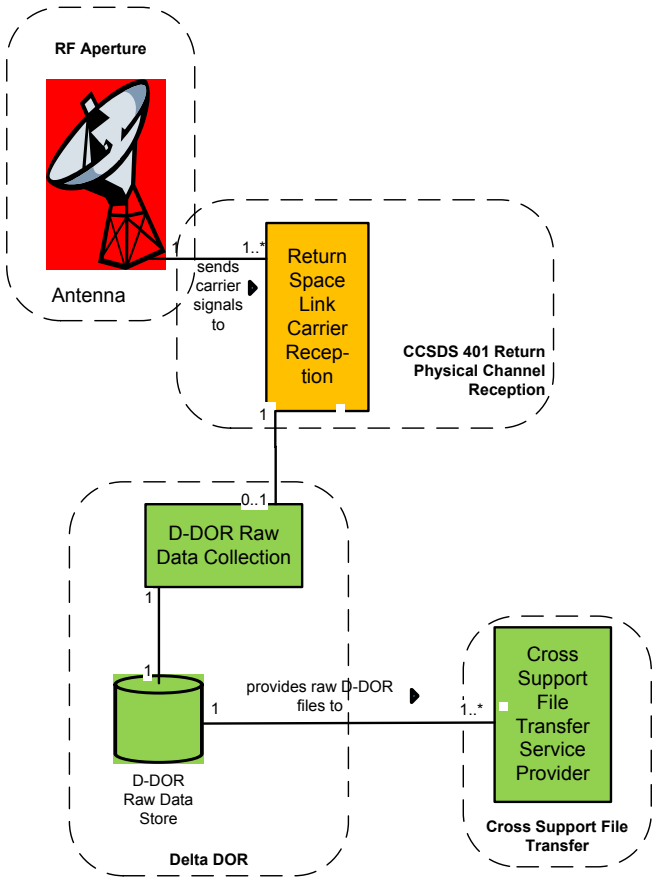

Figure 6-12. Functional Resource Types of the Delta DOR Radio Metric Service

6.5 SERVICE MANAGEMENT FUNCTIONS

6.5.1 ENGINEERING MONITORING DATA DELIVERY

Figure 6-13 illustrates the Functional Resource types that are monitored by the Engineering Monitoring Data Delivery Service Management Function. In addition to being the mechanism for delivering the engineering monitoring data, the Monitored Data Cross Support Transfer Service (MD-CSTS) Provider is also a Functional Resource for which the status is reported to the user of the MD-CSTS service.

As shown in figure 6-13, the MD-CSTS Provider receives the data that it reports from the Monitored Data Production functional resource, which collects monitored data values and event notification from all of the other FR instances that are active during the execution of the Service Package upon which the MD-CSTS instance is reporting.

Figure 6-13: Functional Resource Types Monitored by the Engineering Monitoring Data Delivery Service Management Function

7 FUNCTIONAL RESOURCES IN SERVICE MANAGEMENT AND SERVICE PACKAGE EXECUTION

NOTE

This section has been imported from the technical note "Functional Resources in Service Management and Service Package Execution." As of this version, the contents have not been changed. As time and resources are available, this section will be updated.

7.1 INTRODUCTION

7.1.1 PURPOSE

This section describes an extended scenario that addresses the role and use of functional resources, functional resource types, functional resource identifiers, and the monitored parameters, notifiable events, and directives that are named in the context of functional resources. The purpose of this scenario is to confirm that the functional resource concepts that are being applied to both Cross Support Transfer Services (CSTSes) and Next Generation Space Communication Cross Support Service Management (NextGen SCCS-SM) will provide unambiguous naming of monitored parameters, notifiable events, and directives.

7.1.2 SCENARIO OVERVIEW

The scenario is based on the operational scenario presented in the draft Monitored Data CSTS specification. It has been modified and significantly extended to more fully cover the range of functional resources to be managed.

The scenario involves the support of the XenoSat mission by the Multinet TT&C network.

The XenoSat spacecraft has an S-Band transponder used for spacecraft control and telemetry. Commands are BPSK-modulated onto a subcarrier of the forward S-band link, while the telemetry is separated into two physical channels that are QPSK-modulated directly onto the return S-band carrier.

The XenoSat spacecraft also has an X-band transmitter for the high-rate data generated by its science payload. The science data is BPSK-modulated directly onto the return X-band carrier.

7.1.3 ORGANIZATION

Section 7.2 identifies the functional resource types and associated monitored parameters that Multinet exposes to its user missions.

Section 7.3 identifies the parameter list names that are created during the Service Agreement Development phase.

Section 7.4 describes the configuration profiles that are established between XenoSat and Multinet.

Section 7.5 describes a Space Link Session (SLS) Service Package Request and several Retrieval Service Package Requests.

Section 7.6 describes the Service Packages that are scheduled as a result of the Service Package Requests from section 5, and in particular, the assignment of functional resource instances to the SLS Service Package Result.

Section 7.7 describes the functioning of the MD-CSTS during the execution of the SLE Service Package, in particular the transfer of the monitored parameter values and event notifications.

Section 7.8 provides summary conclusions.

7.2 MULTINET FUNCTIONAL RESOURCES

The Multinet TT&C network provides the following services:

a) Forward (uplink) and return (downlink) communications and tracking services at S Band and X Band;

b) Terrestrial transfer of Space Link Session (SLS) space link data via SLE F-CLTU and complete and timely RAF and RCF services;

c) Terrestrial transfer of offline (Retrieval) space link data via SLE offline RAF and RCF services;

d) Terrestrial transfer of real-time sample tracking data via the Real-Time Tracking CSTS;

e) Real-time Service Package monitoring and event reporting via the Monitored Data Cross Support Transfer Service (CSTS);

f) Control of the Service Package during the execution via the Service Control CSTS.

Multinet has antennas around the globe, including the antennas named Pacific X-Band and Pacific S-Band.

Figure 4-1 illustrates the functional resource types that correspond to the service provided by Multinet. The figure is derived from Figure 3-4, Functions Resource Types – Example, of the draft *Concept for Next Generation Space Communication Cross Support Service Management* Green Book.

Comment [JP17]: fix

NOTE 1- For purposes of simplification, this scenario does not include support for the ROCF or FSP SLE transfer services, nor for complete (offline) tracking data delivery service. Future versions of this note may extend to include complete tracking service

Table 4-1 lists the functional resource types that are supported by Multinet and the ISO Object Identifiers (OIDs) associated with each type. The OIDs are based on the set of OIDs in the technical note "Operational Scenario Implementation", based on the list of functional resources and associated candidate monitored parameters proposed by Wolfgang Hell. The OIDs are listed in OID-IRI [Internationalized Resource Identifier] notation, which uses slashes to separate the node labels.

Comment [JP18]: cR

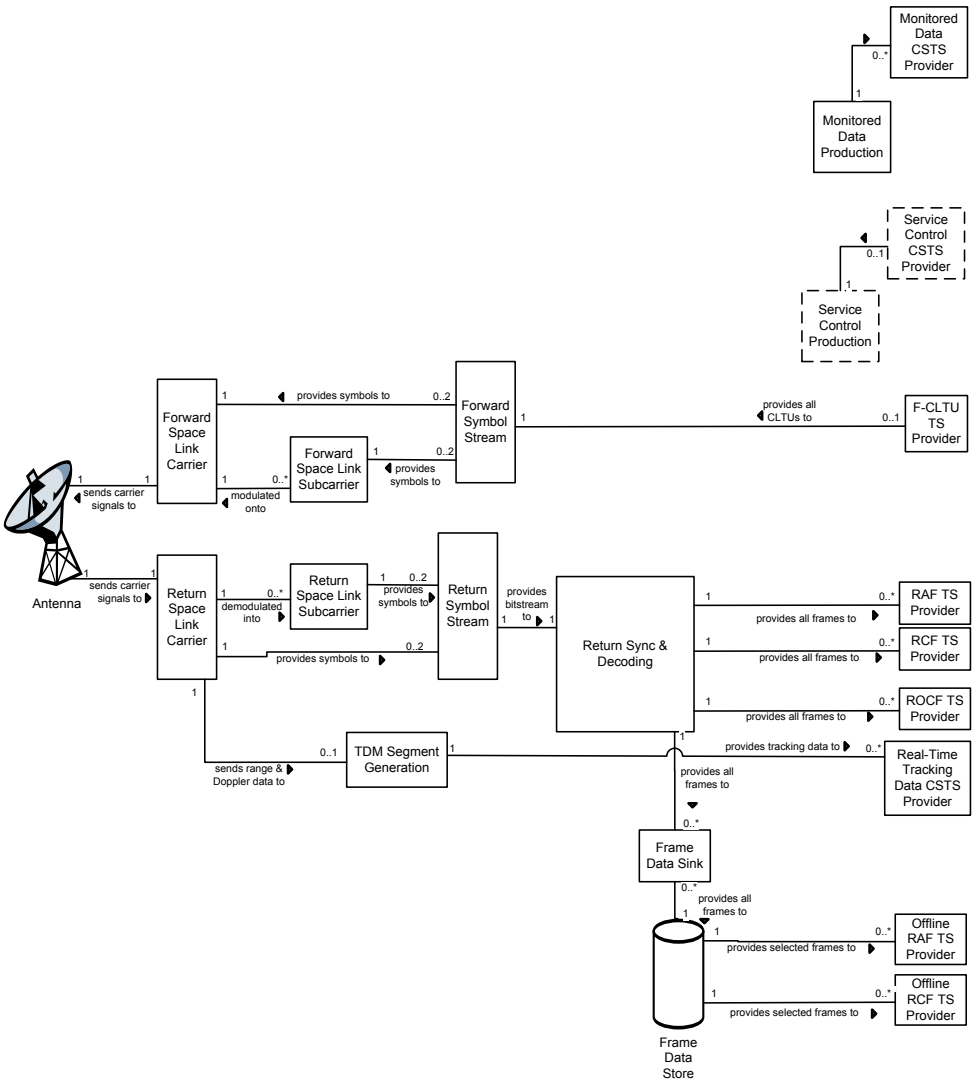

Figure 4-1: Functional Resource Types Supported by Multinet

Table 4-1: Functional Resource Types and OIDs

Functional Resource	OID	
	F.R.	Completed
Antenna	1	3/112/4/4/3/1/1
Forward Space Link Carrier	2	3/112/4/4/3/1/2
Forward Space Link Subcarrier	3	3/112/4/4/3/1/3
Forward Symbol Stream	5	3/112/4/4/3/1/5
FCLTU Service Provider	6	3/112/4/4/3/1/6
Return Space Link Carrier	8	3/112/4/4/3/1/8
Return Space Link Subcarrier	9	3/112/4/4/3/1/9
Return Symbol Stream	10	3/112/4/4/3/1/10
Return Synchronization and Decoding	11	3/112/4/4/3/1/11
Range and Doppler Extraction	12	3/112/4/4/3/1/12
RAF TS Provider	13	3/112/4/4/3/1/13
RCF TS Provider	14	3/112/4/4/3/1/14
Monitored Data CSTS Provider	17	3/112/4/4/3/1/17
Monitored Data Production	18	3/112/4/4/3/1/18
Real-Time Tracking Data CSTS Provider	19	3/112/4/4/3/1/19
Service Control CSTS Provider	20	3/112/4/4/3/1/20
Service Control Production	21	3/112/4/4/3/1/21

NOTE 2 - There are differences in most of the names of the functional resource types between the Hell/Doat material and the Next Generation SCCS-SM Concept (e.g., “Return Space Link Carrier” instead of “Carrier Downlink”) resulting from the sources of those names (i.e., current ESTRACK operations vs. CCSDS Service Management concepts and terminology). Also, some of the parameters associated with the functional resource types differ between the two groups. These differences will eventually be resolved. For this version of this technical note, the functional resource type names and parameters are aligned with the Next Generation SCCS-SM Concept.

NOTE 3- Table 4-1 lists only the functional resource types that are involved in Space Link Sessions (i.e., not offline services). There are currently no requirements to monitor or control offline services via out-of-band services (i.e., MD-CSTS and SC-CSTS).

In accordance with the registration scheme developed as part of the *Cross Support Transfer Service Specification Framework*, functional resource type identifiers are registered under the iso/identified organization (3)/standards producing organization (112)/CCSDS (4)/CSTS (4)/publishedIdentifers (3) node (3/112/4/4/3). There are two sub-nodes under

publishedIdentifiers: crossSupportFunctionalities (1) is used for registering CCSDS-standard functional resource types and associated monitored parameters, events, and directives, and agenciesFunctionalities (2) for use by Agencies to register their own functional resource types and associated monitored parameters, events, and directives.

OIDs for functional resource-specific monitored parameters, events, and directives are registered under parametersId (1), eventsId (2), and directiveId (3) subnodes, respectively, under the OID of the functional resource type. For example, for the Antenna type, which is registered under crossSupportFunctionalities as 3/112/4/4/3/1/1, all Antenna-specific monitored parameters are registered under the (3/112/4/4/3/1/1/1 node.

The *Cross Support Transfer Service Specification Framework* defines another branch for the registration of parameter, event ,and directive OIDs under the iso/identified organization (3)/standards producing organization (112)/CCSDS (4)/CSTS (4)/framework (1) node (3/112/4/4/1). The framework identifiers node (5) is nominally used to register the identifiers of parameters, events, and directives that are defined as parts of the standard operations and procedures of the CSTS SF. However, all framework parameter, event ,and directive OIDs are also available for use in the naming of parameters, events ,and directives (respectively) of functional resource types, including (but not limited to) functional resource types that correspond to CSTS Service Providers.

Comment [JP19]: CR

Multinet publishes monitored parameters, notifiable events, and directives for the functional resource types that it implements. Table 2 lists a sample of the monitored parameters and notifiable events that are published by Multinet. As described above, monitored parameters and notifiable events for a functional resource type can be defined specifically for that functional resource type, or they can be adopted from the set of framework parameters. As shown in the table, there is a mixture of parameters specified specifically for the functional resource types, and - for the F-CLTU, RAF, and RCF TS Provider FR Types – four production status-related notifications that are adopted for those FR Types.

NOTES

1 For the purposes of this technical note, the OIDs that Multinet publishes are assumed to be available to all users of Multinet. That is, they are a network capability and not negotiated through or documented in individual Service Agreements. This assumption is to be examined and either confirmed or changed.

2 Only a few examples of notifiable events – those associated with the change of production status for the SLE transfer services – are provided in table 4-2. These are sufficient to illustrate the concept.

3 No directives are identified in this version of this technical note. Directives (via the Service Control CSTS) will be addressed in a future version.

Table 4-2: Sample of MultiSat Published Monitored Parameters and Notifiable Events (1 of 4)

Functional Resource	Parameter	OID			
		F.R.	Type (P/E/D)		Completed
Antenna		**1**			**3/112/4/4/3/1/1**
	parametersId		**1**		
	Antenna ID			1	3/112/4/4/3/1/1/1/1
	Production status			2	3/112/4/4/3/1/1/1/2
	Actual azimuth			3	3/112/4/4/3/1/1/1/3
	Actual elevation			4	3/112/4/4/3/1/1/1/4
	Commanded azimuth			5	3/112/4/4/3/1/1/1/5
	Commanded elevation			6	3/112/4/4/3/1/1/1/6
	Azimuth error			7	3/112/4/4/3/1/1/1/7
	Elevation error			8	3/112/4/4/3/1/1/1/8
Forward Space Link Carrier		**2**			**3/112/4/4/3/1/2**
	parametersId		**1**		
	Production status			1	3/112/4/4/3/1/2/1/1
	Actual transmit frequency			2	3/112/4/4/3/1/2/1/2
	EIRP			3	3/112/4/4/3/1/2/1/3
	Sweep active			4	3/112/4/4/3/1/2/1/4
Forward Space Link Subcarrier		**3**			**3/112/4/4/3/1/3**
	parametersId		**1**		
	Subcarrier frequency*			1	3/112/4/4/3/1/3/1/1
	Cohernt with data clock*			3	3/112/4/4/3/1/3/1/3
Forward Link Ranging		**4**			**3/112/4/4/3/1/4**
	parametersId		**1**		
	Ranging active*			1	3/112/4/4/3/1/4/1/1
	Ranging type*			2	3/112/4/4/3/1/4/1/2
Forward Symbol Stream		**5**			**3/112/4/4/3/1/5**
	parametersId		**1**		
	Data clock*			1	3/112/4/4/3/1/5/1/1
	Baseband waveform*			2	3/112/4/4/3/1/5/1/2

Table 4-2: Sample of MultiSat Published Monitored Parameters and Notifiable Events (2 of 4)

Functional Resource	Parameter	OID			
		F.R.	Type (P/E/D)		Completed
FCLTU TS Provider		**6**			**3/112/4/4/3/1/6**
	parametersId		**1**		
	Production status			1	3/112/4/4/3/1/6/1/1
	Uplink status			2	3/112/4/4/3/1/6/1/2
	SI state			3	3/112/4/4/3/1/6/1/3
	Number of CLTUs received			4	3/112/4/4/3/1/6/1/4
	Number of CLTUs processed			5	3/112/4/4/3/1/6/1/5
	Number of CLTUs radiated			6	3/112/4/4/3/1/6/1/6
	Number of CLTUs rejected			7	3/112/4/4/3/1/6/1/7
	eventsId from framework identifiers				**3/112/4/4/1/5/2**
	Production configured			1	3/112/4/4/1/5/2/1
	Production interrupted			2	3/112/4/4/1/5/2/2
	Production halted			3	3/112/4/4/1/5/2/3
	Production operational			4	3/112/4/4/1/5/2/4
Return Space Link Carrier		**8**			**3/112/4/4/3/1/8**
	parametersId		**1**		
	Production status			1	3/112/4/4/3/1/8/1/1
	System noise temperature			2	3/112/4/4/3/1/8/1/2
	Actual receive frequency			3	3/112/4/4/3/1/8/1/3
	Frequency offset			4	3/112/4/4/3/1/8/1/4
	Signal level			5	3/112/4/4/3/1/8/1/5
	Polarization angle			6	3/112/4/4/3/1/8/1/6
	Carrier lock			7	3/112/4/4/3/1/8/1/7
Return Space Link Subcarrier		**9**			**3/112/4/4/3/1/9**
	parametersId		**1**		
	Actual subcarrier frequency			1	3/112/4/4/3/1/9/1/1
	Subcarrier lock status			2	3/112/4/4/3/1/9/1/2
	Subcarrier level estimate			3	3/112/4/4/3/1/9/1/3
	Subcarrier demod loop bandwidth*			4	3/112/4/4/3/1/9/1/4

Table 4-2: Sample of MultiSat Published Monitored Parameters and Notifiable Events (3 of 4)

Functional Resource	Parameter	OID			
		F.R.	Type (P/E/D)		Completed
Return Symbol Stream		**10**			**3/112/4/4/3/1/10**
	parametersId		**1**		
	Symbol synchronizer lock status			1	3/112/4/4/3/1/10/1/1
	Actual symbol rate			2	3/112/4/4/3/1/10/1/2
	Es/No			3	3/112/4/4/3/1/10/1/3
	Symbol synchronizer Loop bandwidth*			4	3/112/4/4/3/1/10/1/4
	Symbol Error Rate			5	3/112/4/4/3/1/10/1/5
Return Synchronization and Decoding		**11**			**3/112/4/4/3/1/11**
	parametersId		**1**		
	Frame synchronizer lock status			1	3/112/4/4/3/1/11/1/1
	ASM correlation error			2	3/112/4/4/3/1/11/1/2
	Symbol inversion			3	3/112/4/4/3/1/11/1/3
	Frame error rate			4	3/112/4/4/3/1/11/1/4
Range and Doppler Extraction		**12**			**3/112/4/4/3/1/12**
	parametersId		**1**		
	production status			1	3/112/4/4/3/1/12/1/1
RAF TS Provider		**13**			**3/112/4/4/3/1/13**
	parametersId		**1**		
	Production status			1	3/112/4/4/3/1/13/1/1
	SI state			2	3/112/4/4/3/1/13/1/2
	Number of frames received			3	3/112/4/4/3/1/13/1/3
	Number of good frames received			4	3/112/4/4/3/1/13/1/4
	Number of frames delivered			5	3/112/4/4/3/1/13/1/5
	eventsId from framework identifiers				**3/112/4/4/1/5/2**
	Production configured			1	3/112/4/4/1/5/2/1
	Production interrupted			2	3/112/4/4/1/5/2/2
	Production halted			3	3/112/4/4/1/5/2/3
	Production operational			4	3/112/4/4/1/5/2/4

Table 4-2: Sample of MultiSat Published Monitored Parameters (4 of 4)

Functional Resource	Parameter	OID			
		F.R.	Type (P/E/D)		Completed
RCF TS Provider		**14**			**3/112/4/4/3/1/14**
	parametersId		**1**		
	Production status			1	3/112/4/4/3/1/14/1/1
	SI state			2	3/112/4/4/3/1/14/1/2
	Number of frames received			3	3/112/4/4/3/1/14/1/3
	Number of frames delivered			4	3/112/4/4/3/1/14/1/4
	eventsId from framework identifiers				**3/112/4/4/1/5/2**
	Production configured			1	3/112/4/4/1/5/2/1
	Production interrupted			2	3/112/4/4/1/5/2/2
	Production halted			3	3/112/4/4/1/5/2/3
	Production operational			4	3/112/4/4/1/5/2/4
Monitored Data CSTS Provider		**17**			**3/112/4/4/3/1/17**
	parametersId		**1**		
	Production status			1	3/112/4/4/3/1/17/1/1
Monitored Data Production		**18**			**3/112/4/4/3/1/18**
	parametersId		**1**		
	TBD				
Real-Time Tracking Data CSTS Provider		**19**			**3/112/4/4/3/1/19**
	parametersId		**1**		
	Production status			1	3/112/4/4/3/1/19/1/1
Service Control CSTS Provider		**20**			**3/112/4/4/3/1/20**
	parametersId		**1**		
	Production status			1	3/112/4/4/3/1/20/1/1
Service Control Production		**21**			**3/112/4/4/3/1/21**
	parametersId		**1**		
	TBD				
Frame Data Sink		**22**			**3/112/4/4/3/1/22**
	parametersId		**1**		
	Production status			1	3/112/4/4/3/1/22/1/1
	Percentage data store full			2	3/112/4/4/3/1/22/1/2

7.3 SERVICE AGREEMENT DEVELOPMENT PHASE

During the Service Agreement Development phase between the XenoSat mission and the Multinet network:

a) The Multinet antennas Pacific X-Band and Pacific S-Band are specified in the Service Agreement as supporting antennas; and

b) Two monitored parameter lists are defined. The first, named "Space-Link-Status", has the parameters specified in table 3. The second list is the default list, with parameters specified in table 4. Monitored parameter lists are lists of (Functional Resource Type OID : Monitored Parameter Type OID) pairs. Tables 4-3 and 4-4 identify the textual name as well as the OID for each Functional Resource Type and Monitored Parameter Type.

Table 4-3: Component Parameters of the Monitored Parameter List "Space-Link-Status"

Functional Resource Type ID (Textual Name | OID)	Parameter Type ID (Textual Name | OID)
Forward Space Link Carrier | 3/112/4/4/3/1/2	Actual transmit frequency | 3/112/4/4/3/1/2/1/2
FCLTU TS Provider | 3/112/4/4/3/1/6	SI state | 3/112/4/4/3/1/6/1/3
FCLTU TS Provider/ 3/112/4/4/3/1/6	Number of CLTUs radiated | 3/112/4/4/3/1/6/1/6
Return Space Link Carrier | 3/112/4/4/3/1/8	Actual receive frequency | 3/112/4/4/3/1/8/1/3
Return Space Link Subcarrier | 3/112/4/4/3/1/9	Subcarrier lock status | 3/112/4/4/3/1/9/1/2
Return Synchronization and Decoding | 3/112/4/4/3/1/11	Frame synchronizer lock status | 3/112/4/4/3/1/11/1/1
RAF TS Provider | 3/112/4/4/3/1/13	SI state | 3/112/4/4/3/1/13/1/2
RAF TS Provider | 3/112/4/4/3/1/13	Number of frames delivered | 3/112/4/4/3/1/13/1/5
RCF TS Provider | 3/112/4/4/3/1/14	SI state | 3/112/4/4/3/1/14/1/2
RCF TS Provider | 3/112/4/4/3/1/14	Number of frames delivered | 3/112/4/4/3/1/14/1/4

Table 4-4: Component Parameters of the Default Monitored Parameter List

Functional Resource Type ID (Textual Name | OID)	Parameter Type ID (Textual Name | OID)
FCLTU TS Provider | 3/112/4/4/3/1/6/	Production status | 3/112/4/4/3/1/6/1/1
RAF TS Provider | 3/112/4/4/3/1/13	Production status | 3/112/4/4/3/1/13
RCF TS Provider | 3/112/4/4/3/1/14	Production status | 3/112/4/4/3/1/14/1/1
Monitored Data CSTS Provider | 3/112/4/4/3/1/17	Production status | 3/112/4/4/3/1/17/1/1
Real-Time Tracking Data CSTS Provider | 3/112/4/4/3/1/19	Production status | 3/112/4/4/3/1/19/1/1
Service Control CSTS Provider | 3/112/4/4/3/1/20	Production status | 3/112/4/4/3/1/20/1/1

c) A default list of notifiable events is defined, with events specified in table 4-5. Notifiable event lists are lists of (Functional Resource Type OID : Notifiable Event Type OID) pairs. Table 4-5 identifies the textual name as well as the OIDs for each Functional Resource Type and Monitored Parameter Type

Table 4-5: Component Events of the Default Notifiable Event List

Functional Resource Type ID (Textual Name | OID)	Event Type ID (Textual Name | OID)
FCLTU TS Provider | 3/112/4/4/3/1/6	Production configured | 3/112/4/4/1/5/2/1
FCLTU TS Provider | 3/112/4/4/3/1/6	Production interrupted | 3/112/4/4/1/5/2/2
FCLTU TS Provider | 3/112/4/4/3/1/6	Production halted | 3/112/4/4/1/5/2/3
FCLTU TS Provider | 3/112/4/4/3/1/6	Production operational | 3/112/4/4/1/5/2/4
RAF TS Provider | 3/112/4/4/3/1/13	Production configured | 3/112/4/4/1/5/2/1
RAF TS Provider | 3/112/4/4/3/1/13	Production interrupted | 3/112/4/4/1/5/2/2
RAF TS Provider | 3/112/4/4/3/1/13	Production halted | 3/112/4/4/1/5/2/3
RAF TS Provider | 3/112/4/4/3/1/13	Production operational | /4
RCF TS Provider | 3/112/4/4/3/1/14	Production configured | 3/112/4/4/1/5/2/1
RCF TS Provider | 3/112/4/4/3/1/14	Production interrupted | 3/112/4/4/1/5/2/2
RCF TS Provider | 3/112/4/4/3/1/14	Production halted | 3/112/4/4/1/5/2/3

RCF TS Provider | 3/112/4/4/3/1/14	Production operational | 3/112/4/4/1/5/2/4

NOTE - In the case of a monitored parameter type or notifiable event type that is defined specifically for its parent FR Type, the parameter type OID or event type OID contains the OID of its parent FR Type. If all lists consisted only of FR Type-specific parameter types or event types, there would be no need to separately identify the functional resource However, for parameter type OIDs and event type OIDs that are adopted from the framework, there is no hierarchical relationship among the OIDs. Thus it is necessary in general to specify both FR Type and parameter ty

7.4 CONFIGURATION PROFILES

At some time prior to the first support by Multinet, multiple XenoSat configuration profiles are made available[3] at Multinet, including:

a. A Space Communication Service Profile (spaceCommunicationServiceProfileId = "Nominal Forward and Return S-Band") that contains one F401 Space Link Carrier Profile with carrierFrequency in the S-band (carrierProfileId = "Forward S-Band") and one R401 Space Link Carrier Profile with carrierFrequency in the S-band (carrierProfileId = "Return S-Band").
    1. The F401 Space Link Carrier Profile is configured for BPSK modulation of the data directly onto the carrier. The F401 Space Link Carrier Profile managed object specifies the configuration of the Forward Space Link Carrier functional resource that performs during the execution of the Service Package.
        a) The Forward Space Link Carrier Profile contains an F401SymbolStream managed object that specifies the configuration of the Forward Symbol Stream functional resource that performs during the execution of the Service Package.
        b) The F401SymbolStream contains an FCLTU Transfer Service Map (FcltuTsM) managed object for the single symbol stream that references the FCLTU Transfer Service Profile with transferServiceProfileId = "FCLTU-S" (see item **Error! Reference source not found.**.c). The referenced FCLTU Transfer Service Profile specifies the configuration of the F-CLTU TS Provider functional resource that performs during the execution of the Service Package.
    2. The R401 Space Link Carrier Profile is configured for QPSK modulation of the data onto a subcarrier. The I channel and Q channel each carry a separate symbol stream. The R401 Space Link Carrier Profile managed object specifies the configuration of the Return Space Link Carrier functional resource that performs during the execution of the Service Package. The R401 Subcarrier managed object specifies the configuration of the Return Space Link Subcarrier functional resource that performs during the execution of the Service Package.

[3] How the configuration profiles are defined and made available is outside the scope of this technical note. It could be by bilateral means or through the use of the various configuration profile Add operations.

a) The I channel symbol stream contains an RAF Production (RAF Prod) managed object that specifies the frame synchronization, derandomization, and error decoding configuration to be applied to the Return Sync and Decoding functional resource that performs these functions on the I channel data during execution of the Service Package.
b) The I channel RAF Prod managed object contains an RAF Transfer Service Map (RafTsM) that references the RAF Transfer Service Profile with transferServiceProfileId = "RAF-S-I-onlt" (see item **Error! Reference source not found.**.d). The referenced RAF Transfer Service Profile specifies the configuration of the RAF TS Provider functional resource that performs during the execution of the Service Package.
c) The I channel RAF Prod managed object contains a ReturnLinkFrameDataSink managed object (dataSinkId = "Ret-S-I") with functionalGroupId = "Ret-S-I". The data sink is configured to store all of the VC frames on the I channel symbol stream[4]. The ReturnLinkFrameDataSink managed object specifies the configuration of the Frame Data Sink functional resource that performs during the execution of the Service Package.
d) The Q channel symbol stream contains an RAF Prod managed object that specifies the frame synchronization, derandomization, and error decoding configuration to be applied to the Return Sync and Decoding functional resource that performs these functions on the Q channel data during execution of the Service Package.
e) The Q channel RAF Prod managed object contains an RAF Transfer Service Map that references the RAF Transfer Service Profile with transferServiceProfileId = "RAF-S-Q-onlc" (see item **Error! Reference source not found.**.e). The referenced RAF Transfer Service Profile specifies the configuration of the RAF TS Provider functional resource that performs during the execution of the Service Package.
f) The Q channel RAF Prod managed object contains a ReturnLinkFrameDataSink (dataSinkId = "Ret-S-Q") with functionalGroupId = "Ret-S-Q". The data sink is configured to store all of the VC frames on the Q channel symbol stream[5]. The ReturnLinkFrameDataSink managed object specifies the configuration of the Frame Data Sink functional resource that performs during the execution of the Service Package.

Table 4-6 summarizes the occurrences of the various functional resource types that result from scheduling a Service Package using the Nominal Forward and Return S-Band Space Communication Service Profile.

[4] In this simple scenario, there is only one data sink defined for the data received via the S-band I-channel symbol stream, and it stores all of the frames. Therefore the dataSinkId can be the same as that of the functionalGroupId. In more complex scenarios, multiple data sinks may be associated with the same symbol stream, where each of the data sinks may store different subsets of VCs. In the latter case, different datSinkIds would be used even though the functionalGroupId would be the same for all of them,

[5] See the footnote directly above.

Table 4-6: Occurrences of Functional Resource Types from Space Communication Service Profile "Nominal Forward and Return S-Band"

Functional Resource Type	Managed Object in Profile	Total Number of Occurrences of FR Type
Antenna	undefined in profile	1
Forward Space Link Carrier	F401 Space Link Carrier Profile (Forward S-Band)	1
Forward Symbol Stream	R401 Symbol Stream (Forward S-Band)	1
F-CLTU TS Provider	FCLTU Transfer Service Profile (FCLTU-S)	1
Return Space Link Carrier	R401 Space Link Carrier Profile (Return S-Band)	1
Return Space Link Subcarrier	R401 Subcarrier(Return S-Band)	1
Return Symbol Stream	R401 Symbol Stream (I channel Return S-Band)	2
	R401 Symbol Stream (Q channel Return S-Band)	
Return Sync and Decoding	RAF Prod (I channel Return S-Band)	2
	RAF Prod (Q channel Return S-Band)	
RAF TS Provider	RafTsM (RAF-S-I-onlt)	2
	RafTsM (RAF-S-Q-onlc)	
Frame Data Sink	Return Link Frame Data Sink (I channel Return S-Band)	2
	Return Link Frame Data Sink (Q channel Return S-Band)	

b. A Space Communication Service Profile (spaceCommunicationServiceProfileId = "Nominal Return X-Band") that contains R401 Space Link Carrier Profile with carrierFrequency in the X-band (carrierProfileId = "Return X-Band"). The R401 Space Link Carrier Profile is configured for BPSK modulation of the data onto a subcarrier. The R401 Space Link Carrier Profile managed object specifies the configuration of the Return Space Link Carrier functional resource that performs during the execution of the Service Package. The R401 Subcarrier managed object specifies the configuration of the Return Space Link Subcarrier functional resource that performs during the execution of the Service Package.
   1. The single symbol stream contains an RAF Prod managed object that specifies the frame synchronization, derandomization, and error decoding configuration to be applied to the Return Sync and Decoding functional resource that performs these functions on the data during execution of the Service Package.

2. The RAF Prod managed object contains two RCF Transfer Service Maps that reference the RCF Transfer Service Profiles with transferServiceProfileId = "RCF-X1-onlc" and "RCF-X2-onlc", respectively (see items **Error! Reference source not found.**.f and g). The referenced RCF Transfer Service Profiles specify the configuration of the RCF TS Provider functional resources that performs during the execution of the Service Package.
3. The RAF Prod managed object contains a ReturnLinkFrameDataSink (dataSinkId = "Ret-X") with functionalGroupId = "Ret-X". The data sink is configured to store all of the VCs on the symbol stream[6]. The ReturnLinkFrameDataSink managed object specifies the configuration of the Frame Data Sink functional resource that performs during the execution of the Service Package.

Table 4-7 summarizes the occurrences of the various functional resource types that result from scheduling a Service Package using the Return X-Band Space Communication Service Profile.

Table 4-7: Occurrences of Functional Resource Types from Space Communication Service Profile "Return X-Band"

Functional Resource Type	Managed Object in Profile	Total Number of Occurrences of FR Type
Antenna	undefined in profile	1
Return Space Link Carrier	R401 Space Link Carrier Profile (Return X-Band)	1
Return Space Link Subcarrier	R401 Subcarrier(Return X-Band)	1
Return Symbol Stream	R401 Symbol Stream (Return X-Band)	1
Return Sync and Decoding	RAF Prod (Return X-Band)	1
RCF TS Provider	RcfTsM (RCF-X1-onlc)	
	RcfTsM (RCF-X2-onlc)	2
Frame Data Sink	Return Link Frame Data Sink (Return X-Band)	1

c. An FCLTU Transfer Service Profile (`transferServiceProfileId` = "FCLTU-S") that is configured with `functionalGroupId` = "Fwd-S". The `startTimeOffset` and `stopTimeOffset` parameters are both set to zero, meaning that the service instance provision period will start and stop at the same times as the Space Link Carrier with which it is associated.
d. A timely online RAF Transfer Service Profile (`transferServiceProfileId` = "RAF-S-I-onlt") that is configured with `functionalGroupId` = "Ret-S-I". The `startTimeOffset` and `stopTimeOffset` parameters are both set to zero,

[6] See the footnote above.

meaning that the service instance provision period will start and stop at the same times as the Space Link Carrier with which it is associated.

e. A complete online RAF Transfer Service Profile (`transferServiceProfileId` = "RAF-S-Q-onlc") that is configured with `functionalGroupId` =" Ret-S-Q." The `startTimeOffset` and parameter is set to zero and the `stopTimeOffset` parameter is set to 120 seconds (2 minutes), meaning that the service instance provision period will start at the same time as the Space Link Carrier with which it is associated and continue until 2 minutes after that Space Link Carrier terminates.

f. A complete online RCF Transfer Service Profile (transferServiceProfileId = "RCF-X1-onlc") that is configured with functionalGroupId =" Ret-X." The `startTimeOffset` and parameter is set to zero and the `stopTimeOffset` parameter is set to 60 seconds (1 minutes), meaning that the service instance provision period will start at the same time as the Space Link Carrier with which it is associated and continue until 1 minute after that Space Link Carrier terminates.

g. A complete online RCF Transfer Service Profile (transferServiceProfileId = "RCF-X2-onlc") that is configured with functionalGroupId =" Ret-X." The `startTimeOffset` and parameter is set to zero and the `stopTimeOffset` parameter is set to 60 seconds (1 minute), meaning that the service instance provision period will start at the same time as the Space Link Carrier with which it is associated and continue until 1 minute after that Space Link Carrier terminates.

h. An offline RAF Transfer Service Profile (transferServiceProfileId = "RAF-S-I-offl") that is configured with functionalGroupId = "Ret-S-I".

i. An offline RAF Transfer Service Profile (transferServiceProfileId = "RAF-S-Q-offl") that is configured with functionalGroupId = "Ret-S-Q".

j. An offline RCF Transfer Service Profile (transferServiceProfileId = "RCF-X1-offl") that is configured with functionalGroupId = "Ret-S-I".

k. An offline RCF Transfer Service Profile (transferServiceProfileId = "RCF-X2-offl") that is configured with functionalGroupId = "Ret-S-I".

l. A Monitored Data Cross Support Transfer Service Profile (transferServiceProfileId – "MD1") that is configured with functionalGroupId = "MD-Aggregation".

m. A Real-Time Tracking Data Cross Support Transfer Service Profile (transferServiceProfileId – "TD1") that is configured with functionalGroupId = "TD-Aggregation".

n. A Service Control Cross Support Transfer Service Profile (transferServiceProfileId – "SC") that is configured with functionalGroupId = "Control-Distribution".

7.5 SERVICE PACKAGE REQUESTS

7.5.1 EXTENDED SERVICE PACKAGE REQUEST CLASS DIAGRAM

Figure 4-2 is the extended **<<ServicePackageRequest>>** stereotype class diagram form the Space Communication Cross Support Service Management Service Specification (SCCS-SM, reference [14]). The extensions (shaded in orange) are the **ServiceControlProduction**, SC-CSTS Map (**ScCstsM**), **MonitoredDataProduction**, MD-CSTS Map (**MdCstsM**), **Range&DopplerExtraction**, and TD-CSTS Map (**TdCstsM**) classes.

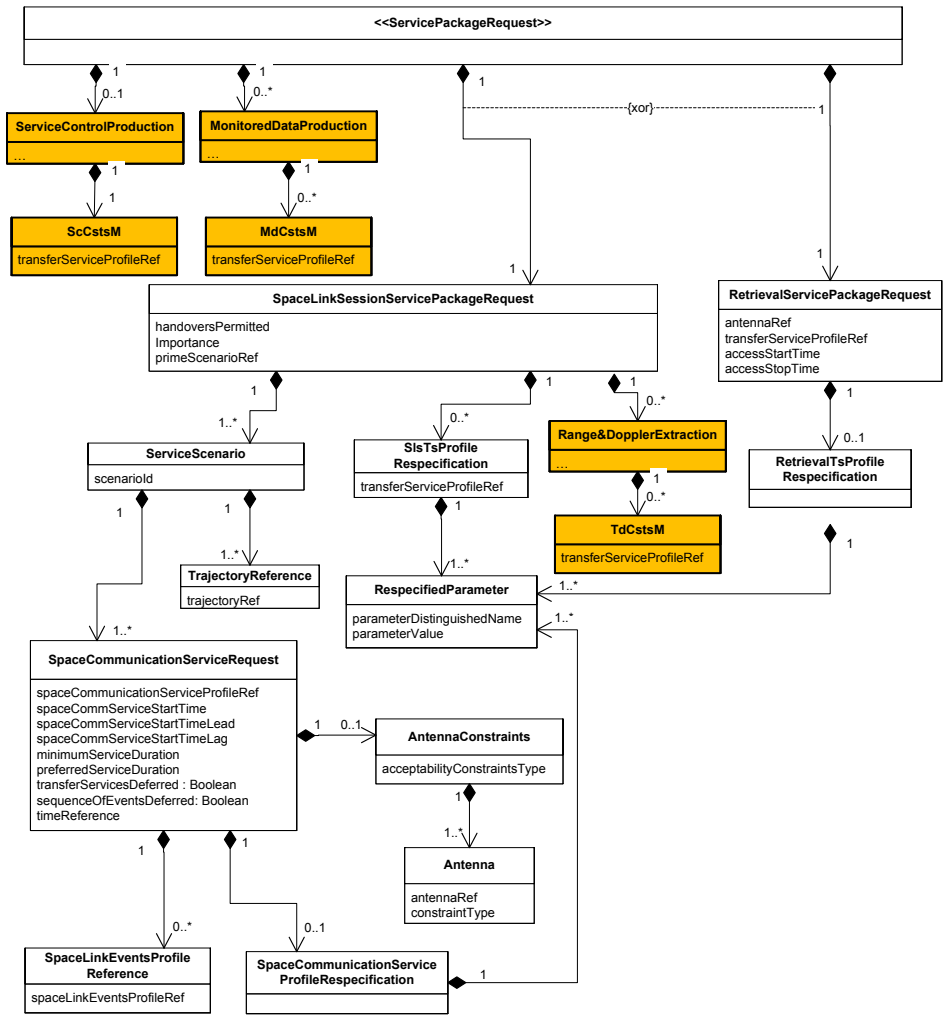

Figure 4-2: <<ServicePackageRequest>> Stereotype Class Diagram Extended for MD-CSTS, CS-CSTS, and TD-CSTS

NOTE 1 - For the purposes of this technical note, the extensions to the **<<ServicePackageRequest**>> stereotype class diagram are limited to those necessary to support the use of functional resources and the addition of the SC, MD, and TD CSTSes. The Next Generation Service Package Request will likely involve even more changes to accommodate other additional features that are outside the scope of this report.

As illustrated in the figure, the **ServiceControlProduction**, **ScCstsM**, **MonitoredDataProduction**, and **MdCstsM** classes apply to the complete Service Package, and can be present in both SLS and Retrieval Service Packages.

NOTE 2 - The association of MD and CS services with Retrieval Service Package means that some types of Retrieval Service Packages can be monitored or controlled. This concept that has not yet been fully explored.

The **Range&DopplerExtraction** and **TdCstsM** classes are present only in SLS Service Packages, and apply to an instance of TD-CSTS that operates concurrently with a Space Link Session in either real-time or complete mode. Pure retrieval instances of TD-CSTS are explicitly shown in the class diagram; they are included by reference via the `transferServiceProfileRef` parameter of the **RetrievalServicePackageRequest** class.

7.5.2 SLS SERVICE PACKAGE REQUEST

The XenoSat mission requests Multinet to create a Space Link Session Service Package with one Service Scenario containing the following components:

a. A Space Communication Service Request that references the Space Communication Service Profile with spaceCommunicationServiceProfileRef = “Nominal Forward and Return S-Band”). The Space Communication Service Request identifies the antenna “Pacific S-Band” as acceptable.

b. A Space Communication Service Request that references the Space Communication Service Profile with spaceCommunicationServiceProfileRef = “Return X-Band”. The Space Communication Service identifies the antenna “Pacific X-Band” as the only one that is acceptable.

c. An MD-CSTS Transfer Service Map (MD-CSTS-TsM). The referenced MD-CSTS Transfer Service Profile specifies the configuration of the Monitored Data CSTS Provider functional resource that performs during the execution of the Service Package.

d. A TD-CSTS Transfer Service Map (TD-CSTS-TsM). The referenced TD-CSTS Transfer Service Profile specifies the configuration of the Real-Time Tracking Data CSTS Provider functional resource that performs during the execution of the Service

Package.

e. An SC-CSTS Transfer Service Map (SC-CSTS-TsM). The referenced SC-CSTS Transfer Service Profile specifies the configuration of the Service Control CSTS Provider functional resource that performs during the execution of the Service Package.

NOTE - For this version of this technical note, no control parameters or directives are defined.

The time constraints on the Service Package Request are such that the Forward and Return S-Band Space Communication Service can be scheduled between 0700 and 1700 on 1500 August of the current year, with a duration of 10 minutes, and the Return X-Band Space Communication Service can be scheduled between 0700 and 1700 on 1500 on 15 August of the current year, with a duration of 5 minutes.

Table 4-8 summarizes the complete set occurrences of the various functional resource types that would result from scheduling the Service Package using the Nominal Forward and Return S-Band Space Communication Service Profile, the Return X-Band Space Communication Service Profile, the MD-CSTS Profile, the Real-Time Tracking Data CSTS Profile, and the Service Control CSTS Profile.

NOTE 5 - The Functional Resource Types shown in the table are not explicitly carried in the SLS Service Package Request.

Table 4-8: Occurrences of Functional Resource Types in SLS Service Package Request

Occurrence of Functional Resource Type in Service Package Request	Functional Resource Type	Total Number of Occurrences of FR Type
Pacific S-Band	Antenna	2
Pacific X-Band		
F401 Space Link Carrier Profile (Forward S-Band)	Forward Space Link Carrier	1
F401 Symbol Stream (Forward S-Band)	Forward Symbol Stream	1
FcltuTsM(FCLTU-S)	F-CLTU TS Provider	1
R401 Space Link Carrier Profile (Return S-Band)	Return Space Link Carrier	2
R401 Space Link Carrier Profile (Return X-Band)		
R401 Subcarrier(Return S-Band)	Return Space Link Subcarrier	2

Table 4-8: Occurrences of Functional Resource Types in SLS Service Package Request

Occurrence of Functional Resource Type in Service Package Request	Functional Resource Type	Total Number of Occurrences of FR Type
R401 Subcarrier(Return X-Band)		
R401 Symbol Stream (I channel Return S-Band)	Return Symbol Stream	3
R401 Symbol Stream (Q channel Return S-Band)		
R401 Symbol Stream (Return X-Band)		
RAF Prod (I channel Return S-Band)	Return Sync and Decoding	3
RAF Prod (Q channel Return S-Band)		
RAF Prod (Return X-Band)		
RafTsM (RAF-S-I-onlt)	RAF TS Provider	2
RafTsM (RAF-S-Q-onlc)		
RcfTsM (RCF-X1-onlc)	RCF TS Provider	2
RcfTsM (RCF-X2-onlc)		
Return Link Frame Data Sink (I channel Return S-Band)	Frame Data Sink	3
Return Link Frame Data Sink (Q channel Return S-Band)		
Return Link Frame Data Sink (Return S-Band)		
MdCstsM (MD1)	Monitored Data CSTS Provider	1
Monitored Data Production	Monitored Data Production	1
TdCstsM (TD1)	Real-Time Tracking Data CSTS Provider	1
Range and Doppler Production	Range and Doppler Production	1
ScCstsM (SC)	Service Control CSTS Provider	1
Service Control Production	Service Control Production	1

7.5.3 RETRIEVAL SERVICE PACKAGES

NOTE - This version of this technical note does not address the functional resources associated with Retrieval Transfer Service Instances. The material below is in place to support future extension of this technical note.

The XenoSat mission requests Multinet to create a Retrieval Service Package referencing the Offline RAF Transfer Service Profile with transferServiceProfileId = “RAF-S-I-offl”. The accessStartTime is 00:00:00 of 15 August, and the accessStopTime is 11:59:59 of 15 September. The antennaRef is “Multinet S-Band”.

The XenoSat mission requests Multinet to create a Retrieval Service Package referencing the Offline RAF Transfer Service Profile with transferServiceProfileId = “RAF-S-Q-offl”. The accessStartTime is 00:00:00 of 15 August, and the accessStopTime is 11:59:59 of 15 September. The antennaRef is “Multinet S-Band”.

The XenoSat mission requests Multinet to create a Retrieval Service Package referencing the Offline RCF Transfer Service Profile with transferServiceProfileId = “RCF-X1-offl”. The accessStartTime is 00:00:00 of 15 August, and the accessStopTime is 11:59:59 of 15 September. The antennaRef is “Multinet X-Band”.

The XenoSat mission requests Multinet to create a Retrieval Service Package referencing the Offline RCF Transfer Service Profile with transferServiceProfileId = “RCF-X2-offl”. The accessStartTime is 00:00:00 of 15 August, and the accessStopTime is 11:59:59 of 15 September. The antennaRef is “Multinet X-Band”.

NOTES

1 The Retrieval Service Packages in this technical note follow the construction as defined in SCCS-SM-B-1. That is, there is one offline SLE transfer service instance per Retrieval Service Package, and each offline transfer service instance obtains its data from the data store associated with the antenna identified by AntennaRef. This is a simple model that should be generalized for NextGen SCCS-SM. For example, instead of AntennaRef, the Retrieval Service Package could be associated with a generalized Data Store functional resource. The Data Store could be associated with an antenna, but it would not necessarily need to be (e.g., there could be one data store for a complete ground station). Also, multiple retrieval transfer service instances could be scheduled via a single Retrieval Service Package. The Retrieval Service Package could also contain the Data Store and MD-CSTS and SC-SC-CSTS instances to monitor and control the Data Store itself. This topic requires further analysis.

2 This version of this technical note does not address scheduling, monitoring, and/or control of Complete-mode CSTS instances. The Complete mode CSTS is a hybrid of online and offline modes: the same Complete CSTS service instance can execute during the execution of an SLS Service Package, but it can also execute outside the purview of any SLS Service Package (i.e., in purely offline mode). This topic requires further analysis.

7.6 SCHEDULED SERVICE PACKAGES

7.6.1 EXTENDED SERVICE PACKAGE RESULT CLASS DIAGRAM

Figure 4-3 is the extended **<<ServicePackageResult>>** stereotype class diagram (part 1) from the SCCS-SM.

The **SlsTsInstanceResult**, **BilateralSlsTsInstanceResult**, **Retrieval-TsInstanceResult**, and **BilateralRetrievalTsInstanceResult**, classes from the 910.11-B-1 version of the **<<ServicePackageResult>>** stereotype class diagram already have **transferServiceInstanceNumber** parameters that are assigned by CM in scheduling the Service Package and that are unique within the Service Package. These instance numbers also serve the purpose of FR Instance numbers for the corresponding Transfer Service Provider FR types.

NOTE - The **SlsTsResult** class corresponds to multiple different TS Provider functional resource types. As depicted in figure 3, the only way to distinguish the specific TS Provider FR type (e.g., an RAF TS Provider from an F-CLTU TS Provider) is by evaluating the type of the transfer service profile that is referenced by the **transferServiceProfileRef** parameter in each **SlsTsResult** object. The Next Gen SM WG may wish to consider whether the type should be more-directly identified in the **SlsTsResult** object itself, e.g., by having service-specific **SlsTsResult** subclasses or by having a `tsProviderFRType` parameter in the **SlsTsResult** class. (Note that with the extension point approach, the general structure of the **<<ServicePackageResult>>** could contain an abstract **SlsTsResult** extension point class but the actual instances of Service Package Results would contain service-specific subclass objects.)

The use of functional resources adds the `functionalResourceInstance` parameter to the **CarrierResult** classes. This modified classes is highlighted in yellow and the new `functionalResourceInstance` parameter is underlined. This parameter is used to identify the Functional Resource Instance number that is assigned to each Space Link Carrier functional resource instance.

The extended **<<ServicePackageResult>>** stereotype also now contains additional classes – **MonitoredDataProdResult**, **ServiceControlProdResult**, **Range&DopplerProdResult**, **MdCstsResult**, **ScCstsResult**, **TdCstsResult**, **SubcarrierResult**, **SymbolStreamResult**, **RafProdResult,** and **ReturnLinkFrameDataSinkResult** – to identify the Functional Resource Instance number that is assigned to each Monitored Data/Service Control/ Tracking Data Production functional resource, instance, MD/SC/TD CSTS provider functional resource instance, Space Link Subcarrier functional resource instance, Symbol Stream functional resource instance, Return Synchronization and Decoding functional resource instance, and Frame Data Sink functional resource, respectively. These new classes are highlighted in orange.

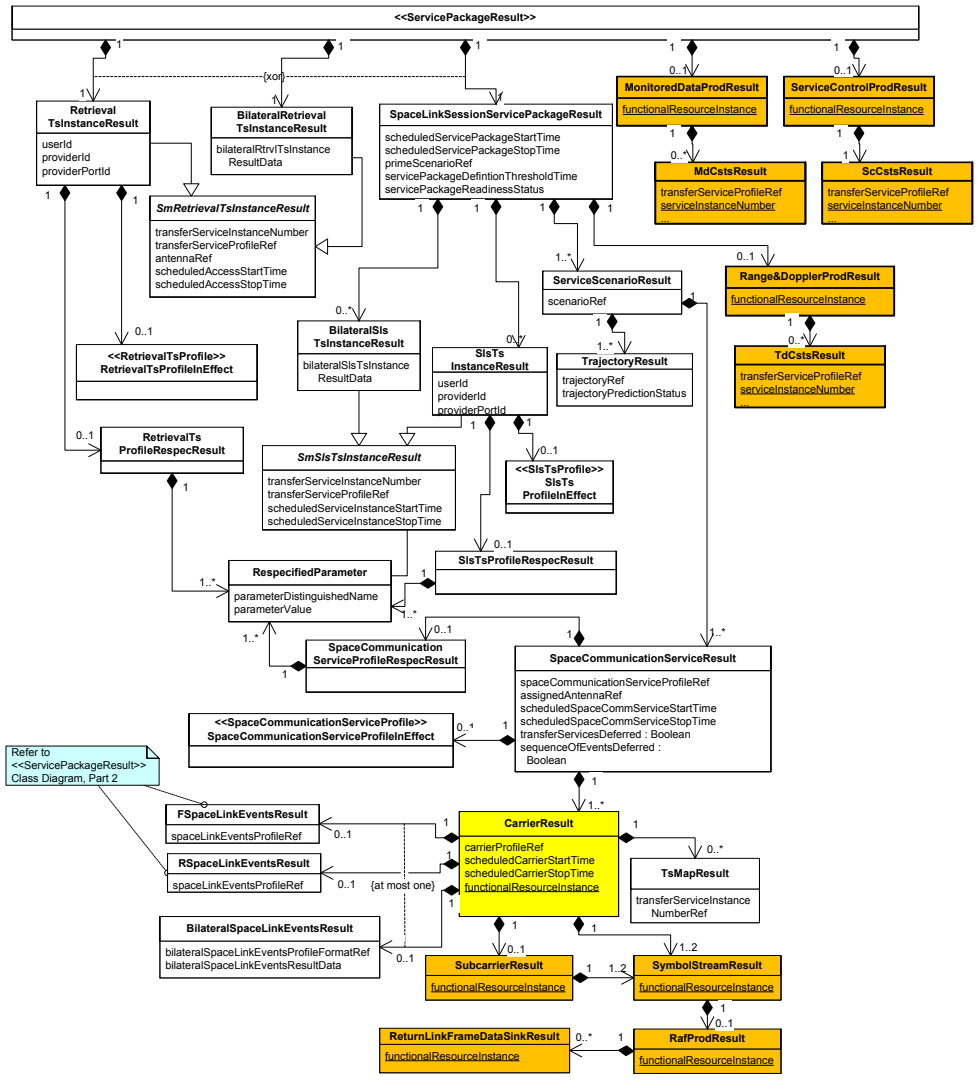

Figure 4-3: <<ServicePackageResult>> Stereotype Class Diagram Extended for MD-CSTS, CS-CSTS, and TD-CSTS and Functional Resource Instance Identification

In the case of the **`MdCstsResult`**, **`ScCstsResult`**, **`TdCstsResult`** classes, CM assigns a unique Service Instance Number to each scheduled CSTS instance. That Service Instance Number, carried in the `serviceInstanceNumber` parameter of the **`xxCstsResult`** object, identifies the Functional Resource Instance number for that TS Provider functional resource instance.

7.6.2 SCHEDULED SLS SERVICE PACKAGE

In response to the SLS Service Package Request, Multinet CM schedules the SLS Service Package to occur beginning at 1200 on 15 August, with the Forward S-Band Space Link Carrier and Return S-Band Space Link Carrier active from 1200 to 1210 and the Return X-Band Space Link Carrier active from 1205 to 1210. The scheduled stop time of the Service Package is 1212, the end of the service instance provision period of the complete online RAF transfer service instance associated with the S-Band Q channel.

Multinet CM assigns a *functional resource instance* to each occurrence of a functional resource type in the scheduled Service Package. Table 9 lists the functional resource instances for the scheduled Service Package. As shown in the table, the assignment of FR Instance numbers is unique within the context of the Functional Resource Type. That is, the same FR Instance number may appear multiple times within a given Service Package Result, but it cannot appear more than once for any given Functional Resource Type.

NOTE - The Functional Resource Types or OIDs shown in the table are not explicitly carried in the SLS Service Package Request.

In table 4-9, the Occurrence of FR Type in Scheduled Service Package column contain the names of the managed object classes (data sets) in the extended <<ServicePackageResult>> stereotype structure that correspond to the various functional resource instances. The *italicized* entries in this column are new managed object classes that do not appear in the <<ServicePackageResult>> stereotype in CCSDS 910.11-B-1 but do appear in figure 3 of this report.

Table 4-9: Occurrences of Functional Resource Types in Scheduled SLS Service Package

Occurrence of FR Type in Scheduled Service Package	Functional Resource Type: FR Type OID	FR Instance
Pacific S-Band	Antenna: 3/112/4/4/3/1/1	1
Pacific X-Band	Antenna: 3/112/4/4/3/1/1	2
Carrier Result (Forward S-Band)	Forward Space Link Carrier: 3/112/4/4/3/1/2	1
Symbol Stream Result (Forward S-Band)	Forward Symbol Stream: 3/112/4/4/3/1/5	1
SlsTsResult (FCLTU-S)	F-CLTU TS Provider: 3/112/4/4/3/1/6	1
Carrier Result (Return S-Band)	Return Space Link Carrier: 3/112/4/4/3/1/8	1
Carrier Result (Return X-Band)	Return Space Link Carrier: 3/112/4/4/3/1/8	2

Table 4-9: Occurrences of Functional Resource Types in Scheduled SLS Service Package

Occurrence of FR Type in Scheduled Service Package	Functional Resource Type: FR Type OID	FR Instance
Subcarrier Result (Return S-Band)	Return Space Link Subcarrier: 3/112/4/4/3/1/9	1
Subcarrier Result (Return X-Band)	Return Space Link Subcarrier: 3/112/4/4/3/1/9	2
Symbol Stream Result (I channel Return S-Band)	Return Symbol Stream: 3/112/4/4/3/1/10	1
Symbol Stream Result (Q channel Return S-Band)	Return Symbol Stream: 3/112/4/4/3/1/10	2
Symbol Stream Result (Return X-Band)	Return Symbol Stream: 3/112/4/4/3/1/10	3
RAF Prod Result (I channel Return S-Band)	Return Sync and Decoding: 3/112/4/4/3/1/11	1
RAF Prod Result (Q channel Return S-Band)	Return Sync and Decoding: 3/112/4/4/3/1/11	2
RAF Prod (Return X-Band)	Return Sync and Decoding: 3/112/4/4/3/1/11	3
SlsTsResult (RAF-S-I-onlt)	RAF TS Provider: 3/112/4/4/3/1/13	1
SlsTsResult (RAF-S-Q-onlc)	RAF TS Provider: 3/112/4/4/3/1/13	2
SlsTsResult (RCF-X1-onlc)	RCF TS Provider: 3/112/4/4/3/1/14	1
SlsTsResult (RCF-X2-onlc)	RCF TS Provider: 3/112/4/4/3/1/14	2
Return Link Frame Data Sink (I channel Return S-Band)	Frame Data Sink: 3/112/4/4/3/1/22	1
Return Link Frame Data Sink (Q channel Return S-Band)	Frame Data Sink: 3/112/4/4/3/1/22	2
Return Link Frame Data Sink (Return X-Band)	Frame Data Sink: 3/112/4/4/3/1/22	3
MdCstsResult (MD1)	Monitored Data CSTS Provider: 3/112/4/4/3/1/17	1
Monitored Data Production	Monitored Data Production: 3/112/4/4/3/1/18	1
TdCstsResult (TD1)	Real-Time Tracking Data CSTS Provider: 3/112/4/4/3/1/19	1
Range and Doppler Production	Range and Doppler Production: 3/112/4/4/3/1/12	1
ScCstsResult (SC)	Service Control CSTS Provider: 3/112/4/4/3/1/20	1

Table 4-9: Occurrences of Functional Resource Types in Scheduled SLS Service Package

Occurrence of FR Type in Scheduled Service Package	Functional Resource Type: FR Type OID	FR Instance
Service Control Production	Service Control Production: 3/112/4/4/3/1/21	1

7.7 SERVICE PACKAGE EXECUTION

7.7.1 MONITORING THE EXECUTION OF THE SLS SERVICE PACKAGE

At 1200 on 15 August (the scheduled start time of the SLS Service Package), Multinet begins executing the scheduled SLS Service Package and starts the service instance provision period of the single MD-CSTS Provider instance that is part of that Service Package.

NOTE - In 910.11-B-1, the start and stop times of SLS transfer service instance provision periods are defined as offsets from the start and stop time of the Service Package itself. In the case of the Monitored Data service, it is probably sufficient to make the service instance provision period always coincident with the Service Package itself.

The MD-CSTS, TD-CSTS, and SC-CSTS service instance provision periods start at 1200 (coincident with the scheduled start time of the SLS Service Package).

At some time after the start of the MD-CSTS service instance provision period, the MD service instance user BINDs to the provider. Shortly after BINDing, the MD-CSTS user STARTs three instances of the Cyclic Report procedure: the prime instance (since Cyclic Report is the prime procedure type for the MD-CSTS) and two secondary instances. The MD-CSTS user also STARTs an instance of the Notification procedure. During the execution of the Service Package, the MD-CSTS user invokes the GET operation of the Information Query procedure to retrieve all monitored parameters of the X-Band Return Space Link Subcarrier.

NOTE - The Cyclic Report procedure TRANSFER-DATA invocation transfers the requested parameter values as *qualified parameters*. The qualifier of the `qualified-parameter` has four possible values: (1) ‘valid’, in which case the value is reported; (2) ‘unavailable’, defined in the CSTS SF as “the Service Provider cannot provide the service” and for which no value is provided); (3) ‘undefined’, defined in the CSTS SF as “in the current Service Provider context, the value is undefined”, and for which no value is provided), and (4) ‘error’, defined as “the processing of the Service Provider resulted in an error”, and for which no value is provided.

In this scenario, some Functional Resources are not executing for the full duration of the Service Package. In such cases, there is some ambiguity as to

whether the qualified parameters reported for such non-executing FRs should be qualified as 'valid' and have dormant values (e.g., carrier lock = 'unlocked') or qualified as either 'unavailable' or 'undefined'. For the purposes of this technical note, the qualifier value depends in part on the production status of the functional resource instance. The SLE transfer services and the CSTS SF identify four *Production Status* values: 'configured', 'operational', 'halted', and 'interrupted'. Originally defined in the context of a transfer service to represent the aggregate readiness of all production resources associated with that transfer service, the Production Status concept may been generalized so that each production functional resource instance has its own Production Status. In this technical note, it is assumed that when a functional resource instance has a production status of 'configured', halted', or 'interrupted', the values of the parameters associated with that functional resource instance have an 'undefined' qualifier value. When a functional resource instance has a production status of 'operational', the values of the parameters associated with that functional resource instance have an 'valid' qualifier value.

This leads to a following question regarding whether the FR in questions is considered to be "configured" even though it is not operating. This question has implications for both production functional resources and transfer service provider functional resources.

a) The relationship between the four Production Status values and the state of the Service Package has never been explicitly stated. Specifically with regard to functional resources that are part of service production, the question is whether a production resource is always in one of the four states (statuses), or whether there can be another undefined state. For the purposes of this technical note, the assumption is that all production functional resources are in one of the four defined statuses. If it is possible for a Complex (Service Provider) to have a different operational concept (e.g.,. that a production functional resource is undefined until some short time before it is needed, even when the Service Package that contains it is executing) then different qualifiers and values may be transferred.

b) A similar ambiguity exists for Transfer Service Provider functional resources. The Operational Scenarios (sections 2.7 of the SLE transfer service specifications) for the SLE transfer services state "some time before the scheduled start time [of the service instance provision period] of the [SLE] service instance, the service instance is created by … Complex Management". The sections 2.6.4.2 (States of the Service Provider) of the SLE transfer service specifications state "Once a[n SLE] service instance is created, the … service provider is in one of three states …". That is, there is no specified relationship between the "creation" of an SLE transfer service and its service instance provision period, other than that the former precede the latter. In the case of SLE

transfer services whose service instance provision periods do not begin until after the start time of the Service Package itself, the service instances may or may not be "created" by the start time of that Service Package, depending on the design and operational procedures of the individual Complex. For the purposes of this technical note, the assumption is that all transfer service provider instances are created at the start of execution of the Service Package, regardless of the start of their service instance provision periods.

7.7.1.1 Prime Instance of Cyclic Report Procedure

The prime instance of the Cyclic Report procedure is STARTed with the parameters set as listed in table 4-10.

Table 4-10: START Parameters of the Prime Instance of the Cyclic Report Procedure

Parameter Name	Parameter Value
delivery-cycle	30
list-of-parameters	NULL (default monitored parameter list)

As soon as the Cyclic Report procedure prime instance successfully starts, the procedure begins to send TRANSFER-DATA invocations on its 30-second delivery-cycle. Each TRANSFER-DATA invocation contains a `qualified-parameter` for each instances of all of the parameters in the default monitored parameter list:

a) One instance of the FCLTU TS Provider FR Type's `production status` parameter (FCLTU-S);

b) Two instances of the RAF TS Provider FR Type's `production status` parameter (RAF-S-I-onlt, RAF-S-Q-onlc);

c) Two instances of the RCF TS Provider FR Type's `production status` parameter (RCF-X1-onlc, RCF-X2-onlc);

Comment [JP20]: When do these complete?

d) One instance of the Monitored Data CSTS Provider FR Type's `production status` parameter (MD1);

e) One instance of the Tracking Data CSTS Provider FR Type's `production status` parameter (TD1);

f) One instance of the Service Control CSTS Provider FR Type's `production status` parameter (SC).

Until the user of each transfer service instance BINDs to its respective service instance provider, the production status reported by the MD-CSTS for that transfer service is

unavailable. Once a transfer service instance is bound, the production status reported by the MD-CSTS for that transfer service instance reports its actual production status.

7.7.1.1.1 Example

Assume that the `production status` parameters of the FCLTU TS, RAF TS, RCF TS, Monitored Data CSTS, Tracking Data CSTS, and Service Control CSTS Provider FR Types are cast as **`TypeAndValue`** type (see D3.3 of the CSTS SF) `enumerated` values of 'configured' [0], 'interrupted' [1], 'halted' [2], and 'operational' [3].

When the MD1 Monitored Data CSTS Provider FR instance has a production status of 'operational', the `qualified parameter` for the production status for that functional resource instance appears in the Cyclic Report TRANSFER-DATA invocation with the following data:

a) Parameter Name, consisting of:

   1) Functional Resource Identifier, consisting of:

      a. Functional Resource Type = 3/112/4/4/3/1/17 (Monitored Data CSTS Provider)

      b. Functional Resource Instance number = 1 (MD1)

   2) ParameterId = 3/112/4/4/3/1/17/1/1 (Monitored Data CSTS Provider production status)

b) Parameter Type and Value (present only when qualifier value = 'valid'):

   1) Parameter Type = 8 (`enumerated`)

   2) Parameter Value = 3 ('operational')

So the complete contents of the qualified-parameter for this parameter would be:

((([3/112/4/4/3/1/17] : 1) : [3/112/4/4/3/1/17/1/1]) : (8:3))

7.7.1.2 First Secondary Instance of Cyclic Report Procedure

The first secondary instance of the Cyclic Report procedure is STARTed with the parameters set as listed in table 4-11.

Table 4-11: START Parameters of the First Secondary Instance of the Cyclic Report Procedure

Parameter Name	Parameter Value
delivery-cycle	20

list-of-parameters	"Space-Link-Status"

As soon as the Cyclic Report procedure first secondary instance successfully starts, the procedure begins to send TRANSFER-DATA invocations on its 20-second delivery-cycle. Each TRANSFER-DATA invocation contains a `qualified-parameter` for each instances of all of the parameters in the Space-Link-Status monitored parameter list:

a) One instance of the Forward Space Link Carrier FR Type's `actual transmit frequency` parameter (S-Band Forward Space Link Carrier);

b) One instance of the FCLTU TS Provider FR Type's `SI state` parameter (FCLTU-S);

c) One instance of the FCLTU TS Provider FR Type's `number of CLTUs radiated` parameter (FCLTU-S);

d) Two instances of the Return Space Link Carrier FR Type's `actual receive frequency` parameter (Return S-Band, Return X-Band);

e) Two instances of the Return Space Link Subcarrier FR Type's `subcarrier lock status` parameter (Return S-Band, Return X-Band);

f) Three instances of the Return Synchronization and Decoding FR Type's `frame synchronizer lock status` parameter (I-Channel Return S-Band, Q-Channel Return S-Band, Return X-Band);

g) Two instances of the RAF TS Provider FR Type's `SI state` parameter (RAF-S-I-onlt, RAF-S-Q-onlc);

h) Two instances of the RAF TS Provider FR Type's `number of frames delivered` parameter (RAF-S-I-onlt, RAF-S-Q-onlc);

i) Two instances of the RCF TS Provider FR Type's `SI state` parameter (RCF-X1-onlc, RCF-X2-onlc);

j) Two instances of the RAF TS Provider FR Type's `number of frames delivered` parameter (RCF-X1-onlc, RCF-X2-onlc).

From 1200 until 1205, the S-Band Forward Space Link Carrier, S-Band Return Space Link Carrier, S-Band Return Space Link Subcarrier, and two S-Band Return Synchronization and Decoding FRs are operational and the MD-CSTS reports valid values for their respective monitored parameters. However, during this time period, the X-Band Return Space Link Carrier, X-Band Return Space Link Subcarrier, and X-Band Return Synchronization and Decoding FR are only configured and the MD-CSTS reports their respective monitored parameters as unavailable.

From 1205 until 1210, all production resource in the Service Package are operational and the MD-CSTS reports valid values for their respective monitored parameters.

Until the user of each transfer service instance BINDs to its respective service instance provider, the production status reported by the MD-CSTS for that transfer service is unavailable. Once a transfer service instance is bound, the production status reported by the MD-CSTS for that transfer service instance reports its actual production status.

7.7.1.2.1 Example

Assume that the `number of frames delivered` parameters of the RAF and RCF TS Provider FR Types are cast as **`TypeAndValue`** type (see D3.3 of the CSTS SF) `unsignedInteger`.

When the RAF-S-Q-onlc RAF TS Provider FR instance has delivered 10134 frames, the `qualified parameter` for the number of frames delivered for that functional resource instance appears in the Cyclic Report TRANSFER-DATA invocation with the following data:

a) Parameter Name, consisting of:

   1) Functional Resource Identifier, consisting of:

      a. Functional Resource Type = 3/112/4/4/3/1/13 (RAF TS Provider)

      b. Functional Resource Instance number = 2 (RAF-S-Q-onlc)

   2) ParameterId = 3/112/4/4/3/1/13/1/5 (RAF TS Provider number of frames delivered)

b) Parameter Type and Value (present only when qualifier value = ‘valid’):

   1) Parameter Type = 1 (`unsignedInteger`)

   2) Parameter Value = 10134

So the complete contents of the qualified-parameter for this parameter would be:

((([3/112/4/4/3/1/13] : 2) : [3/112/4/4/3/1/13/1/5]) : (1:10134))

7.7.1.3 Second Secondary Instance of Cyclic Report Procedure

The second secondary instance of the Cyclic Report procedure is STARTed with the parameters set as listed in table 4-12.

Table 4-12: START Parameters of the Second Secondary Instance of the Cyclic Report Procedure

Parameter Name	Parameter Value
delivery-cycle	10
list-of-parameters	Actual azimuth of Pacific S-Band • FR Type: 3/112/4/4/3/1/1 (antenna) • FR Instance: 1 (Pacific S-Band) • ParameterId: 3/112/4/4/3/1/1/1/3 (actual azimuth) Actual elevation of Pacific S-Band • FR Type: 3/112/4/4/3/1/1 (antenna) • FR Instance: 1 (Pacific S-Band) • ParameterId: 3/112/4/4/3/1/1/1/4 (actual elevation) Actual azimuth of Pacific X-Band (antenna) • FR Type: 3/112/4/4/3/1/1 (antenna) • FR Instance: 2 (Pacific X-Band) • ParameterId: 3/112/4/4/3/1/1/1/3 (actual azimuth) Actual elevation of Pacific X-Band • FR Type: 3/112/4/4/3/1/1 (antenna) • FR Instance: 2 (Pacific X-Band) • ParameterId: 3/112/4/4/3/1/1/1/4 (actual elevation)

As soon as the Cyclic Report procedure second secondary instance successfully starts, the procedure begins to send TRANSFER-DATA invocations on its 10-second delivery-cycle. Each TRANSFER-DATA invocation contains a `qualified-parameter` for each instances of all of the named parameters in the `list-of-parameters` parameter:

a) Two instances of the Antenna FR Type's `actual azimuth` parameter (Pacific S-Band, Pacific X-Band);

b) Two instances of the Antenna FR Type's `actual elevation` parameter (Pacific S-Band, Pacific X-Band).

From 1200 until 1205, the Pacific S-Band Antenna is operational and the MD-CSTS reports valid values for its respective monitored parameters. However, during this time period, the

Pacific X-Band Antenna is only configured and the MD-CSTS reports its respective monitored parameters as unavailable.

From 1205 until 1210, both Antennas are operational and the MD-CSTS reports valid values for their respective monitored parameters.

7.7.1.3.1 Example

Assume that the `actual elevation` parameter of the Antenna FR Type is cast as **`TypeAndValue`** type `float` (see D3.3 of the CSTS SF).

When the Pacific X-Band Antenna FR instance is at an elevation of 67.25 degrees, the `qualified parameter` for the actual elevation for that functional resource instance appears in the Cyclic Report TRANSFER-DATA invocation with the following data:

a) Parameter Name, consisting of:

   1) Functional Resource Identifier, consisting of:

      a. Functional Resource Type = 3/112/4/4/3/1/1 (Antenna)

      b. Functional Resource Instance number = 2 (Pacific X-Band)

   2) ParameterId = 3/112/4/4/3/1/1/1/4 (Antenna actual elevation)

b) Parameter Type and Value (present only when qualifier value = ‘valid’):

   1) Parameter Type = 6 (`float`)

   2) Parameter Value = 67.25

So the complete contents of the qualified-parameter for this parameter would be:

((([3/112/4/4/3/1/1] : 2) : [3/112/4/4/3/1/1/1/4]) : (6:67.25))

7.7.1.4 Notification Procedure Instance

The instance of the Notification procedure is STARTed with the parameters listed in table 4-13.

Table 4-13: START Parameters of the Notification Procedure Instance

Parameter Name	Parameter Value
procedure-instance-identifier	secondaryProcedure:1
list-of-events	NULL (default notifiable events list)

NOTE- - All instance of the Notification procedure of the MD CSTS are secondary instances.

After the Notification procedure instance successfully starts, if any of the events in the default notifiable events list occurs, the procedure sends a NOTIFY invocation with one of the following events in the `notification-type` parameter:

a) ‘production configured’ (FCLTU-S, RAF-S-I-onlt, RAF-S-Q-onlc, RCF-X1-onlc, or RCF-X2-onlc);

b) ‘production interrupted’ (FCLTU-S, RAF-S-I-onlt, RAF-S-Q-onlc, RCF-X1-onlc, or RCF-X2-onlc);

c) ‘production halted’ (FCLTU-S, RAF-S-I-onlt, RAF-S-Q-onlc, RCF-X1-onlc, or RCF-X2-onlc);

d) ‘production operational’ (FCLTU-S, RAF-S-I-onlt, RAF-S-Q-onlc, RCF-X1-onlc, or RCF-X2-onlc);

7.7.1.4.1 Example

The OIDs for the ‘production configured’, production interrupted’, ‘production halted’, and ‘production operational’ event notifications are defined for the FCLTU, RAF, and RCF TS Provider FR Types in table 2.

When the RCF-X2-onlc RCF TS Provider FR instance transitions to the ‘production operational’ production status, the `notification-type` parameter of the Notification procedure NOTIFY invocation contains the following data:

a) Event Name, consisting of:

   1) Functional Resource Identifier, consisting of:

      a. Functional Resource Type = 3/112/4/4/3/1/14 (RCF TS Provider)

      b. Functional Resource Instance number = 2 (RCF-X2-onlc)

   2) EventId = 3/112/4/4/3/1/14/2/4 (production operational)

b) Event Value = “”.

So the complete contents of the qualified-parameter for this parameter would be:

((([3/112/4/4/3/1/14] : 2) : [3/112/4/4/3/1/14/2/4]) : (“”))

NOTE - The July 2012 draft of the CSTS SF specifies that the `notification-type` parameter contain both `event-name` and `event-value` (of type VisibleString) components. The `event-value` component is intended to be used to provide additional information (if any) about the event, but in many cases there is no such meaningful additional information. Such is the case for the production status change notifications. The July 2012 draft of the CSTS SF does not specify the content of the event-value component when there is no valid content. In keeping with the type of `event-value`, the above example sets it to an empty string. However, it might be more formally correct to allow `event-value` to be optional.

7.7.1.5 Information Query Procedure

At some time during the execution of the SLS Service Package, the MD-CSTS user invokes the GET operation of the MD-CSTS instance with the parameters set as listed in table 4-14. This example illustrates the capability to query all monitored parameters of a specified Functional Resource instance.

Table 4-14: GET Invocation Parameters of the Information Query Procedure Instance

Parameter Name	Parameter Value
list-of-parameters	X-Band Return Space Link Subcarrier: a) Functional Resource Type = 3/112/4/4/3/1/9 b) Functional Resource Instance number = 2

In response to the GET invocation, the MD CSTS returns a positive result with a `qualified-parameter` containing the Return X-Band values for each instance of each of the monitored parameters published for the Return Space Link Subcarrier FR type, including:

a) Actual subcarrier frequency;

b) Subcarrier lock status;

c) Subcarrier level estimate;

d) Subcarrier demod loop bandwidth.

7.7.1.5.1 Example

Assume that the `actual subcarrier frequency` parameter of the Return Space Link Subcarrier FR Type is cast as **`TypeAndValue`** type (see D3.3 of the CSTS SF) `unsignedInteger`.

When the Return Space Link Subcarrier FR instance has a subcarrier frequency of 16000 (Hz), the `qualified parameter` for the subcarrier frequency for that functional resource instance appears in the Information Query GET positive result return with the following data:

c) Parameter Name, consisting of:

   3) Functional Resource Identifier, consisting of:

      c. Functional Resource Type = 3/112/4/4/3/1/9 (Return Space Link Subcarrier)

      d. Functional Resource Instance number = 2 (X-Band)

   4) ParameterId = 3/112/4/4/3/1/9/1/1 (Return Space Link Subcarrier actual subcarrier frequency)

d) Parameter Type and Value (present only when qualifier value = 'valid'):

   3) Parameter Type = 1 (`unsignedInteger`)

   4) Parameter Value = 16000

So the complete contents of the qualified-parameter for this parameter would be:

((([3/112/4/4/3/1/9:2] : [3/112/4/4/3/1/9/1/1]) : (1:16000))

7.7.2 CONTROLLING THE EXECUTION OF THE SERVICE PACKAGE

Controlling the execution of the Service Package will be described in a future version of this technical note.

7.8 CONCLUSIONS

Overall, the use of Functional Resources is a viable approach for integrating the configuration and operation of monitored data and service control services into SCCS-SM with minor modifications to the current (B-1) SCCS-SM architecture. While such modifications are not currently envisioned to be retrofit into the B-1 architecture, such accommodations should be easy to make for the Next Generation SCCS-SM architecture.

During the course of exercising the detailed scenarios of this technical note, several areas of mismatch or ambiguity were encountered. None of these were show-stoppers, but rather areas for further work. To recap:

- There are differences in most of the names of the functional resource types between the Hell/Doat material and the Next Generation SCCS-SM Concept (e.g., "Return Space Link Carrier" instead of "Carrier Downlink") resulting from the sources of those names (i.e., current ESTRACK operations vs. CCSDS Service Management concepts and terminology). Also, some of the parameters associated with the

functional resource types differ between the two groups. These differences will eventually be resolved. For this version of this technical note, the functional resource type names and parameters are aligned with those of the Next Generation SCCS-SM Concept.

- The Retrieval Service Packages in this technical note follow the construction as defined in SCCS-SM-B-1. That is, there is one offline SLE transfer service instance per Retrieval Service Package, and each offline transfer service instance obtains its data from the data store associated with the antenna identified by AntennaRef. This is a simple model that should be generalized for NextGen SCCS-SM.

- This technical note includes examples of Functional Resource instances that are not executing for the full duration of the Service Package. In such cases, there is some ambiguity as to whether the qualified parameters reported for such non-executing FRs should be qualified as 'valid' and have dormant values (e.g., carrier lock = 'unlocked') or qualified as either 'unavailable' or 'undefined'. For the purposes of this technical note, the qualifier value depends in part on the production status of the functional resource instance. The SLE transfer services and the CSTS SF identify four *Production Status* values: 'configured', 'operational', 'halted', and 'interrupted'. Originally defined in the context of a transfer service to represent the aggregate readiness of all production resources associated with that transfer service, the Production Status concept may been generalized so that each production functional resource instance has its own Production Status. In this technical note, it is assumed that when a functional resource instance has a production status of 'configured', halted', or 'interrupted', the values of the parameters associated with that functional resource instance have an 'undefined' qualifier value. When a functional resource instance has a production status of 'operational', the values of the parameters associated with that functional resource instance have an 'valid' qualifier value.

- This leads to a following question regarding whether the FR in questions is considered to be "configured" even though it is not operating, and has implications for both production functional resources and transfer service provider functional resources.

- The relationship between the four Production Status values and the state of the Service Package has never been explicitly stated. Specifically with regard to functional resources that are part of service production, the question is whether a production resource is always in one of the four states (statuses), or whether there can be another undefined state. For the purposes of this technical note, the assumption is that all production functional resources are in one of the four defined statuses. If it is possible for a Complex (Service Provider) to have a different operational concept (e.g.,. that a production functional resource is undefined until some short time before it is needed, even when the Service Package that contains it is executing) then different qualifiers and values may be transferred.

- The Operational Scenarios (sections 2.7 of the SLE transfer service specifications) for the SLE transfer services state "some time before the scheduled start time [of the

service instance provision period] of the [SLE] service instance, the service instance is created by … Complex Management". The sections 2.6.4.2 (States of the Service Provider) of the SLE transfer service specifications state "Once a[n SLE] service instance is created, the … service provider is in one of three states …". That is, there is no specified relationship between the "creation" of an SLE transfer service and its service instance provision period, other than that the former precede the latter. In the case of SLE transfer services whose service instance provision periods do not begin until after the start time of the Service Package itself, the service instances may or may not be "created" by the start time of that Service Package, depending on the design and operational procedures of the individual Complex. For the purposes of this technical note, the assumption is that all transfer service provider instances are created at the start of execution of the Service Package, regardless of the start of their service instance provision periods.

ANNEX A

ACRONYMS AND ABBREVIATIONS

DRAFT TECHNICAL NOTE CONCERNING FUNCTIONAL RESOURCES FOR CROSS SUPPORT SERVICES