

Technical Note Concerning Space Data System Standards

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| Functional Resources for cross support services |

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# Introduction

## Purpose OF THIS REPORT

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

## 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 SLE 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 SLE functional groups was to provide the context for the definition of the SLE transfer services. However, the SLE 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 SLE 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 SLE 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 SLE 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 (and possible other CSTSes).

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 *Space Communication Cross Support Service Management – Service Agreement and Configuration Profile Data Formats* Recommended Standard (see the *Extensible Space Communication Cross Support Service Management* *Concept* Green Book, reference [12]).

## 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 station, but in the case of a relay satellite system in which both the ground terminal and the relay satellite belong to the same operational organization such that the operation of the links between the ground terminal and the relay satellite are not exposed to the user mission (such as the NASA Space Network), the ESLT represents the functionality of both the ground terminal *and* the relay satellite.

## Document Organization

Section 2 describes concepts of Functional Resources.

Section 3 describes the concept of Space Communication Cross Support Abstract Service Components and identifies the Abstract Service Components 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, and the relationship of the FR Type to functions and procedures of CCSDS Recommended Standards is identified.

Section 5 describes the concepts of *service templates* and *service profiles*, and how they are composed of Abstract Service Components.

Section 6 identifies the FR Types that are present in each of the IOAG Service Catalog #1 services. For each IOAG service, the Abstract Service Components 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.

## Definitions

TBS.

## 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 2014.

[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] *Return Unframed Telemetry Cross Support Transfer Service*. Recommended Standard. CCSDS 922.?. (future)

[8] *Tracking Data Cross Support Transfer Service*. Draft Recommended Standard. CCSDS 922.2-W-0.6. March 2013.

[9] *IOAG Service Catalog #1*. Issue 1, Revision 4. Interagency Operations Advisory Group. June 2013.

[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. CCSDS-902.0. Green Book. [in publication].

[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, November 2013.

[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] *Space Communication Cross Support Service Management – Service Agreement and Configuration Profile Data Formats*. Future Recommended Standard.

[16] *IOAG Service Catalog #2*. IOAG.T.SC2.2011.V1.1. Issue 1, Revision 1. Interagency Operations Advisory Group. June 2013.

[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] *Encapsulation Service*. Recommendation for Space Data System Standards, CCSDS 133.1-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, October 2009 (Cor. 1 September 2012).

[23] *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.

[24] *Pseudo-Noise (PN) Ranging Systems*. Recommendation for Space Data System Standards, CCSDS 414.1-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, March 2009.

[25] *Data Transmission and PN Ranging for 2 GHz CDMA Link via Data Relay Satellite*. Recommendation for Space Data System Standards, CCSDS 415.1-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2011.

[26] *CCSDS File Delivery Protocol (CFDP)*. Recommendation for Space Data System Standards, CCSDS 727.0-B-4. Blue Book. Issue 4. Washington, D.C.: CCSDS, January 2007.

[27] *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.

[28] *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.

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

[30] *Rationale, Scenarios, and Requirements for DTN in Space*. Report Concerning Space Data System Standards, CCSDS 734.0-G-1. Green Book. Issue 1. Washington, D.C.: CCSDS, August 2010.

[31] *IP Over CCSDS Space Links*. Recommendation for Space Data System Standards, CCSDS 702.1-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, September 2012.

# Concepts of Functional ResourceS

Functional Resources are 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. Functional Resources exist to represent such information as it applies to a cross support interface – if a processing function does not have unique monitored parameters, notifiable events, or any configuration parameters that need to be set (possibly through configuration profiles), queried, or reconfigured(via real-time control directives), 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 data or a signal through an instance of the FR Type – the “function” of the FR Type is the process that it performs on this signal/data. Such processing can involve converting one type of signal to another type of signal, manipulating data to produce another type of data, generating signals from data, or extracting data from signals (e.g., space communication data modulated onto an electromagnetic carrier signal, or Doppler data derived from an electromagnetic carrier signal). 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 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 (reference [23]), 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 [30] and [31]).

The services provided in a Service Package can contain multiple instances of *Functional Resource Types* (FR Types). 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 its Functional Resource Name, which is the combination of the Functional Resource Type with a Functional Resource Instance Number (see the *Cross Support Transfer Service Specification Framework* (reference [4]) for additional details on the formal syntax of Functional Resource identifiers).

# Space Communication Cross Support Abstract Service Components

NOTE - Parts of this section are adapted from material in the *Extensible Space Communication Cross Support Concept* Green Book (reference [12]). That Green Book uses the modeling and terminology of the SCCS Architecture Description Document Green Book (reference [13]). That SCCS ADD terminology is also used in this section. The translation between the SCCS ADD terms used in this section and the terms of the Cross Support Reference Model (reference [1]) is as follows:

* the *Earth Space Link Terminal* (ESLT) is part of the *SLE Complex*;
* the *Space User Node* is equivalent to the *Space Element* (i.e., mission spacecraft);
* the *Earth User Node* is part of the *MDOS*; and
* the *Provider* CSSS is equivalent to the *SLE Complex*.

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 the 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.

The concept of Abstract Service Components (ASCs) accommodates the bundling of related FR Types for the purposes of substitution and extensibility. Organizing the ASCs 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 section 5.

## Abstract Service Components with Concrete specializations

Basing the ASCs 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 ASC. The abstract layered model has the following components:

1. The aperture, which is the physical interface to the space medium. On the “ground side”, the aperture receives and/or transmits an electromagnetic carrier signal.
2. The physical channel, which transfers a stream of channel bits through the aperture across the physical medium (in this case, space). In addition to the transfer of a stream of bits, the physical channel may also carry non-binary signals, e.g. for the purpose of range measurements. 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., a single-feed steerable antenna, an array of geographically-separated steerable antennas, an array of fixed antenna elements that “point” by adjusting the phase differences among those antenna elements) justifies treating apertures separately from physical channels for the purposes of SCCS ASC definition.

1. 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.
2. 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.
3. Data delivery transfer 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.
4. 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.

For the IOAG Service Catalog #1 services performed by an ESLT (which is the current scope of SCCS SM), the composite functionality of these abstract layers conforms to the specifications provided by CCSDS Recommended Standards for space link modulation (reference [23]), synchronization and channel coding (references [5] and [6]), space data link protocols (references [19], [18], and [17]), and terrestrial cross support transfer services (references [27], [2], [3], [29], and [28]). Over time, these Recommended Standards will be augmented to accommodate new space communications and tracking technologies (e.g., radio frequency vs. optical technologies at the aperture and physical channel layers). Each space communications technology may have its own set of management parameters that must be used when that technology is employed in the configuration of an ESLT. In SCCS SM, these abstract communication layers are represented by ASCs.

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



Figure ‑: **SCCS Abstract Service Components for Earth-Space Link Terminals**

NOTES

1. The possible flows shown in Figure 3‑1 are the space communications and radiometric service data flows through these ASCs. They do not include the flows by which these ASCs are configured and controlled in real time and by which monitored parameter values and event notifications are collected from the various ASCs for reporting to the Earth User Node. Such data flows can be considered to occur in a separate management dimension (see the paragraph describing the Service Management Functions ASC below).
2. Figure 3‑1 includes a Space Internetworking ASC, even though space internetworking is an IOAG Service Catalog #2 capability and outside the current scope of this Informational Report. This ASC is included to illustrate how space internetworking can be accommodated within the ASC concept.
3. Although the set of ASCs identified in this Technical Note encompass all services of IOAG Service Catalogs 1 and 2, new SCCS services may be introduced in the future that do not easily fit into the ASCs defined herein. If that happens, new SCCS ASCs will be defined in a way that provides the same kinds of extensibility as the ASCs described in this Technical Note.

The IOAG services are distributed across multiple ASCs to align with the IOAG service categories defined in Service Catalogs #1 and #2 (references [9] and [16], respectively). IOAG services are categorized into *data delivery services* (forward and return), *radiometric services*, and *service management functions*. The data delivery and radiometric service groups are further divided into the *space link interfaces* and *ground link interfaces* of which they are composed.

The set of ASCs that correspond to the Space Link Interface Standards are the Aperture, Forward Physical Channel Transmission, Forward Synchronization and Channel Encoding, Forward Space Link Protocol Transmission, Return Physical Channel Reception, Return Synchronization and Channel Decoding, and/or Return Space Link Protocol Reception ASCs. By definition, these ASCs are present only in SLS configurations.

* The Aperture ASC represents the general class of apertures through which forward space link signals are transmitted and return space link signals are received as part of SLS Service Packages. 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. With respect to the SCCS SM Enterprise Model functions, the Aperture ASC maps to the Space Link Processing function of the Provider CSSS.
* The Forward Physical Channel Transmission and Return Physical Channel Reception ASCs represent the RF modulation, (future) optical modulation, and radiometric measurement functions that are performed as part of SLS Service Packages. With respect to the SCCS SM Enterprise Model functions, the Forward Physical Channel Transmission and Return Physical Channel Reception ASCs are part of the Space Link Processing function of the Provider CSSS.
* The Forward Synchronization and Channel Encoding and Return Synchronization and Channel Decoding ASCs represent the coding/decoding and synchronization functions that are performed as part of SLS Service Packages. With respect to the SCCS SM Enterprise Model functions, the Forward Synchronization and Channel Encoding and Return Synchronization and Channel Decoding ASCs map to the Space Link Processing function of the Provider CSSS.
* The Forward Space link Protocol Transmission and Return Space Link Reception ASCs represent the space link protocol processing functions that are performed as part of SLS Service Packages. With respect to the SCCS SM Enterprise Model functions, the Forward Space link Protocol Transmission and Return Space Link Reception ASCs map to the Space Link Processing function of the Provider CSSS.

The set of ASCs that correspond to the ground link interfaces of the IOAG data delivery and radiometric services are the SLS Data Delivery Production ASC, the SLS Radiometric Data Production ASC, the Offline Data Delivery Production ASC, the Data Delivery Transfer Services ASC, and the Space Internetworking ASC.

* The SLS Data Delivery Production ASC represents the additional production functions beyond those provided by the Aperture, Physical Channel, Synchronization and Channel Coding, and/or Space Link Protocol ASCs that are performed as part of SLS Service Packages. For forward link data, the SLS Data Delivery Production ASC functions provide the additional processing needed to transmit data that is either transferred in real time via a Data Delivery transfer service or extracted from intermediate storage. For return link data, the SLS Data Delivery Production ASC functions provide the additional processing needed to prepare the data for either intermediate storage and/or real-time delivery via a Data Transfer service. With respect to the SCCS SM Enterprise Model functions, the SLS Data Delivery Production ASC maps to the Data Forwarding function of the Provider CSSS.
* The SLS Radiometric Data Production ASC represents the additional production functions (beyond the Aperture and Physical Channel ASC radiometric measurement functions) that are performed as part of SLS Service Packages in order to prepare radiometric data for intermediate storage and/or real-time delivery via a Radiometric Data transfer service. With respect to the SCCS SM Enterprise Model functions, the SLS Radiometric Data Production ASC maps to the Application Service function of the Provider CSSS.
* The Offline Data Storage ASC represents the production functions that are performed as part of Retrieval Service Packages (for return link communication and radiometric data) or a Store and Forward Service Package (for forward link communication data). For return link data, these functions include (but are not necessarily limited to) the data stores and recording buffers that hold data awaiting subsequent retrieval. For forward link data, these functions include (but are not necessarily limited to) the data stores that hold data awaiting subsequent transmission during a space link session. With respect to the SCCS Enterprise Model functions, the Offline Data Delivery Production ASC maps to the Data Store and the Data Forwarding functions of the Provider CSSS.
* The Data Transfer Services ASC represents the various cross-support transfer services that are used to transfer space link communication data and radiometric data across terrestrial networks between a spaceflight Mission ground facility and an ESLT. These services include the SLE transfer services, CSTS that transfer communication data to be sent or that has been received through the space link, services that transfer radiometric data from the ESLT to the Mission ground facility, as well as services that transfer files of communication data that is to be sent or that has been received through the space link. With respect to the SCCS SM Enterprise Model functions, the Data Transfer Services ASC maps to the Data Forwarding function of the Provider CSSS.
* The Space Internetworking ASC represents functions performed to transfer internetwork data across the space link as part of an end-to-end internetwork data transfer. IOAG Service Catalog #1 (reference [9]) does not include internetwork services; those are covered by Service Catalog #2 (reference [16]). These ASCs are included in the set of ESLT ASCs for completeness.

The Service Management Functions ASC corresponds to the IOAG service management The Service Management Functions ASC corresponds to the IOAG service management functions. There are two transfer services that belong to the Service Management Functions ASC: the MD-CSTS and the future SC-CSTS. As noted above, the Service Management Functions interface with all of the other ASCs via connections that exist in a management dimension that is not illustrated in Figure 3‑1. With respect to the SCCS SM Enterprise Model functions, the Service Management Functions ASC maps to the Application Service function of the Provider CSSS.

The ASCs do not have specific management parameters, monitored parameters, notifiable events and real-time control parameters. An ASC must be specialized to a concrete Service Component for a given technology before an appropriate set of parameters and notifiable events can be defined. A set of FR Types is defined for each SC. The SC also defines the relationships among the component FR Types, and which of those FR Types implement the extension point interfaces of the ASC.

Figure 3‑2 depicts the SCs that support the service configurations in IOAG Service Catalogs #1 (reference [9]) and #2 (reference [16]). Each of these specializations corresponds to a CCSDS Recommended Standard. Within the rounded box for each ASC, the SCs of that ASC are depicted as dashed-border rounded boxes. In two cases (SLS Radiometric Data Production and Offline Data Storage) the ASC boxes are not large enough for the SCs. In these cases the SCs are shown in separate boxes at the bottom of the diagram.

NOTES

1 In Figure 3‑2 and subsequent figures that depict the SCs that specialze the ASCs, the placement of the SC icons within the ASC icons is not related to the postion of the arrows entering and leaving the containing parent icons. The figures merely indicate that the SCs belong to their parent ASCs. However, for those ASCs that have both forward and return SCs, the forward SCs are shown in the upper part of the ASC icons, and the return SCs are shown in the lower part of the ASC icons.

2 The functionalities of the CCSDS 401 SC specializations of the Forward Physical Channel Transmission and Return Physical Channel Reception ASCs conform to the CCSDS 401 Recommended Standards for radio frequency and modulation (reference [23]) and optionally to the CCSDS Recommended Standard for pseudo-noise (PN) ranging (reference [24]) where Code Division Multiple Access (CDMA) is not employed. These are the two physical channel-layer Recommended Standards that are explicitly called out in IOAG Service Catalogs #1 (reference [9]) and #2 (reference [16]). IOAG services could also be performed over links that use CDMA in accordance with reference [25], for which different SC specializations of Forward Physical Channel Transmission and Return Physical Channel Reception ASCs will exist.



**Figure 3‑2: Specializations of SCCS Abstract Service Components**

# Functional Resource Types for ESLT Service Component specializations

This section describes the Functional Resource Types that represent the functions that are performed by ESLTs. Primarily, these Functional Resource Types are the ones that represent the functions that are performed in providing 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 Servcie Component (SC) specializations of the Abstract Service Components identified in section 3. The FR Types in the diagram are color-coded to identify the major category of the ASCs to which they belong. The future FR Types that correspond to non-IOAG Service Catalog 1 services are indicated by dashed boxes.

NOTE - Figure 4-1 includes the Return Operational Control Fields Transfer Service User (ROCF TS User) FR Type but does not assign it to any particular ASC (it has no ASC color code). The purpose of the ROCF TS User FR Type is to acquire Communications Link Control Words (CLCWs) from another Provider Cross Support Service System (Provider CSSS) when the return link is supplied by that Provider CSSS and not by the local Provider CSSS. The ROCF TS User FR Type will be assigned to a ASC specialization in a future version of this Technical Note.

In this section, the Functional Resource Types are organized by the specialized ASCs 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.

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

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

## Aperture Abstract Service Component

The Aperture ASC has no Accessor Ports because it terminates the configuration on the space link side. The Aperture ASC has two essential SAP ports: Forward Modulated Waveform and Return Modilated Waveform.

### RF Aperture SC Specialization of the Aperture Abstract Service Component

The RF Aperture SC specialization of the Aperture ASC consists of the Antenna FR Type.



**Figure 4-1: Functional Resource Types for ESLTs**

Table xx

#### 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.

## Forward Physical Channel Abstract Service Component

### CCSDS 401 Forward Physical Channel Transmision SC Specialization of the Forward Physical Channel Abstract Service Component

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

1. Forward 401 Space Link Carrier Transmission; and
2. Forward Link Ranging.

#### Forward 401 Space Link Carrier Transmission

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

The Forward 401 Space Link Carrier Transmission FR Type modulates one stream of forward physical channel symbols and/or a ranging signal into a forward electromagnetic waveform.

#### Forward Link Ranging

The OID of the Forward Link Ranging FR Type is

{crossSupportFunctionalities fwdLinkRanging (4)}.

The Forward Link Ranging FR Type generates the ranging signal that is applied to the forward physical channel. Depending on the ranging technology used, the ranging signal takes the form of ranging tones as defined in CCSDS 401 (reference [23]), a pseudo-noise (PN) sequence as defined in CCSDS 414 (reference [24]), or a ranging code that is modulated onto the QPSK Q channel of a Code Division Multiple Access (CDMA) spread spectrum forward link as defined in CCSDS 415 (reference [25]). The time of radiation of the ranging signal is provided to the Range and Doppler Extraction FR type so that on reception of the ranging signal replica the round-trip delay can be determined.

## Forward Synchronization and Channel EnCoding ASC

### TC Sync and Channel Encoding SC Specialization Of the Forward Synchronization and Channel EnCoding ASC

The TC Sync and Channel Encoding SC specialization of the Forward Sync and Channel Encoding ASC consists of the TC Sync and Channel Encoding FR Type.

#### TC Sync and Channel Encoding

**The CSTSWG is in the process of assigning an FR Type OID to the TC Sync and Channel Encoding FR Type.**

The TC Sync Channel Encoding FR Type corresponds to the following functions:

1. the Physical Layer Operations Procedure (PLOP) as specified in the TC Synchronization and Channel Coding Recommended Standard; and
2. the (optional) frame randomization, BCH encoding, and CLTU generation functions specified in the TC Synchronization and Channel Coding Recommended Standard.

### Forward AOS Sync and Channel Encoding SC Specialization Of the Forward Synchronization and Channel EnCoding ASC

The Forward AOS Sync and Channel Encoding SC specialization of the Forward Sync and Channel Encoding ASC consists of the Forward AOS Sync and Channel Encoding FR Type.

#### Forward AOS Sync and Channel Encoding FR Type

**The CSTSWG is in the process of assigning an FR Type OID to the Forward AOS Sync and Channel Encoding FR Type.**

The Froward AOS Sync and Channel Encoding FR Type corresponds to the following functions:

1. 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.; and
2. the (optional) frame randomization, block (Reed Solomon, Turbo, or LDPC) encoding, frame synchronization marker attachment, and (optional) convolutional encoding functions specified in the TM Synchronization and Channel Coding Recommended Standard.

## Forward Space Link Protocol ASC

### TC Space Link Protocol Specialization of the Forward Space Link Protocol ASC

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

1. TC Master Channel (MC) Multiplexing;
2. TC Virtual Channel (VC) Multiplexing;
3. TC Encapsulation, VC Packet Processing and VC Generation;
4. Multiplexer Access Point (MAP) Multiplexing; and
5. Encapsulation and MAP Packet Processing.

#### TC MasterChannel (MC) Multiplexing

**The CSTSWG is in the process of assigning an FR Type OID to the TC MC Multiplexing FR Type.**

The TC MC Multiplexing FR Type corresponds to the All Frames Generation frame error control function and the MC Multiplexing function of the TC Space Data Link Protocol Recommended Standard.

#### TC Virtual Channel (VC) Multiplexing

**The CSTSWG is in the process of assigning an FR Type OID to the TC Virtual Channel (VC) Multiplexing FR Type.**

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

#### TC Encapsulation, VC Packet , Processing and VC Generation

**The CSTSWG is in the process of assigning an FR Type OID to the TC Encapsulation, VC Packet , Processing and VC Generation FR Type.**

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

1. the Encapsulation function of the Encapsulation Recommended Standard (reference [22]). In this FR Type, the encapsulation occurs directly into TC VCs;

NOTE - The Encapsulation Recommended Standard allows data to be encapsulated in either Space Packets or Encapsulation Packets. The Encapsulation function for this FR Type uses the Encapsulation Packets.

1. the VC Packet Processing function of the TC Space Data Link Protocol Recommended Standard;
2. the Virtual Channel Generation function of the TC Space Data Link Protocol Recommended Standard; and
3. the Frame Operation Procedure-1 (FOP-1) of the Communications Operation Procedure-1 Recommended Standard.

#### Multiplexer Access Point (MAP) Multiplexing

**The CSTSWG is in the process of assigning an FR Type OID to the MAP Multiplexing FR Type.**

The MAP Multiplexing FR Type corresponds to the the MAP Multiplexing function of the TC Space Data Link Protocol Recommended Standard.

#### Encapsulation and MAP Packet ProcessingThe CSTSWG is in the process of assigning an FR Type OID to theEncapsulation, and MAP Packet Processing FR Type.

The Encapsulation and MAP Packet Processing FR Type corresponds to the following functions:

1. the Encapsulation function of the Encapsulation Recommended Standard (reference [22]). In this FR Type, the encapsulation data are carried by Space Packets through a MAP channel; and
2. the MAP Packet Processing function of the TC Space Data Link Protocol Recommended Standard.

### Forward AOS Space Link Protocol Specialization of the Forward Space Link Protocol ASC

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

1. AOS MC Multiplexing;
2. AOS VC Multiplexing; and
3. AOS Encapsulation, Packet Processing and VC Generation.

#### AOS MC Multiplexing

**The CSTSWG is in the process of assigning an FR Type OID to the AOS MC Multiplexing FR Type.**

The AOS MC Multiplexing FR Type corresponds to the All Frames Generation frame error control function and the MC Multiplexing function of the AOS Space Data Link Protocol Recommended Standard.

NOTE - 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.

#### AOS VC Multiplexing

**The CSTSWG is in the process of assigning an FR Type OID 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.

#### AOS Encapsulation, Packet Processing and VC Generation

**The CSTSWG is in the process of assigning an FR Type OID to the AOS Encapsulation, Packet Processing, and VC Generation FR Type.**

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

1. the Encapsulation function of the Encapsulation Recommended Standard. In this FR Type, the encapsulation occurs into AOS VCs;
2. the Packet Processing function of the AOS Space Data Link Protocol Recommended Standard; and
3. the Virtual Channel Generation function of the AOS Space Data Link Protocol Recommended Standard.

## Return Physical Channel Reception ASC

### CCSDS 401 Return Physical Channe;l Reception SC specializationof the Return Physical Channel Reception ASC

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

1. Return 401 Space Link Carrier Reception; and
2. Range and Doppler Extraction.

#### Return 401 Space Link Carrier Reception

The OID of the Return 401 Space Link Carrier Reception FR Type is {crossSupportFunctionalities rtnSpaceLinkCarrierReception (8)}.

The Return 401 Space Link Carrier Reception FR Type demodulates one or two streams of return physical channel symbols and/or a ranging signal from a return electromagnetic waveform.

#### Range and Doppler Extraction

The OID of the Range and Doppler Extraction FR Type is {crossSupportFunctionalities rangeAndDopplerExtraction (12)}.

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

## Return Synchronization and Channel DeCoding ASC

### Return TM Synchronization and Channel DeCoding SC specialization Of the Return Synchronization and Channel DeCoding ASC

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

#### Return TM Synchronization and Channel Decoding

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

The Return TM Synchronization and Decoding FR Type corresponds to the frame synchronization, optional frame de-randomization, block decoding (Reed Solomon, Turbo, or LDPC), and (optional) convolutional decoding 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.

### Telemetry Segmenter SC specialization Of the Return Synchronization and Channel DeCoding ASC

The Telemetry Segmenter SC specialization of the Return Sychronization and Channel Decoding ASC consists of the Telemetry Segmenter FR Type.

#### Telemetry Segmenter

**The CSTSWG will assign an FR Type OID to the Telemetry Segmenter FR Type if and when the RUFT CSTS Recommended Standard is developed.**

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.

## Return Space Link Protocol ASC

### Return TM/AOS Space Link Protocol Specialization of the Return Space Link Protocol ASC

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

1. All Frames Reception
2. MC Demultiplexing and Reception;
3. VC Demultiplexing and Reception; and
4. Packet Extraction and De-encapsulation.

#### All Frames Reception

**The CSTSWG is in the process of assigning an FR Type OID to the All Frames Reception FR Type.**

The MC All Frames Reception FR Type corresponds to the All Frames Reception function (which performs Frame Error Control decoding) of the TM Space Data Link Protocol, and AOS Space Data Link Protocol Recommended Standards.

NOTE - The All Frames Reception function of the AOS Space Data Link Protocol Recommended Standard also includes Frame Header Error Control decoding. However, there are no higher-layer protocols or transfer services that use frames that are errored overall but that can have their frame header errors corrected using Frame Header Error Control decoding. Therefore, Frame Header Error Control decoding is not provided as part fo the protocol processing performed as part of standard cross support services. However, individual spaceflight missions may still be able to use Frame Header Error Control by receiving RAF service configured to deliver all (good and errored) frames, and correcting the header errors of errored frames within the User CSSS.

#### MC Demultiplexing and Reception

**The CSTSWG is in the process of assigning an FR Type OID to the MC Demultiplexing and Reception FR Type.**

The MC Demultiplexing and Reception FR Type corresponds to the MC Reception, and MC Demultiplexing functions of the TM Space Data Link Protocol, and the MC Demultiplexing function of the AOS Space Data Link Protocol Recommended Standards.

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

#### VC Demultiplexing and Reception

**The CSTSWG is in the process of assigning anFR Type OID 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.

#### Packet Extraction and De-encapsulation

**The CSTSWG is in the process of assigning anFR 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-encapsulationfunction of the Encapsulation Service Recommended Standard.

## SLS Data Delivery Production ASC

The SLS Data Delivery Production ASC is the Abstract Service Component for FR Types representing production functions that are (a) associated with Data Delivery Transfer Services and (b) performed during a Space Link Session (i.e., during the execution of an SLS Service Package).

### Frame Data Sink SC Specialization of the SLS Data Delivery Production ASC

The TFrame Data Sink SC specialization of the SLS Data Delivery Production ASC consists of the Frame Data Sink FR Type.

#### 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 (see 4.10.1.1). Each instance of the Frame Data Sink is tied to (and scheduled as part of) a specific SLS Service Package, whereas the Offline Frame Buffer persists across the execution of multiple SLS Service Packages.

The Frame Data Sink FR Type corresponds to the Frame Data Sink managed object defined in the Space Communication Cross Support Service Management - Service Agreement and Configuration Profile Data Formats Recommended Standard.

### Telemetry Segment Sink SC Specialization of the SLS Data Delivery Production ASC

The Telemetry Segment Sink SC specialization of the SLS Data Delivery Production ASC consists of the TM Segment Sink FR Type.

NOTE - The Telemetry Segment Sink SC is implemented in conjunction with the Return Unframed Telemetry (RUFT) CSTS.

#### Telemetry Segment Sink

The CSTSWG will assign an FR Type OID to the Telemetry Segment Sink FR Type if and when the RUFT CSTS Recommended Standard is developed.

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.

### Forward File SC Specialization of the SLS Data Delivery Production ASC

The FR Types that compose the Forward File SC specialization of the SLS Data Delivery Production ASC are:

1. Forward File Service Production; and
2. CFDP Sending Entity.

#### Forward File Service Production

CCSDS will assign an FR Type OID to the Forward File Service Production FR Type if and when the Forward File Service Recommended Standard is developed.

The Forward File Service Production FR Type corresponds to the SLS production functions of the future Forward File Data Delivery Service. Because this service is not yet defined, these production functions have not yet been formally identified, but conceptually they deal with

1. Extracting the file from the Forward File Data Store at the time that they are to be transmitted across the forward space link; and
2. Sending the file using the protocols that have been specified for that file transmission (e.g., in Space Packets, in Encapsulation Packet, over CFDP).

#### CFDP Sending Entity

CCSDS will assign an FR Type OID to the CFDP Sending Entity FR Type if and when the Forward File Service Recommended Standard is developed.

The CFDP Sending Entity FR Type corresponds to the Sending Entity Core Delivery procedures of the CFDP Recommended Standard (reference [26]).

### Return File SC Specialization of the SLS Data Delivery Production ASC

The FR Types that compose the Return File SC specialization of the SLS Data Delivery Production ASC are:

1. CFDP Receiving Entity; and
2. Forward File Service Production.

#### CFDP Receiving Entity

CCSDS will assign an FR Type OID to the CFDP Receiving Entity FR Type if and when the Return File Service Recommended Standard are developed.

The CFDP Receiving Entity FR Type corresponds to the Receiving Entity Core Delivery procedures of the CFDP Recommended Standard (reference [26]).

#### Return File Service Production

CCSDS will assign an FR Type OID to the Return File Service Production FR Type if and when the Return File Service Recommended Standard is developed.

The Return File Service Production FR Type corresponds to the SLS production functions of the future Return File Data Delivery Service. Because this service is not yet defined, these production functions have not yet been formally identified, but conceptually they deal with

1. Receiving the file using the protocols that have been specified for that file reception (e.g., in Space Packets, in Encapsulation Packet, over CFDP); and
2. Placing the file in the Return File Data Store for subsequent retrieval using the Cross Support File Transfer Service.

## SLS Radiometric Data Production ASC

### Real-Time Radiometric Data SC specialization of the SLS Radiometric Data Production ASC

The FR Types that compose the Real-Time Radiometric Data specialization of the SLS Radiometric Data Production ASC are:

1. TDM Segment Generation; and
2. TDM Sink.

#### TDM Segment Generation

The CSTSWG is in the process of assigning an FR Type OID to the TDM Segment Generation FR Type.

TDM Segment Generation constitutes the production functions associated with collecting angle measurements from the antenna, receive frequency and Doppler measurements from the return space link, range measurements from the forward and return space links, and transmit frequency from the forward space link in order to generate Tracking Data Message (TDM) segments containing those measurements.

The TDM Segment Generation FR Type corresponds to the TDM Segment Generationproduction functions defined in the draft Tracking Data CSTS Recommended Standard (reference [8]).

#### TDM Sink

The CSTSWG is in the process of assigning an FR Type OID to the TDM Sink FR Type.

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

The TDM Sink FR Type corresponds to the TDM Sink managed object to be defined in the future *Space Communication Cross Support Service Management - Service Agreement and Configuration Profile Data Formats* Recommended Standard.

### Raw Radiometric Data Collection SC specialization of the SLS Radiometric Data Production ASC

The Raw Radiometric Data Collection SC specialization of the SLS Radiometric Data Production ASC consists of the Raw Radiometric Data Collection FR Type.

#### Raw Radio Metric Data Collection

CCSDS will assign an FR Type OID to the Raw Radiometric Collection FR Type if and when the Validated Data Radiometric Service Recommended Standard is developed.

Raw Radiometric Data Collection constitutes the production functions associated with the collection of raw radiometric data during a space link session.

NOTE - The radiometric validation process involves analyst interaction and is therefore not performed during the space link session. The performance of radiometric data validation is outside the scope of SCCS-SM.

### Delta-DOR Raw Data Collection SC specialization of the SLS Radiometric Data Production ASC

The Delta-DOR Raw Data Collection SC specialization of the SLS Radiometric Data Production ASC consists of the Delta-DOR Raw Data Collection FR Type.

#### D-DOR Raw Data Collection

CCSDS will assign an FR Type OID to the D-DOR Raw Data Collection FR Type if and when the Delta-DOR Service Recommended Standard is developed.

D-DOR Raw Data Collection constists of the production functions associated with collecting the D-DOR raw data samples and organizing them in the standard D-DOR Raw Data file format [**need reference**] for storage.

### Open Loop Receiver/Formatter SC specialization of the SLS Radio Metric Data Production ASC

The Open Loop Receiver/Formatter SC specialization of the SLS Radiometric Data Production ASC consists of the Open Loop Receiver/Formatter FR Type.

#### Open Loop Receiver/Formatter

The OID of the Open Loop Receiver/Formatter FR Type is

{crossSupportFunctionalities openLoopReceiver (16)}.

The Open Loop Receiver/Formatterconstitutes the functions performed during the Space Link Session to receive the open loop signal of the return link, digitize the signal, and route the resulting data to a specific instance of the Open Loop Data Storetype.

The Open Loop Receiver/FormatterFR Type corresponds to the Open Loop Receiver/Formattermanaged object to be defined in the *Space Communication Cross Support Service Management - Service Agreement and Configuration Profile Data Formats* Recommended Standard Recommended Standard.

The functions associated with the Open Loop ReceiverFR Type are outside the scope of the Cross Support Reference Model.

## Offline Data Storage ASC

The Offline Data Storage ASC is the ASC for FR Types representing data storage functions that store forward link data for subsequent transmission during a Space Link Session and that store telemetry received during a Space Link Session for subsequent retrieval via offline or complete data delivery transfer services.

### Offline Frame Buffer SC Specialization of the Offline Data Delivery Production ASC

The Offline Frame Buffer specialization of the Offline Data Storage ASC consists of the Offline Frame Buffer FR Type.

#### Offline Frame Buffer

**The CSTSWG is in the process of assigning an FR Type OID 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 entity defined in the SLE RAF and RCF Service Specification Recommended Standard.

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

### Telemetry Segment Recording Buffer SC Specialization of the Offline Data Storage ASC

The Telemetry Segment Recording Buffer SC specialization of the Offline Storage Production ASC consists of the Telemetry Segment Recording Buffer FR Type.

NOTE - The Telemetry Segment Recording Buffer SC is implemented in conjunctions with the Return Unframed Telemetry CSTS.

#### Telemetry Segment Recording Buffer

CCSDS will assign an FR Type OID to the Telemetry Segment Recording Buffer FR Type if and when the RUFT CSTS Recommended Standard is developed.

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.

### Forward File Data Store SC specialization of the Offline Data Storage ASC

The Forward File Data Store SC specialization of the Offline Data Storage ASC consists of the Forward File Data Store FR Type.

#### Forward File Data Store

CCSDS will assign an FR Type OID to the Froward File Data Store FR Type if and when the Forward File Service Recommended Standard is developed.

The Forward File Data Store is the repository of space data files that are transmitted across the space link as part for the Forward File Service.

### Return File Data Store SCspecialization of the Offline Data Storage ASC

The Return File Data Storws SC specialization of the Offline Data Storage ASC consists of the Return File Data Store FR Type.

#### Return File Data Stores

CCSDS will assign an FR Type OID to the Return File Data Store FR Type if and when the Return File Service Recommended Standard is developed.

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

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

### Tracking Data Message (TDM) Recording Buffer SC Specialization of the Offline Data Storage ASC

The TDM Recording Buffer SC specialization of the Offline Data Storage ASC consists of the TDM Recording Buffer FR Type.

#### TDM Recording Buffer

**The CSTSWG is in the process of assigning an FR Type OID to the TDM 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

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

### Raw radiometric Data Store SC Specialization of the Offline Data Storage ASC

The Raw Radiometric Data Store SC specialization of the Offline Data Storage ASC consists of the Raw Radiometric Data Store FR Type.

#### Raw Radiometric Data Store

CCSDS will assign an FR Type OID to the Raw Radiometric Data Store FR Type if and when the Validated Data Radio Metric Service Recommended Standard is developed.

The Raw Radiometric Data Store constitutes a repository of raw radiometric data that is awaiting validation processing.

### Validated radiometric Data Store SC Specialization of the Offline Data Storage ASC

The Validated Radiometric Data Store SC specialization of the Offline Data Storage ASC consists of the Validated Radiometric Data Store FR Type.

#### Validated Radiometric Data Store

CCSDS will assign an FR Type OID to the Validated Radiometric Data Store FR Type if and when the Validated Data Radio Metric Service Recommended Standard is developed.

The Validated Radiometric Data Store constitutes a repository of radiometric data that has undergone validation processing and is awaiting retrieval via the Cross Support File Transfer Service.

### D-DOR Raw Data Store SC Specialization of the Offline Data Storage ASC

The D-DOR Raw Data Store SC specialization of the Offline Data Storage ASC consists of the D-DOR Raw Data Store FR Type

#### D-DOR Raw Data Store

CCSDS will assign an FR Type OID to the D-DOR Raw Data Store FR Type if and when the Delta-DOR Radio Metric Service Recommended Standard is developed.

The D-DOR Raw Data Store constitutes the repository of D-DOR raw data samples that have been organized in the standard D-DOR Raw Data format. D-DOR raw data stored in the D-DOR Raw Data Store is retrieved via the Cross Support File Transfer Service.

### OpeN Loop Data Store SC Specialization of the Offline Data Storage ASC

The Open Loop Data Store SC specialization of the Offline Data Storage ASC consists of the Open Loop Data Store FR Type.

#### Open Loop Data Store

The CSTSWG is in the process of assigning an FR Type OID to the Open Loop Data Store FR Type.

The Open Loop Data Store is a repository of open loop data acquired by an Open Loop Receiver. The format of the open loop data is proprietary to the service provider. Open Loop data stored in the Open Loop Data Store is retrieved via the Cross Support File Transfer Service.

## Data Transfer ServiceS ASC

### SLE Forward Space Packet Specialization of the Data transfer ServiceS ASC

The SLE Forward Space Packet (F-SP) SC specialization of the Data Transfer Service ASC consists of the F-SP Transfer Service Provider FR Type.

#### 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 (reference [28]).

### SLE Forward CLTU SC Specialization of the Data Transfer ServiceS ASC

The SLE Forward CLTU SC specialization of the Data Transfer Services ASC consists of the F-CLTU Transfer Service Provider FR Type.

#### 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 (reference [27]).

### Forward Frames CSTS SC Specialization of the Data Transfer ServiceS ASC

The Forward Frames CSTS SC specialization of the Data Transfer Services ASC consists of the Forward Frames CSTS Provider FR Type.

#### Forward Frames CSTS Provider

CCSDS will assign an FR Type OID to the Forward Frames CSTS Provider FR Type if and when the Forward Frames CSTS Recommended Standard is developed.

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

### Cross Support File Transfer SC Specialization of the Data Transfer ServiceS ASC

The Cross Support File Transfer SC specialization of the Data Transfer Services ASC 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).

#### Cross Support File Transfer Provider

CCSDS will assign an FR Type OID to the Cross Support File Transfer Service Provider FR Type if and when a CCSDS File Transfer Service Recommended Standard is developed.

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.

### SLE Return All Frames SC specialization of the Data Transfer ServiceS ASC

The Return All Frames (RAF) SC specialization of the Data Transfer Service ASC consists of the RAF TS Provider FR Type.

#### 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.

### SLE Return Channel Frames SC specialization of the Data Transfer ServiceS ASC

The Return Channel Frames (RCF) SC specialization of the Data Transfer Services ASC consists of the RCF TS Provider TS Type.

#### 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.

### SLE Return Operational Control Fields SC specialization of the Data Transfer Services ASC

The Return Operational Control Fields (ROCF) SC specialization of the Data Transfer Services ASC consists of the ROCF Transfer Service Provider FR Type.

#### 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 (reference [29]).

### Return Unframed Telemetry SC specialization of the Data Transfer Services ASC

The Return Unframed Telemetry (RUFT) SC specialization of the Data Transfer Services ASC consists of the RUFT CSTS Provider FR Type.

#### RUFT CSTS Provider

**CCSDS will assign an FR Type OID assigned to the RUFT CSTS Provider FR Type if and when the RUFT CSTS Recommended Standard is developed.**

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

### Tracking Data CSTS SC specialization of the Data Transfer Services ASC

The Tracking Data CSTS specialization of the Data Transfer Services ASC consists of the Tracking Data CSTS Provider FR Type.

#### 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 (reference [8]).

TD-CSTS provides the IOAG Real-Time Data Radiometric service. In addition to delivering radiometric data in “real time” (that is, during the execution of the SLS),the TD-CSTSSLS

## Service Management Functions Abstract Service Component

### Monitored Data specialization of the Service Management Funcitons ASC

The FR Types that compose the Monitored Data specialization of the Service Management Functions ASC are:

1. Monitored Data CSTS Provider;
2. Monitored Data Collection.

#### 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.

#### Monitored Data Collection

**The CSTSWG is in the process of assigning an FR Type OID to the Monitored Data Collection FR Type.**

Monitored Data Collectionconstitutes 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 CollectionFR Type corresponds to the Data Collectionproduction function identified in the draft Monitored Data CSTS Recommended Standard.

The Monitored Data CollectionFR Type and the TDM Data Collectionproduction functions are outside the scope of the Cross Support Reference Model.

### Service Control Specialization of the Service Management Functions ASC

The FR Types that compose the Service Control specialization of the Service Management Functions ASC are:

1. Service Control CSTS Provider FR Type;
2. Service Control Production.

#### 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.

#### Service Control Production

CCSDS will assign an FR Type OID to the Service Control Production FR Type if and when the Service Control CSTS Recommended Standard is developed.

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.

## Space Internetworking Abstract Service Component

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

### IP Over CCSDS Specialization of the Space Internetworking Abstract Service Component

The FR Types that compose the IP over CCSDS specialization of the Space Internetworking ASC are:

1. Forward IP-VC Map; and
2. Return IP over CCSDS Extractor/Router.

#### 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.

##### 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.

# Common Configurations of Abstract Service Components

At the highest level of abstraction, there are six basic types of configurations of functions that are used provide IOAG Service Catalog #1 SCCS services in ESLTs:

* The SLS configuration, in which the ESLT transfers data to or from one or more Space User Nodes of a CSSS across one or more space links during an SLS;
* The SLS data delivery configuration, in which the ESLT provides forward and/or return data transfer services during an executing SLS so that one or more Earth User Nodes communicate with the Space User Node(s) with end-to-end connectivity in “real time”;
* The SLS radio metric configuration, in which the ESLT extracts radio metric measurements from space links of an active SLS and delivers those measurements to the destination Earth User Node in “real time”;
* The retrieval data delivery configuration, in which the ESLT delivers data that was received from a Space User Node to an Earth User Node, but not necessarily during the execution of the SLS by which the data was received;
* The retrieval radio metric configuration, in which the ESLT delivers radio metric measurements to the Earth User Node, but not necessarily during the execution of the SLS during which the radio metric measurements were extracted; and
* The forward offline data delivery configuration, in which the ESLT receives and stores data from an Earth User Node destined for a Space User Node, before the execution of the SLS by which the data is transmitted to the Space User Node.

## Abstract Service ComponentS for SLS Configurations

The three SLS configurations collectively involve all of the ASCs for ESLTs, but only part of the functionality of the following ASCs is used for the provision of services during an SLS:

* 1. The Data Transfer Services ASC is limited to those services that allow Earth User Nodes to interface with the ESLT for the purpose of (1) exchanging data with their respective Space User Nodes in real time via the space links provided by the ESLT, and (2) receiving radio metric data in real time. These SLS cross support transfer services include *online* SLE Transfer Services (see reference [1]) and *realtime* CSTSes (see reference [4]).
  2. The Offline Data Storage ASC is constrained to those functions associated with either (1) transferring to Space User Nodes data that had been received by the ESLT prior to the SLS, (2) receiving and storing data from Space User Nodes for subsequent transfer to Earth User Nodes, and (3) storing radiometric data for subsequent transfer to Earth User Nodes.

Figure 5‑1 illustrates the ASCs that are used in the SLS configurations, including the Space Internetworking ASC for Service Catalog #2 services. Figure 5‑2 shows the connectivity among the SC specializations of those ASCs. Figure 5‑3 shows the FR Types that comprise the SC specializations of those ASCs.



Figure ‑: **SCCS Abstract Service Components Used in SLS Configurations**



Figure ‑: **Connectivity of Abstract Service Component Specializations in SLS Configurations**



Figure ‑: **Functional Resource Types Used in SLS Configurations**

## Abstract Service ComponentS for Data Retrieval Configurations

The retrieval data delivery and retrieval radio metric configurations do not require the above space link communications stack, although in some cases the space link stack may be present. The minimal retrieval data delivery configuration is composed of a retrieval data store and a retrieval cross support transfer service. The retrieval cross support transfer services include *offline* SLE Transfer Services (see reference [1]), *complete* CSTSes (see reference [4]), and the offline retrieval of space data files captured by the ESLT.

Figure 5‑4 shows the ASCs used in the retrieval data delivery and retrieval metric data configurations.



Figure ‑: **SCCS Abstract Service Components Used in Retrieval Configurations**

Figure 5‑5 shows the connectivity among the specializations of those ASCs.



Figure ‑: **Connectivity of Abstract Service Component Specializations in in Retrieval Configurations**

Figure 5‑6 shows the FR Types that comprise the specializations of those ASCs.



Figure ‑: **Functional Resource Types Used in Retrieval Configurations**

## Abstract Service ComponentS for The Forward Offline Data Delivery Configuration

The forward offline data delivery configuration does not involve the space link communications stack – it is composed of a forward offline cross support transfer service and a forward space link data store.

There is only one IOAG Service Catalog 1 service that operates using the forward offline data delivery configuration, the Forward File service. Figure 5‑7 shows the ASCs used in the forward offline data delivery configuration and Figure 5‑8 shows the FR Types that comprise the specializations of those ASCs.



Figure ‑: **SCCS Abstract Service Components Used in Forward Offline Data Delivery Configurations**



Figure ‑: **Functional Resource Types Used in Forward Offline Data Delivery Configurations**

The Extensible Space Communications Cross Support Service Management Concept (reference [12]) provides a discussion of how these Abstract Service Component configurations are used to structure Service Agreements and Configuration Profiles.

# composition of IOAG Service Catalog 1 services By Functional Resource Types

## 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.

## Forward Data Delivery Services

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

1. Forward CLTU;
2. Forward Space Packet;
3. Forward Synchronous Encoded Frame;
4. Forward File.

### 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.

### 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.

### 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.

### 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]](#footnote-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]](#footnote-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.



**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 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.

## Return Data Delivery Services

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

1. Return All Frames;
2. Return Channel Frames;
3. Return Operational Control Fields;
4. Return Unframed Telemetry; and
5. Return File.

### RetuRn ALl Frames

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

### 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**

### ReturN Operational Control Fields

Figure 6-7 illustrates the Functional Resource types that comprise the Return Operational Control Fields 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.

### 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 SLS Data Delivery Production Class, but it could alternatively be defined and a type of Synchronization and Channel Decoding algorithm.

### 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 Operational Control Fields Return Data Delivery Service**

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**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**

## Radio metric Services

The IOAG Service Catalog #1 Radio Metric services are:

1. Validated Data Radio Metric;
2. Raw Data Radio Metric;
3. Delta DOR.

Note that IOAG Service Catalog #1 includes Open Loop Recording as part of the Delta DOR services. However, for the purposes of the Functional Resource model, Open Loop Recording is treated as a separate service.

### 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.



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

### Raw Data Radio metric

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

****

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

### Delta DOR

IOAG SC#1 defines the Delta DOR service as:

This Service enables a Control Center to receive Delta-DOR raw data 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 Delta-DOR Radio Metric service.

### Open Loop Recording

Open Loop Recording is not listed in the IOAG SC#1, but it is included in the services identified in this Technical Note because its functional resource have been included in the SANA FR type registry

The purpose of Open Loop Recording is to convert analog RF waveform data into a digitized signal that is recorded for subsequent analysis. The service consists solely of the digitizing and recording functions; the subsequent retrieval and analysis is done by non-standard means.

Figure 6-13 illustrates the Functional Resource types that comprise the Open Loop Recording Radio Metric service.



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

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**Figure 6-13. Functional Resource Types of the Open Loop Recording Radio Metric Service**

## Service Management Functions

### 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 6-14, the MD-CSTS Provider receives the data that it reports from the Monitored Data Collection 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 6-14: Functional Resource Types Monitored by the Engineering Monitoring Data Delivery Service Management Function**

# Functional Resources in Service Management and Service Package Execution

**NOTE  
This section has not yet been updated to reflect the latest functional resource type, parameter identifier, and event identifier definitions.**

## Introduction

### 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 the next generation Space Communication Cross Support Service Management will provide unambiguous naming of monitored parameters, notifiable events, and directives.

### 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.

### 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.

## Multinet Functional Resources

The Multinet TT&C network provides the following services:

1. Forward (uplink) and return (downlink) communications and tracking services at S Band and X Band;
2. Terrestrial transfer of Space Link Session (SLS) space link data via SLE F-CLTU and complete and timely RAF and RCF services;
3. Terrestrial transfer of offline (Retrieval) space link data via SLE offline RAF and RCF services;
4. Terrestrial transfer of real-time sample tracking data via the Real-Time Tracking CSTS;
5. Real-time Service Package monitoring and event reporting via the Monitored Data Cross Support Transfer Service (CSTS);
6. 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.

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” (reference [[11]], 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.

F1-ScenarioFunctionalResourceTypes-121102

**Figure 4-1: Functional Resource Types Supported by Multinet**

**Table 4-1: Functional Resource Types and OIDs**



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* [[4]] 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.

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)**



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



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



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



## Service Agreement Development Phase

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

1. The Multinet antennas Pacific X-Band and Pacific S-Band are specified in the Service Agreement as supporting antennas; and
2. 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 |

1. 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 | 3/112/4/4/1/5/2/4 |
| 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 type.

## Configuration Profiles

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

1. 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”).
2. 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.
3. 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.
4. 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.
5. 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.
6. 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.
7. 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.
8. 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]](#footnote-4). The ReturnLinkFrameDataSink managed object specifies the configuration of the Frame Data Sink functional resource that performs during the execution of the Service Package.
9. 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.
10. 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.
11. 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]](#footnote-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.

**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) |  |

1. 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.
2. 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.
3. 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.
4. 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]](#footnote-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 |

1. 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.
2. 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, 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.
3. 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.
4. 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.
5. 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.
6. An offline RAF Transfer Service Profile (transferServiceProfileId = “RAF-S-I-offl”) that is configured with functionalGroupId = “Ret-S-I”.
7. An offline RAF Transfer Service Profile (transferServiceProfileId = “RAF-S-Q-offl”) that is configured with functionalGroupId = “Ret-S-Q”.
8. An offline RCF Transfer Service Profile (transferServiceProfileId = “RCF-X1-offl”) that is configured with functionalGroupId = “Ret-S-I”.
9. An offline RCF Transfer Service Profile (transferServiceProfileId = “RCF-X2-offl”) that is configured with functionalGroupId = “Ret-S-I”.
10. A Monitored Data Cross Support Transfer Service Profile (transferServiceProfileId – “MD1”) that is configured with functionalGroupId = ”MD-Aggregation”.
11. A Real-Time Tracking Data Cross Support Transfer Service Profile (transferServiceProfileId – “TD1”) that is configured with functionalGroupId = ”TD-Aggregation”.
12. A Service Control Cross Support Transfer Service Profile (transferServiceProfileId – “SC”) that is configured with functionalGroupId = ”Control-Distribution”.

## Service Package Requests

### 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.

F2-SvcPkgRequestStereo-081208

**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.

### 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:

1. 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.
2. 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.
3. 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.
4. 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.
5. 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 |
| 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 Collection | Monitored Data Collection | 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 |

### 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.

## Scheduled Service Packages

### 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**, **Retrieval­TsInstanceResult**, 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.

F3-ServicePkgResultStereo-P1-090518

**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.

### 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 |
| *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 Collection* | Monitored Data Collection: 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 |
| *Service Control Production* | Service Control Production: 3/112/4/4/3/1/21 | 1 |

## Service Package Execution

### 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.

1. 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.
2. 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.

#### 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:

1. One instance of the FCLTU TS Provider FR Type’s production status parameter (FCLTU-S);
2. Two instances of the RAF TS Provider FR Type’s production status parameter (RAF-S-I-onlt, RAF-S-Q-onlc);
3. Two instances of the RCF TS Provider FR Type’s production status parameter (RCF-X1-onlc, RCF-X2-onlc);
4. One instance of the Monitored Data CSTS Provider FR Type’s production status parameter (MD1);
5. One instance of the Tracking Data CSTS Provider FR Type’s production status parameter (TD1);
6. 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.

##### 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:

1. Parameter Name, consisting of:
2. Functional Resource Identifier, consisting of:
3. Functional Resource Type = 3/112/4/4/3/1/17 (Monitored Data CSTS Provider)
4. Functional Resource Instance number = 1 (MD1)
5. ParameterId = 3/112/4/4/3/1/17/1/1 (Monitored Data CSTS Provider production status)
6. Parameter Type and Value (present only when qualifier value = ‘valid’):
7. Parameter Type = 8 (enumerated)
8. 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))

#### 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:

1. One instance of the Forward Space Link Carrier FR Type’s actual transmit frequency parameter (S-Band Forward Space Link Carrier);
2. One instance of the FCLTU TS Provider FR Type’s SI state parameter (FCLTU-S);
3. One instance of the FCLTU TS Provider FR Type’s number of CLTUs radiated parameter (FCLTU-S);
4. Two instances of the Return Space Link Carrier FR Type’s actual receive frequency parameter (Return S-Band, Return X-Band);
5. Two instances of the Return Space Link Subcarrier FR Type’s subcarrier lock status parameter (Return S-Band, Return X-Band);
6. 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);
7. Two instances of the RAF TS Provider FR Type’s SI state parameter (RAF-S-I-onlt, RAF-S-Q-onlc);
8. Two instances of the RAF TS Provider FR Type’s number of frames delivered parameter (RAF-S-I-onlt, RAF-S-Q-onlc);
9. Two instances of the RCF TS Provider FR Type’s SI state parameter (RCF-X1-onlc, RCF-X2-onlc);
10. 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.

##### 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:

1. Parameter Name, consisting of:
2. Functional Resource Identifier, consisting of:
3. Functional Resource Type = 3/112/4/4/3/1/13 (RAF TS Provider)
4. Functional Resource Instance number = 2 (RAF-S-Q-onlc)
5. ParameterId = 3/112/4/4/3/1/13/1/5 (RAF TS Provider number of frames delivered)
6. Parameter Type and Value (present only when qualifier value = ‘valid’):
7. Parameter Type = 1 (unsignedInteger)
8. 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))

#### 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:

1. Two instances of the Antenna FR Type’s actual azimuth parameter (Pacific S-Band, Pacific X-Band);
2. 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.

##### 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:

1. Parameter Name, consisting of:
2. Functional Resource Identifier, consisting of:
3. Functional Resource Type = 3/112/4/4/3/1/1 (Antenna)
4. Functional Resource Instance number = 2 (Pacific X-Band)
5. ParameterId = 3/112/4/4/3/1/1/1/4 (Antenna actual elevation)
6. Parameter Type and Value (present only when qualifier value = ‘valid’):
7. Parameter Type = 6 (float)
8. 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))

#### 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:

1. ‘production configured’ (FCLTU-S, RAF-S-I-onlt, RAF-S-Q-onlc, RCF-X1-onlc, or RCF-X2-onlc);
2. ‘production interrupted’ (FCLTU-S, RAF-S-I-onlt, RAF-S-Q-onlc, RCF-X1-onlc, or RCF-X2-onlc);
3. ‘production halted’ (FCLTU-S, RAF-S-I-onlt, RAF-S-Q-onlc, RCF-X1-onlc, or RCF-X2-onlc);
4. ‘production operational’ (FCLTU-S, RAF-S-I-onlt, RAF-S-Q-onlc, RCF-X1-onlc, or RCF-X2-onlc);

##### 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:

1. Event Name, consisting of:
2. Functional Resource Identifier, consisting of:
3. Functional Resource Type = 3/112/4/4/3/1/14 (RCF TS Provider)
4. Functional Resource Instance number = 2 (RCF-X2-onlc)
5. EventId = 3/112/4/4/3/1/14/2/4 (production operational)
6. 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.

#### 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:   1. Functional Resource Type = 3/112/4/4/3/1/9 2. 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:

1. Actual subcarrier frequency;
2. Subcarrier lock status;
3. Subcarrier level estimate;
4. Subcarrier demod loop bandwidth.

##### 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:

1. Parameter Name, consisting of:
2. Functional Resource Identifier, consisting of:
3. Functional Resource Type = 3/112/4/4/3/1/9 (Return Space Link Subcarrier)
4. Functional Resource Instance number = 2 (X-Band)
5. ParameterId = 3/112/4/4/3/1/9/1/1 (Return Space Link Subcarrier actual subcarrier frequency)
6. Parameter Type and Value (present only when qualifier value = ‘valid’):
7. Parameter Type = 1 (unsignedInteger)
8. 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))

### 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.

## 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 SCCS 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 the next generation of 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.

1. Acronyms and Abbreviations
2. Reference Bookmarks (to be deleted)

[1] nRef\_910x4\_CSRM

[2] nRef\_911x1RAF

[3] nRef\_911x2\_RCF

[4] nRef\_921x1CstsSFW

[5] nRef231x0\_TcSync

[6] nRef\_131x0\_TmSync

[7] nRef\_922\_RUFT

[8] nRef\_922x2\_TD\_CSTS

[9] nRef\_IOAG1

[10] nRef\_922x1\_MD\_CSTS

[11] nRef\_DoatTN

[12] nRef\_902x0\_ESCCS\_SM

[13] nRef\_901x0\_SCCS\_ADD

[14] nRef\_910x11\_SCCS\_SM

[15] nRef\_902x\_SCCS\_SM\_SA\_CP

[16] nRef\_IOAG\_SC2

[17] nRef\_232x0\_TC\_SDLP

[18] nRef\_732x0\_AOS\_SDLP

[19] nRef\_132x0\_TM\_SDLP

[20] nRef\_133x0\_SPP

[21] nRef\_232x1\_COP\_1

[22] nRef\_133x1\_Encap

[23] nRef\_401\_RF\_Mod

[24] nRef\_414x1\_PN\_ranging

[25] nRef\_415x1\_CDMA

[26] nRef\_727x0\_CFDP

[27] nRef\_912x1\_CLTU

[28] nRef\_912x3\_FSP

[29] nRef\_911x5\_ROCF

[30] nRef\_734x0\_DTN

[31] nRef\_702x1\_IP\_Over\_CCSDS

1. This definition has been modified to include material that was merely referenced in the original IOAG SC#1 definition. [↑](#footnote-ref-1)
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. [↑](#footnote-ref-2)
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. [↑](#footnote-ref-3)
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, [↑](#footnote-ref-4)
5. See the footnote directly above. [↑](#footnote-ref-5)
6. See the footnote above. [↑](#footnote-ref-6)