Report Concerning Space Data System Standards

SPACE COMMUNICATION CROSS SUPPORT—SERVICE MANAGEMENT—OPERATIONS CONCEPT

INFORMATIONAL REPORT

CCSDS 910.14-G-1

GREEN BOOK
May 2011
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AUTHORITY

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<td>Date:</td>
<td>May 2011</td>
</tr>
<tr>
<td>Location:</td>
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This document is published and maintained by:

CCSDS Secretariat  
Space Communications and Navigation Office, 7L70  
Space Operations Mission Directorate  
NASA Headquarters  
Washington, DC 20546-0001, USA
FOREWORD

This document is a technical Report to assist readers in understanding the Space Link Extension Service Management (SCCS-SM) Recommended Standard. The SCCS-SM operations concept described herein is the baseline concept for managing ground data communication within missions that are cross-supported between Agencies of the CCSDS.

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1 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

Management information must be exchanged between space missions and Tracking, Telemetry, and Command (TT&C) service providers for the purposes of negotiating, configuring, and executing space link services and Space Link Extension (SLE) ground transfer services that are provided to the space mission. The various processes that generate, exchange, ingest, and act upon this management information are collectively referred to as service management.

This Report outlines a set of Space Communication Cross Support Service Management (SCCS-SM) services by which TT&C service providers and space missions may exchange information needed to arrange spacecraft contact periods and establish the operating parameters of the space link services and SLE transfer services during those contact periods.

1.2 RELATION TO CROSS SUPPORT REFERENCE MODEL

The Cross Support Reference Model (reference [1]) establishes a model for space mission data exchange as illustrated in figure 1-1. Space mission users and mission management are represented by the Mission Data Operations System (MDOS), which sends data to and receives data from the Space Element. The SLE System transfers these data using SLE transfer services between the SLE System and the MDOS, and using space link services between the SLE System and the Space Element. The SLE transfer services may be provided in an offline delivery mode, in which case the SLE System also provides data storage. In addition, the MDOS and the SLE System exchange management data for managing the space link services and SLE transfer services.

NOTE – The management data exchanged between the Space Element and the MDOS are illustrated for the sake of completeness. However, they are outside the scope of the Cross Support Reference Model and the SCCS-SM Recommended Standard (reference [3]). Also, although this management data exchange is illustrated as a direct link between Space Element and MDOS, it is actually accomplished via the space link and SLE transfer services.

The Cross Support Reference Model provides the framework for defining SLE transfer service specifications (references [9] to [13]) and an SLE-SM service specification. It defines the functional and management components of the MDOS and SLE System. It identifies the SLE transfer services which are used to extend space link services (references [4], [5], [6], and [7]) across the ground segment. It specifies the time spans of various management information entities used in SCCS-SM.

The SCCS-SM service specification expands the scope of SLE-SM as identified in the Cross Support Reference Model to include management of space communication services and cross support transfer services in general, not just those directly related to the transfer of command and telemetry data (i.e., the scope of SLE).
Figure 1-1: *Cross Support Reference Model Space Mission Data Exchange*

1.3 SCOPE

1.3.1 SCCS-SM SERVICES

The SCCS-SM services reflect the common practices of the space operations community and the contents of the SLE transfer specifications. Four SCCS-SM services are defined:

a) *Service Package service*, which addresses the arrangement of spacecraft Space Link Session (SLS) times and execution of the SLE transfer services.

b) *Configuration Profile service*, which addresses the establishment of sets of data concerning the space link and ground station configuration;

c) *Trajectory Prediction service*, which addresses the transfer and updating of spacecraft trajectory data;

d) *Service Agreement service*, which addresses the information that needs to be agreed upon before a cross support service can be established;

1.3.2 SCCS-SM SERVICE PROCEDURES, OPERATIONS AND MESSAGES

The SCCS-SM services are implemented by procedures, operations, and messages that effect the negotiation and commitment of resources for the provision of TT&C network services. This establishes the mechanism by which a user requests services from a provider for individual spacecraft SLSes (also known as contacts, passes, and tracks).
1.3.3 TRANSFER SERVICES ADDRESSED IN THIS REPORT

This Report addresses three of the SLE transfer services defined in the Cross Support Reference Model:1

a) Forward Communications Link Transmission Unit (FCLTU, reference [12]);

b) Return All Frames (RAF, reference [9]);

c) Return Channel Frames (RCF, reference [10]).

1.3.4 RF AND MODULATION SYSTEMS AND SPACE LINK SERVICES ADDRESSED IN THIS REPORT

The SCCS-SM Recommended Standard addresses the scheduling of services that employ radio frequency (RF) and modulation systems that are conformant with CCSDS 401.0-B, Radio Frequency and Modulation Systems—Part 1: Earth Stations and Spacecraft (reference [15]). Space link service providers that provide RF links that conform to CCSDS 401.0-B can implement the full set of capabilities specified herein.

Ground station networks that provide RF links that do not conform to CCSDS 401.0 may still implement a subset of the capabilities specified herein, as described in 3.3.2

Space link service providers that provide RF links that do not conform to CCSDS 401.0-B or the extended parameters and values supported by the specification may use bilaterally defined space link service information, or simply implement a subset of the capabilities specified herein, as described in 3.3.

1.3.5 LIMITATIONS, CONSTRAINTS, EXCLUSIONS AND QUALIFICATIONS

This Report contains the following limitations, constraints, exclusions and qualifications:

a) The concept of staging in the Cross Support Reference Model—distributing the provision of SLE services across two or more SLE Complexes that progressively process and transform a data stream—is not addressed in this document.

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1 The management of other SLE transfer services, including Return Operations Control Field (ROCF, reference [11]), Forward Space Packet (FSP, reference [13]), supported by the Communications Operation Procedure-1 (reference [8]), and a radiometric data transfer service, will be addressed in future versions of this Report.

This Report addresses the management of both online and offline SLE transfer services. Management of transfer services for radiometric observables is deferred to a future version of this document.

2 This report addresses the management of TT&C services. Management of ranging and radiometric services is deferred to a future version of this document. However, the capabilities provided by the Service Management Specification for space communication service scheduling information exchange are not strictly limited to those recommended in CCSDS 401.0-B: for example, the Specification supports the use of additional forward subcarrier frequencies beyond those specified in CCSDS 401.0-B.
b) This Report does not address the mechanism for exchanging authentication and access control information associated with the creation of SLE transfer service credentials.

c) Ground systems and services that are not directly concerned with the transport of transfer frames (references [4] and [6]) and Communications Link Transmission Units (CLTUs—reference [7]) compliant to CCSDS Recommended Standards are not described. Processing of data held within the data fields of source packet Protocol Data Units (PDUs) (reference [4]) is outside the scope of this document.

d) The initial establishment of a service relationship and the negotiation of a mission-length Service Agreement are not covered by this Report.

e) This Report does not define the operations and messages required to perform execution-time monitoring and control of transfer services.

f) The specification of systems to generate information required by SCCS-SM, such as mission planning (scheduling), flight dynamics (trajectory), mission monitoring and control, and ground station selection are outside the scope of this document. It is assumed that these systems will provide the data needed in the required format at the required times.

g) SCCS-SM does not define the way in which Complex Management (CM) interfaces with the equipment that is used to provide the space link and transfer services, so the users in the MDOS do not need to be concerned about the internal workings of the Complex. In other words, CM provides an interface to the user that hides the complexity of the provider’s Complex.

1.4 APPLICABILITY

1.4.1 APPLICABILITY OF THIS REPORT

This Report outlines the basis for the development of compatible Agency standards for SLE systems. Systems covered by this Report include manned and unmanned free-flying spacecraft and space transportation systems. This Report is particularly relevant to SLE systems that are involved in cross support.

Although sharing ground systems between multiple space missions or between multiple spacecraft of the same space mission is not explicitly modeled, this Report in no way precludes sharing ground systems.

1.4.2 LIMIT OF APPLICABILITY

This Report does not outline a design for real space communication service management systems that may be implemented for the control and monitoring of existing or future missions.
1.5 **RATIONALE**

The primary goal of CCSDS is to increase the level of interoperability among Agencies. This Report furthers that goal by describing the means to manage the provision of space link and transfer services to be used in the area where most cross support activity occurs: between the tracking stations or ground data handling systems of various Agencies and the mission specific components of a mission ground system. Reference [2], *Cross Support Concept*, provides further discussion of the rationale for the concept described in this Report.

1.6 **DOCUMENT STRUCTURE**

1.6.1 **ORGANIZATION**

This document is organized as follows:

a) Section 0 provides the purpose, scope, applicability, and rationale of this Report and identifies the conventions and references used throughout the document. This section also describes how this document is organized. A brief description is provided for each section and annex so that the reader will have an idea of where information can be found in the document. It also identifies terminology that is used in this document but is defined elsewhere.

b) Section 2 provides an overview of SCCS-SM, places it in its context, and introduces basic service management concepts.

c) Section 3 gathers more detailed commentary on some aspects of SCCS-SM, where the specification alone may not be intuitively understood.

d) Section 4 describes the protocol for exchanging SCCS-SM messages.

e) Section 5 specifies which parts of the specification must be implemented in order to claim compliance.

f) Section 6 provides the security profile Recommended Standards for SCCS-SM document exchange when XML Schema technology is used.

g) Section 7 provides the mapping of the technology-independent Recommended Standard to XML Schema, which is intended to be the first concrete technology mapping.

h) Annex A contains a list of acronyms.

i) Annex B provides mapping from the SCCS Service Management parameters to the SLE transfer service instance configuration parameters.

j) Annex C describes UML 2.0 conventions used in this report.

1.6.2 HOW TO READ THIS DOCUMENT

It is helpful for readers of this document to have a basic understanding of CCSDS SLE services and SCCS-SM concepts, as described in *Cross Support Concept* (reference [2]).

1.7 DEFINITIONS

1.7.1 DEFINITIONS FROM THE CROSS SUPPORT REFERENCE MODEL

This Report makes use of the following terms defined in the *Cross Support Reference Model*, reference [1]:

a) Invoker;
b) Mission Data Operations System (MDOS);
c) Operation;
d) Performer;
e) Service Agreement;
f) Service Agreement Period;
g) Service Management;
h) Service Package Utilization Phase;
i) (SLE) Complex;
j) (SLE) CM;
k) (SLE) Service Package;
l) (SLE) Utilization Management (UM);
m) (SLE) Transfer Service Instance;
n) SLS;
o) Utilization Phase.

1.7.2 DEFINITIONS FROM THE RAF, RCF, AND CLTU SERVICE SPECIFICATIONS

This Report makes use of the following terms defined in references [9], [10], and [12]:

a) Active (State);
b) Association;
c) Communication Service;
d) Delivery Mode (delivery-mode) (references [9] and [10] only);
e) Invocation;
f) Latency Limit (latency-limit) (references [9] and [10] only);
g) Master Channel;
h) Parameter;
i) Performance;
j) Port Identifier;
k) Reporting Cycle (reporting-cycle);
l) Return;
m) Service Instance Provision Period;
n) Spacecraft Identifier;
o) Transfer Frame Version Number;
p) Virtual Channel;
q) Virtual Channel Identifier.

1.7.3 DEFINITIONS FROM TM SYNCHRONIZATION AND CHANNEL CODING

This Report makes use of the following terms defined in reference [5]:
   a) Attached Sync Marker;
   b) Convolutional Code;
   c) Pseudo-Randomization;
   d) Reed-Solomon Check Symbols;
   e) Reed-Solomon Code;
   f) Turbo Code.

1.7.4 DEFINITIONS FROM TC SYNCHRONIZATION AND CHANNEL CODING

The SCCS-SM service specification makes use of the following terms that are defined in reference [7]:
   a) Communications Link Control Word (CLCW);
b) bit lock;

c) RF availability.

1.7.5 ADDITIONAL DEFINITIONS

1.7.5.1 Introduction

For the purposes of this Report, the following definitions also apply.

1.7.5.2 Two-Phase Operation Procedure Document Exchange Pattern

The SCCS-SM document exchange pattern that is common to all SCCS-SM two-phase operation procedures; that is, operation procedures involving only an invocation and a single return (either a successful or failed return).

1.7.5.3 Three-Phase Operation Procedure Document Exchange Pattern

The SCCS-SM document exchange pattern that is common to all SCCS-SM three-phase operation procedures; that is, operation procedures involving an invocation, an acknowledged return, and either a successful or failed return.

1.7.5.4 Notified Operation Procedure Document Exchange Pattern

The SCCS-SM document exchange pattern that is common to all SCCS-SM notified operation procedures; that is, procedures involving performance of a locally invoked operation, the issuance of a notification, and subsequent confirmation of receipt of that notification.

1.7.5.5 Sender and Receiver

The SCCS-SM document exchange protocol is described in terms of transmitting an SM Message Set from a Sender to a Receiver. On the occurrence of certain exception conditions, the Receiver sends SM Exception Responses (see 1.7.5.7) back to the Sender.

1.7.5.6 SM Document

The term for any communiqué exchanged between SM Sender and Receiver entities, containing either SM Message Sets (see 1.7.5.7) or an SM Exception Response (see 1.7.5.8).
1.7.5.7 SCCS-SM Message Set

An ordered collection of one or more SM messages from a Sender to a Receiver in a single SM Document.

1.7.5.8 SCCS-SM Exception Response

A standard-content communiqué that is returned from the Receiver to the Sender when the processing of a received document results in exception conditions.

1.7.5.9 SM Message

A standard-content component of an SM Message Set that is one of the four generic SM message types: invocation, operation return, notification, and confirmation.

1.7.5.10 Syntactic Validation

Determination that a received document is a properly formed SM document of a version that is supported by the Receiver.

1.7.5.11 Authorization Validation

The validation of an SM Message Set to ensure that the Sender of the message set is authorized to send messages in the context of the Service Agreement and that the Service Agreement is supported by the Receiver.

1.7.5.12 Service Management Validation

The validation of an SM message to ensure that the values of the parameters of the message are consistent among themselves, that the contents of the message are within the scope of the controlling Service Agreement, that all service management information that is prerequisite to the successful performance of the operation is in place, and that all resources required to successfully perform the operation are available (or expected to be available).

1.7.5.13 Space Link Session Transfer Service

A transfer service that is active concurrent with a SLS, such that all data sent via a forward transfer service is transmitted across the forward space link with minimal delay, and data that is received via a return space link is transferred with minimal delay. The standard SLS Transfer Services include the forward SLE transfer services and the return SLE transfer services operating in timely online delivery mode. The MDOS and the Complex may also bilaterally define and implement non–CCSDS-standard SLS transfer services.
NOTE – The standard SLS Transfer Services also include forward Cross Support Transfer Services (CSTSes) and return CSTSes operating in the timely delivery mode.

1.7.5.14 Retrieval Transfer Service

A return transfer service that retrieves space link data from a data store. The data may be retrieved anytime from the beginning of the associated SLS until the end of the scheduled service period of the retrieval transfer service instance, which may be any specified time period up to the end of the Service Agreement period. The standard Retrieval Transfer Services include the return SLE transfer services operating in the offline delivery mode. The MDOS and the Complex may also bilaterally define and implement non–CCSDS-standard retrieval transfer services.

NOTE – The standard Retrieval Transfer Services will also include return Cross Support Transfer Services (CSTSes) operating in the complete delivery mode.

1.7.5.15 Rule-Based Scheduling

*Rule-based scheduling* is a mode of scheduling in which the MDOS and the Complex are able to define a generic set of scheduling rules that CM uses to routinely schedule tentative SLS Service Packages on behalf of the mission. CM proposes each tentative Service Package to UM, which in turn accepts or declines it. Rule-based scheduling is a viable approach when a mission’s requirements can be generically stated (e.g., two return link contacts per day, between 10 and 15 minutes each in duration) and the Complex is able to perform rule-based scheduling. When used appropriately, rule-based scheduling can result in higher efficiency in the utilization of a Complex’s resources by allowing CM to fit the most contacts into a given schedule period. Rule-based scheduling, sometimes known as *generic scheduling* or *standing order* scheduling, is the primary scheduling mode for several TT&C networks.

1.7.5.16 Scenario

A scenario is a collection of space communication services that are scheduled to support an anticipated set of spacecraft activities during the execution of a Service Package. In some cases, it is possible to anticipate that one of several sets of spacecraft activities might occur during the execution of a given Service Package, but specifically which of those sets will occur cannot be known at the time that the Service Package is scheduled. For example, for a planned spacecraft maneuver, it may be possible to anticipate ahead of time two outcomes (the maneuver executes as planned, or the maneuver is aborted, possibly at the last minute), each of which may have different space communication service requirements.

The Service Package is capable of specifying more than one scenario, each specifying the communications services required for each outcome. When a Service Package with more than one scenario is scheduled, the resources are reserved to support all of the scenarios in...
the Service Package, so that the scenario can be changed with minimal delay via the 
SELECT_ALTERNATE_SCENARIO operation.

NOTE – Support for multiple scenarios in a single Service Package is optional and 
depends on the ability of a Complex to reserve multiple sets of space 
communication resources and switch among them with small delay.

1.8 CONVENTIONS

1.8.1 UNIFIED MODELING LANGUAGE CLASS DIAGRAMS

This Informational Report includes Unified Modeling Language (UML) class diagrams that 
follow the notation, semantics, and conventions imposed by the Version 2.0 UML 
specification of the Object Management Group (OMG). A brief description of class diagrams 
is given in annex C.

1.8.2 TYPOGRAPHIC CONVENTIONS

1.8.2.1 New Terms and Key Concepts

*Italic* in textual description is used to introduce to the reader a new term or phrase that 
represents a key concept of the specification. Subsequent usage of the term or phrase is in 
regular non-italicized font.

1.8.2.2 Operation Names

The typographical convention for an operation name is to use non-proportional font, Courier 
New, uppercase and with underscores between the words (e.g., CREATE_SERVICE_PACKAGE). The shorthand convention is to use the first character of 
each word in uppercase. For example, CSP is the shorthand representation of 
CREATE_SERVICE_PACKAGE.

1.8.2.3 Message Names

A message name appears in non-proportional font, Courier New, camel-case, bold, with first 
letter capitalized (e.g., CreateServicePackageInvocation). The shorthand convention is to use the first character of each word in the operation name and add the first 
character of the message type with a hyphen between the operation and message type. For 
example, CSP-I is shorthand for CreateServicePackageInvocation.

Hyphens may appear in message names in order to facilitate readability. The hyphens are not 
part of the message names.
1.8.2.4  Data Set Names

Names of data sets appear in non-proportional font, Courier New, camel-case with first character lowercase, and in bold (e.g., \textit{returnFrequencyOffset}).

Hyphens may appear in data set names in order to facilitate readability. The hyphens are not part of the data set names.

1.8.2.5  Parameter Names

Names of parameters in a data set appear in non-proportional font, Courier New, and camel-case with the first character in lowercase (e.g., \textit{carrierWaveform}).

Hyphens may appear in parameter names in order to facilitate readability. The hyphens are not part of the parameter names.

1.8.2.6  Enumeration Values

Some parameters are enumeration types. Enumeration values appear in non-proportional font, Courier New, and enclosed in single quotes (e.g., ‘\textit{NRZ-L}’).

1.8.2.7  Stereotype Names

Typographical conventions are used to distinguish between a reference to a stereotype definition, a reference to an applied stereotype (as a characteristic of a dataset, for instance), and a reference to all instantiations that apply the stereotype.

a) reference to a stereotype definition appears in non-proportional font, Courier New, camel-case with first character capitalized, and enclosed by a pair of guillemots (e.g., <<\textit{Invocation}>>);  
b) the applied stereotype of an instantiation appears in non-proportional font, Courier New, camel-case, and enclosed by a pair of guillemots (e.g., <<\textit{Invocation}>>);  
c) general reference to all instantiations of a stereotype appears in non-proportional font, Courier New, and camel-case with first character capitalized (e.g., \textit{Invocation}).

Hyphens may appear in stereotype names in order to facilitate readability. The hyphens are not part of the stereotype names.

1.8.3  OTHER CONVENTIONS

The typographical conventions in 1.8.2 are applied to the diagrams with the exception that proportional font is used for document spacing reasons. Color in diagrams is used for emphasis only and does not convey information about a specification. Examples of color...
usage in this document include highlighting UML notes in diagrams and emphasizing enumeration in a class diagram.

1.9 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.


2 OVERVIEW OF SCCS SERVICE MANAGEMENT

2.1 FUNDAMENTAL CONCEPTS

2.1.1 SERVICE MANAGEMENT ENVIRONMENT

The SCCS-SM environment is illustrated in figure 2-1, which is derived from the Cross Support Reference Model (reference [1]). The SCCS-SM model is essentially a generalization of the SLE focus of reference [1] to encompass more space communication cross support services than SLE services.

In this model, SCCS transfer services and SCCS service management, provide the interfaces between an SCCS Complex that provides SCCS transfer services and TT&C space link services, and a spaceflight mission that uses the services that the SCCS Complex provides. The spaceflight mission is composed of a single Mission Spacecraft and the Mission Data Operations System (MDOS), which comprises the mission’s ground-based functions.

A key concept of the SLE architecture (and its generalization for SCCS) is that the MDOS may have multiple transfer service users communicating with multiple instruments or computer applications onboard the mission spacecraft during the same SLS. The transfer services provide individual ‘pipes’ for these multiple connections. Each such pipe is realized as a transfer service instance.

The transfer service instances rely on shared Complex space link resources like antennae, receivers, frame synchronizers, and so on. To facilitate this sharing of space link resources among the various transfer service users, the UM coordinates and manages space link and transfer services on behalf of the service users within the MDOS.

The interactions between UM and CM are the domain of SCCS-SM. The transfer service interactions between the users in the MDOS and the SCCS Complex are the subject of the CCSDS Recommended Standards for transfer services. Communications across the space link are the subject of CCSDS Recommended Standards for RF, modulation, coding, and data links. The interactions between UM and transfer service users, the interactions between CM and the resources that actually provide the space link and transfer services, and the internal management of CM and UM are outside the scope of this report.
2.1.2 THE PURPOSE OF SCCS SERVICE MANAGEMENT

The purpose of SCCS-SM is to standardize and automate, as far as practicable, those interactions between users and providers of space link and SLE services that are required to set the values of the parameters of space link and SLE transfer services. In addition, SCCS-SM provides the means to configure the resources needed by the user and provider to execute those services. In essence, SCCS-SM provides a standard way for the user and provider:

a) to set the values of the parameters involved in space link and transfer services;
b) to specify the services needed to execute space link and transfer services;
c) to configure ground stations for the establishment of space links;
d) to configure ground stations for processing of forward and return space link data;
e) to arrange timely provision of transfer services; and
f) to disseminate Trajectory Predictions.

CM presents the services performed within the SCCS Complex in a standard way to the user, as defined in detail in the later sections of this document.

The roles of UM and CM, and the SCCS-SM services that are set up between them, are outlined in the following subsections.
2.1.3 UTILIZATION MANAGEMENT

UM is the function within the MDOS that coordinates the requests by users for space link and transfer services from the Complex.

UM role:

a) requests periods of provision of space link services and SLE transfer services;

b) provides configuration information for RF, modulation, space link service, and SLE transfer service;

c) provides Trajectory Predictions;

d) interfaces with Mission User Entities within the MDOS to enable the execution of transfer services and to collect status information.

2.1.4 COMPLEX MANAGEMENT

The SCCS Complex is a collection of ground station resources under a single management authority. It may be a single ground station or a network of ground stations. The space mission uses the Complex’s services so that the MDOS can communicate with and track the spacecraft.

The Complex acts as the transfer service producer and provider, which requires that it executes the space link services used to communicate data to and from the mission spacecraft.

CM controls the extent to which UM can affect actual Complex resources. Because CM acts as the intermediary for UM, only those aspects of the resources of a Complex that CM chooses to expose are visible to UM for management operations.

CM role:

a) negotiates types of services, numbers of service instances, and the length of the Service Agreements with UM;

b) responds to requests from the UM for individual SLSes;

c) provides configuration information to the resources of the Complex to enable the production and provision of space communication services, and monitors their correct operation.

2.1.5 SLE MANAGEMENT SERVICES

SCCS-SM comprises a set of services for the standardized exchange of management information. Each of these management services contains sufficient information for authentication, credentials, and general security concerns. The management services are:
a) Service Package service (see 2.3.2);
b) Configuration Profile service (see 2.3.3);
c) Trajectory Prediction service (see 2.3.4); and
d) Service Agreement service (see 2.3.5).

In general, each management service involves procedures, operations and messages to effect negotiation and commitment of resources for the provision of space link and SLE transfer services.

Each of the management services defines the operations that can be invoked by UM and the operations that can be invoked by CM, as well as the messages that are exchanged as part of each operation.

2.1.6 SCCS-SM SPECIFICATION SUMMARY

The information, operations, and reference framework relationships associated with the SCCS-SM services are summarized in figure 2-2.

The names of operations that are performed upon invocation from an external entity use the second-person imperative, present-tense verb form, while the names of notify operations (which emit a notification after a management function has been performed) use the past participle.

Figure 2-2 summarizes the services, their respective information, and operations, which are presented in the following subsections.
Figure 2-2: SCCS-SM Specification Summary
2.2 INFORMATION MANAGED BY SCCS SERVICE MANAGEMENT

2.2.1 INFORMATION OVERVIEW

To facilitate the standardization and automation of the interactions between UM and CM that are involved in requesting space link and transfer services, SCCS-SM establishes a common set of managed information to be exchanged and operated upon by the SCCS-SM services. This common set of managed information defines and enables the space link and SLE transfer services provided by an SCCS Complex.

Subsection 2.2.2 describes the space link and service resources that are within the purview of SCCS-SM. This resource model provides the context for SCCS-SM managed information; it is a logical abstraction of the Complex physical resources that provide space link and transfer services. The managed parameters associated with the components of the resource model collectively form the basis of SCCS-SM managed information.

SCCS-SM organizes the managed information into four conceptual types of information entities:

a) The Service Agreement, which covers all aspects of SCCS-SM and defines the bounds for the three other SCCS-SM information entities;

b) Configuration Profiles, which are used by CM and UM to define preset configurations of space link and transfer service production parameters;

c) Trajectory Predictions, each of which defines the course of the spacecraft over a period of time; and

d) Service Packages, each of which specifies the antenna, space link and transfer service configuration, and time span for a particular SLS, or the transfer service configuration and time span for a particular offline transfer service instance provision period.

Subsection 2.2.3 provides an overview of the content and organization of the Service Agreement. Subsection 2.2.4 addresses the Configuration Profile, subsection 2.2.5 addresses the Trajectory Prediction, and subsection 2.2.6 addresses the Service Package.

NOTES

1. Spacecraft attitude information is not included in Configuration Profiles. The UM is expected to handle any loss of signal strength due to spacecraft attitude by invoking different Configuration Profiles, or by respecifying the Equivalent (or Effective) Isotropic Radiated Power (EIRP) parameter of the Configuration Profile used, with a lower spacecraft return EIRP or higher forward EIRP. Respecification of individual parameters is described in 3.5.

2. In order to encourage incremental adoption of SCCS-SM, the specification allows for certain information, including configuration profiles and trajectory predictions, to be provided by methods and using formats other than those described, by bilateral
agreement between the organizations engaging in a Service Agreement. This report indicates where bilateral data sets may be used but does not exhaustively identify all bilateral options provided by the specification.

2.2.2 RESOURCES OF COMPLEXES MANAGED VIA SCCS-SM

Figure 2-3 is a representation of the resource model for SCCS-SM services associated with the forward and return TT&C space link services. The colored boxes show how use of the Complex resources may be controlled by the different SCCS-SM configuration profiles. In addition, use of all resources is controlled by the Service Agreement.

NOTE – The SCCS-SM resource model described in this subsection addresses the resources that are nominally and explicitly supported by the SCCS-SM services. However, some SCCS-SM services can be used by TT&C networks that support different underlying resource models and associated management information, as long as the management information associated with those resource models can be made to conform to the SCCS-SM reference framework (see 2.2.7).

The space link carrier production resource modulates and amplifies symbols onto a carrier signal for transmission across free space (in the forward [uplink] direction), and detects and demodulates symbols from received carrier signals (in the return [downlink] direction). Each
space link carrier production resource uses an antenna to transmit or receive its carrier signals. (A single antenna may be used concurrently by multiple carrier resources—both forward and return—depending on the design of the antenna and carrier production resources and/or the frequency bands involved.)

The forward CLTU transfer service provision resource performs the TT&C service provider-side of the CLTU transfer service. It provides CLTUs to a forward link protocol production resource, which generates a bitstream and provides it to a forward symbol stream production resource. The forward symbol stream production resource transforms the bitstream into symbols and provides them to the forward space link carrier resource, which modulates them onto the carrier signal.

Each return space link carrier resource sends its output symbols to one or two return symbol stream production resources, depending on the modulation scheme employed on the return link. Each return symbol stream production transforms its symbol stream into a bitstream. Each bitstream is processed by a return link protocol production resource, which synchronizes, decommutates, and error-detects/corrects any CCSDS telemetry transfer frames that are present within the bitstream. The resulting stream of transfer frames is then provided either to any number of RAF online transfer service provision resources and/or RCF online transfer service provision resources, or to any number of data sinks, or both. The RAF and RCF online transfer service provision resources perform the TT&C service provider-side of the RAF and RCF online transfer services, respectively. The data sinks each provide data to one data store.

The data stores support retrieval of data independent of the SLS during which the data was acquired. They provide data to the RAF and RCF offline transfer service provision resources, which perform the TT&C service provider-side of the RAF and RCF offline transfer services, respectively.

### 2.2.3 SERVICE AGREEMENTS

#### 2.2.3.1 General

A Service Agreement holds information that enables management interaction between UM and CM. This information is negotiated between the two entities by a means outside the scope of the SCCS-SM service specification.

Issue 1 of the SCCS-SM service specification does not define an operation for creating a Service Agreement as participating agencies have not yet agreed on a common way to negotiate these agreements. This is to be addressed in the future. However, the parameters of the Service Agreement that are necessary for SCCS-SM will be made available to the UM and CM in electronic form so that they can be ingested into the SCCS-SM systems at the UM and CM.
Figure 2-4 shows the information contained in the Service Agreement, which includes:

1. name of agencies involved in the Service Agreement;
2. identification of the Complex that will provide the SCCS services;
3. spacecraft/mission name;
4. references to contractual documents relevant to the Service Agreement;
5. Service Agreement period;
6. list of supported versions of the SCCS-SM service specification;
7. list of supported SCCS-SM operations within the Service Agreement, which reflects the level of compliance to the SCCS-SM service specification (see section 5);
8. CM and UM usernames authorized to generate SCCS-SM documents under the Service Agreement;
9. indication of whether ownership constraints are to be enforced;
10. timeout for the receipt of notification confirmation messages;
11. constraints on the provision of the Event Sequence capability;
12. configuration constraints for the forward and return Space Link Carrier, Subcarrier, Symbol Stream, and Production parameters;
13. ranges for the values of forward and return RF link parameters covered by the agreement;
14. operational constraints relating to the Service Packages, Trajectory Predictions and Configuration Profiles;
15. operation timeout limits;
16. any required additional bilaterally defined information related to the Service Agreement negotiated between UM and CM.
The Service Agreement contains information about the services to be provided, including spacecraft communication characteristics, antennas which may be used, maximum frequency and duration of contacts, agreed data formats, service timeout limits, and other configuration parameters which remain static over the lifetime of the Service Agreement. It also specifies the range in which the exact values of parameters in Service Packages, Configuration Profiles, and Trajectory Predictions are allowed to fall. The information contained in the Service Agreement assists the provider in determining the resources needed to support the mission (e.g., RF equipment, data storage, terrestrial network bandwidth).
Service Packages, Configuration Profiles, and Trajectory Predictions are submitted within the scope of the Service Agreement. The parameter values for the Service Packages, Configuration Profiles, and Trajectory Predictions are validated against the limits and constraints imposed by the applicable Service Agreement. A mission may have several Service Agreements if the level of support is to vary among the different phases of spacecraft operation. For example, a planetary mission might have separate Service Agreements with a provider for launch and early flight, cruise, and target planet exploration phases, if each phase represents a different level of support, uses different sets of antennas, or requires different configurations of TT&C Services.

In addition to the definition of parameter boundaries and constraints, the Service Agreement also contains configuration data that is considered static for the lifetime of the Service Agreement and hence does not need to be defined for each Configuration Profile or Service Package.

It is the responsibility of the CM to ensure that the negotiated parameter values in a Service Agreement are consistent with the capabilities that are available (or will become available) in the Complex during the Service Agreement period.

2.2.3.2 Establishing the Service Agreement

The space mission establishes one or more Service Agreements with TT&C service providers. Each Service Agreement is limited in scope to a single mission. Negotiation of a Service Agreement typically occurs on the order of years in advance of the first support period provided to the mission.

Service Agreement establishment is not a standardized process. The content, format, and media of the document(s) used to establish the Service Agreement(s) are agreed upon by the service provider(s) and the spaceflight mission organization(s).

Although the data format and methods of information interchange are not standardized for the creation of Service Agreements, the normative recommendation defines a standard query that the UM can invoke to obtain the data from the Service Agreement that are relevant to the service. This is needed to validate Configuration Profiles, Service Package, and Trajectory Predictions against the information contained within the Service Agreement.

2.2.3.3 Operational Constraints Agreement

2.2.3.3.1 Service Package Operations Constraints

For the Service Package services, the following constraints are defined:

a) list of antenna identifiers available to UM;

b) list of authorized users and authorized providers of transfer services;
c) maximum number of Service Packages (see 2.2.6.1) allowed in the context of the Service Agreement (defined independently for Space Link Session Service Packages and Retrieval Service Packages);

d) maximum number of Service Packages (see 2.2.6.1) allowed per defined number of days (defined independently for Space Link Session Service Packages and Retrieval Service Packages);

e) maximum temporal span for a Service Package;

f) maximum number of Service Scenarios that can be defined within a Service Package;

g) maximum temporal span for a Service Scenario;

h) maximum Service Instance time offsets relative to signal acquisition time;

i) maximum number of Service Instances that can be defined within a Service Package;

j) minimum time interval before service execution time by which all deferred parameters in the Service Package should be defined;

k) operational timeout limits;

l) the effective owner name of service packages proposed by CM.

2.2.3.3.2 Configuration Profile Operations Constraints

For the Configuration Profile services, the following constraints are defined:

   a) maximum number of Carrier Profiles that can reside at CM at any given time;

   b) maximum number of Space Link Events Profiles that can reside at CM at any given time;

   c) list of bilaterally agreed Carrier Profile, Events Profile, and Transfer Service Profile formats;

   d) operational timeout limits.

2.2.3.3.3 Trajectory Prediction Operations Constraints

For the Trajectory Prediction service, the following constraints are defined:

   a) list of allowed Trajectory Prediction formats, including bilaterally agreed formats;

   b) maximum size of the Trajectory Prediction storage area in the Complex;

   c) operational timeout limits.
2.2.3.3.4 Service Agreement Operations Constraints

For the Service Agreement service, operational timeout limits are defined.

2.2.3.4 Bilaterally Agreed Service Agreement

SCCS-SM allows the Service Agreement format and content to be agreed bilaterally. In particular, an MDOS and a Complex may negotiate service management policies and procedures for activities not currently covered by the SCCS-SM service specification (e.g., active support for conflict resolution, accounting, billing, spacecraft emergency operations, etc.). The negotiation and querying of any such bilateral agreement is outside the scope of SCCS-SM.

2.2.4 CONFIGURATION PROFILES

2.2.4.1 General

A Configuration Profile specifies a reusable set of space link or transfer services parameters that are established between UM and CM for supporting a mission spacecraft during the lifetime of the Service Agreement.

Once established, a Configuration Profile can be referenced by any number of Service Packages. Use of Configuration Profiles allows the full set of configuration parameters to be defined independently of the Service Packages. It allows the clear separation between the reusable configuration data of the Configuration Profile from the dynamic schedule information contained in Service Packages.

The use of Configuration Profiles is well suited to the majority of spacecraft that have one or more well-defined modes of TT&C operation, e.g., housekeeping, high rate instrument operation, tracking, and various combinations thereof.

There are four categories of Configuration Profiles: Space Communication Service Profiles, Space Link Events Profiles, SLS Transfer Service Profiles, and Retrieval Transfer Service Profiles.

2.2.4.2 Space Communication Service Profiles

The Space Communication Service Profile (SCS Profile) contains one or more Space Link Carrier Profiles. It describes the collection of forward and return RF links needed for a single SLS. Each Carrier Profile captures RF, modulation, and coding parameters for a single carrier across the space link. In order for an RF link to be used in a Service Package, the Service Package must reference a Space Communication Service Profile, resident at the Complex, which contains a Carrier Profile that sets the values of the configurable parameters for that RF link. If the mission intends to operate a given RF link with different operating parameters, it may either store multiple Carrier Profiles (contained in one or more SLS
Profiles) at the complex, or respecify individual parameters as needed for each Service Package.

All Carrier Profiles include the start and stop time of the carrier, expressed relative to the start and stop times of the SLS.

There are two\(^3\) subcategories of Carrier Profile, the *Forward Spacelink Carrier Profile* and *Return Spacelink Carrier Profile*, used to configure forward and return carriers, respectively. Figure 2-5 illustrates the high-level composition of each of these profile types.

\(^3\) Strictly, three: Bilateral Carrier Profiles are also permitted.

---

**Figure 2-5:** Space Communication Service Profile Information Overview
The parameters of a Forward Spacelink Carrier Profile include:

a) carrier frequency;
b) waveform;
c) modulation index;
d) polarization;
e) subcarrier frequency and waveform (if modulation is not direct to carrier);
f) frequency sweep parameters;
g) EIRP.

In addition to the parameters necessary to configure the RF and modulation characteristics of a forward carrier, each Forward Spacelink Carrier Profile contains Forward Symbol Stream information that specifies the symbol rate for the symbol stream that is modulated onto the forward carrier, and a reference to one Forward SLE Transfer Service profile.

Each Forward SLE Transfer Service profile contains a reference to precisely one SLS Transfer Service Profile, which must be a CLTU or bilateral transfer service profile, and which contains configuration parameters for the CLTU transfer service instance that extends the forward space link to the transfer service user in the MDOS.

The parameters of a Return Spacelink Carrier Profile include:

a) nominal carrier frequency;
b) waveform;
c) modulation index, type, and power ratio;
d) polarization;
e) subcarrier frequency and waveform (if modulation is not direct to carrier);
f) frequency relationship to the forward link frequency (if any);
g) coherent or non-coherent relationship of the carrier to the forward carrier.

In addition to the parameters necessary to configure the RF and modulation characteristics of a return carrier, each Return Spacelink Carrier Profile contains configuration parameters for each symbol stream that is modulated onto the return carrier. The symbol stream parameters include:

a) symbol rate;
b) convolutional coding;
c) RAF production parameters, including telemetry frame length and coding characteristics.

Each return symbol stream may supply CCSDS telemetry frames to one or more RAF and RCF SLE transfer service instances, and/or to multiple data sinks which will store the data for subsequent retrieval. For each return symbol stream, the Return Spacelink Carrier Profile may contain

a) references to multiple SLS Transfer Service Profiles, which must be RAF, RCF, or bilateral transfer service profiles, each of which contains the configuration parameters for a single transfer service instance;

b) references to multiple data sinks, including storage selection criteria for each data sink.

While the transfer service profiles may be configured using SCCS Service Management (see 2.2.4.4), the available data sinks are described in the Service Agreement between UM and CM.

The values of the various parameters of the forward and return Carrier Profiles and their components are constrained by the Forward Carrier Agreement and Return Carrier Agreement components, respectively, of the Service Agreement between UM and CM (see 2.2.3).

2.2.4.3 Space Link Events Profiles

A second type of SCCS-SM Configuration Profile is the Space Link Events Profile (see figure 2-6), which provides a time-ordered sequence of changes that the spacecraft will be making to the specified RF parameters. The Complex uses the Space Link Events Profile to determine the corresponding changes to be executed by the Complex in order to maintain communication with the spacecraft.

Space Link Events Profiles contain information about sequences of predefined events that need to be triggered and executed at specific times. The event times in a Space Link Events Profile may be defined in absolute terms, or in relative terms for use by one or more Service Packages. Relative times are specified with respect to the scheduled start time of the carrier identified by the Space Link Events Profile.
2.2.4.4 SLS Transfer Service Profiles

SLS Transfer Service Profiles provide configuration parameters for SLE online Transfer Services.

The only forward transfer service supported is CLTU, with a single configuration parameter, the notification mode.

Supported return transfer services are RAF and RCF. Return transfer service parameters include

a) transfer buffer size;

b) latency limit;

c) data rate limitation;

d) delivery mode (timely or complete);

e) frame quality (for RAF);

f) the set of channel ID to transfer (for RCF).
2.2.4.5 Retrieval Transfer Service Profiles

The Retrieval Transfer Service Profile captures the configuration parameters for a retrieval (offline) transfer service instance. The parameters include:

a) applicable SLE Transfer Service version;
b) functional group ID;
c) transfer buffer size;
d) user ID;
e) frame quality (for RAF);
f) the set of channel ID to transfer (for RCF).

2.2.5 TRAJECTORY PREDICTION

2.2.5.1 General

The Complex uses trajectory data to derive the pointing angles and Doppler compensation settings needed to acquire and track the mission spacecraft. UM is responsible for providing the trajectory data necessary to support contacts. CM is responsible for informing UM of remaining storage area. The information involved in this operation is shown in figure 2-7.

<table>
<thead>
<tr>
<th>Trajectory Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trajectory prediction identifier</td>
</tr>
<tr>
<td>Trajectory prediction data</td>
</tr>
<tr>
<td>Storage space remaining for Trajectory Predictions</td>
</tr>
</tbody>
</table>

Figure 2-7: Trajectory Prediction Information Overview

2.2.5.2 Trajectory Data Formats

A Trajectory Prediction contains a unique identifier and the trajectory data in one of the following formats:

a) one of the two standard message formats defined by CCSDS for use in transferring spacecraft orbit information between space agencies:

1) the Orbit Parameter Message (OPM), either in plain text (see reference [14]) or in XML format (see reference [16]),
2) the Orbit Ephemeris Message (OEM), either in plain text (see reference [14]) or in XML format (see reference [16]);

b) a bilaterally agreed message format.

The allowed trajectory data formats are restricted to the ones recorded in the Service Agreement.

2.2.5.3 Multiple Trajectory Data Sets

Multiple trajectory data sets can reside at the Complex for the same spacecraft for the same (or overlapping) time period(s). For example, different ephemeris sets may be calculated and put in place for nominal and contingency maneuver results. Each Service Package (or scenario within a Service Package) references the trajectory data set that applies to that Service Package or scenario. During the execution of the Service Package, spacecraft acquisition is performed using the trajectory data referenced by the active scenario within the Service Package.

Multiple trajectory data sets may also reside at the Complex for bodies other than the spacecraft. If the trajectory data set for the spacecraft describes a trajectory relative to a body whose own trajectory is not known \textit{a priori} to the Complex, then the second body’s trajectory must also be provided. In principle, this mechanism may cascade, for example when the spacecraft orbits a moon of a planet not otherwise tracked by the Complex.

2.2.5.4 Extension of Trajectory Data

Two methods are available for superseding Trajectory Predictions or extending temporal coverage further into the future. The first involves supplying a new prediction, using a new unique identifier. In this case, any established service package which refers to a superseded prediction must explicitly be updated to refer to the new prediction. The second method allows UM to augment an existing prediction with new data, which provides a refined and/or longer prediction. In this case, any established service package which refers to the prediction will use the newer data without further intervention from UM.

NOTE – A more detailed description of trajectory prediction management is contained in 3.7.

2.2.6 SERVICE PACKAGES

2.2.6.1 General

There are two types of Service Package, one defining an SLS and one describing a Retrieval Transfer Service Instance.

An SLS Service Package holds information about the types of transfer services to be executed (e.g., CLTU, RAF, and RCF) and the periods the services that are to be provided,
the end users that access the services, and the agreed configuration(s) for the space link and transfer service production processes, for specific SLSes. The services in a Service Package may be related.

Among the space link and transfer service capabilities facilitated by the Service Package are:

a) Multiple forward and return space link carriers, each with its own preferred and acceptable start/stop time windows.

b) Multiple transfer service instances, each with a start/stop time specified relative to the start/stop times of the associated space link carrier.

c) Multiple alternate scenarios, by which CM is able to reserve resources for several contingency support modes concurrently, and to change between them on relatively short notice from UM. This capability is envisioned for use when circumstances may require different service configurations; for example:

   - those associated with tracking through not only a nominal spacecraft trajectory change but also any of several preplanned contingency situations such as under burn/over burn/no burn;

   - configurations to support different RF configurations such as changing symbol rate, when the need to switch between configurations, or the schedule to do so, cannot be determined in advance (where switching can be scheduled in advance, the event sequencing mechanism provides more convenient support).

Because only one of the scenarios can be executing at any given time, the same Complex resources can be allocated concurrently to multiple scenarios of the same Service Package. Not all providers will support alternate scenarios, and those that do will likely limit their use to periods of critical operations.

d) Optional time-sequencing of events, by which UM specifies a time sequence of parameter changes to be automatically executed by the Complex at the specified times. Event sequencing allows for proper coordination between the space element and the tracking complex for situations such as the carrier being temporarily unavailable because of occultation by an intervening planetary body, etc. As with alternate scenarios, not all providers will support time sequencing of events.

A Retrieval Transfer Service Instance Service Package holds information about a single retrieval transfer service instance. It includes:

a) start and stop times of access to the Data Store for data retrieval;

b) reference to the antenna associated with the Data Store from which this service instance is to retrieve data;

c) reference to a Retrieval Transfer Service profile.
2.2.6.2 SLS Service Package Contents

The logical organization of the Service Package is illustrated in figure 2-8. A Service Package contains one or more scenarios (each of which has a unique identifier) and designation of the prime scenario, the scenario that is to be executed unless subsequently changed by UM. The overall Service Package scheduled start and stop times encompass all scenarios: the Service Package starts at the time the earliest carrier in any scenario in the service package starts, and stops when the last carrier stops.

No explicit start and stop times are allocated to scenarios. Each Service Scenario defines the following information:

a) **Spacecraft trajectory information**—by reference to the appropriate Trajectory Prediction data set already resident at CM (see 2.2.5, Trajectory Prediction).

b) **One or more space communication services**—each of which may specify an antenna, and defines the configuration of the RF, modulation, and coding and transfer services by reference to Space Communication Service Profiles.

c) Each space communication service may have one or more forward and/or return space link carriers, consistent with the design of the spacecraft and the capabilities of the Complex. The space communication services in a scenario may run concurrently (e.g., forward and return services at different antennas) or sequentially, possibly with overlap (e.g., handovers). Carrier start and stop time offsets are specified independently in the different carrier profiles, so each carrier may start and stop at different times.

d) **Event Sequence**—availability states and change events for space link carriers and data transports (see 2.2.4). Event sequences provide the mechanism to change configuration at predefined times. The event sequence is associated with the service package by reference to a Space Link Events Sequence Profile, which may be expressed in absolute times, or relative to the scheduled carriers, but CM always reports the resulting event sequence information in absolute time reference.

A Service Package may also specify one or more transfer service instances, which are each created once for the service package, independent of the space link scenarios and sessions. The transfer service configuration indicates when each of the SLE transfer service instances is to be active and provides coordination information such that UM and CM can initiate the transfer services. The specification of transfer service configurations is accomplished by reference to transfer service Configuration Profiles resident at CM.

Each carrier may reference one or more transfer service instances. The transfer service start time is calculated relative to the earliest start time within the (prime) scenario of all carriers which reference that transfer service instance; similarly, the stop time is calculated relative to the latest stop time of all referencing carriers. Only one carrier in each space communication service may reference each transfer service instance.
Reference to space link session profile to utilize in providing space link and transfer services

Reference to Antenna assigned for providing space link service

Scheduled start and stop time for space link session

Indication of the prime scenario of the service package (to be executed)

Indication whether handovers are permitted

Reference to trajectory prediction to utilize in servicing the scenario

Service Scenario Id

Service Scenario

Transfer Service Instance

Scheduled start and stop time for space link extension transfer service

Identification of transfer service user (Id that UM will utilize)

Identification of transfer service provider (Id that CM will utilize)

Identification of transfer service port to be extended by provider

Trajectory Reference

Sequence of scheduled space link availability states

Reference to space link events profile

Optional event sequence for providing space link service

Scheduled start and stop time for carrier

0..1

0..*

1..*

1..*

0..*
A three-way relationship (e.g., forward and return space links from different antennas) may be achieved using a single service package or multiple ones. If a three-way relationship is defined in multiple Service Packages, it is the responsibility of the UM to constrain those Service Packages so that any potential change CM might make to any Service Package (within those constraints) does not adversely affect the three-way relationship. If the three-way relationship is modeled in a single Service Package, no explicit extra action is needed, since all requirements are expressed in the specification.

2.2.6.3 Retrieval Service Package

The Retrieval Service Package describes one retrieval transfer service instance (see figure 2-9). It includes

a) start and stop times of the transfer service provision;

b) reference to a transfer service profile;

c) reference to the antenna associated with the data store from which this service instance is to retrieve data.

![Service Package Diagram](image)

Figure 2-9: Service Package Information Overview (for Retrieval)
2.2.7 INFORMATION AND SERVICES COORDINATION REFERENCE FRAMEWORK

The SCCS-SM operations make extensive use of cross-references among Service Agreements, Configuration Profiles, Service Packages, and Trajectory Predictions:

a) Configuration Profiles, Service Packages, and Trajectory Predictions reference the controlling Service Agreement to authorize those operations.

b) Each Space Communication Service Profile, Transfer Service Profile, and Space Link Events Profile references its controlling Service Agreement to identify constraints on the parameters of that profile.

c) An SLS Service Package references Space Communication Service Profiles, Carrier Profiles, Transfer Service Profiles, and Space Link Events Profiles to populate the values of the configuration parameters of the space link and transfer services that are requested by the user.

d) An SLS Service Package references the Trajectory Prediction information that describes the trajectory of the spacecraft associated with each scenario in the package.

e) A Retrieval Service Package references a Retrieval Transfer Service Profile to populate the values of the configuration parameters of the transfer service that is requested by the user.

f) Various replace and delete operations reference the entities that they are replacing or deleting.

g) In an operation to create a new or update an existing Service Package, each Space Link Service Request within a Service Scenario references a Space Communication Service Profile, which in turn contains Carrier Profiles and references Transfer Service Profiles.

Figure 2-10 presents the SCCS-SM reference framework.
Figure 2-10: SCCS Service Management Reference Framework
2.3 OVERVIEW OF SCCS MANAGEMENT SERVICES

2.3.1 INTRODUCTION

The following subsections summarize the operations of each of the four SCCS-SM services: Service Package, Configuration Profile, Trajectory Prediction, and Service Agreement.

2.3.2 SERVICE PACKAGE SERVICE

2.3.2.1 General

The SCCS-SM Service Package service is used to request new contacts or modify or delete existing scheduled contacts.

There are seven Service Package operations that CM can perform when invoked by UM:

a) CREATE_SERVICE_PACKAGE (CSP)—to request CM to create a Service Package;

b) REPLACE_SERVICE_PACKAGE (RSP)—to replace parameters or references in an existing Service Package at CM;

c) DELETE_SERVICE_PACKAGE (DSP)—to delete a Service Package that resides at CM;

d) QUERY_SERVICE_PACKAGE (QSP)—to query the content of an existing Service Package;

e) SELECT_ALTERNATE_SCENARIO (SAS)—to select an alternate Service Scenario of an existing Service Package at CM to be the scenario to be used before or during the execution of the Service Package;

f) APPLY_NEW_TRAJECTORY (ANT)—to apply a new Trajectory Prediction to an existing Service Package at CM.

g) APPLY_NEW_SPACE_LINK_EVENT_SEQUENCE (ANSLEP)—to apply a new Space Link Event Sequence to an existing Service Package at CM.

There are two Service Package operations that CM can perform autonomously and notify UM:

a) SERVICE_PACKAGE_CANCELLED (SPC)—to cancel an existing Service Package due that is no longer supportable by the Complex;

b) SERVICE_PACKAGE_MODIFIED (SPM)—to modify an existing Service Package because of a change in conditions in the Complex that makes the Service Package supportable only if modifications are applied.
There is one Service Package operation that UM can perform when invoked by CM:

CONFIRM_TENTATIVE_SERVICE_PACKAGE (CTSP)—to confirm acceptance of a Service Package proposed as a result of rule-based scheduling by CM. Proposing a Service Package implies either

a) that resources to support the scenario contained within that package have been committed by the Complex, or

b) that such resources were potentially available at the time of the CTSP invocation, but will not be committed until and unless the package is accepted by UM (as defined by the schedulingMode parameter in the Service Agreement).

The following subsections more fully describe the Service Package operations.

2.3.2.2 CREATE_SERVICE_PACKAGE

UM invokes a CREATE_SERVICE_PACKAGE operation to request either (a) that an SLS (a.k.a. contact, pass) be scheduled at a future time (as specified within the invocation), or (b) that a retrieval transfer service instance be established to enable the user to retrieve return link data stored by the Complex during the course of one or more SLSes.

For an SLS Service Package, the CreateServicePackageInvocation (CSP-I) message contains essentially the same information that is contained in the SLS Service Package that results from the invocation, with the following exceptions:

a) For each space link carrier in each scenario, UM may defer selection of the antenna(s) to CM, or constrain or influence the selection. Antenna selection by CM is based on availability and visibility at the time of the requested contact of an antenna identified in the Service Agreement, and conformance with the space link characteristics of the referenced Carrier Profile. UM may constrain the selection to a subset of the antennas identified in the Service Agreement, and, whether thus constrained or not, may indicate a subset of preferred antennas. CM will first attempt to schedule a preferred antenna if indicated; if this is not possible, it will attempt to schedule any acceptable antenna.

NOTE – A more detailed description of antenna selection is contained in 3.6.

b) For each space link carrier in each scenario, the preferred start time, minimum/preferred contact durations, and optional start lag/lead times are specified instead of the specific start and stop times found in the Service Package itself. These parameters allow CM latitude in fitting the request into the schedule.

c) Transfer service instances may be active through changes across multiple scenarios. Each scenario in a CSP-I contains a references to an SLS Profile, containing Carrier Profiles, which in turn reference one or more Transfer Service Profiles, for which corresponding transfer service instances may be enabled. The resulting service package contains, in effect, a pool of transfer service instances that may be used by
multiple scenarios. Each transfer service instance may be referenced with a service mapping by carriers in more than one scenario. This allows UM to request transfer service instances that will persist if different scenarios are selected while the Service Package is in execution.

d) The transfer service instances within the pool contain offset start and offset stop times instead of specific start and stop times. These offsets are relative to the start and stop times of the carriers with which the transfer service instances are associated. Also, the transfer service instances do not contain the specific provider interface port information that specifies how they are to be accessed.

e) A CSP may defer specification of transfer service instances. If an incomplete (that is, without transfer services specified) CSP-I is accepted by CM, UM must subsequently fill in the missing elements of the Service Package (i.e., the specific transfer services to be provided) by invoking a complete REPLACE_SERVICE_PACKAGE operation prior to the start time of the Service Package. This capability supports the mode of operation wherein UM needs to schedule the space link weeks or months in advance, and only needs to be concerned about the details of the transfer services for contacts once the space link carriers are scheduled.

For a Retrieval Service Package, the CSP-I message contains essentially the same information that is contained in the Retrieval Service Package that results from the invocation, except that the transfer service instance does not contain the specific provider interface port information that specifies how it is to be accessed. That information is supplied to the Service Package by CM.

In response to a CSP-I, CM acknowledges the invocation. An acknowledgement is followed by a successful return or a failed return at or before the expected disposition time.

The Service Package is generated by CM as a result of the successful performance of a CREATE_SERVICE_PACKAGE operation. A CreateServicePackageSuccessfulReturn (CSP-SR) contains the successfully scheduled Service Package. For SLS Service Packages, the CSP-SR indicates that the resources needed to support all of the scenarios in the Service Package are being held in reserve and will be applied at the specified time. It contains the definition of the space link carrier start and stop times and service instance provision periods (given the time window options defined in the CSP-I) and the provider-specific information required for the service provision to take place, e.g., provider access information. It also contains details of events which affect availability or configuration of the space link, if event sequences were specified for the service package. For Retrieval Service Packages, the CSP-SR indicates that the resources needed to allow the user to retrieve stored return link data are available for the time span specified in the Service Package.

A CreateServicePackageFailedReturn (CSP-FR) indicates that some aspect of the CSP-I could not be accommodated within the time window specified. Each failed return identifies the reason(s) for failure.
2.3.2.3 REPLACE_SERVICE_PACKAGE

UM invokes the REPLACE_SERVICE_PACKAGE operation to modify one or more parameters of an already created Service Package. Such a modification might be driven, for example, by an updated ‘acquisition of signal’ or ‘loss of signal’ calculation, or by the need to complement a partial Service Package with transfer service configuration details. This allows the UM to update a Service Package without releasing any already allocated resources but simply to add, remove, or change certain parameters and invoke any necessary re-processing by CM.

The ReplaceServicePackageInvocation (RSP-I) has almost exactly the same information as the CSP-I, the only difference being that whereas the CSP-I contains the identifier of the new Service Package to be created, the RSP-I contains a reference to the identifier of the existing Service Package that is to be replaced.

Invocation of the RSP operation triggers revalidation of the Service Package as CM determines if the new space link and transfer service configuration(s) can be supported using the resources already allocated to the Service Package or other resources as necessary. If the replacement is successful, the original Service Package is deleted and the replacement takes its place. If the replacement fails, CM retains the original Service Package and informs UM of the reason for rejecting the replacement.

2.3.2.4 DELETE_SERVICE_PACKAGE

UM invokes the DELETE_SERVICE_PACKAGE operation to remove an existing Service Package from CM. Upon successful completion of this operation CM will no longer carry the Service Package in its operational schedule; i.e., the resources needed to provide the services will be released.

2.3.2.5 QUERY_SERVICE_PACKAGE

UM invokes the QUERY_SERVICE_PACKAGE operation to obtain the contents of an existing Service Package. With the potential exception of the prime scenario designation, the contents of the returned Service Package are identical to that provided in the last successful return message for either a CSP or RSP operation (i.e., CSP-SR and RSP-SR). The return information will also reflect an updated prime scenario designation as a result of successful SELECT_ALTERNATE_SCENARIO operations, if any, applied to the Service Package since the CSP or RSP.

2.3.2.6 SELECT_ALTERNATE_SCENARIO

UM may invoke the SELECT_ALTERNATE_SCENARIO operation for service provision in accordance with an alternate scenario of an existing Service Package. Since, as a condition of accepting either a CSP-I or RSP-I CM commits to providing sufficient resources to
support all of the alternate scenarios in the Service Package, an alternate scenario can be invoked on much shorter time scale and with much higher probability of success than if UM were to invoke a CSP or RSP operation.

2.3.2.7 APPLY_NEW_TRAJECTORY

UM invokes an APPLY_NEW_TRAJECTORY operation for an existing Service Package to indicate that Doppler compensation and antenna pointing are to be in reference to the new trajectory. CM re-evaluates all of the scenarios of the existing Service Package that UM indicates are to be in reference to the new trajectory to ensure that it (CM) can continue to provide the agreed upon support. If it can continue to provide the services, CM returns the updated Service Package information, indicating the new, updated trajectory references. If it cannot, CM returns the appropriate error information, but does not update the Service Package to utilize the updated trajectory information; i.e., the Service Package is retained as is prior to the ANT-I.

2.3.2.8 APPLY_NEW_SPACE_LINK_EVENTS_PROFILE

UM invokes an APPLY_NEW_SPACE_LINK_EVENTS_PROFILE operation for an existing Service Package to indicate that an events profile, currently referenced by one or more service packages, is to be superseded by a different events profile, which must already be stored at CM. CM re-evaluates all of the scenarios of the indicated existing Service Packages that reference the superseded events profile to ensure that it (CM) can continue to provide the agreed upon support. If it can continue to provide the services, CM returns the updated Service Package information, indicating the new, updated events. If it cannot, CM returns the appropriate error information, but does not update the Service Package to utilize the updated events profile; i.e., the Service Package is retained as is prior to the ANSLEP-I.

2.3.2.9 CONFIRM_TENTATIVE_SERVICE_PACKAGE

CM invokes a CONFIRM_TENTATIVE_SERVICE_PACKAGE operation to offer a contact at a time specified within the invocation, as determined by rule-based scheduling performed by CM. All details of such rule-based scheduling are bilaterally agreed between UM and CM and are beyond the scope of the SCCS Service Management Recommended Standard. A ConfirmTentativeServicePackageInvocation (CTSP-I) message contains a description of the tentative Service Package, which has the following restrictions:

a) the Service Package will contain precisely one service scenario;
b) retrieval transfer services are not available via rule-based scheduling;
c) space link event profiles are not available via rule-based scheduling;
d) specification of transfer services cannot be deferred in rule-based schedules.
The trajectory reference in a tentative Service Package is in reference to a trajectory data set that had been provided by (or on behalf of) UM to CM prior to CM’s attempting to find a slot in the schedule for the Service Package. CM uses the previously provided trajectory data to confirm visibility prior to making the proposal. Multiple trajectory data sets may be referenced by a single tentative Service Package in cases where concurrent Trajectory Predictions in multiple frames of reference are required to properly schedule and configure the network. For example, a planetary mission may require concurrent Trajectory Predictions in both Earth-oriented and target-planet-oriented frames of reference.

UM confirms the service package by sending a `ConfirmTentativeServicePackageSuccessfulReturn (CTSP-SR)`. If UM does not want to use the tentative service package, it declines by sending a `ConfirmTentativeServicePackageFailedReturn (CTSP-FR)`.

**2.3.2.10 SERVICE_PACKAGE_CANCELLED**

CM invokes a `SERVICE_PACKAGE_CANCELLED` operation when it is unable to continue with a commitment to provide the agreed upon services for an existing Service Package. This may be the result either of internal CM conditions or of a Service Package’s still having items, such as transfer services or event sequences deferred beyond the mutually agreed minimum service definition lead time (prior to the start time of the Service Package).

This operation results in a notification to UM of the cancelled Service Package.

**2.3.2.11 SERVICE_PACKAGE_MODIFIED**

CM invokes a `SERVICE_PACKAGE_MODIFIED` operation only when it can continue to support the Service Package if modifications are applied. As condition of performing this operation, CM ensures that it is within all of the constraints of the CSP-I of the Service Package and any subsequent RSP-I, or SAS-I applied to the Service Package. In other words, CM continues to honor any start and stop window constraints, agreed-to minimum contact duration, etc.

This operation results in a notification to UM of the modified Service Package.

**2.3.3 CONFIGURATION PROFILE SERVICE**

A Configuration Profile holds predefined sets of detailed configuration that are referenced in Service Packages and subsequently used by CM to configure the Complex to provide the various space communication services.

The SCCS-SM Configuration Profile service is used to add, delete, and query the configuration profile information entities that are referenced by Service Packages. The Configuration Profile service handles four types of configuration profiles: Space
Communication Service Profiles (each of which specifies the RF, modulation, and coding characteristics of one or more space link carriers), SLS Transfer Service Profiles (each of which specifies the configuration of an online SLE transfer service instance), Retrieval Transfer Service Profiles (each of which specifies the configuration of an offline SLE transfer Service instance) and Space Link Events Profiles (each of which specifies one or more time-referenced sequences of predefined space link carrier configuration parameter value changes).

There are 10 Configuration Profile operations that CM can perform when invoked by UM:

a) **ADD_SPACE_COMMUNICATION_SERVICE_PROFILE (ASCSP)**—to add a new SLS Profile at CM;

b) **DELETE_SPACE_COMMUNICATION_SERVICE_PROFILE (DSCSP)**—to delete an SLS Profile that currently resides at CM;

c) **QUERY_SPACE_COMMUNICATION_SERVICE_PROFILE (QSCSP)**—to query the content of an SLS Profile that resides at CM;

d) **ADD_SPACE_LINK_EVENTS_PROFILE (ASLEP)**—to add a new Space Link Events Sequence Profile at CM;

e) **DELETE_SPACE_LINK_EVENTS_PROFILE (DSLEP)**—to delete a Space Link Events Sequence Profile that currently resides at CM;

f) **QUERY_SPACE_LINK_EVENTS_PROFILE (QSLEP)**—to query a Space Link Events Sequence Profile that currently resides at CM.

g) **ADD_SLS_TRANSFER_SERVICE_PROFILE (ASTSP)**—to add a new SLS Transfer Service Profile at CM;

h) **ADD_RETRIEVAL_TRANSFER_SERVICE_PROFILE (ARTSP)**—to add a new Retrieval Transfer Service Profile at CM;

i) **DELETE_TRANSFER_SERVICE_PROFILE (DTSP)**—to delete a Retrieval or SLS Transfer Service Profile that currently resides at CM;

j) **QUERY_TRANSFER_SERVICE_PROFILE (QTSP)**—to query the content of a Retrieval or SLS Transfer Service Profile that resides at CM.

There are no Configuration Profile operations that are performed by UM.

UM invokes the **ADD_SPACE_COMMUNICATION_SERVICE_PROFILE, ADD_SLS_TRANSFER_SERVICE_PROFILE, ADD_RETRIEVAL_TRANSFER_SERVICE_PROFILE, or ADD_SPACE_LINK_EVENTS_PROFILE** operation to add a new profile to the set of Configuration Profiles on record at the Complex. Each new Profile is validated by CM against the previously negotiated Service Agreement to determine if the parameter values are within the scope of the agreement. If they are, CM accepts the new profile and informs UM.
If the request is invalid, CM rejects the new profile and informs UM, citing the reason(s) for rejection.

**UM invokes the DELETE_SPACE_COMMUNICATION_SERVICE_PROFILE, DELETE_TRANSFER_SERVICE_PROFILE** (which applies to both SLS and Retrieval Transfer Service Profiles), or **DELETE_SPACE_LINK_EVENTS_PROFILE** operation to delete no-longer-needed profiles. Normally CM will comply with the invocation, delete the profile, and confirm the deletion to UM. However, if the Profile is being referenced by a scheduled Service Package or another available Configuration Profile when the delete operation is invoked, CM will not delete the Profile, but instead will inform UM that the deletion operation failed because the Profile is being referenced by a Service Package or Configuration Profile.

**UM invokes the QUERY_SPACE_COMMUNICATION_SERVICE_PROFILE, QUERY_TRANSFER_SERVICE_PROFILE** (which applies to both SLS and Retrieval Transfer Service Profiles), or **QUERY_SPACE_LINK_EVENTS_PROFILE** operation to query the content of a specified profile on record at CM. This invocation provides a mechanism for validating consistency between UM and CM databases.

The configuration parameters explicitly specified in the ASCSP and QSCSP operations, and their allowed ranges of values, are conformant with the CCSDS standards for RF and modulation systems (reference [15]), channel coding (references [5] and [7]), telemetry framing (references [4] and [6]) and the RAF, RCF, and CLTU SLE transfer services (references [9], [10], and [12]). However, it is possible for space link service providers to use SCCS-SM even though their services are not conformant with some or all of these CCSDS standards. The ASCSP operation supports the submission of Carrier Profiles characterizing other space link carrier configurations, as long as UM and CM agree on the format and content of those bilaterally defined Space Communication Service Profiles by means outside the scope of the standard. Similarly, the QSCSP operation allows for UM to query the contents of such bilaterally agreed Space Communication Service Profiles. Similar capabilities are provided by the ASTSP, ARTSP, and QTSP operations for SLE and Retrieval Transfer Service Profiles, and by the ASLEP and QSLEP operations for Space Link Events Profiles.

### 2.3.4 TRAJECTORY PREDICTION SERVICE

#### 2.3.4.1 General

The SCCS-SM Trajectory Prediction operations are used to manage the spacecraft trajectory data that are used by CM to compute the data needed to acquire and maintain communication links between the space body and the Complex, such as antenna pointing angles, Doppler compensation offsets, signal-level adjustments, and light-time compensation adjustments.

There are four Trajectory Prediction operations that CM can perform when invoked by UM:
a) **ADD_TRAJECTORY_PREDICTION** (ATP)—to add a new Trajectory Prediction to the set of Trajectory Predictions that are available at CM;

b) **EXTEND_TRAJECTORY_PREDICTION** (ETP)—to extend a Trajectory Prediction that is already available at CM by appending a trajectory prediction segment for a later time period.

c) **DELETE_TRAJECTORY_PREDICTION** (DTP)—to delete a Trajectory Prediction that is available at CM (as long as the Trajectory Prediction is not referenced by any Service packages at the time that the DTP is invoked);

d) **QUERY_TRAJECTORY_PREDICTION** (QTP)—to query the content of a Trajectory Prediction is available at CM;

There are no Trajectory Prediction operations that are performed by UM.

The ATP, ETP, and QTP operations explicitly support the exchange of Trajectory Predictions that conform to CCSDS orbit data message Recommended Standards (references [14] and [16]). In addition, these operations support the exchange of bilaterally defined Trajectory Predictions, as long as UM and CM agree on the format and content of those bilaterally defined Trajectory Predictions by means outside the scope of the Recommended Standard.

**NOTES**

1. Submission of trajectory data occurs on the order of months, days, or minutes in advance of the support period to which the trajectory data applies.

2. In addition to using Trajectory Predictions to compute the data needed to acquire and maintain communication links between the space body and the Complex, Trajectory Predictions may also be used during the Service Package scheduling process to confirm mutual visibility between the space body and the antenna of the Complex that will be used to support the Service Package. Agreement to use Trajectory Predictions for scheduling of Service Packages is recorded as part of the Service Agreement.

### 2.3.4.2 Storage Area at CM

There is a limited amount of storage space available at CM for Trajectory Predictions. The maximum allowed storage area is defined in the applicable Service Agreement. CM will reject new Trajectory Predictions once this storage space is exceeded.

There are three modes of Trajectory Prediction (TP) storage management supported by SCCS-SM: *invoked deletion only, auto TP deletion, and auto segment deletion*.

In the invoked deletion only mode of Trajectory Prediction storage management, all trajectory information associated with each Trajectory Prediction is retained by CM until UM
explicitly deletes that Trajectory Prediction via the DTP operation. This mode puts complete control of and responsibility for the management of Trajectory Prediction storage on UM.

In the auto TP deletion mode, CM discards segments of a Trajectory Prediction as they expire, freeing the storage resources associated with each of those segments. Once all segments of the Trajectory Prediction have expired, the Trajectory Prediction itself is automatically deleted by CM. This mode relieves UM from responsibility for routine management of Trajectory Prediction storage management. However, if UM operates by extending Trajectory Predictions, UM will ensure that it extends each Trajectory Prediction before it expires and is automatically deleted.

In the auto segment deletion mode, CM discards segments of a Trajectory Prediction as they expire, freeing the storage resources associated with each of those segments. However, in contrast to the auto TP deletion mode, even if all segments of the Trajectory Prediction have expired, CM continues to retain the Trajectory Prediction until the Trajectory Prediction is explicitly deleted by UM via the DTP operation. An example use for this mode is the case of a simple mission that establishes a Trajectory Prediction once at the beginning of the Service Agreement period and extends it with additional Trajectory Prediction segments whenever it is useful, even though the previous Trajectory Prediction segments may have expired.

NOTE – Support for these Trajectory Prediction storage management modes is dependent upon the capabilities of the individual Complex, and only one mode is applicable to (and recorded by) any given Service Agreement.

2.3.4.3 Trajectory Prediction Validation

When UM requests the addition of a new Trajectory Prediction, the validation performed by CM is limited, i.e., checking of storage space available at CM, sanity checking of time window, conformance to indicated format, uniqueness of Trajectory Prediction identifier. Further locally defined checks may be performed by CM as part of the validation of a Service Package that references the Trajectory Prediction.

When UM requests the extension of a Trajectory Prediction, CM performs additional validation to ensure that the extension data supplied is compatible with the existing prediction data.

Requests for deletion of Trajectory Predictions that are referenced by pending or executing Service Packages will be rejected.

To allow UM to keep track of referenced Trajectory Predictions, the QUERY_TRAJECTORY_PREDICTION operation returns the list of pending or executing Service Packages that reference the queried Trajectory Prediction.
2.3.5 SERVICE AGREEMENT SERVICE

The negotiation and generation of the Service Agreement are beyond the scope of the Recommended Standard. For this reason, there is only one Service Agreement operation that can be invoked by UM:

\texttt{QUERY\_SERVICE\_AGREEMENT} (QSA)—to query the content of a Service Agreement that resides at CM. The QSA operation has been defined to support the return of Service Agreement data either in the format defined in the specification or in a bilaterally agreed format.

No Service Agreement operations can be invoked by CM.
3 USAGE CONCEPTS

3.1 OVERVIEW

This section discusses a number of aspects of SCCS-SM where an explanation in more detail than the plain specification may be helpful. It is by no means exhaustive; rather it should be read in the spirit of a ‘frequently asked questions’ list. The topics addressed are:

- Ownership of SCCS-SM information, and the restrictions that may be enforced on operations with respect to ownership (3.2);
- The timing relationships among the various components of an SLS Service Package (3.3);
- Completing a service package in stages by deferring certain details until nearer the time of contact (3.4);
- Modifying a service configuration profile for a single Service Packages (3.5);
- How UM may constrain or determine the selection of antenna for a Service Package (3.6);
- Handling Trajectory Predictions (3.7);
- Service Package scheduling, either by UM, requesting specific service periods, or by CM on the basis of mutually agreed scheduling rules (3.8);
- Accommodating autonomous deep space mission operations via Space Link Event Profiles (3.9);
- Use of frequency sweep parameters in establishing forward carrier/command service to a spacecraft (3.10).

3.2 CREATION AND OWNERSHIP OF SCCS-SM INFORMATION

Although UM is conceptually a single entity for a given MDOS, in practice the functions that UM performs may be distributed to different entities within that MDOS. For example, scheduling of contacts for a spacecraft may be performed by a different management entity than the entity that is concerned with updating predicted trajectory information.

Each Service Package, Configuration Profile, and Trajectory Prediction is associated with a single owner name. SCCS-SM allows multiple entity names to be used by different management entities within the MDOS to invoke operations within the context of a single Service Agreement. In almost all cases, the owner of an information entity is the source (the generator) of the invocation which created that entity. The one exception is that a Service Package which is proposed by CM, using the CTSP operation, is owned by the name identified by the proposedServicePackageOwnerName parameter of the Service Agreement.
There is no provision for sharing or reassigning ownership.

The management entity name serves two purposes within the context of a particular Service Agreement:

a) it establishes a sequence number space for uniquely identifying SCCS-SM messages;

b) it may be used to establish authority to perform SCCS-SM operations.

If the Service Agreement parameter `enforceOwnership` is set to ‘true’, then only the owner of a management information entity may modify or delete that entity. Any UM service management entity may query the content of any information entity within the context of the services covered by the Service Agreement, including the Service Agreement itself, regardless of the setting of `enforceOwnership`.

If `enforceOwnership` is set to ‘false’, then CM does not enforce any ownership restrictions.

In the context of a single Service Agreement, SCCS-SM also allows CM to have multiple names associated with different service management entities within the Complex.

Entity names are logical and are not necessarily associated with a particular physical device or person. For example, in the case of failure of a primary control center function, a name might be transferred to a backup entity, at which point that backup can manipulate the services associated with the owner name.

### 3.3 TIMING RELATIONSHIPS

Figures 3-1 and 3-2 graphically illustrate an example of timing relationships among the various components of an SLS Service Package as it is represented in a `SpaceLinkSessionServicePackageResult`. The different data sets that make up the `SpaceLinkSessionServicePackageResult` are represented by bars of different colors. The beginning (left side) of the bar corresponds to the start time of the physical or logical component described by that data set. The end (right side) of the bar corresponds to the end time of the physical or logical component described by that data set.

The example illustrated in these figures represents the following scenario:

- The Service Package establishes two Space Communication Service instances, one for each of two Complex antennas (ground stations), corresponding to the track of the satellite, by using two antennas with an overlap to provide a longer pass and delivery of data.
- The Service Package handles only telemetry (return carrier).
- The Service Package employs a Space Link Events sequence (where an occultation occurs during the tracking of the first antenna).
Figure 3-1: Example Top-Level Timing Relationships in a Service Package Result
**Figure 3-2: Example Timing Relationships in a SpaceCommunicationServiceResult Component of a Service Package Result**

Figure 3-1 illustrates the top-level timing relationships within the Service Package Result, down to the component *SpaceCommunicationServiceResult* data sets and the *SlsTsInstanceResult* data set. It illustrates how the timing of the *SlsTsInstanceResult* is related to the two *CarrierResult* data sets. Figure 3-2 illustrates the timing relationships among the components that comprise the first *SpaceCommunicationServiceResult* data set. Parameters are shown in color to match the containing data set. Parameters shown in grey are taken from profiles and are used to calculate the result, but do not appear in the result data set.

**NOTE** – This example illustrates a few but not all relationships among timing parameters. The complete description of the relationships is found in the SCCS-SM service specification.

The start and stop time offsets for carriers are limited so that the carrier does not start before or end after the containing SLS. Those for transfer services are not explicitly restricted with
respect to the referencing carriers. For example, in figure 3-1 the transfer service instance (\texttt{SlsTsInstanceResult}) starts before the carrier itself, but it stops while the carrier is still active. The overall service package start and stop times include all space communications services and all transfer service instances.

Events profiles may be stated in absolute or relative time reference.

When absolute time reference is used, those availability states in the referenced events profile which lie within the scheduled SLS are scheduled, and all other availability states of the reference profile are ignored.

With relative time reference, the start and end times of each state are calculated as offsets from the scheduled start time of the space link carrier.

Within each Space Link Available State window, there may be multiple Space Link Data Transport States with differences such as symbol rate and convolutional coding. The data transport states have start and end times (each with lead and lag times). If they are stated as relative times, they are specified relative to the scheduled start time of the space link carrier (\textbf{not} with respect to the containing Space Link Available State). The space link events concepts are further discussed in 3.9.

\section{3.4 DEFERMENT}

The Service Package Service supports a mode of operation wherein UM needs to schedule use of the space link weeks or months in advance, but needs to be concerned only about the details of the transfer services for contacts, and/or sequences of events which specify changes to space link carrier or data transport parameters, nearer the time of contact. To achieve this, CM may accept an incomplete \texttt{CREATE_SERVICE_PACKAGE} invocation, in which any or all of the following hold:

\begin{itemize}
  \item transfer services are stated to be deferred;
  \item every default transfer service instance (defined by the referenced Space Communication Service Profile) is marked as disabled;
  \item the sequence of events are stated to be deferred.
\end{itemize}

In this case, UM must subsequently fill in the missing elements of the Service Package (i.e., the specific transfer services to be provided, or sequence of events to apply) by invoking a complete \texttt{REPLACE_SERVICE_PACKAGE} operation prior to the start time of the Service Package.

The Service Agreement specifies a minimum lead time before the Service Package start time, by which time all details should be defined. If they have not been, CM may cancel the Service Package. At its discretion, CM may delay cancellation of the Service Package if that is operationally feasible; however, SCCS-SM does not support any method either for negotiating or for notifying the availability of such a delay.
3.5 RESPECIFICATION OF CONFIGURATION PROFILE VALUES

The configuration profile service allows multiple configurations to be stored, both for space link carriers and for transfer services. There are, however, mission scenarios where storing new profiles for each foreseen combination of parameter values is unwieldy. For example:

- Values may vary over a range (e.g., EIRP changing with spacecraft attitude).
- Several parameters may vary independently. The number of possible combinations is the product of the number of possibilities for each parameter.

To avoid a proliferation of profiles for such cases, there is a mechanism to allow individual parameter values within referenced configuration profiles to be respecified (overridden) for the duration of single service packages.

A CREATE_SERVICE_PACKAGE or REPLACE_SERVICE_PACKAGE invocation may contain:

- Respecified parameters for one or more parameters of a Space Communication Service Profile instantiated within a single service scenario. If the same space link service profile is referenced by multiple scenarios, it must be explicitly respecified for each scenario where respecification is desired.
- Respecified parameters for one or more parameters of a Transfer Service Profile instantiated within the Service Package. Respecification of a Transfer Service profile parameter applies to all instances of that transfer service throughout the Service Package.

Each respecified parameter identifies the parameter name and the new value to be applied for the Service Package. The parameter name must necessarily be unambiguously specified. If a referenced configuration profile can have multiple instances of the ‘same’ parameter, the ‘distinguished name’ adds the data to distinguish them (e.g., for a carrier profile that has I & Q channels and therefore two symbol rate parameters, the distinguished names would logically be of the form ‘I-channel:symbolRate’ and ‘Q-channel:symbolRate’. The actual syntax used depends on the specific representation mapping used. For XML, it will be an XPath expression.

If any parameters of a profile have been respecified in the invocation that successfully creates or replaces a Service Package, the response from CM to UM will include both

- the list of respecified parameters;
- the complete affected Transfer Service Profile or Space Communication Service Profile, with values as modified by respecification.
3.6 ANTENA SELECTION

The CREATE_SERVICE_PACKAGE operation provides four antenna selection qualifiers. UM may

a) specify multiple preferred antennas;

b) specify multiple acceptable antennas or multiple unacceptable antennas (but not both types concurrently);

c) decline to specify any antenna constraints, in which case CM will assign a suitable antenna from the list of allowed antennas in the Service Agreement.

NOTE – All references to CREATE_SERVICE_PACKAGE (CSP) in this section apply equally to the RSP operation.

A preferred designation represents the highest level of desirability on the part of UM for the Service Package. If one or more antennas are designated as preferred in a CSP-I, CM should assign one of the preferred antennas if it is available and meets the requirements of the Service Package (e.g., has visibility of the spacecraft within the time window specified in the CSP-I. If one or more antennas are designated preferred but none of the preferred antennas are available, CM attempts to assign any antenna identified as available to support the mission in the Service Agreement, subject to acceptability constraints as described in the following paragraphs.

An acceptable designation is used for one or more antennas if UM determines that only a subset of the antennas that are identified in the Service Agreement are acceptable for the particular Service Package. For example, UM may ‘know’ that the attitude of the spacecraft during the time window of the Service Package will be such that the signal power of only certain antennas will be sufficient during that Service Package, and use the acceptable designation to limit the choices that CM can make to that subset. If one or more antennas are designated as acceptable in a CSP-I and no antennas are designated preferred, CM must assign one of the acceptable antennas if it is available and meets the requirements of the Service Package, and otherwise fail the CSP operation. If one or more antennas are designated as acceptable in a CSP-I and one or more other antennas are designated preferred, CM must first attempt to assign one of the preferred antennas (by definition, a preferred antenna is also an acceptable antenna), and if none of the preferred antennas is available, CM shall assign one of the acceptable antennas if it is available and meets the requirements of the Service Package, and otherwise fail the CSP operation.

Alternatively, the unacceptable designation can be used by UM to direct CM to not consider certain antennas that are identified in the Service Agreement. This is a convenience mechanism for UM; the same effect can be achieved by use of the acceptable designation, but if only (for example) one antenna is to be excluded, it is easier to list that one as unacceptable than to have to list all antennas except that one as acceptable. If one or more antennas are designated as unacceptable in a CSP-I and one or more other antennas are designated preferred, CM must first attempt to assign one of the preferred antennas, and if
none of the preferred antennas is available, CM shall assign any antenna identified in the
Service Agreement that meets the requirements of the Service Package except the
unacceptable antennas. If one or more antennas are designated as unacceptable in a CSP–I
and no antennas are designated preferred, CM shall assign any antenna identified in the
Service Agreement that meets the requirements of the Service Package except the
unacceptable antennas. If there is no antenna identified in the Service Agreement that both
meets the requirements of the Service Package and is not designated as unacceptable, CM
shall fail the CSP operation.

The selection logic is therefore as follows:

1 If the CSP–I contains Antenna Constraints:

   1.1 If there are one or more antennas designated as preferred:

      1.1.1 If one or more of the preferred antennas are available and meet the requirements
              of the Service Package, CM must assign one of the suitable preferred antennas.

      1.1.2 If all of the preferred antennas are unavailable or otherwise fail to meet the
              requirements of the Service Package:

         1.1.2.1 If the Antenna Constraints contain acceptability constraints:

            1.1.2.1.1 If the acceptability constraints type is ‘acceptable’:

               1.1.2.1.1.1 If one or more of the acceptable antennas are available and meet the
                          requirements of the Service Package, CM must assign one of the suitable
                          acceptable antennas.

               1.1.2.1.1.2 If all of the acceptable antennas are unavailable or fail meet the
                          requirements of the Service Package, CM must fail the CSP.

            1.1.2.1.2 If the acceptability constraints type is ‘unacceptable’:

               1.1.2.1.2.1 CM must assign one of the allowed antennas (as specified in the
                          Service Agreement), except any of the designated unacceptable antennas.

               1.1.2.1.2.2 If all of the allowed antennas (excluding the unacceptable ones) are
                          unavailable or otherwise fail to meet the requirements of the Service Package,
                          CM must fail the CSP.

         1.1.2.2 If the Antenna Constraints do not contain acceptability constraints:

            1.1.2.2.1 If one or more of the allowed antennas are available and meet the
                          requirements of the Service Package, CM must assign one of the suitable
                          allowed antennas.
1.1.2.2 If all of the allowed antennas are unavailable or otherwise fail to meet the requirements of the Service Package, CM must fail the CSP.

1.2 If there are no antennas designated as preferred:

1.2.1 If the acceptability constraints type is ‘acceptable’, CM proceeds according to 1.1.2.1.1, above.

1.2.2 If the acceptability constraints type is ‘unacceptable’, CM proceeds according to 1.1.2.1.2, above.

NOTE – If there are Antenna Constraints but no preferred antennas, then there must be either acceptable or unacceptable antennas designated.

2 If the CSP-I does not contain Antenna Constraints:

2.1 If one or more of the allowed antennas are available and meet the requirements of the Service Package, CM must assign one of the suitable allowed antennas.

2.2 If all of the allowed antennas are unavailable or otherwise fail to meet the requirements of the Service Package, CM must fail the CSP.

The above logic is presented in the flowchart in figure 3-3.
3.7 HANDLING OF TRAJECTORY PREDICTIONS

3.7.1 GENERAL

A Trajectory Prediction is a set of data that allows the future position and velocity of a spacecraft to be estimated. The predictions may have different degrees of accuracy and are labeled accordingly. The acquisition grade Trajectory Predictions are used by SCCS Complexes to compute data needed to acquire and maintain the space link(s) between the spacecraft and the Complex, such as antenna pointing angles, Doppler compensation offsets, signal level adjustments, and light-time compensation adjustments. It represents trajectory information of the highest resolution. The schedule grade Trajectory Predictions are used to support scheduling of Service Packages in relation to considerations such as determining mutual view between the antenna(s) of the Complex and the Mission spacecraft. As such, it does not contain information of sufficient resolution to compute the data necessary for maintaining the space link. It should be noted that the acquisition grade, which tends to be more finely grained and more voluminous, also supports scheduling of service packages.
The Trajectory Prediction service provides the **ATP**, **ETP**, **QTP**, and **DTP** operations for management of Trajectory Predictions. Their use in support of the different trajectory handling methods identified in 2.2.5 is discussed in the following subsections.

**NOTE** – SCCS Complexes may establish local methods for establishing, updating, querying, and deleting Trajectory Prediction data. Such local Trajectory Prediction-handling methods may be used in lieu of, or in addition to, the SCCS-SM-standard operations. For example, a Mission and Complex may mutually agree that the Complex will periodically (e.g., daily) ‘pull’ a state vector for the mission spacecraft from a server. Such locally defined mechanisms must associate identifiers with the Trajectory Predictions such that they can be referenced by Service Packages. Otherwise, locally defined Trajectory Prediction-handling methods (used either by themselves or in conjunction with some or all of the SCCS-SM-standard operations) are outside the scope of SCCS-SM.

### 3.7.2 ESTABLISHMENT AND USE OF TRAJECTORY PREDICTIONS

#### 3.7.2.1 UM invokes the **ATP** operation to establish a Trajectory Prediction and populate it with initial Trajectory Prediction data. The **ATP** invocation carries a *TP segment*, formatted in accordance with one of several standards, e.g., CCSDS Orbit Parameter Message (OPM). Figure 3-4 is the class diagram for the **ATP-I**.
3.7.2.1.1 The ATP supplies a unique name for the Trajectory Prediction. The ATP also specifies the grade of the trajectory (see 3.7.5 for more information).

3.7.2.1.2 Each TP segment has trajectory start and stop times which delineate the period during which the TP segment represents the expected trajectory of the spacecraft with accuracy sufficient for spacecraft acquisition and in some cases scheduling.

3.7.2.1.2.1 The trajectory start time of the TP segment must be greater than the messageTimestamp of the ATP-I that carries the extension segment. If not, the ATP-I results in an ATP-FR with diagnostic ‘trajectory start time already past’.

3.7.2.1.2.2 For an OPM TP segment (i.e., a single vector that must be propagated):

3.7.2.1.2.2.1 The start time of the TP segment must be equal to or later than the epoch of the vector. If not, the ATP fails with the diagnostic ‘incompatible time’.

Figure 3-4: ATP-I Class Diagram
3.7.2.1.2.2 The effective portion of the OPM TP segment is that portion of the Trajectory Prediction bounded by the designated start and stop times, resulting from the propagation of the vector to at least the designated stop time.

3.7.2.1.2.3 For an Orbit Ephemeris Message (OEM) TP segment (i.e., a sequence of multiple state vectors):

3.7.2.1.2.3.1 The start time of the TP segment must be equal to or later than the epoch of the first vector of the OEM. If not, the ATP fails with the diagnostic ‘incompatible time’.

3.7.2.1.2.3.2 The stop time of the TP segment must be equal to or earlier than the epoch of the first vector of the OEM. If not, the ATP fails with the diagnostic ‘incompatible time’.

3.7.2.1.2.3.3 The effective portion of the OEM TP segment is that subset of the sequence of vectors with epoch times greater than or equal to the designated start time less than or equal to the designated bounded by the designated start and stop times, resulting from the propagation of the vector to at least the designated stop time.

3.7.2.1.3 Successful performance of the ATP operation instantiates the Trajectory Prediction and puts it in the ‘available’ state.

3.7.2.2 If the Service Agreement supports use of the (two-phase) ETP operation, the Trajectory Prediction established by the ATP is an extendable Trajectory Prediction which UM subsequently updates using the ETP. Each ETP invocation carries an extension TP segment. Figure 3-5 is the class diagram for the ETP-I.

3.7.2.2.1 The ETP-I must reference an available Trajectory Prediction. If not, the ETP-I results in an ETP-FR with diagnostic ‘trajectoryRef non-existent’.

3.7.2.2.2 The trajectory start time of the extension TP segment must be greater than the messageTimestamp of the ETP-I that carries the extension TP segment. If not, the ETP-I results in an ETP-FR with diagnostic ‘trajectoryStartTime already past’.

3.7.2.2.3 The trajectory start and stop times of the TP segment must be consistent with the epochs of the contained state vectors, as described in 3.7.2.1.2.3.3, above.

3.7.2.2.4 The stop time of an extension TP segment must be later than the stop time of the available Trajectory Prediction that it is extending. If not, the ETP-I results in an ETP-FR with diagnostic ‘incomplete extension’.
3.7.2.2.5 The extension TP segment must be of a format that is permitted by the Service Agreement. If not, the ETP-I results in an ETP-FR with diagnostic ‘parameter value not supported by referenced Service Agreement’.

3.7.2.2.6 If the start time of the extension TP segment is less than the stop time of the available Trajectory Prediction:

3.7.2.2.6.1 If the checkContinuity flag is set in the ETP-I, CM should validate continuity of the extension with the available Trajectory Prediction at the start time of the extension TP segment (whether CM actually does this, and the degree of sophistication with which it does it, is a local matter, but both sides must understand what it means when CM validates that the extension is continuous with the in-place Trajectory Prediction). Failure of the ETP-I to meet the continuity requirements of the Complex results in an ETP-FR with diagnostic ‘discontinuous extension’.

NOTE – The checkContinuity flag should be set whenever UM expects the extension to be continuous. The ability to unset the flag is provided for use when UM intends the extension to be discontinuous, e.g., an extension to realign the available Trajectory Prediction with the true trajectory following an off-nominal change in the orbit.
3.7.2.2.6.2 If the **ETP-I** is valid, an **ETP-SR** is returned and the extension segment replaces the portion of the available Trajectory Prediction from the start time of the extension. The result is the effective Trajectory Prediction, which is used for spacecraft acquisition and in some cases scheduling.

3.7.2.2.7 If the trajectory start time of the extension segment is greater than the stop time of the available Trajectory Prediction, the extension segment is added to the available Trajectory Prediction and an **ETP-SR** is returned with the Boolean `trajectoryGapPresent` parameter set to **true**.

NOTE – Some Complexes might be used by a spaceflight mission only intermittently, and it may not be necessary to maintain a continuous trajectory prediction at such sites for long periods of time. The **ETP** enables Trajectory Predictions to cover only those portions of the trajectory that will be supported by the Complex. However, the warning is returned in case the gap was not intended.

3.7.2.3 UM may establish multiple Trajectory Predictions using the **ATP**, using different names for the different Trajectory Predictions. These Trajectory Predictions may have disjoint or overlapping time spans.

3.7.2.4 UM submits multiple requests to create Service Packages using the **CSP** operation. Each scenario in the **CSP-I** names the Trajectory Prediction(s) to use if that scenario is designated to be the prime scenario.

NOTE – If the Service Agreement does not support the use of multiple scenarios, the single scenario is always the prime scenario.

3.7.2.4.1 For missions that extend Trajectory Predictions using the **ETP** operation, multiple Service Packages may reference the same Trajectory Prediction over long periods of time (possibly the lifetime of the Service Agreement), since a single Trajectory Prediction can be extended indefinitely.

3.7.2.4.2 For missions that do not/cannot use the **ETP**, the mission’s Service Packages will usually, over time, reference different Trajectory Predictions, since each Service Package can reference only Trajectory Predictions that have corresponding time spans, and normally each (non-extended) Trajectory Prediction will eventually pass the end of its period of applicability.

3.7.2.4.3 CM evaluates each requested Service Package against antenna-to-spacecraft mutual visibility information to determine if the Service Package is supportable.

3.7.2.4.3.1 If mutual visibility is not present, the attempt to create the Service Package fails.

3.7.2.4.3.2 The mutual visibility may be calculated by CM using Trajectory Prediction information, or it may use other bilaterally defined information. (See 3.7.5 for more details.)
3.7.2.4.4 If CM schedules Service Packages using visibility information other than the Trajectory Predictions referenced in the Service Packages, and a requested Service Package is otherwise schedulable, CM may check to determine if each Trajectory Prediction referenced by the requested Service Package is available (i.e., it resides at CM) and is applicable for the time span required by the Service Package (i.e., from \((\text{scheduledServicePackageStartTime} - \text{trajectoryPredictionTimeWindowExtension})\) through \((\text{scheduledServicePackageStopTime} + \text{trajectoryPredictionTimeWindowExtension})\)). The CSP-SR contains a \text{trajectoryPredictionStatus} parameter associated with each Trajectory Prediction referenced by the Service Package. The \text{trajectoryPredictionStatus} parameter has the possible values:

3.7.2.4.4.1 ‘trajectory prediction available to support the Service Package’: the referenced Trajectory Prediction is suitable for generation of spacecraft acquisition products in support of the Service Package.

3.7.2.4.4.2 ‘trajectory prediction available but does not support the Service Package’: the referenced Trajectory Prediction is available at CM but does not cover the time span required by the Service Package. The referenced Trajectory Prediction must be either extended or replaced (via \text{ANT}) before the Service Package can transition from the Pending to the Defined state. If the referenced Trajectory Prediction is neither extended nor replaced by \text{minServiceDefinitionLeadTime} prior to the start time of the Service Package, the Service Package will be cancelled.

3.7.2.4.4.3 ‘trajectory prediction not currently available’: the referenced Trajectory Prediction is not yet available at CM. The referenced Trajectory Prediction must be added before the Service Package can transition from the Pending to the Defined state. If the referenced Trajectory Prediction is not added by \text{minServiceDefinitionLeadTime} prior to the start time of the Service Package, the Service Package will be cancelled.

3.7.2.5 If the spacecraft may possibly follow one of several trajectories during an SLS, and the possible trajectories are anticipated prior to the scheduling of the Service Package for that SLS, the use of multiple scenarios allows a distinct scenario to be established for the nominal and each anticipated alternate trajectory in the Service Package. Then, at any time before or during the execution of the Service Package, the SAS operation can be used to switch Trajectory Predictions with minimal delay.

3.7.2.6 However, once Service Packages are scheduled, if any Trajectory Predictions change significantly from the available Trajectory Predictions that are referenced by those scheduled Service Packages, one of two methods is used to allow the already-scheduled Service Packages to reference appropriate Trajectory Predictions:

3.7.2.6.1 If the Service Agreement supports use of the \text{ETP} operation, UM can use the \text{ETP} to overlay that portion of the Trajectory Prediction that changes significantly. All Service Packages that reference that Trajectory Prediction will automatically follow the overlaid trajectory. This method is particularly useful for routine updates based on continuous refinement of the trajectory information as time progresses, where better trajectory estimates
can be provided enough ahead of time to ensure that the extensions will be in place when they are needed.

3.7.2.6.2 If the Service Agreement supports use of the ANT operation, UM can first use the ATP to establish the more-correct trajectory as a separate Trajectory Prediction, and then use the ANT operation to re-reference the affected Service Packages to the new Trajectory Prediction. This method can also be used for routine Trajectory Prediction refinements if the ETP operation is not supported by the Service Agreement. However, even if the Service Agreement also supports the ETP, use of the ANT is preferable in situations where there is enough lead time to establish the alternate Trajectory Prediction so that it can be made fully useable by CM before any decision is made to actually use it. Once that decision is made, the switch can be invoked with minimal delay (see scenario 2, below).

3.7.2.7 Scenarios for use of Trajectory Predictions are:

3.7.2.7.1 Scenario 1: Extending the Nominal Trajectory Prediction. Figure 3-6 illustrates the incremental extending of a Trajectory Prediction to eventually be applicable to the period t1 to t8.

3.7.2.7.1.1 UM uses the ATP to establish the initial segment of the ‘nominal’ TP for the period t1 - t3.

3.7.2.7.1.2 Subsequent ETP invocations are used to add extension TP segments to the TP: ‘nominal’ segment 2 for the period (t2 - t5), ‘nominal’ segment 3 for (t4 - t7), and ‘nominal’ segment 4 for (t6 - t8). The effective Trajectory Prediction used to track the spacecraft is also shown in the figure.

If the single ‘nominal’ Trajectory Prediction is used for the lifetime of the Service Agreement, all Service Packages will reference the ‘nominal’ TP, and that trajectoryRef value can be hard-coded into the CSP-I's.
Figure 3-6: Extending the ‘nominal’ Trajectory Prediction

3.7.2.7.2 Scenario 2: Applying an Alternate TP to Replace the Nominal (Extended) TP. Figure 3-7 illustrates a scenario in which both extending of a Trajectory Prediction and use of an alternate Trajectory Prediction via the ANT operation are used. In this scenario, the spacecraft is initially planned to be in a stable orbit from t1 through t8, but an unplanned maneuver subsequently requires that a previously scheduled Service Package be re-referenced to a new TP that characterizes the maneuver.

3.7.2.7.2.1 As in Scenario 1, UM uses the ATP and ETP operations to establish and update the ‘nominal’ Trajectory Prediction for the period t1 - t8. Multiple Service Packages are scheduled during the t1 - t8 period, including SP 587 (shown).

NOTE – In figure 3-7 and following figures, the symbol depicting a circle containing a capital ‘I’ is used to indicate the time of invocation of the associated operation.

3.7.2.7.2.2 At some time later, a previously unplanned maneuver is determined necessary, to begin at t3. UM invokes the ATP operation at t2 to establish an alternate ‘correction_burn’ TP (‘correction_burn’ segment 1) for the period t3 - t6. Because Service Package 587, the SP that has already been scheduled to execute when the maneuver will be performed, was not scheduled with alternate scenarios related to the maneuver, UM then invokes the ANT operation to cause Service Package 587 (the only SP to be executing in the t3 - t6 time span) to use the ‘correction_burn’ TP instead of the nominal one.

3.7.2.7.2.3 The UM then uses the ETP (with checkContinuity = false) to overlay and extend the ‘nominal’ Trajectory Prediction to reflect the trajectory following the maneuver (‘nominal’ segment 5) with sufficient lead time before t6 to transform the ‘nominal’ update into the form needed for internal use by the Complex. Because the Service Packages that were scheduled to begin after t6 were never re-referenced away from the ‘nominal’ TP, those Service Packages simply continue to use the updated ‘nominal’ TP.
Figure 3-7 also shows the effective Trajectory Prediction that is used to track the spacecraft, consisting of portions of the original and ‘nominal’ TP, the ‘correction_burn’ alternate TP, and the updated ‘nominal’ TP.

**Figure 3-7: Using an Extended ‘nominal’ Trajectory Prediction and Applying a New ‘correction_burn’ Trajectory Prediction via the ANT**

### 3.7.2.7.3 Scenario 3: Selecting an Alternate Scenario to Replace a Nominal TP

Figure 3-8 illustrates a scenario in which both extending of a Trajectory Prediction and use of an alternate TP via the SAS operation are used. In this scenario, the spacecraft is in a stable orbit from t1 through t3, with a maneuver scheduled to begin at t3. While the ‘nominal’ Trajectory Prediction follows the planned burn, there is a chance that the maneuver will be cancelled at the last minute. A ‘noburn’ contingency Trajectory Prediction is calculated in addition to the nominal (burn as planned) TP. Service Package 362, the SP that will be
executing during the maneuver, is established with two scenarios, the ‘nominal’ scenario that follows the nominal trajectory, and the ‘noburn’ scenario that follows the noburn trajectory.

Figure 3-8: Using an Extended ‘nominal’ Trajectory Prediction and Selecting a ‘noburn’ Trajectory Prediction via the SAS

3.7.2.7.3.1 UM uses the ATP and ETP operations as in Scenarios 1 and 2 to establish an update the ‘nominal’ Trajectory Prediction for the period t1 - t8. UM uses the ATP to establish a parallel, ‘noburn’ TP (‘noburn’ segment 1) for the period t3 - t6.

3.7.2.7.3.2 At t3, the maneuver is indeed cancelled, and UM invokes the SAS very soon after t3 to switch Service Package 362 to the ‘noburn’ scenario.

3.7.2.7.3.3 The UM then uses the ETP (with checkContinuity = ‘false’) to overlay and extend the ‘nominal’ Trajectory Prediction to reflect the cancellation of the maneuver (‘nominal’ segment 5) with sufficient lead time before t6 to transform the ‘nominal’ update
into the form needed for internal use by the Complex. Because the Service Packages that were scheduled to begin after t6 were never re-referenced away from the ‘nominal’ TP, those services simply continue to use the new ‘nominal’ TP, which has been updated to correctly track the spacecraft along the noburn trajectory.

Figure 3-8 also shows the effective Trajectory Prediction that is used to track the spacecraft, consisting of portions of the original and ‘nominal’ TP, the ‘noburn’ alternate TP, and the updated ‘nominal’ TP.

3.7.3 QUERYING TRAJECTORY PREDICTIONS

3.7.3.1 UM may query the content of any available Trajectory Prediction.

3.7.3.2 A successful return for a QTP operation returns those portions of the TP segments that constitute the effective available Trajectory Prediction at the time the QTP is performed.

3.7.3.2.1 The TP segments are returned in start-time order.

3.7.3.2.2 Only those TP segments that are part of the available Trajectory Prediction are returned.

3.7.3.2.2.1 For each OPM that (when propagated) contributes to the available Trajectory Prediction, the QTP-SR shall include the TP segment with that OPM, with trajectory start and stop times bounding the time during which the propagated OPM forms part of the effective Trajectory Prediction.

3.7.3.2.2.2 For each OEM that contributes to the available Trajectory Prediction, the QTP-SR shall contain only those vectors that form part of the effective Trajectory Prediction, with trajectory start and stop times bounding the time during which the propagated OEM forms part of the effective Trajectory Prediction.

NOTE – Subsection 3.7.4, Expiration of Trajectory Prediction Segments and Termination of Trajectory Predictions, contains additional discussion of what constitutes an available Trajectory Prediction at any given time.

3.7.3.2.3 If the Trajectory Prediction is available but has no effective segments (for a mission that operates in the ‘auto segment deletion’ mode, see 3.7.4.3), CM shall return a QTP-SR containing no TP segments.

3.7.4 EXPIRATION OF TRAJECTORY PREDICTION SEGMENTS AND TERMINATION OF TRAJECTORY PREDICTIONS

3.7.4.1 The Service Agreement contains a trajectoryPredictionDeletionMode parameter, which is used to specify the desired behavior of the Complex when TP segments
expire. This parameter has three values: ‘invoked deletion only’, ‘auto TP deletion’, and ‘auto segment deletion’.

3.7.4.2 For missions for which trajectoryPredictionDeletionMode = ‘invoked deletion only’: Each Trajectory Prediction retains the contents of all of its TP segments until the trajectory prediction is deleted via invocation of the DTP operation by UM.

NOTE – Failure by UM to delete expired Trajectory Predictions may result in exceeding the data storage allocated by the Complex to that Mission’s Trajectory Predictions, with subsequent rejection of additional Trajectory Predictions. This is especially important for extended Trajectory Predictions, because all TP segments would be retained until deleted by UM.

3.7.4.3 For missions for which trajectoryPredictionDeletionMode = ‘auto TP deletion’:

3.7.4.3.1 Each TP segment is automatically removed from the available Trajectory Prediction by the Complex when its period of applicability expires, and any Complex resources associated with maintaining that TP segment are released (e.g., they may be removed from storage). The period of applicability of a TP segment extends to the earliest of either (a) the trajectoryStopTime of the TP segment or (b) if an extension TP overlays the end of the TP segment, the trajectoryStartTime of the overlaying TP segment.

3.7.4.3.2 When the period of applicability of all TP segments of a Trajectory Prediction have expired, the trajectory prediction itself is deleted.

3.7.4.4 For missions for which trajectoryPredictionDeletionMode = ‘auto segment deletion’:

3.7.4.4.1 Each TP segment is automatically removed from the available Trajectory Prediction by the Complex when its period of applicability expires, and any Complex resources associated with maintaining that TP segment are released (e.g., they may be removed from storage). The period of applicability of a TP segment extends to the earliest of either (a) the trajectoryStopTime of the TP segment or (b) if an extension TP overlays the end of the TP segment, the trajectoryStartTime of the overlaying TP segment.

3.7.4.4.2 When the period of applicability of all TP segments of a Trajectory Prediction have expired, the Trajectory Prediction remains in the ‘available’ state even though it has no content.

NOTE – This mode is the same as the ‘auto TP deletion’ mode, with the exception that the TP, although ‘empty’, still exists and can be extended. An example use for this mode is the case of a simple mission that establishes a TP once at the beginning of the Service Agreement period and extends it with additional TP segments whenever it is useful, even though the previous TP segments have expired.

3.7.4.5 Scenarios for querying and terminating Trajectory Predictions are:
3.7.4.5.1 Scenario 4: Invoked deletion only mode for non-extended Trajectory Predictions. Mission_X creates only non-extended (that is, single-segment) TPs. At some time before t1, Mission_X UM uses ATP to establish the ‘orbit_N’ Trajectory Prediction, which is valid for the period t1 - t2, where t1<t2. At some time after t2, Mission_X UM uses the DTP to delete the ‘orbit_N’ Trajectory Prediction.

- If Mission_X UM invokes QTP for the ‘orbit_N’ Trajectory Prediction any time after the TP has been added and before the Trajectory Prediction has been deleted, a QSP-SR will be returned containing the single orbit_N segment.

- If Mission_X UM invokes QTP for the ‘orbit_N’ Trajectory Prediction any time after the Trajectory Prediction has been deleted, a QTP-FR will be returned with diagnostic ‘trajectoryRef non-existent’.

3.7.4.5.2 Scenario 5: Automatic TP deletion mode for extended Trajectory Predictions. Mission_Y uses Trajectory Prediction extension under a Service Agreement that call for automatic TP deletion.

Mission_Y UM uses the ATP to establish the initial OPM TP segment of the ‘nominal’ TP for the period t1 - t3. Subsequent ETPs are used to add extension TP segments to the TP: ‘nominal’ OPM segment 2 for the period (t2 - t5), ‘nominal’ OEM segment 3 for (t4 - t7), and ‘nominal’ OEM segment 4 for (t6 - t8). All of these TP segments are established prior to t1.

Figure 3-9 illustrates the available ‘nominal’ Trajectory Prediction for Mission_Y as a function of time.
3.7.4.5.2.1 If Mission_Y UM invokes QTP for the ‘nominal’ Trajectory Prediction at any time after the four TP segments have been added/extended and prior to \( t_1 \), a QTP-SR is returned with the following:

a) Segment 1 containing the original OPM segment 1, with \( \text{trajectoryStartTime} = t_1 \) and \( \text{trajectoryStopTime} = t_2 \);

b) Segment 2 containing the original OPM segment 2, with \( \text{trajectoryStartTime} = t_2 \) and \( \text{trajectoryStopTime} = t_4 \);

c) Segment 3 containing the vectors for \( t_4 \) to \( t_6 \) from the original OEM segment 3, with \( \text{trajectoryStartTime} = t_4 \) and \( \text{trajectoryStopTime} = t_6 \); and

d) Segment 4 containing the vectors for \( t_6 \) to \( t_8 \) from the original OEM segment 4, with \( \text{trajectoryStartTime} = t_6 \) and \( \text{trajectoryStopTime} = t_8 \).

3.7.4.5.2.2 If Mission_Y UM invokes QTP for the ‘nominal’ Trajectory Prediction at any time between \( t_1 \) and \( t_2 \), a QTP-SR is returned with the following:

a) Segment 1 containing the original OPM segment 1, with \( \text{trajectoryStartTime} = <\text{time of QTP performance}> \) and \( \text{trajectoryStopTime} = t_2 \);
b) Segment 2 containing the original OPM segment 2, with \texttt{trajectoryStartTime} = t2 and \texttt{trajectoryStopTime} = t4;

c) Segment 3 containing the vectors for t4 to t6 from the original OEM segment 3, with \texttt{trajectoryStartTime} = t4 and \texttt{trajectoryStopTime} = t6; and

d) Segment 4 containing the vectors for t6 to t8 from the original OEM segment 4, with \texttt{trajectoryStartTime} = t6 and \texttt{trajectoryStopTime} = t8.

3.7.4.5.2.3 At t2 the contribution of segment 1 expires because segment 2 becomes the effective segment at that time, and segment 1 is removed from the available TP. If Mission\_Y UM invokes QTP for the ‘nominal’ Trajectory Prediction at any time between t2 and t4, a QTP-SR is returned with the following:

a) Segment 2 containing the original OPM segment 2, with \texttt{trajectoryStartTime} = \textit{<time of QTP performance>} and \texttt{trajectoryStopTime} = t4;

b) Segment 3 containing the vectors for t4 to t6 from the original OEM segment 3, with \texttt{trajectoryStartTime} = t4 and \texttt{trajectoryStopTime} = t6; and

c) Segment 4 containing the vectors for t6 to t8 from the original OEM segment 4, with \texttt{trajectoryStartTime} = t6 and \texttt{trajectoryStopTime} = t8.

3.7.4.5.2.4 Similarly, at t4 the contribution of segment 2 expires because segment 3 becomes the effective segment at that time, and segment 2 is removed from the available TP. If Mission\_Y UM invokes QTP for the ‘nominal’ Trajectory Prediction at any time between t4 and t6, a QTP-SR is returned with the following:

a) Segment 3 containing the vectors for \textit{<time of QTP performance>} to t6 from the original OEM segment 3, with \texttt{trajectoryStartTime} = \textit{<time of QTP performance>} and \texttt{trajectoryStopTime} = t6; and

b) Segment 4 containing the vectors for t6 to t8 from the original OEM segment 4, with \texttt{trajectoryStartTime} = t6 and \texttt{trajectoryStopTime} = t8.

3.7.4.5.2.5 At t6 the contribution of segment 3 expires and is removed from the available TP. If Mission\_Y UM invokes QTP for the ‘nominal’ Trajectory Prediction at any time between t6 and t8, a QTP-SR is returned with Segment 4 containing the vectors for \textit{<time of QTP performance>} to t8 from the original OEM segment 4, with \texttt{trajectoryStartTime} = \textit{<time of QTP performance>} and \texttt{trajectoryStopTime} = t8.

3.7.4.5.2.6 At t8, the last segment of the TP, segment 4, expires and is removed and the ‘nominal’ Trajectory Prediction itself is automatically deleted. If Mission\_Y UM invokes QTP for the ‘nominal’ Trajectory Prediction at any time after t8, a QTP-FR will be returned with diagnostic ‘trajectoryRef non-existent’.
3.7.4.5.2.7 If Mission_Y UM attempts to invoke the ETP operation on the ‘nominal’ Trajectory Prediction after t8, an ETP-FR will be returned with diagnostic ‘trajectoryRef non-existent’.

3.7.4.5.3 Scenario 6: Automatic segment deletion mode for extended Trajectory Predictions. For this scenario, Mission Y still uses Trajectory Prediction extension, but the Service Agreement calls for automatic segment deletion instead of automatic TP deletion. For this scenario, Mission_Y uses the Complex routinely but not continuously; e.g., the orbit of the Mission_Y spacecraft is such that it is not visible to the Complex’s antennas for approximately one week out of each month. Mission_Y does not send Trajectory Prediction information for the periods of time for which there is no visibility. Figure 3-10 illustrates this scenario.

3.7.4.5.3.1 The ‘nominal’ TP is established and extended, and the segments expire, exactly the same as described in (1) - (4) of scenario 5.

3.7.4.5.3.2 At t8, the last segment of the TP, segment 4, expires and is removed.

3.7.4.5.3.3 At t9, Mission_Y UM invokes the ETP operation (with checkContinuity = ‘false’) to extends the ‘nominal’ OPM TP with segment 5, with start time of t10. The TP is successfully added, with the trajectoryGapPresent warning true in the ETP-SR (see 3.7.2.2.7).

3.7.4.5.3.4 If Mission_Y UM invokes QTP for the ‘nominal’ Trajectory Prediction at any time between t8 and t9, a QTP-SR is returned containing no segments.

3.7.4.5.3.5 If Mission_Y UM invokes the QTP for the ‘nominal’ Trajectory Prediction at any time between t9 and t10, a QTP-SR is returned containing the original OPM segment 5 with trajectoryStartTime = t10 and trajectoryStopTime = t11.

3.7.4.5.3.6 If Mission_Y UM invokes the QTP for the ‘nominal’ Trajectory Prediction at any time between t10 and t11, a QTP-SR is returned containing the original OPM segment 5 with trajectoryStartTime = <time of QTP performance> and trajectoryStopTime = t11.
Figure 3-10: Availability of the ‘nominal’ Trajectory Prediction in Auto Segment Deletion Mode

3.7.4.5.3.7 (Not shown in the figure). At some time after t11, UM invokes the DTP operation to delete the ‘nominal’ Trajectory Prediction. If Mission_Y UM invokes QTP for the ‘nominal’ Trajectory Prediction at any time after the TP has been deleted, a QTP-FR will be returned with diagnostic ‘trajectoryRef non-existent’.

3.7.5 USE OF TRAJECTORY PREDICTIONS IN SCHEDULING OF SERVICE PACKAGES

There are multiple uses of trajectory-related information in the support supplied by a Complex to a Mission. With respect to the management services supported by the Version 1 SCCS-SM service specification, two uses of trajectory-related information are relevant: in the scheduling of SLS Service Packages, and in the generation of communication and tracking configuration information used to acquire and track the spacecraft.

The Trajectory Prediction that is referenced by the Service Package is used for the purposes of generating the spacecraft acquisition information.
For the purposes of validating spacecraft visibility during the time span of candidate SLS Service Packages, some Complexes use the Trajectory Predictions referenced by the CSP-I/s/RSP-I's. However, other Complexes use different trajectory-related information entities for scheduling purposes.

SCCS-SM supports the use of Trajectory Predictions for scheduling as well as for spacecraft acquisition, but it does not require that the Trajectory Predictions referenced by Service Packages be used for their scheduling. The following paragraphs identify the characteristics of Trajectory Predictions and their operations as they relate to scheduling of Service Packages.

3.7.5.1 Each ATP-I and ETP-I carries a trajectorySegmentGrade parameter, which indicates one of 5 grades of accuracy of the TP segment:

   a) ‘acquisition’—Used to acquire and track the spacecraft (the highest accuracy);

   b) ‘sequence’—Suitable for use in event sequencing;

   c) ‘schedule’—Suitable for use in scheduling;

   d) ‘lifeOfMission’—To be used for very long-range planning;

   e) ‘other’—Bilaterally defined.

NOTE – For the purposes of Version 1 of SCCS-SM, only the ‘acquisition’ and ‘schedule’ grades are relevant. The other values may be used to meet other, locally defined uses for Trajectory Predictions.

3.7.5.2 The Service Agreement specifies whether the scheduling of Service Packages is to use the Trajectory Predictions that are referenced by Service Packages or by use of some other, bilaterally defined method.

3.7.5.3 If a bilaterally defined method is to be used, the method is documented in the contractualReference of the Service Agreement.4

3.7.5.4 Scenarios for Use of Trajectory-Related Information in Scheduling

3.7.5.4.1 Scenario 7: Locally Defined Scheduling Aid Data. Figure 3-11 illustrates this scenario, which extends Scenario 1 to include use of locally defined scheduling aid information in the form of NASA Predicted Site Acquisition Tables (PSATs). This is the mode that most closely fits the operations procedures of the NASA Space Network and Ground Network.

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4 Future versions of the SCCS-SM may provide alternate standard methods and trajectory-related information products for use in scheduling.
3.7.5.4.1.1 By locally defined means, PSATs for the Mission spacecraft are established at CM to cover at least four weeks into the future, which is sufficient to cover the scheduling horizon of that complex. For this scenario, assume that t8 is approximately t1 + four weeks.

![Diagram showing the use of locally defined scheduling aids]

**Figure 3-11: Use of Locally Defined Scheduling Aids**

3.7.5.4.1.2 At some time prior to t1, UM uses the ETP to extend the already-established ‘nominal’ Trajectory Prediction for the period t1 - t4.

**NOTE** – Normally, the ‘nominal’ TP segments would have a trajectorySegmentGrade value of ‘acquisition’, but whether this is in any way enforced is a local matter.

3.7.5.4.1.3 At some time between t1 and t2, UM invokes CSP to create SP 9732, which is to execute sometime between t8 and t9. CM determines that a conformant resource configuration is available with antenna visibility as defined by the PSAT data, and the Service Package is scheduled. At the time that the CSP is performed, the referenced ‘nominal’ Trajectory Prediction exists but does not at that time contain trajectory data for the time period corresponding to the execution of SP 9732. The **CSP-SR** is returned with trajectoryPredictionStatus = ‘trajectory prediction available but does not support the Service Package’ (see 3.7.2.4.4.2).

3.7.5.4.1.4 Between t2 and t6, UM uses to ETP to extend the ‘nominal’ TP through t9.
3.7.5.4.1.5 At minServiceDefinitionLeadTime before the start of SP 9732, CM confirms that the ‘nominal’ TP provides data for the lifetime of SP 9732, and executes as planned.

NOTE – If the ‘nominal’ TP does not contain usable data for the lifetime of SP 9732 at minServiceDefinitionLeadTime before the start of SP 9732, SP 9732 is cancelled and CM notifies UM via the SERVICE_PACKAGE_CANCELLED operation.

3.7.5.4.2 Scenario 8: Trajectory Predictions Used for Both Scheduling and Acquisition. Figure 3-12 illustrates this scenario, in which fixed Trajectory Predictions are used for both scheduling and acquisition. This is the scenario that represents the way the DSN is currently planning to operate.

Figure 3-12: Use of Trajectory Predictions for Both Scheduling and Acquisition

3.7.5.4.2.1 At t1, UM uses the ATP to establish a scheduling-grade TP 5387 for the Mission spacecraft, which covers the period t3 through t9, where t9 is several weeks after t1.

NOTE – Nominally, TP 5387 will have a trajectorySegmentGrade value of ‘schedule’, but whether this is in any way enforced is a local matter.
3.7.5.4.2.2 At t2, UM invokes CSP for SP 4012, which is to execute from t7 to t8. SP 4012 references TP 5387. If a conformant resource configuration is available with antenna visibility as determined by using TP 5387, SP 4012 is scheduled. Because TP 5387 covers the Service Package lifetime, the CSP-SR is returned with trajectoryPredictionStatus = 'trajectory prediction available to support the Service Package' (see 3.7.2.4.2).

NOTE – Because the Trajectory Prediction is also used for scheduling, the value of trajectoryPredictionStatus must be 'trajectory prediction available to support the Service Package'. Otherwise, the Service Package could not be scheduled in the first place.

3.7.5.4.2.3 At t4, a few days before t7, UM uses the ATP to establish an acquisition-grade TP 5421 for the Mission spacecraft, which covers the period t6 to t9.

NOTE – Nominally, TP 5421 will have a trajectorySegmentGrade value of 'acquisition', but whether this is in any way enforced is a local matter.

3.7.5.4.2.4 At t5, UM uses the ANT to re-reference SP 4012 from TP 5387 to TP 5421.

3.7.5.4.2.5 At minServiceDefinitionLeadTime before the start of SP 4012, CM confirms that TP 5421 provides data for the lifetime of SP 4012, and executes as planned.

NOTE – If the TP 5421 does not contain usable data for the lifetime of SP 4012 at minServiceDefinitionLeadTime before the start of SP 4012, SP 4012 is cancelled and CM notifies UM via the SERVICE_PACKAGE_CANCELLED operation.

3.7.6 USE OF TRAJECTORY PREDICTIONS IN RULE-BASED SCHEDULING OF SERVICE PACKAGES

For rule-based scheduling, CM may create the tentative Service Packages on the basis of either TPs or locally defined scheduling aid data.

3.7.6.1 The Service Agreement contains an optional set of DefaultTrajectory-Prediction data sets, for use in rule-based scheduling. Each DefaultTrajectoryPrediction data set contains a trajectoryRef parameter that names a nominally extendable Trajectory Prediction. One DefaultTrajectoryPrediction data set exists for each parallel trajectory used to support the mission.

NOTE – Some missions and networks use multiple parallel trajectory predictions concurrently (e.g. one with respect to Earth and another with respect to another planet). If such a mission uses rule-based scheduling, an extendable trajectory must named for each parallel trajectory prediction that is expected to be used at some time during the Service Agreement period.
3.7.6.2 The CSTP-I contains one or more AppliedTrajectory data sets, each of which contains a trajectoryRef parameter and a trajectoryPredictionStatus parameter.

3.7.6.3 For tentative Service Packages generated using Trajectory Predictions as the basis for scheduling:

3.7.6.3.1 UM must ensure that the applicable default Trajectory Predictions are populated with valid data through the end of the rule-based scheduling horizon (i.e., from

\[(\text{scheduledServicePackageStartTime} - \text{trajectoryPredictionTimeWindowExtension})\] through \[(\text{scheduledServicePackageStopTime} + \text{trajectoryPredictionTimeWindowExtension})\].

NOTE – The applicability of default Trajectory Predictions to any given Service Packages is mission- and/or Complex-dependent and outside the scope of SCCS-SM standardization.

3.7.6.3.2 CM uses the applicable default Trajectory Prediction(s) to generate the tentative Service Packages, and includes an AppliedTrajectory data set in the resultant CSTP-I. Each of the AppliedTrajectory data sets contains a trajectoryRef parameter that names the default trajectory prediction that was used in the scheduling of the tentative Service Package, and a trajectoryPredictionStatus parameter with the value ‘trajectory prediction available to support the Service Package’.

NOTE – Since CM uses the Trajectory Prediction to generate the tentative Service Package, by definition the TP must be sufficient to support the SP.

3.7.6.3.3 If the proposed Service Package is accepted (UM sends CTSP-SR), UM may either:

3.7.6.3.3.1 Allow CM to use the default Trajectory Prediction(s) to generate spacecraft acquisition products to be used during the execution of the Service Package. This may require UM to update the default TP(s) through the ETP operation.

3.7.6.3.3.2 Subsequently use the ANT operation to rebind the Service Package to (a) different trajectory prediction(s) that is(are) accurate enough for use for spacecraft acquisition.

3.7.6.3.4 At minServiceDefinitionLeadTime before the start of the Service Package, CM confirms that the TP(s) currently referenced by the SP provide(s) trajectory data needed to support the Service Package (i.e., from

\[(\text{scheduledServicePackageStartTime} - \text{trajectoryPredictionTimeWindowExtension})\] through \[(\text{scheduledServicePackageStopTime} + \text{trajectoryPredictionTimeWindowExtension})\]), and executes as planned.
NOTE – If all of the referenced Trajectory Predictions do not contain usable data sufficient for the complete Service Package as of minServiceDefinitionLeadTime before the start of the Service Package, the Service Package is cancelled and CM notifies UM via the SERVICE_PACKAGE_CANCELLED operation.

3.7.6.4 For tentative Service Packages that are not generated using Trajectory Predictions as the basis for scheduling (i.e., some other bilaterally agreed scheduling aids (such as PSATs) are used):

3.7.6.4.1 CM uses the bilaterally agreed scheduling aids to generate the tentative Service Packages.

3.7.6.4.2 CM may check the status of the applicable default Trajectory Predictions at the time that a tentative Service Package is generated.

3.7.6.4.2.1 If CM checks the status of the default Trajectory Predictions at the time that the tentative Service Package is generated:

3.7.6.4.2.1.1 For each applicable default trajectory prediction that is populated with data sufficient to support the tentative Service Package, the corresponding AppliedTrajectory data set in the resultant CTSP-I contains a trajectoryPredictionStatus parameter with the value ‘trajectory prediction available to support the Service Package’.

3.7.6.4.2.1.2 For each applicable default trajectory prediction that is populated with data that is not sufficient to support the tentative Service Package, the corresponding AppliedTrajectory data set in the resultant CTSP-I contains a trajectoryPredictionStatus parameter with the value ‘trajectory prediction available but does not support the Service Package’.

3.7.6.4.2.2 If CM does not check the status of the default Trajectory Predictions at the time that the tentative Service Package is generated, the corresponding AppliedTrajectory data set in the resultant CTSP-I contains a trajectoryPredictionStatus parameter with the value ‘trajectory prediction status not evaluated’.

3.7.6.4.3 If the proposed Service Package is accepted (UM sends CTSP-SR), UM may either:

3.7.6.4.3.1 Allow CM to use the default Trajectory Prediction(s) to generate spacecraft acquisition products to be used during the execution of the Service Package. This may require UM to update the default TP(s) through the ETP operation.

3.7.6.4.3.2 Subsequently use the ANT operation to rebind the Service Package to (a) different Trajectory Prediction(s) that is(are) accurate enough for use for spacecraft acquisition.
3.7.6.4 At \( \text{minServiceDefinitionLeadTime} \) before the start of the Service Package, CM confirms that the TP(s) currently referenced by the SP provide(s) trajectory data needed to support the Service Package (i.e., from

\[
(scheduledServicePackageStartTime - \\
\text{trajectoryPredictionTimeWindowExtension})
\]

through

\[
(scheduledServicePackageStopTime + \\
\text{trajectoryPredictionTimeWindowExtension})
\]

and executes as planned.

NOTE – If all of the referenced Trajectory Predictions do not contain usable data sufficient for the complete Service Package as of \( \text{minServiceDefinitionLeadTime} \) before the start of the Service Package, the Service Package is cancelled and CM notifies UM via the SERVICE_PACKAGE_CANCELLED operation.

3.8 SPECIFIC PERIOD SCHEDULING AND RULE-BASED SCHEDULING

3.8.1 GENERAL

The scheduling of individual SLS Service Packages involves: the spaceflight mission identifying the space communication services that are required and the desirable or acceptable times for SLSes during which those service are to be provided; and the Complex attempting to identify resources that can be made available to provide those services within the designated timeframes. Two scheduling patterns have evolved in the world’s TT&C networks, which are referred to here as specific period scheduling and rule-based scheduling. SCCS-SM supports both of these patterns. The remainder of this section describes each pattern in turn, and describes how they are supported in SCCS-SM.

NOTE – Rule-based scheduling is available only for SLS Service Packages. Retrieval Service Packages may be scheduled only through the specific scheduling method.

3.8.2 SPECIFIC PERIOD SCHEDULING

In specific-period scheduling, UM determines exactly or approximately when an SLS is desired and invokes the CREATE_SERVICE_PACKAGE (CSP) operation to request that the Complex schedule an SLS. If a Mission requires an exact start time and duration for the SLS, its UM sets the preferred start time and preferred service duration parameters of the CSP invocation (\text{CSP-I}) to those exact start time and duration values.

However, it is often the case that a particular start time may be preferred but not required, and/or that a particular duration is desired but a shorter duration would be acceptable if that is all that is available. For example, a spacecraft may record all of its science telemetry on an
onboard storage device, and only need to downlink the telemetry at sometime within four hours of recording the data. In such cases, the CSP operation allows the UM to request the SLS with some flexibility in the constraints. Start time lead and lag parameters of the CSP-I are used by UM to indicate that any start time is acceptable in the period bounded by the lead time before the preferred start time and the lag time following the preferred start time. Similarly, the minimum service duration parameter of the CSP-I is used by UM to indicate that if the preferred duration is not possible, anything equal to or longer than the minimum service duration is acceptable. The more flexible that a UM can be in allowing the start time to move and the duration to vary, the better the chances that CM will be able to schedule an SLS that meets those constraints.

UM also has flexibility to constrain which antennas of the Complex are permitted or desired to be used in the SLS. Subsection 3.6 (Antenna Selection) of this Concept Book describes the modes of specifying antenna constraints in the CSP-I.

NOTE – In order for an SLS Service Package to be successfully scheduled, the antenna selection constraints and start time and duration constraints in the CSP-I must be mutually compatible with the predicted antenna visibility information that CM uses to verify the viability of the requested SLS. (See 3.7.5.4.2.2 for a description of sources of predicted antenna visibility information.)

As the lead and lag times increase and the antenna constraints are minimized in the CSP-I, UM essentially delegates to CM more flexibility in deciding when the SLS will actually occur. Even so, there is always only one Service Package scheduled per CSP-I, and UM is always responsible for initiating the creation of each Service Package.

3.8.3 RULE-BASED SCHEDULING

Rule-based scheduling extends the concept of delegating to CM the responsibility for determining when the SLS will occur. CMs that implement rule-based scheduling support spaceflight missions with very generic SLS requirements (e.g., 6 downlinks per week, between 15 and 30 minutes each, no less than 6 hours and no more than 30 hours apart) by generating multiple proposed Service Packages that conform to those generic rules on behalf of the spaceflight mission.

In keeping with the idea that ruled-based scheduling is based on routine requirements for TT&C services, the Service Packages that result from rule-based scheduling are simpler than Services Packages created via the CSP operation. Proposed Service Packages contain only one scenario per Service Package, and each scenario has only one Space Link Communication Service (although the single Space Link Communication Service can still have any number of component Space Link Carriers (just as with CSP-created Service Packages)).

Also, proposed Service Packages do not contain Space Link Events-related information, since by definition such events are related to spacecraft activities that CM is not expected to know. However, once a proposed Service Package has been actually scheduled, UM may use
the RSP operation to append Space Link Events data to the Service Package and subsequently update the Space Link Events data via the APPLY_NEW_SPACE_LINK_EVENTS_PROFILE operation.

The structure and content of the rules by which any Complex and Spaceflight Mission agree to allow the CM to generate proposed Service Packages are generally complex and unique to the scheduling capabilities of the individual CMs. Thus the structure and content of these rules are outside the scope of the current version of SCCS-SM.

CM requests UM to confirm or reject each of these proposed Service Packages by invoking the CTSP operation. UM then accepts or rejects each proposed Service Package by returning a CTSP Successful Return or CTSP Failed Return, respectively.

Depending on the scheduling mode in which a CM performs rule-based scheduling, CM either commits the resources to each proposed Service Package as soon as it is generated, or simply treats the proposed Service Package as a provisional opening in the schedule that exists. For provisionally proposed Service Packages, there is the possibility that the resources that were available at the time the proposed Service Package was generated will be allocated elsewhere before the UM can respond to the proposal. If UM returns a CSTP Successful Return but the necessary resources have been allocated elsewhere, CM uses the SERVICE_PACKAGE_CANCELLED notification to inform the UM that the Service Package is no longer available.

Once the proposed Service Package has been successfully scheduled, UM may be subsequently modify, query, and delete it via the UM-invoked Service Package operations (RSP, ANT, ANSLEP, DSP). Because each proposed Service Package supports only a single scenario, the SELECT_ALTERNATE_SCENARIO operation is not applicable to an original proposed Service Package. However, UM may subsequently replace (via RSP) the original Service Package with one that contains multiple scenarios (in effect using the proposed Service Package as a ‘starter’ or ‘placeholder’ SP), and the SAS can then be applied to the replacement SP.

CM may subsequently cancel the Service Package (via the SPC operation). CM may modify the Service Package (via the SPM operation) as long as the modified Service Package satisfies the scheduling rules for the mission.

3.9 SPACE LINK EVENT PROFILES

3.9.1 GENERAL

Use of Space Link Event Profiles is primarily intended for deep space mission operations. With this type of mission, spacecraft typically operate autonomously as they tend to be far enough from Earth that the light-time propagation delay, which in extreme cases can be in excess of 24 hours, renders (near) real-time control of the spacecraft from Earth-based mission operations centers infeasible. As the spacecraft is operating anonymously, there can be no assumption that the spacecraft is able to communicate with an SCCS Complex ground
station even though the communication geometry affords a clear line of sight between the spacecraft and the ground station. For example, from a communications perspective, the spacecraft may not be Earth pointed as a result of spacecraft usage considerations in relation to an ongoing observation campaign. The service management recommendation accommodates this type of mission operations scenarios via Space Link Event Profiles.

3.9.2 GENERAL SCENARIO FOR MANAGEMENT OF EVENT PROFILES

The general service management operational scenario starts with reservation of particular service times via creation of service packages (CSP operation) with event sequences deferred. The mission operations center may subsequently develop and submit event sequences via the ASLEP operation, referencing the appropriate forward and return carrier profiles. (Only a small subset of the information defined for a forward or return carrier is subject to change during a service package execution, with the majority of the information not subject to change during service package execution and therefore defined in the referenced carrier profile.)

With an event sequence profile resident at CM, UM may subsequently invoke an RSP (REPLACE_SERVICE_PACKAGE) operation for those service packages that are to execute with the planned event profile. When an event profile has already been associated with a service package, a different one may be specified using the ANSLEP operation. ANSLEP is preferred over RSP if only the event profile is to be changed, as RSP is a more complex operation for changing many aspects of a service package at once.

For event profiles that are no longer needed or referenced by service packages that are pending execution, they may be removed from CM by UM invoking the DSLEP operation.

3.9.3 INFORMATION CONCEPTS OF EVENT PROFILES

In reference to figure 2-6, it may be noted that the event sequence is essentially composed of space link availability states which are in turn composed of data transport states each with associated change events. This structuring is oriented with respect to physically operating a space link between a ground station and a spacecraft.

A *Forward Space Link Available State* indicates that the spacecraft expects to receive a carrier, and a *Return Space Link Available State* indicates that the spacecraft is transmitting a carrier.

A *Forward Data Transport Available State* indicates that the spacecraft is expecting to receive a modulated carrier, while a *Return Data Transport Available State* indicates that the spacecraft is modulating the return carrier.

For each time period that a carrier is in the Space Link Available state, a corresponding SpaceLinkAvailableState data set exists in the Space Link Event Profile. Similarly, for each...
time period that a carrier is in the Data Transport Available state, a corresponding DataTransportAvailableState data set exists in the Space Link Event Profile.

*Space Link Unavailable* and *Data Transport Unavailable* states correspond to the periods outside the Available states. They do not have explicit data sets.

By definition, each event profile, when executed as part of a service package is in the Space Link Unavailable state, although the transition to the Space Link Available state may occur immediately. The transitions into and out of availability states are based on time, as expressed from the point of view of the spacecraft (i.e., spacecraft ephemeris or event time – SCET). Within the Space Link Availability state, a small set of changes to the effective isotropic radiated power (as an example) may be noted as a change event but are considered to be transitions within the available state meaning that the Spacelink is still available, albeit at a different power level. The return Space Link Available State is an indication that the spacecraft is transmitting a signal at the start time for the particular state until the end time of that state. The forward space link Available State is an indication that the spacecraft is ready to receive the signal radiated to it (from a ground station).

By definition, as the Data Transport states are sub-states of the Space Link Available state, each data transport is in the unavailable state, although the transition to the available state may occur immediately upon establishment of a Space Link Available state. The transitions into and out of the data transport availability states are based on time in the same manner as the Space Link availability states. Within the data transport state, a small set of changes based on the type of service may be noted as a change event but are considered to be transitions within the data transport state meaning that the data transport is still in an available state albeit in a different configuration. For the command service an example of this is a change in a modulation index. For telemetry service an example of this is a change in symbol rate.

The general relationship between space link and data transport availability states is shown in figure 3-13.

For all states, and change events, uncertainty intervals may be expressed via usage of lead and lag times if the onboard sequencing or communications geometry considerations are not known to a high level of precision. As noted in 3.3, event profiles may be stated in absolute or relative terms. The lead and lag times are always stated relative to their particular event; i.e., if a particular available state is indicated as starting at, for example, in absolute terms at 15:50 hrs, the lead and lag time indicate the number of seconds relative to that absolute time (e.g., state start is at 15:50 +/- 15 seconds).

Each state and change event definition allows for the inclusion of a *umAdvisory* that may be utilized by UM to supply comments to CM. CM may similarly include *cmAdvisory* information as comments for UM.
3.9.4 COMMUNICATIONS GEOMETRY AND EVENT PROFILES

The SCCS-SM conceptual model assumes that space link available states include both spacecraft and communications geometry considerations in their statement. It is possible to consider a conceptual model whereby CM is able to calculate various occultations due to intervening planetary bodies along the line-of-sight when rendering communication services to or from a particular spacecraft. In this case the space link availability states can be stated by UM without regard to planetary body occultations, focusing on events from the spacecraft point of view exclusively. (For example, if a spacecraft continues to radiate and modulate telemetry even though, from the ground station perspective, it is not visible behind a planet, this can be considered as still being a space link available state from the point of view of the spacecraft.) Another conceptual model is that where mission operations are well aware of the occultations and supply this information to CM. This is the concept supported by the SCCS-SM; i.e., it is expected the information from UM to CM models both the spacecraft and communications geometry.

![Event Profile Availability States diagram]

Figure 3-13: Event Profile Availability States
3.10 FREQUENCY SWEEP (TUNE-IN) PARAMETERS

Forward 401 Space Link Carriers within SLS Profiles may be configured to execute single- or multi-leg frequency sweeps through the appropriate configuration of the parameters of the F401SpaceLinkCarrierProfile and FrequencySweepLeg data sets of the <<SpaceCommunicationServiceProfile>> stereotype (see figure 3-14 below).

Figure 3-14: SpaceCommunicationServiceProfile Class Diagram
The **F401SpaceLinkCarrierProfile** data set contains the following sweep-related parameters:

- **initialHoldDuration**: the duration (in seconds) at which the initial radiated frequency is to be held (beginning at the carrier start time) before the frequency sweep begins, where the initial radiated frequency is defined as the carrier rest frequency (as specified by the **carrierFrequency** parameter) plus the value of the **sweepInitialFreqOffset** parameter, and possibly compensated for Doppler (see **sweepFreqDopplerComp**).

- **sweepInitialFreqOffset**: The offset (in Hz) to be applied to the value of the **carrierFrequency** parameter in order to define the initial non–Doppler-compensated radiated frequency.

- **sweepFreqDopplerComp**: Specifies whether the frequency is to be Doppler-compensated during the sweep. The values are ‘fixed’ (uncompensated) or ‘DopplerCompensated’ (Doppler compensation applied).

**NOTES**

1. **sweepFreqDopplerComp** determines whether Doppler compensation is applied only during the frequency sweep period. The presence or absence of Doppler compensation on the carrier following the frequency sweep period is governed by the **dopplerComp** parameter.

2. Both **sweepInitialFreqOffset** and **sweepFreqDopplerComp** result in adjustments to the carrier rest frequency. The difference is that **sweepInitialFreqOffset** is a predefined offset value, whereas the adjustment that results when **sweepFreqDopplerComp** = ‘DopplerCompensated’ is calculated by the Complex (e.g., CM) and dynamically adjusted throughout the frequency sweep period.

The **F401SpaceLinkCarrierProfile** data set contains zero or more *ordered* **FrequencySweepLeg** data sets. Each **FrequencySweepLeg** data set contains the parameters that govern the behavior of a leg of the forward carrier frequency sweep. Here ‘ordered’ means that the legs are to be executed in the order that the **FrequencySweepLeg** data sets are contained by the **F401SpaceLinkCarrierProfile** data set.

The **FrequencySweepLeg** data set contains the following parameters:

- **sweepEndFreqOffset**: The frequency offset (in Hz) from the value of the **carrierFrequency** parameter at which the sweep leg is to end. A positive value results in a sweep leg end frequency that is higher than **carrierFrequency**, a negative value results in a sweep leg end frequency that is lower than **carrierFrequency**, and a zero value results in the sweep leg ending at
carrierFrequency. If sweepFreqDopplerComp = ‘DopplerCompensated’, the sweep leg end frequency is Doppler-compensated.

- sweepRate: the rate (in Hz/sec) at which the sweep leg transitions from the frequency at the beginning of the leg (sweep leg beginning frequency) to the frequency at the end of the leg (sweep leg end frequency). The sweep rate is always a positive value.

- endHoldDuration: the duration (in seconds) at which the sweep leg end frequency is to be held constant (although possibly Doppler-compensated, if applied) before the leg ends.

NOTE – The duration of the sweep leg is determined as follows:
Sweep Leg Duration = (Sweep Leg End Frequency - Sweep Leg Beginning Frequency)/Sweep Rate + End Hold Duration.

The sweep leg end frequency of the last leg of the sweep is the frequency at which the carrier remains for the remainder of the duration of the carrier period, unless dopplerComp = ‘DopplerCompensated’, in which case the frequency will continue to be adjusted to compensate for the changing Doppler shift.

NOTE – The value of sweepEndFreqOffset will typically be zero for the last leg, as most frequency sweeps conclude at the carrier rest frequency.

Using these constructs, frequency sweeps of arbitrary numbers of legs and initial and end conditions can be created. It is even possible to create a ‘no sweep’ forward carrier, by setting initialHoldDuration = 0, sweepInitialFreqOffset = 0, and having no FrequencySweepLeg data set.


4 SERVICE MANAGEMENT DOCUMENT EXCHANGE

SCCS-SM operations are realized through the execution of procedures that involve the exchange of messages that are contained within SCCS-SM documents. All exchanges of SCCS-SM messages conform to a document exchange protocol that ensures that

a) operations are invoked only by entities that are authorized within the scope of a given Service Agreement;

b) documents are validated as properly formatted SCCS-SM documents;

c) documents that are not properly formatted SCCS-SM documents are handled in a context-appropriate manner; and

d) messages contained within SCCS-SM documents are processed in the proper sequence.

The SCCS-SM document exchange protocol is fully specified, at a level independent of information representation and communication services, by the SCCS-SM service specification (reference [3]).

No specific information representation is mandated by the standard, either for SCCS-SM documents or SCCS-SM messages. One mapping, to XML Schema, has been implemented. The mapping process is documented in section 7.

SCCS-SM document exchange operates across a communication service connecting UM and CM. Because SCCS-SM is intended to operate using a variety of transport technologies (e.g., email (SMTP), transmission control protocol [TCP] connections, hypertext transfer protocol [HTTP], simple object access protocol [SOAP]), the details of the establishment and maintenance of the communication service are specific to the transport technology used. However, all underlying communication services must perform a minimum set of functions in order to support the proper operation of the SCCS-SM document exchange protocol. In a bilateral agreement, a UM and a CM must select a communication service that performs the required functions; the specification does not cover such arrangements.

Figure 4-1 illustrates the relationship between the underlying communication service, SCCS-SM document exchange protocol, SCCS-SM message type, and SCCS-SM operation procedures.
Figure 4-1: Relationship among SCCS-SM Operation Procedures, Document Exchange Protocol, and Underlying Communication Service

Figure 4-2 shows the responsibilities of the different layers in the SCCS-SM Document Exchange Protocol ‘stack’.

On top of the stack are the SCCS-SM operations described in 2.3, which define the application-level service management interactions.

Each SCCS-SM operation procedure uses one of three operation procedure patterns: two-phase operation, three-phase operation, or notified operation.

– The two-phase operation procedure pattern is used by SCCS-SM operations that can be validated and performed in relatively short time. The invoker sends an invocation to the performer. The performer validates the invocation, and if it is valid and the operation can be performed, performs it and responds with a successful return. If the message was not valid, the performer responds with a failed return. If it was valid, but could not be performed, the performer responds with a failed return with denial.

– The three-phase operation procedure pattern is used by SCCS-SM operations that may require an extended period of time before they can be validated and/or performed. It is similar to the two-phase operation procedure pattern, but differs in that the performer carries out initial validation and then sends an acknowledged return which indicates that the invocation was received, and states a time by which a final disposition will be provided. The pattern is completed by sending a successful return, failed return, or failed return with denial, as in the two-phase pattern.

– The notified operation procedure pattern is used by SCCS-SM operations that are notified to the recipient after they have been performed. The notifier sends a notification to the recipient. The recipient cannot deny or refuse the operation, but sends a confirmation return to indicate that the notification has been received.
The SCCS-SM Document Exchange layer supports exchange of the messages used by the operation procedures. One or more messages are bundled into a *message set* which is contained in an SCCS-SM document. The document identifies the source of the message(s), and references the Service Agreement to which it or they apply. This layer includes

- **Syntactical validation:**
  - Where relevant, against the controlling syntax for information exchange, e.g., XML Schema;
  - Beyond that, to ensure that all data composition requirements are met.

- **Limited sequencing of invocation messages.** Because no requirement is placed on the underlying communications protocol that it preserve the sequence of messages, the only way to ensure that a set of invocations is processed in a particular order is to group them in a message set in a single SCCS-SM document.

- **Authorization:** verification that the source of the document is authorized to send messages using the given name (see section 3), and that the source name is authorized to create messages relating to the referenced service agreement.

- **Verification** that the specific operation is supported under the referenced Service Agreement.
Correlation of return messages with the invocations or notifications they respond to.

Generation of \textit{exception responses} to received documents and messages which do not pass the above validations. Receipt of an exception response in an operation, instead of the expected return, will cause termination of the operation.

The underlying communication service is used to exchange SCCS-SM documents among SCCS-SM application entities. This service and its protocols must be bilaterally agreed: the Recommended Standard does not specify them. It does, however, make certain requirements on the underlying communication service.

At a minimum, the underlying communication service must authenticate the \textit{Source} of each document carried by the service, and validate that the Source is recognized by the \textit{Destination} as an entity that is permitted to send documents to it. Documents for which the Source cannot be authenticated and recognized are dropped by the communication service. Only when the underlying communication service authenticates the Source and recognizes it as an legitimate Source for the intended Destination does it deliver the document to the Destination.

If data privacy and data integrity are required for the exchange of documents, these capabilities are also expected to be provided by the underlying communication service. Section 6 specifies the security mechanisms for authentication, data privacy, and data integrity that are recommended for use when the SCCS-SM documents are encoded as XML documents.

The underlying communication service provides the ability for an SCCS-SM entity to send documents to two logically separate ports on a peer SCCS-SM entity, the \textit{SCCS-SM message set port} and the \textit{SCCS-SM exception response port}, used by the document exchange protocol to separate SCCS-SM operation message traffic from protocol exception reporting traffic. The realization of the separate logical ports is dependent on the technology used by the communication service. For example, it could be multiple TCP sockets, multiple URLs, or the use of different Subject lines in email messages.

5 INCREMENTAL ADOPTION AND LEVELS OF COMPLIANCE

The specification recognizes that an installed base of service management information and interfaces for SCCS-SM exists. Therefore, the specification allows for incremental adoption and deployment towards standardized SCCS-SM.

Table 5-1 identifies the minimum set of operations that need to be implemented to be SCCS-SM compliant.

If an implementation is not fully compliant with the specification, it is said to be bilateral, which means that a particular UM and CM have agreed to accommodate variations from the specification. An implementation may be bilateral in the definition of the content of the management information, or in the mechanisms used to exchange (e.g., create, delete, query) the information. If the table indicates that bilaterally defined exchange is allowed for a particular type of management information, an implementation is not required to use the SCCS-SM service defined for that information.

An implementation may be compliant in one aspect and bilateral in another. For example, for Configuration Profile operations, the message contents may be compliant, but the procedure for transferring the data between UM and CM may be outside the SCCS-SM Recommended Standard. This case is an example of ‘bilaterally defined exchange allowed’.

An example of ‘bilaterally defined content allowed’ is the case where a network provides services that are not completely in conformance with all of the CCSDS standards upon which the standard Carrier Profiles are based, e.g., because a non–CCSDS-standard modulation scheme is used. In such a case, an appropriate (bilaterally defined) carrier profile format might be developed and agreed to by UM and CM, but could be exchanged via the standard ASCSP and QSCSP operations. Thus space link service providers that support both CCSDS and non–CCSDS-conformant spacecraft can use the common SCCS-SM service infrastructure to support both sets of clients.

The Service Package service is the highest priority service for interoperability. As such, the operations CSP or CTSP, together with DSP and SPC, represent the minimum level of compliance required for effective SCCS-SM in conformance with the SCCS-SM Recommended Standard. Furthermore, implementation of any Service Package operation must be compliant in both content definition and document exchange.

All other SCCS-SM services are optional and no minimum set of operations is defined for compliance with any of the services. However, if one or more of the other SCCS-SM services is implemented, the implementation is required to comply as indicated in table 5-1. For example, the ATP operation is allowed both bilaterally defined content and exchange, whereas the DTP operation is allowed only bilaterally defined exchange (i.e., the contents of the DTP operation are required to conform with the SCCS-SM recommend standard). It is recommended that, for any entity, both ‘ADD’ and ‘DELETE’ operations are provided, or neither.
Table 5-1: SCCS-SM Operations Compliance Levels

<table>
<thead>
<tr>
<th>Service</th>
<th>Operations</th>
<th>Bilaterally Defined Content Allowed</th>
<th>Bilaterally Defined Exchange Allowed</th>
<th>Implementation required for minimal specification compliance</th>
<th>Notes</th>
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<td>Y</td>
<td>Y</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>ASTSP</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>ARTSP</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>DSLSP</td>
<td></td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>2</td>
</tr>
<tr>
<td>DTSP</td>
<td></td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>2</td>
</tr>
<tr>
<td>QSLSP</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>3</td>
</tr>
<tr>
<td>QTSP</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>3</td>
</tr>
<tr>
<td>ASLEP</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>DSLEP</td>
<td></td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>2</td>
</tr>
<tr>
<td>QSLEP</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>3</td>
</tr>
<tr>
<td>Trajectory Prediction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATP</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>DTP</td>
<td></td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>2</td>
</tr>
<tr>
<td>QTP</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>3</td>
</tr>
<tr>
<td>Service Agreement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QSA</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>3</td>
</tr>
</tbody>
</table>

Legend

- Y = Yes
- N = No
- P = Partial
- A = Alternative option for compliance
- Operation required for an implementation to reach minimal compliance.
- Either CSP or PSP must be provided. Implementations may provide both.

Notes

1. Bi-laterally defined content allowed only in successful return messages in relation to event sequencing information.
2. Messages involved with delete operations have very minimal content definitions.
3. Return messages only; query invocations have very minimal content definitions.
6 SECURITY PROFILE RECOMMENDATIONS FOR SCCS SERVICE MANAGEMENT

6.1 OVERVIEW

This section provides a recommended security profile for securing the XML documents that are exchanged for SCCS-SM. The security profile utilizes a combination of current industry standards for securing XML documents in general.

6.2 CURRENT STANDARDS

6.2.1 INTRODUCTION

The following are standards for XML-processing security and Web-services security managed by the World Wide Web Consortium (W3C) and the Organization for the Advancement of Structured Information Standards (OASIS).

6.2.2 XML ENCRYPTION SYNTAX AND PROCESSING

XML Encryption Syntax and Processing is a standard provided by W3C for encrypting data and representing the result in XML. The standard allows for encrypting the whole XML document or partial document (an element within a document).

6.2.3 XML DIGITAL SIGNATURE SYNTAX AND PROCESSING

XML Digital Signature Syntax and Processing is a standard provided by W3C for capturing the result of a digital signature operation on any digital content including XML data. As with the XML encryption specification, the XML Digital signature specification allows for signing only a specific portion of the XML document or the whole document.

6.2.4 XML KEY MANAGEMENT SPECIFICATION (XKMS)

XML Key Management Specification is a protocol specification provided by W3C that provides for request and response exchanges to establish trust for a service. The protocol has two major components:

a) XML Key Information Service Specification (X-KISS) for the processing of key information;

b) XML Key Registration Service Specification (X-KRSS) for registering key pairs for use in XKMS.
They are part of an overall infrastructure to support XML Digital Signature. XKMS shields the complexity of managing public keys and specific Public Key Infrastructure (PKI) (such as X.509) from the client application that needs to support XML Digital Signature.

### 6.3 RECOMMENDATION FOR SCCS SERVICE MANAGEMENT

Utilization of XML Key Management Specification (XKMS), XML Encryption, and XML-Signature (references [18], [19], and [20], respectively) is recommended for achieving security for CCSDS SCCS-SM.

Figure 6-1 depicts the application of these standards for securing a CSP invocation.

![Diagram of Security Standards Application](image)

**Figure 6-1: Application of Security Standards for SCCS Service Management**

The following are also recommended:

- Encryption should be applied to whole document (versus selected elements). The rationale is to provide data confidentiality with a minimum of overhead (i.e., avoiding the need for coordination of which elements are being encrypted between a particular UM/CM pair, etc.).

- Whole document (versus selected elements) should be digitally signed. The rationale is to provide authentication to the entire document.
– The signature should be applied after encryption of the SCCS-SM message. The rationale is to allow for the recipient of the message to decrypt the signature and authenticate the message without expending further resources (for decryption) should the document prove to be inauthentic.

– UM and CM should agree upon a mutually trusted third party for providing XKMS trust services or should at least agree to implement this bilaterally. The rationale is to protect the keys involved in the encryption/decryption algorithms. The rationale for allowing bilateral trust implementation is the recognition that CCSDS cannot recommend any third party and that any third party trust service may be deemed prohibitively expensive for an agency.

6.4 AVAILABLE IMPLEMENTATIONS

The following are current toolkits that implement the standards listed above.

<table>
<thead>
<tr>
<th>Name</th>
<th>Provider</th>
<th>Standards supported</th>
<th>Resource(s)</th>
</tr>
</thead>
</table>

6.5 REFERENCES

The following are references for the XML security standards:

– XKMS, reference [18]:
  [http://www.w3.org/TR/xkms2](http://www.w3.org/TR/xkms2)

– XML Encryption Syntax and Processing, reference [19]:
  [http://www.w3.org/TR/xmlenc-core/](http://www.w3.org/TR/xmlenc-core/)

– XML-Signature Syntax and Processing, reference [20]:
  [http://www.w3.org/TR/xmldsig-core/](http://www.w3.org/TR/xmldsig-core/)

The following is a useful article on Web services security:

6.6 ADDITIONAL INFORMATION ON SECURITY STANDARDS

The WS-Security specification provided by OASIS (Organization for the Advancement of Structured Information Standards) defines a set of SOAP (Simple Object Access Protocol) header extensions for end-to-end SOAP messaging security. It supports message integrity and confidentiality by allowing communicating partners to exchange signed and encrypted messages in a Web services environment. Because it is based on the XML digital signature and XML Encryption standards, a digital signature and encryption can be applied to any combination of message parts. WS-Security supports multiple security models, such as username/password-based and certificate-based models. XKMS is not currently part of WS-Security.

The general trend toward Web services and Service Oriented Architecture (SOA) represents a viable architectural pattern for UM and/or CM SCCS-SM implementations; as such, security models provided by WS-Security, when combined with XKMS, are an obvious fit.
7 MAPPING OF SCCS SERVICE MANAGEMENT SPECIFICATION TO XML SCHEMA

7.1 INTRODUCTION

This section defines the mapping of the SCCS-SM service specification onto XML Schema technology and provides an introduction to the SCCS Service Management XML Schema.

The SCCS Service Management (SCCS-SM) XML Schema (reference [17]) is located at the following URL:

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

7.2 XML SCHEMA MAPPING

7.2.1 USE OF W3C SCHEMA

The SCCS Service Management (SCCS-SM) XML Schema adopts the XML Schema standard as approved by the World Wide Web Consortium (W3C) (http://www.w3.org/).

The specification of the W3C XML Schema can be found at the following URL:

http://www.w3.org/XML/Schema

7.2.2 MAPPING STRATEGY

7.2.2.1 General

The following guidelines serve as the overall mapping strategy of the SCCS-SM service specification onto XML Schema and should be adopted for future extensions of the SCCS-SM XML Schema:

- Organization of XML Schema files is based on SCCS-SM services. The mapping from services to files is described in further detail in 7.2.2.2, ‘File Organization’.
- XML Schema technology uses concepts that can be modeled by UML. The UML class diagrams used in message definition in the SCCS-SM service specification are used for structuring XML schema. Subsection 7.3, ‘Mapping Definition’, describes these mapping definitions in greater detail.
- The SCCS-SM XML Schema is structured so as to maximize the amount of validation that can be performed by the XML parser, minimizing the need to develop specific validation code at the application level.
- The XML Schema features used in the SCCS-SM XML Schema are selected so as to be supported by a high number of available XML parsers. This means XML Schema
features not supported by the main available XML parsers are avoided wherever the quality and clarity of the SCCS-SM Schema are not compromised.

– The SCCS-SM XML Schema is constructed having the clarity and readability of the XML instance documents in mind. For this reason, there is an explicit attempt to minimize the depth of nested XML tags, wherever possible.

– The complex and simple types defined as part of the SCCS-SM XML Schema are placed in files with extension .xsd, are organized according to the directory and file organization described in 7.2.2.2 and are listed alphabetically within each .xsd file.

– Any new schema files added to the SCCS-SM XML Schema directory should use the namespaces defined in 7.2.2.3.

– The version numbering scheme defined in 7.2.2.4 is adhered to.

### 7.2.2.2 File Organization

The SCCS-SM Schema files are held together in a single directory and have been organized according to the Service Management services (see 2.1.5). The files and their contents are listed below:

– **SmSchema-v1.0.0.xsd**—contains the high level SCCS SM Document Exchange Protocol data sets. This file contains the two root elements of the SM schemas:
  
  • SmMessageSet – the root element of an XML document that contains an SM Message Set; and

  • SmExceptionResponse – the root element of an XML document that contains an SM Exception Response.

– **SmSchemaCommonTypes-v1.0.0.xsd**—contains the simple and complex types used by more than one Service Management service, and hence by more than one .xsd file in the SCCS-SM Schema.

– **SmSchemaServicePackage-v1.0.0.xsd**—contains the messages, data sets and parameters specific to the Service Package service.

– **SmSchemaConfigurationProfile-v1.0.0.xsd**—contains the messages, data sets and parameters specific to the Configuration Profile service.

– **SmSchemaTrajectoryPrediction-v1.0.0.xsd**—contains the messages, data sets and parameters specific to the Trajectory Prediction service.

– **navSchema-v1.0.0.xsd** – acts as a container for ODM-defined XML schema (e.g., the OEM XML Schema and the OPM XML Schema).

**NOTE** – This is necessary to allow for multiple XML formats in the same navigation namespace, as described in 7.2.2.3, Namespaces.
– SmSchemaServiceAgreement-v1.0.0.xsd—contains the messages, data sets and parameters specific to the Service Agreement service.

– ODM-defined schemas are kept in separate files (the version numbering scheme for these files is independent from the SCCS-SM Schema files, as defined in reference [16] and further explained in 7.2.2.5):
  • ndxml-R1.5-navwg-common.xsd—contains complex and simple types common to both OEM and OPM Schema files.
  • ndxml-R1.5-ccsds-common.xsd—contains complex and simple types common to both OEM and OPM Schema files, which have potential use elsewhere.
  • ndxml-R1.5-oem-p1.1.xsd—contains the OEM XML Schema.
  • ndxml-R1.5-opm-p1.1.xsd—contains the OPM XML Schema.

The Schema directory contents are listed in figure 7-1.

Figure 7-1: SCCS-SM Schema Files

### 7.2.2.3 Namespaces

The SCCS-SM Schema declares the following namespace and prefix:

```xml
xmlns="urn:ccsds:recommendation:service_management:schema:sccs:R1.0"
xmlns:xsd='http://www.w3.org/2001/XMLSchema'
```

The SCCS-SM Schema defines the following target namespace:

```xml
targetNamespace="urn:ccsds:recommendation:service_management:schema:sccs:R1.0"
```

As a result, the SCCS-SM Schema types are not prefixed and the native W3C XML Schema types are prefixed with ‘xsd:’.

The URLs used as a namespace and target namespace are not dereferenceable; they do not map to an actual resource.
The ODM-defined schema is given a separate target namespace because it belongs to a different domain, outside the SCCS Service Management scope:

```xml
xmlns="urn:ccsds:recommendation:service_management:schema:sccs:R1.0"
xmlns:xsd='http://www.w3.org/2001/XMLSchema'
targetNamespace="urn:ccsds:recommendation:service_management:schema:sccs:R1.0"
```

The `SmSchemaTrajectoryPrediction-v1.0.0.xsd`, which is the only SCCS-SM Schema file that uses the ODM Schema, imports (using the XML Schema element, ‘import’) the ODM Schema files and defines a prefix to be used for the ODM types:

```xml
xmlns:nav="urn:ccsds:recommendation:navigation:schema:ndmxml:R1.5"
```

This means that the ODM types need to be prefixed with ‘nav:’.

### 7.2.2.4 Version Numbering

The SCCS-SM Schema version numbering scheme has been defined as follows:

\[ v<1^{\text{st}} \text{ digit}>.<2^{\text{nd}} \text{ digit}>.<3^{\text{rd}} \text{ digit}> \]

Where

- 1\textsuperscript{st} digit represents the CCSDS Recommended Standard Blue book version.
- 2\textsuperscript{nd} digit represents the approved baseline drafts by the CCSDS Service Management Working Group. It is intended to mark the draft baseline versions used for prototypes and/or corresponding to Red Book releases. Increments to this digit only occur with the addition of new capabilities, e.g., new operations, or significant additions to existing operations (e.g., event sequences).
- 3\textsuperscript{rd} digit represents either updates to a draft baseline version to fix problems and/or inconsistencies detected after the draft baseline release; or a ‘work-in-progress’ version towards a new draft baseline; or, exceptionally, a correction to an operational version.

Schemas are released for operational purposes only in concert with the release of version of Recommended Standard – that is, all operational schema sets have version numbers with a non-zero value for the first digit and zero values for the second and third digits. Non-zero values in the second and third digits represent experimental or developmental versions. In exceptional circumstances, however, a correction to a released Schema would be numbered

---

5 There is a CCSDS Recommended Standard currently under preparation that will contain the XML Specification for Navigation Data Messages. The plan is to migrate to the Navigation Data Messages XML Schema when it is completed. Therefore the target namespace, ‘urn:ccsds:recommendation:service_management:schema:sccs:R1.0’, is subject to change once the Navigation Data Messages schema is delivered.
with an increment to the 3\textsuperscript{rd} digit. This would only be done for a correction which would not invalidate instance documents which valid correctly against the uncorrected version.

All versions of the SCCS-SM Schemas that use this scheme are approved by the Service Management Working Group (SMWG).

7.2.2.5 Version Numbering for OPM/OEM Trajectory Prediction Formats

The Trajectory Prediction service allows the exchange of OPM- and OEM-formatted data either in plain text or in XML. Plain text OPM and OEM data sets are treated as octet strings that are defined in the SmSchemaTrajectoryPrediction-v1.0.0.xsd file. The OPM and EPM XML Schema definitions conform to a numbering scheme that is defined and incremented independently of the SCCS-SM version numbering scheme (see reference [16]).

7.3 MAPPING DEFINITION

7.3.1 GENERAL

7.3.1.1 Overview

The following are mapping definitions from SCCS-SM service specification to XML Schema:

7.3.1.2 Mapping SCCS-SM data sets

Except in the special case described in the following paragraph, SCCS-SM data sets are mapped onto XML Schema complex types. The complex types are named after the original SCCS-SM data sets with the word ‘Type’ appended to the end of the data set name. For example, the \texttt{spaceLinkCarrierProfile} data set is mapped to the ‘spaceLinkCarrierProfileType’. The convention for capital first letter is maintained.

The exception to the above mapping relationship occurs when an SCCS-SM data set (1) contains only a single parameter of simple type, and that parameter is contained only in that data set (that is, there is a one-to-one relationship between data set and parameter), and (2) that single-parameter data set is itself contained by another data set (referred to here as the \textit{superior} data set). In such instances, the SCCS-SM data set and parameter are mapped onto XML Schema as follows:

\begin{itemize}
  \item[a)] The (single) SCCS-SM parameter is mapped onto a XML Schema element that is contained by the XML complex type that corresponds to the superior data set.
  \item[b)] The name of the resultant XML Schema element is the same as the name of the corresponding SCCS-SM parameter.
  \item[c)] The type of the resultant XML Schema element is set to the type of the corresponding parameter contained within the original SCCS-SM data set.
\end{itemize}
For example, in the Service Package section the ReplaceServicePackageInvocation data set contains a SCCS-SM data set ServicePackageReference, which contains a single parameter servicePackageRef of type ‘String256’. This combination of data set and contained parameter map into the XML Schema element ‘servicePackageRef’ of type ‘String256Type’, where the ‘servicePackageRef’ element is a component of the ReplaceServicePackageInvocationType complex type.

SCCS-SM abstract data sets are mapped onto XML Schema abstract complex types.

7.3.1.3 Mapping SCCS-SM UML Stereotypes

UML stereotypes in the SCCS-SM service specification are mapped to XML Schema abstract complex types.

7.3.1.4 Mapping SCCS-SM Parameters

The SCCS-SM parameters are mapped onto XML Schema elements. The type of a parameter can be of simple or complex content and it can be defined in XML Schema as either an embedded type, i.e., together with the element definition, or as a predefined simple or complex type.

Examples:

- The SCCS-SM parameter confirmationTimeout in the ServiceAgreement data set has been mapped onto an XML Schema element of type ‘xsd:unsignedLong’, which is one of the XML Schema native types.

- The SCCS-SM parameter fSpaceLinkDataTransportParameter in the FSpaceLinkDataTransportChangeEvent data set has been mapped onto an element of complex content, defined as an embedded type, as a sequence of ‘fSpaceLinkDataTransportParameter’ elements, which in turn are of type ‘FSpaceLinkDataTransportParametersType’ (a simple type defined in the same schema file).

- In the SCCS-SM ServiceAgreement data set, the element ‘OperationsConstraintsSpecification’ has been defined of type ‘OperationsConstraintsSpecificationType’, which is a complex type, defined in the same schema file.

The data types defined for the SCCS-SM service specification, reference [3], annex A, are mapped to XML Schema native types as shown in table 7-1.
Table 7-1: Mapping SCCS-SM Annex F Data Types to XML Schema

<table>
<thead>
<tr>
<th>SCCS-SM service specification</th>
<th>SCCS-SM XML Schema</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boolean</td>
<td>xsd:boolean</td>
</tr>
<tr>
<td>Integer</td>
<td>xsd:integer</td>
</tr>
<tr>
<td>Unsigned Integer</td>
<td>xsd:unsignedLong</td>
</tr>
<tr>
<td>Positive Integer</td>
<td>xsd:positiveInteger</td>
</tr>
<tr>
<td>Negative Integer</td>
<td>xsd:negativeInteger</td>
</tr>
<tr>
<td>String</td>
<td>xsd:string</td>
</tr>
<tr>
<td>StringX</td>
<td>StringXType; where X is replaced with actual values (such as 128, 256)</td>
</tr>
<tr>
<td>UTC</td>
<td>UTCTimeType</td>
</tr>
<tr>
<td>Opaque</td>
<td>xsd:hexBinary</td>
</tr>
<tr>
<td>BilateralData</td>
<td>xsd:anyType</td>
</tr>
</tbody>
</table>

7.3.1.5 Mapping a Parameter of Type ‘Set of Enumerated Values’

A parameter that is defined as a set of enumerated values is mapped to an XML schema ‘all’ group of elements (representing the enumerations) with attributes ‘minOccurs’ equal to zero, ‘type’ equal to boolean, and ‘fixed’ equal to ‘true’.

In the following example, there are parameters that define the set of options available to the Configuration Profiles under the Service Agreement. These allow the selection of the required configuration options and the omission of the ones not needed in the Service Agreement.

Example 1: Mapping a Set of Enumerated Values

```xml
<xsd:element name="convolutionalCodingOptions">
  <xsd:complexType>
    <xsd:all>
      <xsd:element name="notUsed" type="xsd:boolean" fixed="true" minOccurs="0"/>
      <xsd:element name="rateOneHalf" type="xsd:boolean" fixed="true" minOccurs="0"/>
      <xsd:element name="rateTwoThirds" type="xsd:boolean" fixed="true" minOccurs="0"/>
      <xsd:element name="rateThreeQuarters" type="xsd:boolean" fixed="true" minOccurs="0"/>
      <xsd:element name="rateFiveSixths" type="xsd:boolean" fixed="true" minOccurs="0"/>
      <xsd:element name="rateSevenEights" type="xsd:boolean" fixed="true" minOccurs="0"/>
    </xsd:all>
  </xsd:complexType>
</xsd:element>
```
7.3.1.6  Mapping a Parameter of Type ‘List of [data type]’

A parameter that is defined as a list of [data type] is mapped to an XML schema ‘sequence’
group of elements of that data type with attribute ‘maxOccurs’ equal to ‘unbounded’.

7.3.1.7  Mapping Nullable SCCS-SM Parameters

A parameter that can have null content is represented in the SCCS-SM XML Schema as an
element with the ‘minOccurs’ attribute set to 0 (zero). This allows the XML instance
document to exclude the element when it has null content.

7.3.1.8  XML Schema Naming Conventions

The XML Schema elements are named after their type (if defined as a ‘complexType’),
 omitting the suffix ‘Type’. The camel case conventions from the SCCS-SM service
specification are used for the name of all elements and types in the SCCS-SM Schema.

7.3.1.9  Mapping SCCS-SM Data Set Relationships

7.3.1.9.1  General

Relationships between data sets are described in the SCCS-SM service specification as
having containment relationships; i.e., a data set may contain another data set. This is
described in the class diagrams using UML composition. The mapping for the UML
conventions used in the class diagrams of the SCCS-SM service specification (as defined in
1.7) is as follows:

– UML composition in the SCCS-SM service specification is mapped onto either the
  ‘sequence’ group or the ‘choice’ group depending on the constraints that apply to the
data sets association. As a basic rule, composition is mapped onto sequence groups,
where the XML Schema tag <sequence> is used. The exceptions are for the cases
where constraints exist. These cases are discussed individually in the next bullet
point.

– UML constraints on associations between two or more data sets in the SCCS-SM
service specification are represented in the SCCS-SM Schema either as restrictions
on the combination of sets of elements that can be contained by a complex type or by
annotating the relevant element or type in the schema stating the constraint in words.

7.3.1.9.2  Mapping the ‘Exclusive OR’ Constraint for Contained Data Sets

For the case of the exclusive OR (‘{xor}’) constraint applied to contained data sets, one of
two mappings are used in the Schema to represent that only one of the data sets can be used:
(a) a substitution group or (b) a simple choice group.
NOTE – The SCCS-SM Schemas began by using the simple choice group approach, and the majority of exclusive OR constraints are mapped this way in the Version 1 Schemas. However, the substitution groups approach has the advantages of, first, automatically enforcing the exclusivity at the schema validation level and, second, allowing the schema to be extended more easily if other options are specified in the future. In future versions of the SCCS-SM Schemas, the exclusive OR constraints will be mapped into substitution groups.

The class diagram in figure 7-2 is a class diagram that contains an exclusive OR data set containment constraint. The SCCS-SM Schema extract shown below the class diagram uses the substitution group approach to map the constraint.

![Figure 7-2: Use of the ‘Exclusive OR’ Constraint with Substitution Group](image-url)
Example 2: Mapping UML Composition and the ‘Exclusive OR’ Constraint to XML Schema with Substitution Groups

```xml
<xsd:complexType name="AddTrajectoryPredictionInvocationType">
  <xsd:complexContent>
    <xsd:extension base="InvocationType">
      <xsd:sequence>
        <xsd:element name="trajectoryId" type="String256Type"/>
        <xsd:element ref="TrajectoryPredictionSegment"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<!-- ******************************************************************************* -->
<xsd:element name="OrbitBilateralMessage" type="OrbitBilateralMessageType"
    substitutionGroup="TrajectoryPredictionSegment">
</xsd:element>

<!-- ******************************************************************************* -->
<xsd:element name="OrbitEphemerisMessageText" type="OrbitEphemerisMessageTextType"
    substitutionGroup="TrajectoryPredictionSegment">
</xsd:element>

<!-- ******************************************************************************* -->
<xsd:element name="OrbitEphemerisMessageXml" type="OrbitEphemerisMessageXmlType"
    substitutionGroup="TrajectoryPredictionSegment">
</xsd:element>

<!-- ******************************************************************************* -->
<xsd:element name="OrbitParameterMessageText" type="OrbitParameterMessageTextType"
    substitutionGroup="TrajectoryPredictionSegment">
</xsd:element>

<xsd:element name="OrbitParameterMessageXml" type="OrbitParameterMessageXmlType"
    substitutionGroup="TrajectoryPredictionSegment">
</xsd:element>

<xsd:complexType name="OrbitEphemerisMessageXmlType">
  <xsd:complexContent>
    <xsd:extension base="TrajectoryPredictionSegmentType">
      <xsd:sequence>
        <xsd:element name="oemXmlData" type="nav:OemXmlDataType"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<!-- ******************************************************************************* -->
<xsd:complexType name="OrbitBilateralMessageType">
  <xsd:complexContent>
    <xsd:extension base="TrajectoryPredictionSegmentType">
      <xsd:sequence>
        <xsd:element name="bilateralTrajectoryFormatId" type="String256Type"/>
        <xsd:element name="bilateralTrajectoryData" type="xsd:anyType"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

(The remaining message types are omitted for brevity).
The class diagram fragment in figure 7-3 also contains an exclusive OR data set containment constraint. The SCCS-SM Schema extract shown below that class diagram uses the choice group approach to map the constraint.

Figure 7-3: Use of the ‘Exclusive OR’ Constraint with Choice Group

```xml
<xsd:complexType name="ServicePackageRequestStereotype">
    <xsd:choice>
        <xsd:element name="spaceLinkSessionServicePackageRequest" type="SpaceLinkSessionServicePackageRequestType"/>
        <xsd:element name="retrievalServicePackage" type="RetrievalServicePackageRequestType"/>
    </xsd:choice>
</xsd:complexType>

7.3.1.9.3 Mapping the ‘At Least One of’ Constraint for Contained Data Sets

For the case of restrictions on containment such as the one illustrated in the figure below, where data set ConfigurationConstraintsSpecification must contain at least one F401SpaceLinkCarrierAgreement or one R401SpaceLinkCarrierAgreement, the schema uses a sequence of the elements, each of which has ‘minOccurs’ equal to ‘0’ and ‘maxOccurs’ equal to ‘unbounded’

The Schema extract is given below the class diagram (figure 7-4).
Example 3: Mapping UML Composition and ‘At Least One of’ Constraint to XML Schema

```xml
<xsd:complexType name="ConfigurationConstraintsSpecificationType">
  <xsd:sequence>
    <xsd:annotation>
      <xsd:documentation>At least one f401SpaceLinkCarrierAgreement or one r401SpaceLinkCarrierAgreement must be present.</xsd:documentation>
    </xsd:annotation>
    <xsd:element name="f401SpaceLinkCarrierAgreement" type="F401SpaceLinkCarrierAgreementType" minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="r401SpaceLinkCarrierAgreement" type="R401SpaceLinkCarrierAgreementType" minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="transferServiceAgreement" type="TransferServiceAgreementType"/>
  </xsd:sequence>
</xsd:complexType>
```

7.3.1.9.4 Mapping a Composition Constraint with Enumeration Parameter

For the cases where in the SCCS-SM service specification the value of an enumeration parameter is involved in the definition of the constraint on the data set composition, the
mapping to SCCS-SM schema presents the data set containment according to the enumeration values. This is better explained with the use of an example.

In the SCCS-SM service specification, the \texttt{R401SpaceLinkCarrierProfile} data set contains the enumeration parameter \texttt{carrierModulationType}, which is set to one of the following options: ‘BPSK’, ‘QPSK’, ‘UQPSK’, ‘OQPSK’, ‘GMSK’, ‘PCM/PM’, ‘8PSK’, ‘unmodulated’. The specification of this data set also includes the following data set composition rules:

- If the value of the \texttt{carrierModulationType} parameter of a \texttt{R401SpaceLinkCarrierProfile} data set is ‘BPSK’, then the \texttt{R401SpaceLinkCarrierProfile} data set shall contain one \texttt{R401SymbolStream} data set.

- If the value of the \texttt{carrierModulationType} parameter of the \texttt{R401SpaceLinkCarrierProfile} data set is ‘UQPSK’, then the \texttt{R401SpaceLinkCarrierProfile} data set shall contain one \texttt{R401SymbolStream} data set.

- (similar composition rules exist for all of the enumeration values of \texttt{carrierModulationType}).

Thus the \textit{number} of \texttt{R401SymbolStream} data sets contained by the \texttt{R401SpaceLinkCarrierProfile} data set as governed by the value of figure 7-5 is the portion of the \texttt{carrierModulationType} parameter. Figure 7-6 is the portion of the \texttt{R401SpaceLinkCarrierProfile} data set class diagram that illustrates the data sets of interest in this example.

In the SCCS-SM Schema this constraint has been represented as shown in the XML extract below. For simplification and clarity purposes, only the ‘BPSK’ and ‘QPSK’ enumeration values are included in the XML extract. In the simplified extract, ‘carrierModulationType’ contains a choice group that allows the selection among the ‘BPSK’ and ‘QPSK’ options. According to the enumeration value, the schema defines whether one or two \texttt{R401SymbolStream} data sets are contained.
Figure 7-5: UML Class Diagram Showing Composition

Example 4: Mapping UML Composition and Enumeration Constraint

```xml
<xsd:element name="carrierModulationType">
  <xsd:complexType>
    <xsd:choice>
      <xsd:element name="bpsk">
        <xsd:complexType>
          <xsd:sequence>
            <xsd:element name="symbolStream" type="R401SymbolStreamType"/>
          </xsd:sequence>
        </xsd:complexType>
      </xsd:element>
      <xsd:element name="qpsk" type="QpskSymbolStreamType"/>
    </xsd:choice>
  </xsd:complexType>
</xsd:element>

<xsd:complexType name="QpskSymbolStreamType">
  <xsd:choice>
    <xsd:element name="interleavedIandQChannels">
      <xsd:complexType>
        <xsd:sequence>
          <xsd:element name="symbolStream" type="R401SymbolStreamType"/>
        </xsd:sequence>
      </xsd:complexType>
    </xsd:element>
    <xsd:element name="separatelandQChannels">
      <xsd:complexType>
        <xsd:sequence>
          <xsd:element name="iChannel">
            <xsd:complexType>
              <xsd:sequence>
                <xsd:element name="symbolStream" type="R401SymbolStreamType"/>
              </xsd:sequence>
            </xsd:complexType>
          </xsd:element>
        </xsd:sequence>
      </xsd:complexType>
    </xsd:element>
  </xsd:choice>
</xsd:complexType>
```
7.3.1.9.5 Mapping Multiplicity Constraints

Multiplicity in UML composition or a Data set Relationship Requirement for the SCCS-SM service specification data sets is expressed using the XML Schema attributes ‘minOccurs’ and ‘maxOccurs’. Attributes ‘minOccurs’ and ‘maxOccurs’ determine the minimum and maximum number of times an element may appear, respectively. The default value for both ‘minOccurs’ and ‘maxOccurs’ is 1; therefore if both attributes are omitted, the element must appear exactly once.

Any multiplicity that includes zero as a lower bound (e.g., [0..n], [0..1], etc.), is represented in the SCCS-SM XML Schema with ‘minOccurs’ equal to zero.

7.3.1.9.6 Mapping Other Constraints

Further constraints for data set composition, as denoted by text within curly brackets below the data set rectangles in a UML class diagram (see figure 7-4 for an example), are expressed in the annotation of the relevant element or type.

7.3.1.10 Mapping SCCS-SM Annotation

The annotation for complex types, simple types and elements in the SCCS-SM Schema are replicated from the SCCS-SM service specification. Some extra annotation is added where it is necessary to explain a particular aspect of the mapping to XML Schema or dependencies that could not be expressed using the available XML Schema features.

7.3.1.11 Mapping SCCS-SM Abstract data sets Relationships—Inheritance

7.3.1.11.1 General

Abstract data sets in the SCCS-SM service specification are mapped to XML Schema abstract complex types. By definition, abstract data sets cannot be instantiated and will be involved in inheritance (or generalization in UML terms) relationships with other data sets.
Inheritance in the SCCS-SM service specification is mapped to either derived types by using extension or to straight containment by using the choice group tag `<choice>` in the SCCS-SM Schema.

For the inheritance cases that do not require typecasting, the mapping is direct, using derivation by extension. An example is given below. In this example the complex type ‘F401SpaceLinkCarrierAgreementType’ derives by extension from the complex type ‘Ccsds401SpaceLinkCarrierAgreementType’.

```
<xsd:complexType name="F401SpaceLinkCarrierAgreementType">
  <xsd:complexContent>
    <xsd:extension base="Ccsds401SpaceLinkCarrierAgreementType">
      <xsd:sequence>
        <xsd:element name="fMinEirp" type="xsd:integer">
          <xsd:annotation>
            <xsd:documentation>dBm</xsd:documentation>
          </xsd:annotation>
        </xsd:element>
        (...further elements omitted for brevity)
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>
```

Example 5: Mapping Data Set Inheritance—No Typecasting

In the inheritance cases that require typecasting, the element is defined as a substitution group providing a choice among the derived classes. An example is given below. In this example, the complex type ‘SmMessageSetType’ can contain one or more (according to the defined cardinality) of the elements within the choice group. There is one element for each of the complex types that derive by extension from the ‘SmMessageType’. In this case, there are further levels of inheritance before concrete derived classes are reached.

```
<xsd:complexType name="SmMessageSetType">
  <xsd:complexContent>
    <xsd:choice group="MessageSet">
      <xsd:element name="smMessageSetType" type="SmMessageType"/>
      (...further levels of inheritance)
    </xsd:choice>
  </xsd:complexContent>
</xsd:complexType>
```

NOTE – This example contains extracts from the SCCS-SM Schema, which exemplify the substitution group approach for a single line of inheritance, to the derived type `QueryServiceAgreementInvocationType`.
Example 6: Mapping Data Set Inheritance—with Typecasting

```xml
<xsd:complexType name="SmMessageSetType">
  <xsd:complexContent>
    <xsd:extension base="SmDocumentType">
      <xsd:sequence>
        <xsd:element name="smSource" type="String256Type"/>
        <xsd:element name="smDestination" type="String256Type"/>
        <xsd:element name="serviceAgreementRef" type="String256Type"/>
        <xsd:choice>
          <xsd:element ref="Invocation" maxOccurs="unbounded"/>
          <xsd:element ref="Return"/>
          <xsd:element ref="Notification"/>
          <xsd:element ref="Confirmation"/>
        </xsd:choice>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>
```

```xml
<xsd:element name="queryServiceAgreementInvocation" type="QueryServiceAgreementInvocationType" substitutionGroup="Invocation">
  <xsd:annotation>
    <xsd:documentation>global element for Invocation substitution group</xsd:documentation>
  </xsd:annotation>
</xsd:element>
```

```xml
<xsd:complexType name="InvocationType" abstract="true">
  <xsd:complexContent>
    <xsd:extension base="SmMessageType">
      <xsd:sequence>
        <xsd:element name="urgentFlag" default="routine">
          <xsd:annotation>
            <xsd:documentation>Specifies the timeframe in which the invoked operation is to be performed. The interpretation of the enum values is operation-specific</xsd:documentation>
          </xsd:annotation>
        </xsd:element>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>
```

```xml
<xsd:complexType name="SmMessageType" abstract="true">
  ...<!-- Optional content -->...
</xsd:complexType>
```

7.3.1.11.2 Mapping Application of Stereotypes

Common patterns in the specification are expressed as stereotypes. Stereotypes are defined using the UML stereotype conventions, which define the pattern, identify where context specific data apply, and provide a name for the stereotype. UML stereotype conventions are also used to handle the application of a defined stereotype. When a stereotype is applied to a model element, which could be a sequence, activity or data set in the specification, the element is referred to as an instance of the stereotype. Structurally, the element is extending that stereotype, i.e., using the pattern and adding traits and/or behavior to it.

When a stereotype is applied in combination with other stereotypes, the instantiated data set is mapped to a non-abstract complex type.

The main stereotype (as selected by the schema author) is applied by having the data set derive by extension from the abstract data set (i.e., the stereotype). Each additional stereotype is applied by adding an element of type equal to the abstract data set defining each stereotype.

An example is given below for the ServicePackageModifiedNotification data set that applies the stereotypes <<Notification>> and <<ServicePackageResult>>. In mapping to XML Schema, the ServicePackageModifiedNotification data set is mapped to a complex type, named `ServicePackageModifiedNotificationType`, and derives by extension from the abstract complex type `NotificationMessage` (that represents the mapping for the stereotype `<<Notification>>`) and has an element named `modifiedServicePackageResult` of type `ServicePackageResultStereotype` that represents the mapping for the stereotype `<<ServicePackageResult>>`. The schema snippet is shown below:
7.3.2 XML PATH LANGUAGE (XPATH)

7.3.2.1 General

The SCCS Service Management (SCCS-SM) XML Schema adopts the use of the XML Path Language (XPath) standard as approved by the World Wide Web Consortium (W3C) (http://www.w3.org/).

The specification of the W3C XML Path Language (XPath) 1.0 can be found at the following URL:

http://www.w3.org/TR/xpath.html

7.3.2.2 Format of Parameter and Data Set Cross-References: erroredItem, deniedItem and itemRef

Several parameters in the SCCS-SM service specification cross-reference another parameter or a data set in the same message or a separate message. For example, the erroredItem parameter of a CreateServicePackageFailedReturn references a parameter in a previously sent CreateServicePackageInvocation message. An addressing syntax or language is necessary to identify the correct parameter such that it is unambiguous to the receiver as to which parameter is being referenced within the context of the whole SmDocument. To complement the use of XML for the message instances, XPath is used to define the syntax of the parameter or data set location.

The following parameters use XPath to format their values:
Table 7-2: SCCS-SM Parameters Using XPath

<table>
<thead>
<tr>
<th>Parameter Name</th>
<th>Applicable Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>erroredItem</td>
<td>all instances of &lt;&lt;FailedReturn&gt;&gt; and &lt;&lt;FailedReturnWithDenial&gt;&gt;</td>
</tr>
<tr>
<td>deniedItem</td>
<td>all instances of &lt;&lt;FailedReturnWithDenial&gt;&gt;</td>
</tr>
<tr>
<td>itemRef</td>
<td>SPM-N</td>
</tr>
</tbody>
</table>

Example 7: Using XPath in CSP-FR

Consider the invocation message received by a CM:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<SmMessageSet xmlns="urn:ccsds:recommendation:service_management:schema:sccs:R1.0"
               xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <sccsSmVersionRef>1.0.0</sccsSmVersionRef>
  <smSource>Interop.Red3.ESOC.ESA</smSource>
  <smDestination>CSSXP</smDestination>
  <serviceAgreementRef>ESOC.ESA:JPL.NASA:Red3:InteropTest-01</serviceAgreementRef>
  <createServicePackageInvocation>
    <messagePrivateAnnotation/>
    <messageSequenceNumber>2367</messageSequenceNumber>
    <messageTimestamp>2009-04-06T17:34:11Z</messageTimestamp>
    <urgentFlag>routine</urgentFlag>
    <servicePackageId>SP-71-1</servicePackageId>
    <createServicePackageRequest>
      <spaceLinkSessionServicePackageRequest>
        <handoversPermitted>false</handoversPermitted>
        <importance>Standard</importance>
        <primeScenarioRef>S1</primeScenarioRef>
        <serviceScenario>
          <scenarioId>S1</scenarioId>
          <spaceCommunicationServiceRequest>
            <spaceCommunicationServiceProfileRef>SCSP-700-A</spaceCommunicationServiceProfileRef>
            <spaceCommServiceStartTime>2009-05-01T00:00:00Z</spaceCommServiceStartTime>
            <spaceCommServiceStartTimeLag>0</spaceCommServiceStartTimeLag>
            <spaceCommServiceStartTimeLead>0</spaceCommServiceStartTimeLead>
            <minimumServiceDuration>3600</minimumServiceDuration>
            <preferredServiceDuration>3600</preferredServiceDuration>
            <transferServiceDeferred>true</transferServiceDeferred>
            <sequenceOfEventsDeferred>true</sequenceOfEventsDeferred>
            <antennaConstraints>
              <acceptabilityConstraintsType>acceptable</acceptabilityConstraintsType>
              <antenna>
                <antennaRef>DSS-34</antennaRef>
                <constraintType>preferred</constraintType>
              </antenna>
            </antennaConstraints>
          </spaceCommunicationServiceRequest>
        </serviceScenario>
      </spaceLinkSessionServicePackageRequest>
    </createServicePackageRequest>
  </createServicePackageInvocation>
</SmMessageSet>
```
In this scenario, it is validated by the CM, which determines that the required antenna, ‘DSS-34’ is not available given the acquisition parameters of the request. Subsequently, the CM denies the invocation message and produces a CreateServicePackageFailedReturn return message:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<SmMessageSet xmlns="urn:ccsds:recommendation:service_management:schema:sccs:R1.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <sccsSmVersionRef>1.0.0</sccsSmVersionRef>
    <smSource>CSSXP</smSource>
    <smDestination>Interop.Red3.ESOC.ESA</smDestination>
    <serviceAgreementRef>ESOC.ESA:JPL.NASA:Red3:InteropTest-01</serviceAgreementRef>
    <createServicePackageFailedReturn>
        <messageSequenceNumber>8765</messageSequenceNumber>
        <messageTimestamp>2009-04-06T17:34:15Z</messageTimestamp>
        <invocationMessageSequenceNumber>2367</invocationMessageSequenceNumber>
        <cspDenial>
            <deniedItem>
                /SmMessageSet/createServicePackageInvocation/createServicePackageRequest/spaceLinkSessionServicePackageRequest/serviceScenario/spaceCommunicationServiceRequest/antennaConstraints/antenna/antennaRef
            </deniedItem>
            <reason>resource(s) not available</reason>
        </cspDenial>
        <servicePackageRef>SP-71-1</servicePackageRef>
    </createServicePackageFailedReturn>
</SmMessageSet>
```

The value of deniedItem is a valid XPath format, which identifies the antennaRef of the invocation message. Here is the XPath for closer inspection:

```xml
/SmMessageSet/createServicePackageInvocation/createServicePackageRequest/spaceLinkSessionServicePackageRequest/serviceScenario/spaceCommunicationServiceRequest/antennaConstraints/antenna/antennaRef
```

There are various ways of expressing this path. The specification does not make any preference as to how the XPath is expressed, but the XPath shall be valid and unambiguous to the reader or parser.
ANNEX A

ACRONYMS AND ABBREVIATIONS

ANSLEP* APPLY_NEW_SPACE_LINK_EVENTS_PROFILE
AOS Advanced Orbiting Systems
ARTSP* ADD_RETRIEVAL_TRANSFER_SERVICE_PROFILE
ASCSP* ADD_SPACE_COMMUNICATION_SERVICE_PROFILE
ASLEP* ADD_SPACE_LINK_EVENTS_PROFILE
ASTSP* ADD_SLS_TRANSFER_SERVICE_PROFILE
ANT* APPLY_NEW_TRAJECTORY
ATP* ADD_TRAJECTORY_PREDICTION
BPSK binary phase shift key
CLCW communications link control word
CLTU communications link transmission unit
CM complex management
CMM carrier modulation mode
CSP* CREATE_SERVICE_PACKAGE
CTSP* CONFIRM_TENTATIVE_SERVICE_PACKAGE
CSTS Cross Support Transfer Services
dBW decibels referenced to one watt
DSCSP* DELETE_SPACE_COMMUNICATION_SERVICE_PROFILE
DSLEP* DELETE_SPACE_LINK_EVENTS_PROFILE
DSP* DELETE_SERVICE_PACKAGE
DTP* DELETE_TRAJECTORY_PREDICTION
DTSP* DELETE_TRANSFER_SERVICE_PROFILE
EIRP equivalent (or effective) isotropic radiated power
ETP* EXTEND_TRAJECTORY_PREDICTION
FCLTU forward communications link transmission unit
FSP forward space packet
GMSK Gaussian Minimum Shift Key
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTTP</td>
<td>hypertext transfer protocol</td>
</tr>
<tr>
<td>LCP</td>
<td>left-hand circular polarization</td>
</tr>
<tr>
<td>MDOS</td>
<td>mission data operations system</td>
</tr>
<tr>
<td>NRZ-L</td>
<td>non-return to zero-level</td>
</tr>
<tr>
<td>NRZ-M</td>
<td>non-return to zero-mark</td>
</tr>
<tr>
<td>OASIS</td>
<td>Organization for the Advancement of Structured Information Standards</td>
</tr>
<tr>
<td>ODM</td>
<td>orbit data message</td>
</tr>
<tr>
<td>OEM</td>
<td>orbit ephemeris message</td>
</tr>
<tr>
<td>OMG</td>
<td>Object Management Group</td>
</tr>
<tr>
<td>OPM</td>
<td>orbit parameter message</td>
</tr>
<tr>
<td>OQPSK</td>
<td>offset quaternary/quadrature/quadra phase shift key</td>
</tr>
<tr>
<td>PCM</td>
<td>Pulse Code Modulation</td>
</tr>
<tr>
<td>PDU</td>
<td>protocol data unit</td>
</tr>
<tr>
<td>PKI</td>
<td>Public Key Infrastructure</td>
</tr>
<tr>
<td>PLOP</td>
<td>Physical Layer Operations Procedure</td>
</tr>
<tr>
<td>PM</td>
<td>Phase Modulation</td>
</tr>
<tr>
<td>PSAT</td>
<td>Predicted Site Acquisition Tables</td>
</tr>
<tr>
<td>PSK</td>
<td>Phase Shift Key</td>
</tr>
<tr>
<td>QPSK</td>
<td>quaternary/quadrature/quadra phase shift key</td>
</tr>
<tr>
<td>QSA</td>
<td>QUERY_SERVICE_AGREEMENT</td>
</tr>
<tr>
<td>QSCSP</td>
<td>QUERY_SPACE_COMMUNICATION_SERVICE_PROFILE</td>
</tr>
<tr>
<td>QSLEP</td>
<td>QUERY_SPACE_LINK_EVENTS_PROFILE</td>
</tr>
<tr>
<td>QSP</td>
<td>QUERY_SERVICE_PACKAGE</td>
</tr>
<tr>
<td>QTP</td>
<td>QUERY_TRAJECTORY_PREDICTION</td>
</tr>
<tr>
<td>QTSP</td>
<td>QUERY_TRANSFER_SERVICE_PROFILE</td>
</tr>
<tr>
<td>RAF</td>
<td>return all frames</td>
</tr>
<tr>
<td>RCF</td>
<td>return channel frames</td>
</tr>
<tr>
<td>RCP</td>
<td>right-hand circular polarization</td>
</tr>
<tr>
<td>RF</td>
<td>radio frequency</td>
</tr>
<tr>
<td>ROCF</td>
<td>return operations control field</td>
</tr>
<tr>
<td>RSP</td>
<td>REPLACE_SERVICE_PACKAGE</td>
</tr>
<tr>
<td>SAS</td>
<td>SELECT_ALTERNATE_SCENARIO</td>
</tr>
<tr>
<td>Acronyms</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>SCCS</td>
<td>Space Communication Cross Support</td>
</tr>
<tr>
<td>SCET</td>
<td>spacecraft event time</td>
</tr>
<tr>
<td>SDU</td>
<td>service data unit</td>
</tr>
<tr>
<td>SLE</td>
<td>space link extension</td>
</tr>
<tr>
<td>SLS</td>
<td>Space Link Session</td>
</tr>
<tr>
<td>SM</td>
<td>service management</td>
</tr>
<tr>
<td>SMTP</td>
<td>simple mail transport protocol</td>
</tr>
<tr>
<td>SOA</td>
<td>Service Oriented Architecture</td>
</tr>
<tr>
<td>SOAP</td>
<td>simple object access protocol</td>
</tr>
<tr>
<td>SP</td>
<td>Service Package</td>
</tr>
<tr>
<td>SPC</td>
<td>SERVICE_PACKAGE_CANCELED</td>
</tr>
<tr>
<td>SPM</td>
<td>SERVICE_PACKAGE_MODIFIED</td>
</tr>
<tr>
<td>TC</td>
<td>Telecommand</td>
</tr>
<tr>
<td>TCP</td>
<td>transmission control protocol</td>
</tr>
<tr>
<td>URL</td>
<td>uniform resource locator</td>
</tr>
<tr>
<td>TM</td>
<td>Telemetry</td>
</tr>
<tr>
<td>TP</td>
<td>Trajectory Prediction</td>
</tr>
<tr>
<td>TT&amp;C</td>
<td>tracking, telemetry, and command</td>
</tr>
<tr>
<td>UM</td>
<td>utilization management</td>
</tr>
<tr>
<td>UML</td>
<td>unified modeling language</td>
</tr>
<tr>
<td>UQPSK</td>
<td>unbalanced quaternary/quadrature/quadra phase shift key</td>
</tr>
<tr>
<td>URL</td>
<td>uniform resource locator</td>
</tr>
<tr>
<td>UTC</td>
<td>coordinated universal time</td>
</tr>
<tr>
<td>W3C</td>
<td>World Wide Web Consortium</td>
</tr>
<tr>
<td>XKMS</td>
<td>XML Key Management Specification</td>
</tr>
<tr>
<td>XML</td>
<td>extensible markup language</td>
</tr>
</tbody>
</table>

* Acronyms for SCCS-SM operations may appear with one of the following suffixes:

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR</td>
<td>Acknowledged Return</td>
</tr>
<tr>
<td>C</td>
<td>Confirmation</td>
</tr>
<tr>
<td>C</td>
<td>CM – indicates a requirement for CM</td>
</tr>
<tr>
<td>D</td>
<td>Data; indicates a Data Set Composition and Relationship requirement</td>
</tr>
</tbody>
</table>
FR       Failed Return
I        Invocation
N        Notification
SR       Successful Return
U        UM – indicates a requirement for UM
ANNEX B

MAPPING OF SCCS SERVICE MANAGEMENT PARAMETERS TO SLE TRANSFER SERVICE INSTANCE CONFIGURATION PARAMETERS

B1 INTRODUCTION

The purpose of this annex is to establish the mapping from the SCCS Service Management parameters to the SLE service instance configuration parameters. The service instance configuration parameters are defined in the CCSDS Recommended Standards for each service type (references [9], [10], and [12]).

The values for the service instance configuration parameters are available from the SCCS Service Management data sets after the appropriate data exchange between UM and CM has taken place.

A table is presented for each SLE service type supported by SCCS Service Management, as defined in this document. The parameter definitions, data types and units are specified in the CCSDS Recommended Standards (references [9], [10], and [12]), and not repeated here to avoid duplication and inconsistencies.

In addition to that, it is important to note that the detailed content, structure and format of the configuration database that contains the service instance configuration parameters are implementation-specific and must be documented for an implementation together with the procedures for entry and update of configuration parameters.

The SLE Data Transfer Services specification does not prescribe how the database is created and how it is accessed. The configuration database can consist of a simple text file or a set of files, or it can be distributed to one or more directory systems or management information databases.

B2 SERVICE INSTANCE PARAMETERS

B2.1 GENERAL

The service instance parameters are presented in the tables below and include:

a) Service instance configuration parameters, as identified in table 3-1 of the respective SLE transfer service specification.

b) Allowed values for BIND operation parameters.

c) Further service instance configuration parameters, not directly defined in table 3-1 of the respective SLE transfer service specification (references [9], [10], and [12]), but
identified elsewhere in the service specification as being configured by Service Management.

d) Cross-reference to the applicable table(s) in reference [3].

**B2.2 RAF SERVICE**

<table>
<thead>
<tr>
<th>Name</th>
<th>Applicable Service Parameter(s)</th>
<th>Cross-reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>delivery-mode</td>
<td>‘timelyOnline’ and ‘completeOnline’ values for onlineDeliveryMode in RafTransferServiceProfile data set, offline inherent in OfflineRafTsProfile data set</td>
<td>Table 5-81</td>
<td>The RafTransferServiceProfile data set is used only for online service instances, and the OfflineRafTsProfile data set is used only for offline service instances.</td>
</tr>
<tr>
<td>latency-limit</td>
<td>latencyLimit in RafTransferServiceProfile data set</td>
<td>Table 5-81</td>
<td>parameter maxDataRateLimitation constrains the allowed values for parameter dataRateLimitation</td>
</tr>
<tr>
<td>maximum-delivery-rate</td>
<td>dataRateLimitation in RafTransferServiceProfile data set maxDataRateLimitation in TransferServiceAgreement data set</td>
<td>Table 5-81, 7-47</td>
<td>parameter upperBoundReportingPeriod constrains the allowed values for parameter reporting-cycle in the RAF-SCHEDULE-STATUS-REPORT operation; parameter upperBoundReportingPeriod, in turn, is constrained by parameter maxUpperBoundReportingPeriod</td>
</tr>
<tr>
<td>maximum-reporting-cycle</td>
<td>upperBoundReportingPeriod in RafTransferServiceProfile data set maxUpperBoundReportingPeriod in TransferServiceAgreement data set</td>
<td>Table 5-81, 7-47</td>
<td>parameter lowerBoundReportingPeriod constrains the allowed values for parameter reporting-cycle in the RAF-SCHEDULE-STATUS-REPORT operation; parameter lowerBoundReportingPeriod, in turn, is constrained by parameter minLowerBoundReportingPeriod</td>
</tr>
<tr>
<td>minimum-reporting-cycle</td>
<td>lowerBoundReportingPeriod in RafTransferServiceProfile data set minLowerBoundReportingPeriod in TransferServiceAgreement data set</td>
<td>Table 5-81, 7-47</td>
<td>parameter permittedFrameQualities constrains the allowed values for parameter requested-frame-quality-set</td>
</tr>
<tr>
<td>permitted-frame-quality-set</td>
<td>permittedFrameQualities in RafTransferServiceProfile data set</td>
<td>Table 5-81</td>
<td>parameter permittedFrameQualities constrains the allowed values for parameter requested-frame-quality-set</td>
</tr>
<tr>
<td>Name</td>
<td>Applicable Service Management Parameter(s)</td>
<td>Cross-reference</td>
<td>Notes</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------</td>
<td>----------------</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td>return-timeout-period</td>
<td>returnTimeoutPeriod in Raf-TransferServiceProfile data set</td>
<td>Table 5-81</td>
<td>quality in the RAF-START operation</td>
</tr>
<tr>
<td>service-instance-provision-period</td>
<td>scheduledServiceInstance-StartTime and scheduled-ServiceInstanceStopTime in SlsTsInstanceResult data set</td>
<td>Table 4-23</td>
<td></td>
</tr>
<tr>
<td>service-version-number</td>
<td>currentTsVersion in Raf-TransferServiceProfile data set</td>
<td>Table 5-81</td>
<td></td>
</tr>
<tr>
<td>transfer-buffer-size</td>
<td>transferBufferSize in Raf-TransferServiceProfile data set</td>
<td>Table 5-81</td>
<td></td>
</tr>
</tbody>
</table>

**Table B-2: RAF-BIND Operation Parameters**

<table>
<thead>
<tr>
<th>Name</th>
<th>Applicable Service Management Parameter(s)</th>
<th>Cross-reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>initiator-identifier</td>
<td>userId in SlsTsInstanceResult data set</td>
<td>Table 4-23</td>
<td>Service Management currently does not support the provision of authentication information</td>
</tr>
<tr>
<td>Invoker-credentials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>performer-credentials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>responder-identifier</td>
<td>providerId in SlsTsInstanceResult data set</td>
<td>Table 4-23</td>
<td>Service Management currently does not support the provision of authentication information</td>
</tr>
<tr>
<td>responder-port-identifier</td>
<td>providerPortId in SlsTsInstanceResult data set</td>
<td>Table 4-23</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Applicable Service Management Parameter(s)</td>
<td>Cross-reference</td>
<td>Notes</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------------------------------------------------------------------------------------------------</td>
<td>-----------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| service-instance-identifier | -  `sagr = value of serviceAgreementRef`  
-  `spack = value of servicePackageRef`  
-  `rsl-fg = value of functionalGroupId`  
-  `raf =`  
  •  `onlc` plus value of transferService-InstanceNumber, if onlineDeliveryMode = 'completeOnline',  
  •  `onlt` plus value of transferServiceInstance-Number, if onlineDeliveryMode = 'timelyOnline' | Table 3-4, 4-17, 5-94, 5-81 | The service-instance-identifier has the following format:  
`sagr=xyz.spack=abc.rsl-fg=mno.raf=onlc2'  
The column on the left defines the applicable Service Management parameter(s) for each field that composes the service instance identifier.  
-  `serviceAgreementRef` belongs to SmMessageSet data set  
-  `servicePackageRef` belongs to Service-PackageReference data set  
-  `functionalGroupId` belongs to the RafTransferServiceProfile data set if online or OfflineRafTsProfile data set if offline  
-  `transferService-InstanceNumber` belongs to SlsTsInstanceResult data set  
-  `onlineDeliveryMode` belongs to RafTransferServiceProfile data set |
| service-type         |                                                                                                           | Table 5-81      | The service type is derived from the data set type; e.g., RafTransferServiceProfile data set represents the service-type value of 'Rtn All Frames' |
| version-number       |  `currentTsVersion` in RafTransferServiceProfile data set                                                | Table 5-81      |                                                                                                                                 |
Table B-3: Further RAF Service Instance Configuration Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Applicable Service Management Parameter(s)</th>
<th>Cross-reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>bind initiator</td>
<td>-</td>
<td>-</td>
<td>Although the RAF specification allows either the user or the provider to initiate the association, all existing implementations of the RAF service are limited to user initiation. Therefore, Service Management currently only supports user initiation, by default</td>
</tr>
<tr>
<td>size of online frame buffer</td>
<td>rOnlineFrameBufferSize in TransferServiceAgreement data set</td>
<td>Table 7-47</td>
<td></td>
</tr>
<tr>
<td>number of frames to be discarded in case the online frame buffer gets full</td>
<td>rOnlineFrameBufferOverflow-DiscardNumber in TransferServiceAgreement data set</td>
<td>Table 7-47</td>
<td></td>
</tr>
</tbody>
</table>
## B2.3 RCF SERVICE

### Table B-4: RCF Service Configuration Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Applicable Service Management Parameter(s)</th>
<th>Cross-reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>delivery-mode</td>
<td>‘timelyOnline’ and ‘completeOnline’ values for onlineDeliveryMode in RcfTransferServiceProfile data set, offline inherent in OfflineRcfTsProfile data set</td>
<td>Table 5-82</td>
<td>The RcfTransferServiceProfile data set is used only for online service instances, and the OfflineRcfTsProfile data set is used only for offline service instances.</td>
</tr>
<tr>
<td>latency-limit</td>
<td>latencyLimit in RcfTransferServiceProfile data set</td>
<td>Table 5-82</td>
<td>parameter maxDataRateLimitation constrains the allowed values for parameter dataRateLimitation</td>
</tr>
<tr>
<td>maximum-delivery-rate</td>
<td>dataRateLimitation in RcfTransferServiceProfile data set maxDataRateLimitation in TransferServiceAgreement data set</td>
<td>Table 5-82, 7-47</td>
<td>parameter maxUpperBoundReportingPeriod constrains the allowed values for parameter reporting-cycle in the RCF-SCHEDULE-STATUS-REPORT operation; parameter upperBoundReportingPeriod, in turn, is constrained by parameter maxUpperBoundReportingPeriod</td>
</tr>
<tr>
<td>maximum-reporting-cycle</td>
<td>upperBoundReportingPeriod in RcfTransferServiceProfile data set maxUpperBoundReportingPeriod in TransferServiceAgreement data set</td>
<td>Table 5-82, 7-47</td>
<td>parameter lowerBoundReportingPeriod constrains the allowed values for parameter reporting-cycle in the RCF-SCHEDULE-STATUS-REPORT operation; parameter lowerBoundReportingPeriod, in turn, is constrained by parameter minLowerBoundReportingPeriod</td>
</tr>
<tr>
<td>minimum-reporting-cycle</td>
<td>lowerBoundReportingPeriod in RcfTransferServiceProfile data set minLowerBoundReportingPeriod in TransferServiceAgreement data set</td>
<td>Table 5-82, 7-47</td>
<td>parameter permittedGlobalVcidSet constrains the allowed values for parameter requested-global-VCID in the RCF-START operation</td>
</tr>
<tr>
<td>permitted-global-VCID-set</td>
<td>permittedGlobalVcidSet in RcfTransferServiceProfile data set</td>
<td>Table 5-82</td>
<td>parameter permittedGlobalVcidSet in RcfTransferServiceProfile data set</td>
</tr>
<tr>
<td>return-timeout-period</td>
<td>returnTimeoutPeriod in RcfTransferServiceProfile data set</td>
<td>Table 5-82</td>
<td></td>
</tr>
<tr>
<td>service-instance-provision-period</td>
<td>scheduledServiceInstanceStartTime and scheduledServiceInstanceStopTime</td>
<td>Table 4-23</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Applicable Service Management Parameter(s)</td>
<td>Cross-reference</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------------------------</td>
<td>-----------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>service-version-number</td>
<td>currentTsVersion in Rcf-TransferServiceProfile data set</td>
<td></td>
<td></td>
</tr>
<tr>
<td>transfer-buffer-size</td>
<td>transferBufferSize in Rcf-TransferServiceProfile data set</td>
<td></td>
<td></td>
</tr>
<tr>
<td>initiator-identifier</td>
<td>userId in SlsTsInstanceResult data set</td>
<td>Table 4-23</td>
<td></td>
</tr>
<tr>
<td>invoker-credentials</td>
<td>-</td>
<td>-</td>
<td>Service Management currently does not support the provision of authentication information</td>
</tr>
<tr>
<td>performer-credentials</td>
<td>-</td>
<td>-</td>
<td>Service Management currently does not support the provision of authentication information</td>
</tr>
<tr>
<td>responder-identifier</td>
<td>providerId in SlsTsInstanceResult data set</td>
<td>Table 4-23</td>
<td></td>
</tr>
<tr>
<td>responder-port-identifier</td>
<td>providerPortId in SlsTsInstanceResult data set</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Applicable Service Management Parameter</td>
<td>Cross-reference</td>
<td>Notes</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------------</td>
<td>-----------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| service-instance-identifier | – sagr = value of serviceAgreementRef   | Table 3-4, 4-17, 5-94, 5-81 | The service-instance-identifier has the following format: “sagr=xyz.spack=abc.rsl-fg=mno.rcf=onlc2” The column on the left defines the applicable Service Management parameter(s) for each field that composes the service instance identifier.  
  - serviceAgreementRef belongs to SmMessageSet data set  
  - servicePackageRef belongs to ServicePackageReference data set  
  - functionalGroupId belongs to the RcfTransferServiceProfile data set if online or OfflineRafTsProfile data set if offline  
  - transferServiceInstanceNumber belongs to SlsTsInstanceResult data set  
  - onlineDeliveryMode belongs to RcfTransferServiceProfile data set |
<p>| service-type                | -                                       | Table 5-82      | The service type is derived from the data set type; i.e., RcfTransferServiceProfile data set represents the service-type value of ‘Rtn Ch Frames’ |
| version-number              | currentTsVersion in RcfTransferServiceProfile data set | Table 5-82      |                                                                                                                                       |</p>
<table>
<thead>
<tr>
<th>Name</th>
<th>Applicable Service Management Parameter</th>
<th>Cross-reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>bind initiator</td>
<td>-</td>
<td>-</td>
<td>Although the RCF specification allows either the user or the provider to initiate the association, all existing implementations of the RCF service are limited to user initiation. Therefore, Service Management currently only supports user initiation, by default</td>
</tr>
<tr>
<td>size of online frame buffer</td>
<td>rOnlineFrameBufferSize in TransferServiceAgreement data set</td>
<td>Table 7-47</td>
<td></td>
</tr>
<tr>
<td>number of frames to be discarded in case the online frame buffer gets full</td>
<td>rOnlineFrameBufferOverflow-DiscardNumber in TransferServiceAgreement data set</td>
<td>Table 7-47</td>
<td></td>
</tr>
</tbody>
</table>
### B2.4 CLTU SERVICE

#### Table B-7: CLTU Service Configuration Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Applicable Service Management Parameter(s)</th>
<th>Cross-reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>acquisition-sequence-length</td>
<td>acquisitionSequenceLength in <strong>FTcModulationProdAgreement</strong> data set</td>
<td>Table 7-35</td>
<td></td>
</tr>
<tr>
<td>bit-lock-required</td>
<td>bitLockConfirmationRequired in <strong>FcltuProdAgreement</strong> data set</td>
<td>Table 7-36</td>
<td>This parameter was added to the set of FCLTU parameters to be controlled by Service Management in the version of the FCLTU Blue Book that appeared after the publication of the current (version 1) SCCS-SM service specification, resulting in names that are notably different.</td>
</tr>
<tr>
<td>clcw-global-VCID</td>
<td>reportingChannelId parameter in the <strong>FcltuProdAgreement</strong> data set.</td>
<td>Table 7-36</td>
<td>This parameter was added to the set of FCLTU parameters to be controlled by Service Management in the version of the FCLTU Blue Book that appeared after the publication of the current (version 1) SCCS-SM service specification.</td>
</tr>
<tr>
<td>clcw-physical-channel</td>
<td>Not explicitly represented by a data set parameter of the version 1 SCCS-SM. It must be specified in a document that is referenced by the <code>contractualReference</code> parameter of the <strong>ServiceAgreement</strong> data set.</td>
<td>Table 7-3</td>
<td>This parameter was added to the set of FCLTU parameters to be controlled by Service Management in the version of the FCLTU Blue Book that appeared after the publication of the current (version 1) SCCS-SM service specification.</td>
</tr>
<tr>
<td>delivery-mode</td>
<td>-</td>
<td>-</td>
<td>The F-CLTU service is provided only in the online delivery mode, as defined in reference [1].</td>
</tr>
<tr>
<td>maximum-cltu-length</td>
<td>maxLengthCltu in <strong>FcltuProdAgreement</strong> data set</td>
<td>Table 7-36</td>
<td></td>
</tr>
<tr>
<td>maximum-reporting-cycle</td>
<td>upperBoundReportingPeriod in <strong>FcltuTransferService-Profile</strong> data set</td>
<td>Table 5-80, 7-47</td>
<td>parameter <code>upperBound-ReportingPeriod</code> constrains the allowed values for parameter <code>reporting-cycle</code> in the <strong>FCLTU-SCHEDULE-STATUS-REPORT</strong> operation; parameter <code>upperBoundReportingPeriod</code>, in turn, is constrained by parameter <code>maxUpperBoundReportingPeriod</code>.</td>
</tr>
<tr>
<td>minimum-delay-time</td>
<td>minDelayTime in <strong>FcltuProdAgreement</strong> data set</td>
<td>Table 7-36</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Applicable Service Management Parameter(s)</td>
<td>Cross-reference</td>
<td>Notes</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------</td>
<td>-----------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>minimum-reporting-cycle</td>
<td>lowerBoundReportingPeriod in RcfTransferServiceProfile data set</td>
<td>Table 5-80,</td>
<td>parameter lowerBoundReportingPeriod constrains the allowed values for parameter reporting-cycle in the RCF-SCHEDULE-STATUS-REPORT operation; parameter lowerBoundReportingPeriod, in turn, is constrained by parameter minLowerBoundReportingPeriod</td>
</tr>
<tr>
<td></td>
<td>minLowerBoundReportingPeriod in TransferServiceAgreement data set</td>
<td>7-47</td>
<td></td>
</tr>
<tr>
<td>modulation-frequency</td>
<td>fSubcarrierFrequency in F401SpaceLinkCarrier data set</td>
<td>Table 5-7</td>
<td></td>
</tr>
<tr>
<td>modulation-index</td>
<td>modulationIndex in F401SpaceLinkCarrier data set</td>
<td>Table 5-7</td>
<td></td>
</tr>
<tr>
<td>notification-mode</td>
<td>notificationMode in FcltuTransferServiceProfile data set</td>
<td>Table 5-80,</td>
<td>Optional parameter (see annex G of reference [12])</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7-47</td>
<td></td>
</tr>
<tr>
<td>plop-1-idle-sequence-length</td>
<td>plopOneIdleSequenceLength in FTcModulationProdAgreement data set.</td>
<td>Table 7-35.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>plop-in-effect</td>
<td>plopInEffect in FTcModulationProdAgreement data set</td>
<td>Table 7-35.</td>
<td></td>
</tr>
<tr>
<td>protocol-abort-mode</td>
<td>protocolAbortMode in FcltuProdAgreement data set</td>
<td>Table 7-36</td>
<td></td>
</tr>
<tr>
<td>return-timeout-period</td>
<td>returnTimeoutPeriod in FcltuTransferServiceProfile data set</td>
<td>Table 5-80</td>
<td></td>
</tr>
<tr>
<td>rf-available-required</td>
<td>rfAvailabilityConfirmation Required in FcltuProdAgreement data set</td>
<td>Table 7-36</td>
<td></td>
</tr>
<tr>
<td>service-instance-provision-period</td>
<td>scheduledServiceInstanceStartTime and scheduledServiceInstanceStopTime parameters in SlsTsInstanceResult data set</td>
<td>Table 4-23</td>
<td></td>
</tr>
<tr>
<td>service-version-number</td>
<td>currentTsVersion in FcltuTransferServiceProfile data set</td>
<td>Table 5-80</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Applicable Service Management Parameter(s)</td>
<td>Cross-reference</td>
<td>Notes</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>subcarrier-to-bit-rate-ratio</td>
<td>The subcarrier frequency is given by rSubcarrierFrequency in F401SpaceLinkCarrier data set. The uplink data rate can be calculated from the symbolRate in F401SymbolStream data set according to the coding scheme.</td>
<td>Table 5-7</td>
<td>Defined as the ratio of the subcarrier frequency to the uplink data rate (i.e., the bit rate)</td>
</tr>
</tbody>
</table>
Table B-8: CLTU-BIND Operation Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Applicable Service Management Parameter</th>
<th>Cross-reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>initiator-identifier</td>
<td>userId</td>
<td></td>
<td>Table 4-23</td>
</tr>
<tr>
<td>invoker-credentials</td>
<td>-</td>
<td></td>
<td>Service Management currently does not support the provision of authentication information</td>
</tr>
<tr>
<td>performer-credentials</td>
<td>-</td>
<td></td>
<td>Service Management currently does not support the provision of authentication information</td>
</tr>
<tr>
<td>responder-identifier</td>
<td>providerId in SlsTsInstanceResult data set</td>
<td></td>
<td>Table 4-23</td>
</tr>
<tr>
<td>responder-port-identifier</td>
<td>providerPortId in SlsTsInstanceResult data set</td>
<td></td>
<td>Table 4-23</td>
</tr>
</tbody>
</table>
| service-instance-identifier | -                                     |                 | The service-instance-identifier has the following format:  
|                        |  
|                        |  
|                        |  
|                        |  
|                        |  
|                        |  
|                        |  
|                        |  
|                        |  
|                        |  
|                        |  
|                        |  
| service-type           | -                                      |                 | The service type is derived from the data set type; i.e., FcltuTransferServiceProfile data set represents the service-type value of ‘fwdCltu’ |
| version-number         | currentTsVersion in FcltuTransferServiceProfile data set |                 | Table 5-7                                                                                 |
### Table B-9: Further CLTU Service Instance Configuration Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Applicable Service Management Parameter</th>
<th>Cross-reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>event-identifier</td>
<td>allowedThrowEventIdentifiers in TransferServiceAgreement data set</td>
<td>Table 7-47</td>
<td>parameter allowedThrowEventIdentifiers constrains the allowed values for parameter event-identifier in the CLTU-THROW-EVENT operation</td>
</tr>
</tbody>
</table>
ANNEX C

UML 2.0 USAGE IN THIS REPORT

C1 OVERVIEW

This Informational Report includes Unified Modeling Language (UML) class diagrams that follow the notation, semantics and conventions imposed by the Version 2.0 UML specification of the Object Management Group (OMG). This annex briefly explains the main conventions used; for further information, large amount of dedicated literature is widely available.

C2 CLASS DIAGRAM

C2.1 GENERAL

A UML class diagram describes the structure of a message; its parts; and how those parts interrelate. A UML class, represented in the diagram as a box, represents a data set. Class diagram conventions include composition, generalization, multiplicity and constraints. Enumeration notation is also used but only when it is involved in a composition constraint.

C2.2 CLASS DIAGRAM EXAMPLE

Figure C-1 demonstrates the UML conventions that are used in the class diagrams in the service specification and in this Informational Report. This Informational Report uses only a subset of the UML class diagram conventions that are depicted.
Figure C-1: UML Class Diagram Example

C3 ACTIVITY DIAGRAM

C3.1 GENERAL

A UML activity diagram describes the possible actions that can take place given the flow of an invocation message of an operation procedure document exchange pattern. Activity diagram conventions include partitions to show whether UM or CM is responsible for the action, forks/joins to show parallel activity, guards and decisions/merges to guide flow, and pins to show parameterization of an action. The parameter pins are used in the definition of a stereotype or an activity group.
C3.2 ACTIVITY DIAGRAM EXAMPLES

The following diagrams demonstrate the UML conventions used in the activity diagrams.

Activity Diagram 1 is illustrated in figure C-2. It shows the notion of ‘swim lanes’ and the lower-level graphical constructs used throughout the activity diagrams in the specification.

Activity Diagram 2 is illustrated in figure C-3. It is an example of an activity diagram that ‘calls’ or utilizes another of the detailed activities stated in another activity diagram. This technique is used to factor out commonly recurring activities in the specification such that they do not have to be repeated in detail in addressing higher-level activity flows.
Activity Diagram 3 is illustrated in figure C-4. It is an example of an activity diagram that is utilized or ‘called’ from another activity. As the intention is to have it utilized for multiple higher-level activities, it is parameterized. This example also identifies other graphical constructs used in the specification (such as ‘Parameter Pins’, etc.).
C4  SEQUENCE DIAGRAM

C4.1  GENERAL

Sequence diagrams focus on message interactions between the UM and CM, clearly showing which messages are sent and who sends them. They describe the document exchange in a nominal scenario and use interaction frames to show conditional sequencing of messages, i.e., other scenarios.

C4.2  SEQUENCE DIAGRAM EXAMPLE

Figure C-5 demonstrates the UML conventions used in the sequence diagrams.

UML provides a convention for specifying asynchronous and synchronous messages using variations in arrowheads. All messages in the specification of an operation are asynchronous, and thus all sequence diagrams will use the open arrowhead per the convention specified in the UML 2.0 specification.
Lifetime - represents a participant in the complete interaction, indicating either the source or destination of a message.

Interaction Frame - 'alt' - only one fragment will execute based on the guard of each fragment. Additional interaction frames include 'loop' and 'ref'. A 'loop' frame will execute multiple times based on the conditions stated in the associated guard.

Message - represents communication between lifelines e.g. a request.

Guard - states a condition for the sequence included in the relevant frame or fragment to execute.

Interaction Frame - 'ref' - frame refers to a previously defined sequence, called 'ReturnChange'.

Parameters of this re-usable sequence. Drink and money are variables that will determine what is return as change.

This frame defines a parameterized and re-usable sequence. The name of the sequence is 'ReturnChange' and has two parameters.

Figure C-5: Sequence Diagram Example
C5 STATE MACHINE DIAGRAM

C5.1 GENERAL

State machine diagrams show the dynamic behavior of an entity based on its response to events, showing how the entity reacts to events depending on its state. They can specify the behavior of an interaction from the point of view of one partner in the interaction. When the focus is on the dialogue between UM and CM, separate state machines show the behavior at either end. When the focus is on the life cycle of an information entity managed by CM in response to interaction with UM, then the states of that entity are shown as seen by CM.

C5.2 STATE MACHINE DIAGRAM EXAMPLE

The following diagrams demonstrate the UML conventions used in the state machine diagrams.

Figure C-6 shows the same events have different effects depending on the state they arrive in, and possibly on ‘guard conditions’. For example, if the customer selects a drink before inserting enough money to pay for it, the machine transitions to the ‘Selected’ state, whereas if enough money has already been inserted, the machine immediately starts dispensing.

An event may cause a return to the same state, shown as an arrow returning to the state it starts from.

![State Machine Diagram Example 1](image-url)

**Figure C-6: State Machine Diagram Example 1**
The ‘Dispensing’ state is a composite state: it has a number of substates. It is shown in detail in figure C-7.

![State Machine Diagram Example 2]

**Figure C-7: State Machine Diagram Example 2**

If more money is inserted when the machine is already dispensing, it will go on with whatever it was already doing. This is shown by the ‘history’ pseudo-state (the ‘H’ in a circle), which means ‘return to the substate that the machine was in when it last left this state’

**C6 STEREOTYPES**

Common patterns in the specification are expressed as stereotypes. Stereotypes are defined using the UML stereotype conventions, which define the pattern, identify where context
specific data apply, and provide a name for the stereotype. UML stereotype conventions are also used to handle the application of a defined stereotype. When a stereotype is applied to a model element, which could be a sequence, activity or data set in the specification, the element is referred to as an instance of the stereotype. Structurally, the element is extending that stereotype, i.e., using the pattern and adding traits and/or behavior to it. The typographical conventions for stereotypes and their usage are listed in 1.8.2.7.
ANNEX D

SERVICE MANAGEMENT DOCUMENT EXCHANGE

D1 OVERVIEW

This annex provides more-detailed descriptions of the step-by-step interactions involved in the Document Exchange Protocol and in the operation procedure patterns that employ the Document Exchange Protocol.

D2 SM DOCUMENT EXCHANGE PROTOCOL

D2.1 GENERAL

In order to ensure that related messages are transferred across the SM interface with their intended sequencing preserved regardless of the underlying communication service, the SM document exchange protocol is used to exchange SM documents between SM entities (i.e., UM and CM). There are two major categories of SM documents: the message set and the exception response.

The message set carries the SM operation messages that are exchanged by UM and CM. A message set contains operation invocation, return, notification, or confirmation messages. In the case of invocations, multiple invocations may be contained within a single message set (hence the set) in order to preserve the sequential ordering among related invocation messages that are intended to be processed by the receiver in a specific order (e.g., a new Space Communication Service Profile has to have been processed before any Service Packages can reference it), even though the underlying delivery mechanism does not guarantee sequence preservation. Message sets are exchanged between communicating SM entities via the SM message set ports of those entities.

An exception response is generated in response to a document that is received as a purported message set but which cannot be interpreted as a valid and authentic message set, or in response to an invocation or notification message contained in a message set that cannot be submitted to the target service management operation. Exception responses of the first kind are UnrecognizedMessageSetResponses; those of the second kind are Invalid-InvocationResponses and InvalidNotificationResponses, respectively. Exception responses are exchanged between communicating SM entities via the SM exception response ports of those entities.

Figure D-1 illustrates the exchange of message sets and exception responses between the port pairs of the Sender and Receiver, where in this particular example UM is the Sender and CM is the Receiver.
The SM document exchange protocol is described in terms of transmitting an SM message set from a Sender to a Receiver. On the occurrence of certain exception conditions, the Receiver sends exception responses back to the Sender.

The following subsections describe the Sender and Receiver activities involved in the execution of the SM document exchange protocol.

### D2.2 SENDER GENERATES MESSAGE SET

The execution of the SM document exchange protocol begins with a Sender generating an SmMessageSet containing one or more SM messages, and sending the message set to the SM message set port of the intended Receiver.

The messages carried by an SmMessageSet generated by a Sender are:

- one or more invocation messages that are used to invoke the various SM operations;
- a single return message that reports the status, outcome, or product of an operation;
- a single notification message that informs of the occurrence of a non-routine event; or
- a single confirmation message that confirms receipt of a notification.

Each message in a message set is given a messageSequenceNumber. For invocation messages within the same message set, the messageSequenceNumber indicates the order in which the messages are to be processed by the Receiver within that message set. A Sender application process that requires invocation messages to be processed by the Receiver in a certain sequence puts those messages in the same message set and order the message-
SequenceNumbers of the message in the desired order. For other message types (returns, notifications, and confirmations), the messageSequenceNumber indicates the order in which the messages are created.

D2.3 RECEIVER RECEIVES AND VALIDATES SM MESSAGE SET

Upon receipt of a document via the Receiver’s SM message set port, the Receiver performs message set validation. Message set validation consists of several validation steps (syntactic, authorization, sequencing of invocation messages within the message set, and verification of support for the invoked operation), some of which are performed only when certain message types are contained in the message set. These validation steps are described in subsequent paragraphs.

Syntactic validation. The Receiver performs syntactic validation of the document to ensure that the document is a properly formatted SM message set of a version that is supported by the Receiver. If the Receiver cannot syntactically validate the message set, the Receiver generates and send an UnrecognizedMessageSetResponse exception response to the exception response port of the Sender, after which the Receiver has no further obligation for interpreting and acting upon the document.

Authorization validation. Once the received document has been validated as a syntactically correct message set, the Receiver performs authorization validation of the message set to ensure (a) that the Network Source of the message set is authorized to use the smSource (see table 3-4 of reference [3] contained in the message set, (b) that the Service Agreement identified by the serviceAgreementRef (table 3-4 of reference [3]) in the message set is supported by the Receiver, (c) that the SM entity identified by the smSource in the message set is authorized to send messages in the context of the Service Agreement identified by the serviceAgreementRef in the message set, and (d) that the smDestination in the message set is authorized for use by the Receiver to receive messages in the context of the Service Agreement. If the Receiver is unable to validate the authorization of the message set, the Receiver sends an UnrecognizedMessageSetResponse exception response with appropriate diagnostic information (as specified in table 3-25 of reference [3]) to the exception response port of the Sender, after which the Receiver has no further obligation for interpreting and acting upon the message set.

NOTES

1. As described in section 4, the SM document exchange protocol relies on the underlying communication service to authenticate the identity of the Network Source of the message carried by the SM document exchange protocol, and to supply the identity of the Network Source of the message to the SM document exchange protocol.

2. Because the format of the identification of the Network Source used by the underlying communication service is technology dependent, the mapping between that identification and the smSource is also technology dependent.
Sequencing of invocation messages within the message set. If a message set contains invocation messages, the `messageSequenceNumber` (see table 3-6 of reference [3]) parameter of each of the contained invocations are given unique values within the message set, within the context of the same `smSource` and `serviceAgreementRef`. If the Receiver is unable to validate the sequencing of any invocation message in the message set, the Receiver sends an `InvalidInvocationResponse` exception response to the exception response port of the Sender with appropriate diagnostic information (as specified in table 3-26 of reference [3]), after which the Receiver has no further responsibility for interpreting and acting upon the invalidly sequenced message.

NOTE – The Receiver does not perform message sequence number checking for any type of message other than invocations.

Verification of support for the invoked operation. Because different implementations of the SCCS-SM Recommended Standard may support different subsets of the SM set of operations (see section 5, Incremental Adoption Approach), the Receiver validates that the operation associated with each message is supported by the SM entity associated with the Receiver. If the Receiver does not support the operation invocation or notification type of a received message, the Receiver sends one `InvalidInvocationResponse` exception response to the exception response port of the Sender for each unsupported-operation invocation message, or one `InvalidNotificationResponse` exception response to the exception response port of the Sender for each unsupported-operation notification message, respectively, and has no further responsibility for interpreting and acting upon the unsupported-operation message. If the Receiver does not support the operation return or confirmation type of any received message, the Receiver ignores the unsupported-operation return or confirmation message and has no further responsibility for interpreting and acting upon the unsupported-type message.

NOTE – An operation return or confirmation can only be legitimately sent in response to an invocation or notification (respectively), so that if a Receiver receives a return or confirmation that it could not have possibly sent because it is for an operation that the Receiver does not support, it is an indication of a serious protocol breakdown. In such cases the association between the Receiver and the Sender is completely unreliable and should not be used even to transmit an `InvalidInvocationResponse` or `InvalidNotificationResponse`.

Message processing external to the document exchange protocol. The appropriate Receiver application process processes all messages that pass syntactic, authentication, invocation sequencing (as appropriate), and supported-operation validation, as defined in the procedure patterns in D3 and the specific operations defined in sections 4 through 7 of the SCCS-SM service specification (reference [3]).
D2.4 SENDER RECEIVES AND VALIDATES SM EXCEPTION RESPONSES

D2.4.1 General

If the Sender sent a message set that was unrecognizable to the Receiver or that contained messages that were invalid to the Receiver, the Sender receives one or more exception responses (UnrecognizedMessageSetResponse, InvalidInvocationResponse, or InvalidNotificationResponse) from the Receiver via the Sender’s exception response port.

NOTE – ‘Sender’ herein refers to the transmitter of the original message set, and not to the transmitter of the exception response(s) (which is the Receiver).

D2.4.2 Exception Response Validation

Upon receipt of a document at the Sender’s exception response port, the Sender performs syntactic validation and (for an InvalidInvocationResponse or InvalidNotificationResponse) authorization validation. These validation steps are described in subsequent paragraphs.

Syntactic validation. The Sender performs syntactic validation of the document to ensure that the document is a properly formatted exception response (that is, an UnrecognizedMessageSetResponse, an InvalidInvocationResponse, or an InvalidNotificationResponse). If the Sender cannot syntactically validate the SM document as an exception response, the Sender terminates processing of the document and has no further obligation for interpreting and acting upon the document. However, the Sender may perform locally defined troubleshooting activities.

Authorization validation. If the syntactically valid SM document contains an InvalidInvocationResponse or InvalidNotificationResponse, the Sender performs authorization validation of the message to ensure (a) that the Receiver is authorized to use the smSource (see table 3-4 of reference [3]) in the InvalidInvocationResponse or InvalidNotificationResponse that contains the message, (b) that the Service Agreement identified by the serviceAgreementRef (table 3-4 of reference [3]) in the InvalidInvocationResponse or InvalidNotificationResponse is supported by the Sender, and (c) that the Receiver is authorized to send messages in the context of the Service Agreement identified by the serviceAgreementRef in the InvalidInvocationResponse or InvalidNotificationResponse. If the Sender is unable to validate the authorization of the Receiver, the Sender terminates processing of the InvalidInvocationResponse or InvalidNotificationResponse, after which the Sender has no further obligation for interpreting and acting upon the message. However, the Sender may perform locally defined troubleshooting activities such as contacting the source of the unauthorized InvalidInvocationResponse or InvalidNotificationResponse.
D2.4.3 Exception Response Processing External to the Document Exchange Protocol

Operation-level processes external to the document exchange protocol use the diagnostic information contained in the `UnrecognizedMessageSetResponse`, `InvalidInvocationResponse`, and `InvalidNotificationResponse` messages to modify the local state of the affected operations and possibly take other actions. The nature of these other actions is determined by the operation, the message, and/or the role of the Sender in the operation, and are defined in further detail in the procedure patterns in D3 and the operation specifications in sections 4 through 7 of reference [3].

D2.5 SEQUENCE DIAGRAMS

The message set is the primary unit of exchange for the document exchange protocol. Figure D-2 is the sequence diagram for the SM Document Exchange Protocol. At the document exchange protocol level, SM operation messages are unrelated. For example, the SM document exchange protocol does not associate operation returns with the invocations that trigger them. Such associations among messages exist within the operation procedures, the patterns for which are defined in D3 and the concrete instantiations of which are defined in sections 4 through 7 of reference [3]. The SM Document Exchange Protocol sequence diagram is a parameterized, reusable diagram.

Whereas the message set is the unit of interest from the perspective of the document exchange protocol, it is the individual messages that are contained within a message set that are important to the SM operations themselves. Figure D-3 is the sequence diagram for the transmission of a single SM message within a message set. As can be seen, the Send Message sequence diagram uses the SM Document Exchange Protocol sequence diagram of figure D-2. The SM Send Message sequence diagram is in turn parameterized and reusable, and serves as a component of sequence diagrams for the procedure patterns defined in D3.

D2.6 ACTIVITY DIAGRAM

Figure D-4 is the activity group diagram for the SM Document Exchange Protocol. The Document Exchange Protocol activity group incorporates two lower-level activity groups, Receive and Validate SM Message Set (figure D-5) and Receive and Validate SM Exception Response (figure D-6). The SM Document Exchange Protocol activity group is a component of the activity diagrams for the procedure patterns defined in D3.
Sender

Add SM message to SmMessageSet

SmMessageSet

receiver

alt

[if message set is not syntactically valid or authorized]

UnrecognizedMessageSetResponse exception response

[else]

[if the message set contains any invocations that have repeated sequence numbers within the message set or that invoke operations that are not supported by the receiver]

InvalidInvocationResponse exception response

[else]

[for each invocation that is an invocation that repeats a sequence number or that invokes an operation that is not supported by the receiver]

InvalidInvocationResponse exception response

[else]

[if the message set contains a notification for a notify operation that is not supported by the receiver]

InvalidNotificationResponse exception response

[else]

No exception response is provided to the sender if the message set is valid and every contained message is: (a) a valid and in-sequence invocation, (b) a valid notification, (c) a return, or (d) a confirmation

No exception response is provided to the sender if the message set is valid and every contained message is: (a) a valid and in-sequence invocation, (b) a valid notification, (c) a return, or (d) a confirmation

Figure D-2: SM Document Exchange Protocol Sequence Diagram

messageSender

ref

Document Exchange Protocol (message, messageSender, messageReceiver)

messageReceiver

Figure D-3: SM Send Message Sequence Diagram
Receive and validate SM message set

Unrecognized MessageSet Response

InvalidInvocation Response

InvalidNotification Response

<<external application process>>
create SM Message

Sender

Document Exchange Protocol

<<loop>>
Include message in SmMessageSet

Transmit SmMessageSet

<<external application process>>
modify state of operations

<<external application process>>
modify state of operations

<<external application process>>
inform receiver by other means

Receiver

<<external application process>>
perform operation processing of message

message set port of Receiver

message set

{{loop}}

[message set contains all messages that are to be sent concurrently]

External process may use the diagnostic information supplied in the response to investigate potential problems and/or to generate a corrected message or message set

<<external application process>>
inform receiver by other means

<<external application process>>
modify state of operations

<<external application process>>
create SM Message

Figure D-4: SM Document Exchange Protocol Activity Diagram
Figure D-5: Receive and Validate SM Message Set Activity Group Diagram
Receive and validate SM exception response

1. Receive SM document
2. Validate exception response syntax
   - [Passed]
   - [Syntactic Validation Failed]
3. Validate authorization
   - [Authorization Validation Failed]
   - [Authorization Validation Passed]
4. [document contains UnrecognizedMessageSetResponse]
5. [document contains InvalidInvocationResponse or InvalidNotificationResponse]
6. Receiver of recognizable document may contact source of document for troubleshooting purposes
7. Termination of the flow means that there are no further standard actions specified. It does not imply that any associated operations are terminated.

Figure D-6: Receive and Validate SM Exception Response Activity Group Diagram
D3  SM OPERATION PROCEDURE PATTERNS

D3.1  TWO-PHASE OPERATION PROCEDURE PATTERN

D3.1.1  General

The two-phase operation procedure pattern is used by SM operations that can be validated and performed in relatively short time.

The two-phase operation procedure pattern specifies the messages exchanged between Invoker and Performer associated with a two-phase operation, the activities of the Invoker and Performer in response to those messages, the time constraints under which those activities are to be carried out, and the behavior of the Invoker and Performer if the time constraints are violated.

D3.1.2  Procedure Pattern

The two-phase operation procedure begins with an Invoker generating an operation invocation message, placing it in an SM message set, transmitting the message set to the Performer’s message set port using the SM document exchange protocol defined in D2, and starting the disposition timer for the operation. If the urgent parameter of the invocation is ‘true’, the disposition timer is set to the urgent two-phase timeout value specified in the Service Agreement (see section 7 of reference [3]) for that operation type; otherwise, the disposition timer is set to the routine two-phase timeout value for that operation.

Upon receipt of the SmMessageSet containing the invocation, the Performer performs message set validation as specified for the Receive and Validate SM Message Set activity subgroup of the Document Exchange Protocol activity group in D2. If the SmMessageSet fails message set validation, the Performer generates and transmits an exception response containing an UnrecognizedMessageSetResponse or InvalidInvocation-Response (as appropriate to the exception) to the Invoker’s exception response port, as specified in D2.

If the Invocation message passes message set validation, the Performer starts a local disposition timer that is based on the messageTimestamp value of the Invocation message, the value of the urgent parameter and the associated timeout value in the Service Agreement, and the expected message transit time for a return message to the Invoker (see note 1, below) and performs service management validation on the invocation. The details of service management validation are specific to each operation, and are specified in the associated Invoker and Performer requirements for each operation.

NOTES

1  In order for the Performer to ensure that any return to an Invocation arrives at the Invoker before the Invoker’s disposition timer expires, the Performer adjusts (i.e., shorten) its local disposition timer value by some amount of time to compensate for
the transit of the return across the communications network that connects them. The method by which the Performer determines this adjustment factor is outside the scope of the SCCS-SM service specification.

2 It is assumed that the time standards upon which the Invoker and Performer set their disposition timers are synchronized to within one (1) second of each other. If this assumption cannot be made for a particular pair of Invoker and Performer, then additional methods may be required to compensate for the ambiguity (such as further decreasing the Performer’s disposition timer value to account for the ambiguity). Any such adjustment for time standard ambiguity is outside the scope of the SCCS-SM service specification.

If the Invocation is valid at the service management level and the operation can be performed before the disposition timeout is reached, the Performer performs the invoked operation and returns a SuccessfulReturn message to the Invoker’s message set port. The details of the performance of the operation and the information returned as part of the result are operation-specific. The Performer may perform local functions specific to a successful operation as part of completing the operation procedure.

If the Invocation is not valid at the service management level, or if the Performer cannot complete service management validation before its disposition timer expires, the Performer terminates the operation procedure and returns a FailedReturn or FailedReturn-WithDenial message to the Invoker’s message set port such that the Invoker receives the result before the disposition timer expires. Whether it is a FailedReturn or a Failed-ReturnWithDenial that is returned depends on the specific operation. In the remainder of the SCCS-SM service specification, the term FailedReturn* is used to designate a message that conforms to either the <<FailedReturn>> or <<FailedReturnWithDenial>> message stereotype. Each FailedReturn* message contains operation-specific diagnostic information. The Performer may perform local functions specific to a failed operation as part of completing the operation procedure.

Upon receipt of an UnrecognizedMessageSetResponse or Invalid-InvocationResponse, the Invoker validates the exception response in accordance with the Receive and Validate SM Exception Response activity subgroup of the Document Exchange Protocol activity group specified in D2. The Invoker attempts to correlate the contents of each syntactically correct UnrecognizedMessageSetResponse and InvalidInvocationResponse with SM operation Invocations that have been sent by the Invoker. If the UnrecognizedMessageSetResponse or Invalid-InvocationResponse can be correlated to one or more Invocations, the Invoker terminates the correlated operation(s), and completes the procedure. The Invoker may perform local functions specific to an unknown or invalid Invocation as part of completing the operation procedure (e.g., update local databases to reflect failure of the operation, contact the Performer to troubleshoot the failure).

Upon receipt of the SmMessageSet containing the SuccessfulReturn message, the Invoker performs message set validation as specified for the Receive and Validate SM
Message Set activity subgroup of the Document Exchange Protocol activity group in D2. If the **SmMessageSet** passes message set validation, the Invoker performs service management validation on the **SuccessfulReturn**. The details of service management validation are specific to each operation, and are specified in the associated Invoker and Performer requirements for each operation. If the **SuccessfulReturn** passes service management validation, the Invoker successfully completes the operation. The Invoker may perform local functions specific to a successful operation as part of completing the operation (e.g., updating local databases to reflect success of the operation). If the message set fails syntactic or authorization validation, the Invoker generates and transmits an exception response containing an **UnrecognizedMessageSetResponse** to the Performer’s exception response port, as specified in D2. If the **SuccessfulReturn** message fails service management validation, the message is deemed invalid and the Invoker is not required to interpret or act upon the message any further.

Upon receipt of the **SmMessageSet** containing the **FailedReturn** message, the Invoker performs message set validation as specified for the Receive and Validate SM Message Set activity subgroup of the Document Exchange Protocol activity group in D2. If the **SmMessageSet** passes message set validation, the Invoker performs service management validation on the **FailedReturn**. The details of service management validation are specific to each operation, and are specified in the associated Invoker and Performer requirements for each operation. If the **FailedReturn** passes service management validation, the Invoker performs failure processing for the operation. The Invoker may perform local functions specific to a failed operation as part of failure processing (e.g., update local databases to reflect failure of the operation, contact the Performer to troubleshoot the failure). If the **SmMessageSet** fails syntactic or authorization validation, the Invoker generates and transmits an exception response containing an **UnrecognizedMessageSetResponse** to the Performer’s exception response port, as specified in D2. If the **FailedReturn** message fails service management validation, the message is deemed invalid and the Invoker is not required to interpret or act upon the message any further.

If the Invoker does not receive a validated result (successful or failed) before its disposition timer for that operation expires, the Invoker determines the disposition of the operation by bilaterally defined means (e.g., contact the Performer by voice) and complete the operation procedure.

**NOTE** – The failure by the Invoker to validate an operation return or correlate an **UnrecognizedMessageSetResponse** or **InvalidInvocation-Response** from the Performer will eventually result in the expiration of the associated disposition timer, which in turn will result in the Invoker determining the status of the operation by other means.

Upon receipt of an **UnrecognizedMessageSetResponse**, the Performer performs exception response validation in accordance with the Receive and Validate SM Exception Response activity subgroup of the Document Exchange Protocol activity group specified in D2. The Performer attempts to correlate the contents of the syntactically correct
UnrecognizedMessageSetResponse with a return that has been sent by the Performer. If the UnrecognizedMessageSetResponse can be correlated to a return, the Performer informs the Invoker (by other means) of the content of the return. The Performer may also perform local functions to determine why the return was not validated by the Invoker.

### D3.1.3 Sequence Diagram

Figure D-7 is the sequence diagram for the two-phase operation procedure pattern. It is composed of multiple instances of the Send Message sequence specified in figure D-3.

![Sequence Diagram](image)

**FailedReturn* designates either a FailedReturn or FailedReturnWithDenial, as appropriate to the specific operation.**

**Figure D-7: Sequence Diagram for Two-Phase Operation Pattern**

### D3.1.4 Activity Diagram

Figure D-8 is the activity diagram for the two-phase operation procedure pattern.
FailedReturn* designates either a FailedReturn or FailedReturnWithDenial, as appropriate to the specific operation.

Figure D-8: Two-Phase Operation Procedure Pattern Activity Diagram
D3.2 THREE-PHASE OPERATION PROCEDURE PATTERN

D3.2.1 General

The three-phase operation procedure pattern is used by SM operations that may require an extended period of time before they can be validated and/or performed.

The three-phase operation procedure pattern specifies the messages exchanged between Invoker and Performer associated with a three-phase operation, the activities of the Invoker and Performer in response to those messages, the time constraints under which those activities are to be carried out, and the behavior of the Invoker and Performer if the time constraints are violated.

D3.2.2 Procedure Pattern

The three-phase operation procedure begins with the Invoker generating an operation Invocation message, placing it in an SmMessageSet, transmitting the SmMessageSet to the Performer’s message set port using the SM document exchange protocol defined in D2, and starting the disposition timer for the operation. If the urgent parameter of the invocation is ‘true’, the disposition timer is set to the urgent three-phase timeout value specified in the Service Agreement (see section 7 of reference [3]) for that operation type; otherwise, the disposition timer is set to the routine three-phase timeout value for that operation.

Upon receipt of the SmMessageSet containing the Invocation, the Performer performs message set validation as specified for the Receive and Validate SM Message Set activity subgroup of the Document Exchange Protocol activity group in D2. If the SmMessageSet fails message set validation, the Performer generates and transmits an exception response containing an UnrecognizedMessageSetResponse or InvalidInvocation-Response (as appropriate to the exception) to the Invoker exception response port, as specified in D2.

If the Invocation message passes message set validation, the Performer estimates how long it will take to perform the operation, returns to the Invoker’s message set port an AcknowledgedReturn message containing in the expectedDispositionTime parameter (see table 3-15 of reference [3]) the maximum estimated time until a final disposition can be provided, and starts a local disposition timer based on that value. If the urgent parameter of the invocation is ‘true’, the expectedDispositionTime value is constrained to be no longer than that allowed by the urgent three-phase timeout value specified for the operation in the Service Agreement (see section 7 of reference [3]); otherwise, the expectedDispositionTime value is constrained to be no longer than that allowed by the routine three-phase timeout value specified for the operation. The AcknowledgedReturn message may also contain locally defined further information explaining the conditions that determined the expectedDispositionTime value in the privateAnnotation parameter (e.g., ‘next weekly schedule run’).
NOTES

1. In order for the Performer to ensure that any return to an Invocation arrives at the Invoker before the specified expectedDispositionTime, the Performer adjusts (i.e., shorten) its local disposition timer value by some amount of time to compensate for the transit of the return across the communications network that connects them. The method by which the Performer determines this adjustment factor is outside the scope of the SCCS-SM service specification.

2. It is assumed that the time standards upon which the Invoker and Performer set their disposition timers are synchronized to within one (1) second of each other. If this assumption cannot be made for a particular pair of Invoker and Performer, then additional methods may be required to compensate for the ambiguity (such as further decreasing the Performer’s disposition timer value to account for the ambiguity). Any such adjustment for time standard ambiguity is outside the scope of the SCCS-SM service specification.

The Performer performs service management validation on the Invocation. The details of service management level validation are specific to each operation.

If the Invocation is valid at the service management level and the operation can be performed before the disposition timeout is reached, the Performer performs the invoked operation and returns a SuccessfulReturn message to the Invoker’s message set port. The details of the performance of the operation and the information returned as part of the result are operation-specific. The Performer may perform local functions specific to a successful operation as part of completing the operation procedure.

If the Invocation is not valid at the service management level, or if the Performer cannot complete service management validation before the disposition timer expires, the Performer terminates the operation procedure and returns a FailedReturn* message to the Invoker’s message set port such that the Invoker receives the result before the disposition timer expires. The FailedReturn* message contains operation-specific diagnostic information. The Performer may perform local functions specific to a failed operation as part of completing the operation procedure.

Upon receipt of an UnrecognizedMessageSetResponse or InvalidInvocationResponse, the Invoker validates the exception response in accordance with the Receive and Validate SM Exception Response activity subgroup of the Document Exchange Protocol activity group specified in D2. The Invoker attempts to correlate the contents of each syntactically correct UnrecognizedMessageSetResponse and InvalidInvocationResponse with SM operation Invocations that have been sent by the Invoker. If the UnrecognizedMessageSetResponse or InvalidInvocationResponse can be correlated to one or more Invocations, the Invoker terminates the correlated operation(s), and completes the procedure. The Invoker may perform local functions specific to an unknown or invalid Invocation as part of
completing the operation procedure (e.g., update local databases to reflect failure of the operation, contact the Performer to troubleshoot the failure).

Upon receipt of the SmMessageSet containing the AcknowledgedReturn message, the Invoker performs message set validation as specified for the Receive and Validate SM Message Set activity subgroup of the Document Exchange Protocol activity group in D2. If the SmMessageSet passes message set validation, the Invoker performs service management validation on the AcknowledgedReturn. The details of service management validation are specific to each operation, and are specified in the associated Invoker and Performer requirements for each operation. If the AcknowledgedReturn passes service management validation, and if the expectedDispositionTime parameter value results in an expected disposition time that is sooner than that the disposition timer value based on the urgent/routine three-phase timer value, the Invoker resets the disposition timer to the value of expectedDispositionTime. If the SmMessageSet containing the AcknowledgedReturn message fails syntactic or authorization validation, the Invoker generates and transmits an exception response containing an UnrecognizedMessageSetResponse to the Performer’s exception response port, as specified in D2. If the AcknowledgedReturn message fails service management validation, the message is deemed invalid and the Invoker is not required to interpret or act upon the message any further.

Upon receipt of the SmMessageSet containing the SuccessfulReturn message, the Invoker performs message set validation as specified for the Receive and Validate SM Message Set activity subgroup of the Document Exchange Protocol activity group in D2. If the SmMessageSet passes message set validation, the Invoker performs service management validation on the SuccessfulReturn. The details of service management validation are specific to each operation, and are specified in the associated Invoker and Performer requirements for each operation. If the SuccessfulReturn passes service management validation, the Invoker successfully completes the operation. The Invoker may perform local functions specific to a successful operation as part of completing the operation procedure (e.g., updating local databases to reflect success of the operation). If the message set fails syntactic or authorization validation, the Invoker generates and transmits an exception response containing an UnrecognizedMessageSetResponse to the Performer’s exception response port, as specified in D2. If the SuccessfulReturn message fails service management validation, the message is deemed invalid and the Invoker is not required to interpret or act upon the message any further.

Upon receipt of the SmMessageSet containing the FailedReturn* message, the Invoker performs message set validation as specified for the Receive and Validate SM Message Set activity subgroup of the Document Exchange Protocol activity group in D2. If the SmMessageSet passes message set validation, the Invoker performs service management validation on the FailedReturn*. The details of service management validation are specific to each operation, and are specified in the associated Invoker and Performer requirements for each operation. If the FailedReturn* passes service management validation, the Invoker performs failure processing for the operation. The
Invoker may perform local functions specific to a failed operation as part of failure processing (e.g., update local databases to reflect failure of the operation, contact the Performer to troubleshoot the failure). If the SmMessageSet fails syntactic or authorization validation, the Invoker generates and transmits an exception response containing an UnrecognizedMessageSetResponse to the Performer’s exception response port, as specified in D2. If the FailedReturn* message fails service management validation, the message is deemed invalid and the Invoker is not required to interpret or act upon the message any further.

If the Invoker does not receive a validated result (successful or failed) before the disposition timer for that operation expires, the Invoker determines the disposition of the operation by bilaterally defined means (e.g., contact the Performer by voice) and complete the operation procedure.

If the Invoker receives an AcknowledgedReturn after it receives a Successful-Return or FailedReturn for the same operation, or after the expiration of the disposition timer for that operation, the Invoker ignores the AcknowledgedReturn.

NOTE – The failure by the Invoker to validate an operation return or correlate an UnrecognizedMessageSetResponse or InvalidInvocation-Response from the Performer will eventually result in the expiration of the associated disposition timer, which results in the Invoker determining the status of the operation by other means.

Upon receipt of an UnrecognizedMessageSetResponse, the Performer performs exception response validation in accordance with the Receive and Validate SM Exception Response activity subgroup of the Document Exchange Protocol activity group specified in D2. The Performer attempts to correlate the contents of the syntactically correct UnrecognizedMessageSetResponse with a return that has been sent by the Performer. If the UnrecognizedMessageSetResponse can be correlated to a return, the Performer informs the Invoker (by other means) of the content of the return. The Performer may also perform local functions to determine why the return was not validated by the Invoker.

D3.2.3 Sequence Diagram

Figure D-9 is the sequence diagram for the three-phase operation procedure pattern. It is composed of multiple instances of the Send Message sequence specified in figure D-3.
FailedReturn* designates either a FailedReturn or FailedReturnWithDenial, as appropriate to the specific operation.

**Figure D-9: Sequence Diagram for Three-Phase Operation Pattern**

**D3.2.4 Activity Diagram**

Figure D-10 is the activity diagram for the three-phase operation procedure pattern.
FailedReturn* designates either a FailedReturn or FailedReturnWithDenial, as appropriate to the specific operation.

Figure D-10: Three-Phase Operation Procedure Pattern Activity Diagram
D3.3 NOTIFY OPERATION PROCEDURE PATTERN

D3.3.1 General

The notify operation procedure pattern is used for an operation that one service management entity uses to notify another management entity that it has autonomously performed a management activity that affects services of interest to that other entity. An operation that is used to transfer the notification is called a notify operation. The entity that performs the autonomous activity and generates the notification is called the Notifier. The entity that receives the notification is called the Recipient. Because the notification is issued after the management activity has been performed, the Recipient cannot reject the performance of the management activity. However, the Recipient confirms to the Notifier that the notification has been received.

The notify operation procedure pattern specifies the messages exchanged between Notifier and Recipient associated with a notify operation, the activities of the Invoker and Performer in response to those messages, the time constraints under which those activities are to be carried out, and the behavior of the Notifier and Recipient if the time constraints are violated.

D3.3.2 Procedure Pattern

The notify operation procedure pattern begins with the Notifier performing a notify operation, generating the resultant Notification message, placing it in an SmMessageSet, transmitting the SmMessageSet to the Recipient’s message set port using the SM document exchange protocol defined in D2, and starting the confirmation timer for the notification. The confirmation timer is set to the confirmationTimeout value specified for all confirmations in the Service Agreement.

Upon receipt of the SmMessageSet containing the Notification, the Recipient performs message set validation as specified for the Receive and Validate SM Message Set activity subgroup of the Document Exchange Protocol activity group in D2. If the SmMessageSet fails message set validation, the Recipient generates and transmits an exception response containing an UnrecognizedMessageSetResponse or InvalidNotificationResponse (as appropriate to the exception) to the Notifier’s exception response port, as specified in D2.

If the Notification message passes message set validation, the Recipient performs service management validation on the Notification. The details of service management validation are specific to each notify operation, and are specified in the associated Notifier and Recipient requirements for each notify operation.

If the Notification is valid at the service management level, the Recipient returns a Confirmation message to the Notifier’s message set port. The information returned as part of the Confirmation is operation-specific. The Recipient may perform local
functions specific to a Notification as part of processing the Notification (e.g., updating local databases to reflect the Notification).

Upon receipt of an UnrecognizedMessageSetResponse or InvalidNotificationResponse, the Notifier performs exception response validation in accordance with the Receive and Validate SM Exception Response activity subgroup of the Document Exchange Protocol activity group specified in D2. The Notifier attempts to correlate the contents of each syntactically correct UnrecognizedMessageSetResponse and InvalidNotificationResponse with a Notification that has been sent by the Notifier. If the UnrecognizedMessageSetResponse or InvalidNotificationResponse can be correlated to a Notification, the Invoker informs (by other means) the Recipient of the information contained in the Notification, and completes the procedure. The means by which the Notifier informs the Recipient (e.g., attempt to retransmit the Notification vs. contact by voice) is a local matter and may depend on the operation with which the Notification is associated. The Notifier may also perform other local functions as a result of the failure of the Notification.

Upon receipt of the SmMessageSet containing the Confirmation, the Notifier performs message set validation as specified for the Receive and Validate SM Message Set activity subgroup of the Document Exchange Protocol activity group in D2. If the Confirmation is valid at the service management level, the Notifier completes the notify operation procedure. The Notifier may perform local functions specific to a Confirmation as part of completing the procedure (e.g., updating local databases to reflect success of the Notification). If the SmMessageSet fails syntactic or authorization validation, the Notifier generates and transmits an UnrecognizedMessageSetResponse to the Recipient’s exception response port as specified in D2. If the Confirmation message fails service management validation, the message is deemed invalid and the Notifier is not required to interpret or act upon the message any further.

If the Notifier does not receive a validated Confirmation before the confirmation timer for that notification expires, the Notifier informs the Recipient of the information contained in the Notification and completes the procedure. The means by which the Notifier informs the Recipient (e.g., attempt to retransmit the Notification vs. contact by voice) is a local matter and may depend on the operation with which the Notification is associated. The Notifier may also perform other local functions as a result of the failure of the Notification (e.g., manually update local databases to reflect that the Recipient has been notified).

NOTE – The failure of syntactic and authorization validation of an UnrecognizedMessageSetResponse, an InvalidNotificationResponse, or a Confirmation from the Recipient will eventually result in the expiration of the associated disposition timer, which results in the Notifier’s informing the Recipient of the event by other means.
Upon receipt of an **UnrecognizedMessageSetResponse**, the Recipient performs exception response validation in accordance with the Receive and Validate SM Exception Response activity subgroup of the Document Exchange Protocol activity group specified in D2. The Recipient attempts to correlate the contents of the syntactically correct **UnrecognizedMessageSetResponse** with a **Confirmation** that has been sent by the Recipient. If the **UnrecognizedMessageSetResponse** can be correlated to a **Confirmation**, the Recipient informs the Notifier (by other means) that it received the **Notification**. The Recipient may also perform local functions to determine why the **Confirmation** was not validated by the Notifier.

### D3.3.3 Sequence Diagram

Figure D-11 is the sequence diagram for the notify operation procedure pattern. It is composed of multiple instances of the Send Message sequence specified in figure D-3.

![Sequence Diagram for Notify Operation Procedure Pattern](image)

**Figure D-11: Sequence Diagram for Notify Operation Procedure Pattern**

### D3.3.4 Activity Diagram

Figure D-12 is the activity diagram for the notify operation procedure pattern.
Figure D-12: Notify Operation Procedure Pattern Activity Diagram