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1 INTRODUCTION

1.1 Scope

This document constitutes IOAG Service Catalog #2 complementing IOAG Service Catalog #1 defined in [IC1]. It identifies the cross-support service types that should be provided by the ground tracking assets [1] operated by the IOAG member agencies participating in the Solar System Internetworking (SSI) based on DTN and / or IP technologies.

While IOAG Service Catalog #1 services are limited to the provision of space communication and tracking capabilities for interaction between a spacecraft control center and a spacecraft directly reachable via a ground tracking asset as shown in Figure 2-1, IOAG Service Catalog #2 defines services for in-space relay and networked cross support scenarios. The IOAG Services defined in Catalog #1 can be regarded as a subset of Catalog #2 with the understanding that the applicability of IOAG Catalog #1 Services is limited to the ABA scenario defined in Figure 2-1 and the classification into core and extended services given in that Catalog does not change.

Related to the provision of the above services is their Service Management, which is understood as all the interactions needed to make the service provision happen and to monitor it. For the simple ABA scenario addressed in Catalog #1, Service Management in addition interacts with the service provider as required to establish physical and link layer communications between the spacecraft and the ground tracking asset.

In the networked environment covered by Service Catalog #2, Service Management is (conventionally) limited to the management of the service provisioning and to provide the required control needed to ensure that the relevant SSI nodes interact as needed to enable the service provisioning. Conversely, the aspects related to the management of the SSI Network (i.e. those related to the [DTN-S] protocol suite and those related to network schedule information) are controlled by SSI Network Management functions. [2]

IOAG Service Catalog #1 is structured into “core” and “extended” services with the understanding that “core” services shall be implemented by all IOAG Agencies by 2020, while “extended” services shall be considered for bi-lateral cross supports. IOAG Service Catalog #2 defines additional core and extended cross-support services to be provided through ground tracking assets or (one or more) spacecraft operated by the IOAG member agencies in the SSI. The IOAG agencies’ current capabilities are documented in the IOAG Communications Asset Table [XSCA].

[1] Ground Tracking Assets may be Ground Stations, Ground Data Systems or a combination of both.

[2] The term “Network Management” is somewhat unfortunate as it could be misread to refer to the management of the network layer within the OSI reference model and a further complication is that space flight agencies tend to call the collection of their tracking assets a network (e.g. DSN), but from the communications perspective, these could be regarded as subnets, but certainly not networks. For this reason it has been decided to use the terms “Service Management” and “SSI Network Management”.

CCSDS is currently (planning to) prepare a “Service Catalog Template” to allow agencies to report their capabilities in a standard manner.

IOAG Service Catalog #2 is intended to provide guidance to CCSDS with respect to the focus and priority of those standards that need to be developed. These are mentioned as “to be written” in the list of applicable documents and their titles are therefore indicative and to be confirmed by CCSDS.

1.2 Definition of Service

In order to provide a clear set of definitions for use in the rest of this document a number of terms are defined here:

Service

- A service is a provision of an exposed interface of a system to support actions of another system. A service is described by the set of operations that can be invoked and performed through the service interface.
- Service specifications define the external interfaces and behavior of a system, but do not define the implementation.

Service Interface

- An interface is a set of interactions provided by a system for participation with another system for some purpose, along with constraints on how they can occur. A service interface is an external interface where the behavior of an object is exposed.

Service Provider System

- A system that offers a service to another system by means of one of its interfaces is called a service provider (*provider*).

Service User System

- A system that uses a service provided by another system is called a service user (*user*). Any given system may be a provider of some services and a user of others.

1.3 Services in Networked Environment

The services described in this catalog are a set of standard service types provided by the IOAG member agencies for cross support purposes. The services support mission operations that are relevant to an operational context where a service provider (e.g., a tracking asset or a communications network) offers communications and tracking support [3] to a service user, i.e., a

[3] The terms communications and tracking as used here shall be understood to encompass both terrestrial and space link communications as required to achieve the data flow between the user and the peer asset with which the user needs to communicate. The term tracking is not limited to the tracking capabilities of a supporting ground station such as antenna pointing and collection of radiometric observables. It also refers to pointing and radiometric measurements as needed for in space links such as Proximity-1.

flight project's mission control center. Figure 1-1 describes an example "service provider – service user" relationship in the service paradigm. The individual service types as defined are distinguished from one another by the functions provided, level of processing involved, and/or the type(s) of source data. A service provision interface might be exposed internal to the user entity in the form of an API and not be exposed by a Ground Tracking Asset.

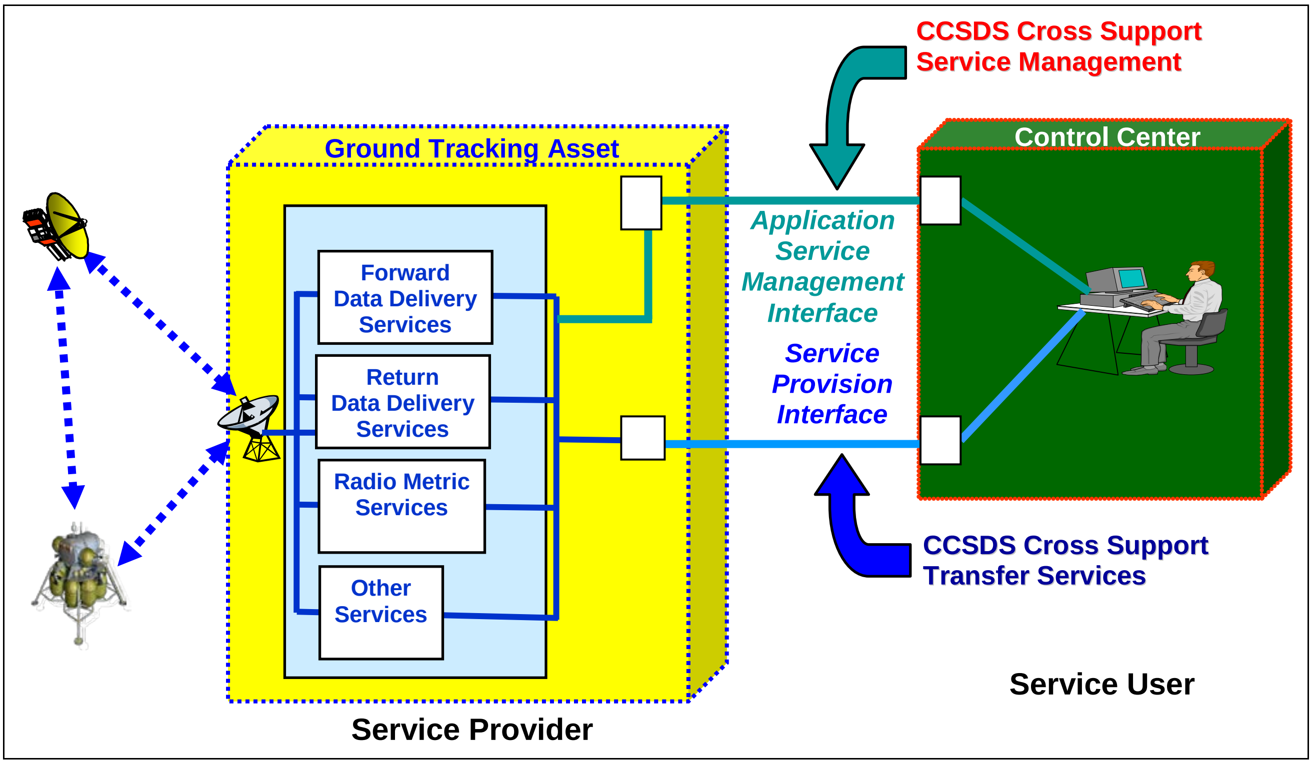

Figure 1-1 Context of the Cross Support Services

The service embraces the complete task in a systems sense. It typically involves end-to-end support using a combination of software components, computing and communications hardware, personnel and the procedures they follow, as well as facilities. Further, the service is also the "whole job" in the life-cycle sense. A service accepts one or more requests and returns one or more responses through a well-defined, standard service interface. Services are specified from the user's point of view, i.e., in terms of the behavior exposed at the service interface offered by the service provider. Therefore, a service is solely specified in terms of its behavior, functionality and performance without prescribing a particular implementation.

In an ABA configuration the service interface is easily understood to be the interface exposed on the ground between the service user and the service provider. In ABCBA and more complex configurations these underlying interfaces are still present on the terrestrial link between the Orbiter Mission Operations Center (MOC) and the Ground Station, and are a key part of providing and managing the basic space link connectivity. However, the upper layer networking services typically do not have a service interface that is as simple to define because they are end-to-end services implemented at a series of points along the path. A file transfer over BP shall serve here as an example.

From an end user/application point of view the service provided is the file transfer from its origin to its destination. For example, the user wants to move a file from the User MOC to a landed User Asset on Mars. This is done as a series of network layer transfers over a set of underlying, possibly sporadically connected, links. That means that the primary cross support service is the transfer of DTN bundles on a hop by hop basis. There will be a protocol DTN Service Access Point (SAP) exposed in the end user nodes, but this is essentially a programming interface or API. The file transfer service is implemented as an application layer service that runs on top of the networking layer, and these service entities will solely exist in the end nodes that are, in this example, both under organization A responsibility and outside any cross support consideration.

The network layer services are implemented as a standard set of interoperable DTN protocol elements. Similarly, the file transfer service is implemented as a standard pair of CFDP protocol entities[4]. These CFDP protocol "agents" may have their own defined API that can be called by a user program, or they may offer a user interface; since the CCSDS standards do not specify these, interoperability is achieved by protocol compatibility. It should also be understood that the DTN Bundle transfer can carry both end-to-end file transfer (CFDP) and/or other application level protocols, such as asynchronous message traffic (AMS).

It should be noted that this document largely assumes that traffic is flowing from the Earth out to some end node and then acknowledgement is sent back to Earth. There is nothing in the SSI architecture that prevents nodes in space neither from initiating data transfers nor for these nodes to use the SSI protocols to communicate among themselves. As for any SSI connectivity, the underlying point-to-point, i.e. link layer, connections have to be scheduled and established such that the network layer elements of the SSI can use these space links.

1.4 Applicable Documents

CCSDS documents are available at http://www.ccsds.org .

1.4.1 GROUND LINK STANDARDS

[AMS]	Asynchronous Message Service – Blue Book. TBW
[CC]	CCSDS Clock Correlation Procedures – Magenta Book. TBW
[CLTU]	CCSDS 912.1-B Space Link Extension – Forward CLTU Service Specification. Blue Book.
[CFFS]	CSTS Forward File Service – Blue Book. TBW

[4] It is assumed that any CFDP file transfer using DTN is done using CFDP class 1 operations (unacknowledged). Where reliability is required, it is obtained from LTP.

[CFXS] CSTS Transfer File Service – Blue Book. TBW

[CRFS] CSTS Return File Service – Blue Book. TBW

[EDM] CCSDS 922.1-B Monitored Data - Cross Support Transfer Services – Blue Book. TBW

[FF] CSTS Forward Frame Service – Blue Book. TBW

[FSEF] SLE Forward Synchronous Encoded Frame Service – Blue Book. TBW

[RCF] CCSDS 911.2-B Space Link Extension – Return Channel Frames Service Specification. Blue Book.

[SM] CCSDS 910.11-B Space Communication Cross Support - Service Management - Service Specification. Blue Book.

[TS] CCSDS Time Synchronization – Blue Book. TBW

1.4.2 SPACE LINK STANDARDS

[AOS] CCSDS 732.0-B AOS Space Data Link Protocol. Blue Book.

[CDA] CCSDS Delivery Agent – Blue Book. TBW

[CFDP] CCSDS 727.0-B CCSDS File Delivery Protocol (CFDP). Blue Book.

[ENC] CCSDS 133.1-B Encapsulation Service. Blue Book.

[IPOC] CCSDS 702.1-M IP over CCSDS Space Links – Magenta Book. [5]

[PR1] The Proximity-1 set of Blue Books:

- CCSDS 211.0-B Proximity-1 Space Link Protocol—Data Link Layer.
- CCSDS 211.1-B Proximity-1 Space Link Protocol—Physical Layer.
- CCSDS 211.2-B Proximity-1 Space Link Protocol—Coding and Synchronization Sublayer.

[5] Still in “red book” state, to be published.

[RFM] CCSDS 401.0-B Radio Frequency and Modulation Systems--Part 1: Earth Stations and Spacecraft. Blue Book.
This standard includes numerous concise recommendations developed for conventional near-Earth and deep-space missions having moderate communications requirements. Section 2 focuses upon the technical characteristics of RF and modulation systems for Earth stations and spacecraft and it has been subdivided into six modules, each containing an individual subject:

1. Earth-to-Space Radio Frequency (Forward Link)
2. Telecommand (Forward Link)
3. Space-to-Earth Radio Frequency (Return Link)
4. Telemetry (Return Link)
5. Radio Metric
6. Spacecraft (Transponder)

It also includes policy constraints, and procedural elements relating to communications services provided by radio frequency and modulation systems.

[SPP] CCSDS 133.0-B Space Packet Protocol. Blue Book.

[TC-COP] CCSDS 232.1-B Communications Operation Procedure-1. Blue Book.

[TC-DLP] CCSDS 232.0-B TC Space Data Link Protocol. Blue Book.

[TC-S&C] The collection of:

CCSDS 231.0-B TC Synchronization and Channel Coding. Blue Book.

CCSDS 131.2-B Flexible Advanced Coding and Modulation Scheme for High Rate Telemetry Applications. Blue Book.

CCSDS 131.3-B CCSDS Space Link Protocols over ETSI DVB-S2 Standard. Blue Book.

[TM-DLP] CCSDS 132.0-B TM Space Data Link Protocol. Blue Book.

[TM-S&C] CCSDS 131.0-B TM Synchronization and Channel Coding. Blue Book.

[TT] CCSDS Time Transfer – Blue Book. TBW

1.4.3 DATA STRUCTURES STANDARDS

Some of the standards mentioned here below are widely used by the other applicable documents mentioned in section 1 and are listed here despite they may not be directly referenced in the rest of this document.

[ODM] CCSDS 502.0-B Orbit Data Messages. Blue Book.

[SLID] “Registries.” Space Assigned Number Authority. http://sanaregistry.org/r/. This replaces CCSDS 135.0-B Space Link Identifiers. Silver Book.

[TCF] CCSDS 301.0-B-3 Time Code Formats. Blue Book.

[TDM] CCSDS 503.0-B Tracking Data Message. Blue Book.

1.4.4 IOAG DOCUMENTS

[IC1] IOAG Service Catalog #1, Issue 1.3, 04 March 2010, Approved 30 March 2010. https://www.ioag.org/Public%20Documents/IOAG%20Service%20Catalog%201.pdf

[INFT] CCSDS Standards Infusion into IOAG Networks (updated 6.10.07). https://www.ioag.org/Public%20Documents/Forms/AllItems.aspx

[XSCA] IOAG Cross-Support Communications Assets https://www.ioag.org/Public%20Documents/Forms/AllItems.aspx

1.4.5 INTERNETWORKING STANDARDS

[DTN-S] CCSDS 734.2-B Bundle Protocol for CCSDS – Blue Book. TBW

Bundle Security Protocol for CCSDS – Blue Book. TBW [6]

CCSSD 734.1-B Licklider Transmission Protocol for CCSDS – Blue Book. TBW

DTN bundles can travel both on the Ground Link (e.g. on top of TCP/IP) and on the Space Link (in Encapsulation Packets).

[DTN-M] Single-Agency BP Network Management – Blue Book. TBW

[IP] Internet Protocol - RFC2460 - Internet Protocol, Version 6 (IPv6) Specification. http://www.faqs.org/rfcs/rfc2460.html

Internet Protocol - RFC791 - Internet Protocol, Version 4 (IPv4 Specification. http://www.faqs.org/rfcs/rfc791.html

The implementation of the full Internet Protocol Suite requires a number of other RFCs that are not detailed here.

IP datagrams can travel both on the Ground Link and on the Space Link (in Encapsulation Packets).

[SSI-CP] SSI Contact Plan Standard – TBW

[TCP] Internet Protocol – RFC793 - Transmission Control Protocol. http://www.faqs.org/rfcs/rfc793.html

1.5 Acronyms

AMS Asynchronous Message Service
AOS Advanced Orbiting Systems
BP Bundle Protocol
CCSDS Consultative Committee for Space Data Systems
CFDP CCSDS File Delivery Protocol

[6] The definition of the Bundle Security Protocol may be a subset of the Bundle Protocol Specification book.

CLTU	Communication Link Transmission Unit
CSTS	Cross Support Transfer Services
DOR	Differential One-Way Ranging
DTN	Delay/Disruption Tolerant Network
IOAG	Interagency Operations Advisory Group
IOP	Inter Operability Plenary
IP	Internet Protocol
ISO/OSI	International Organization for Standardization / Open Systems Interconnection
ISP	Internet Service Provider [7]
LTP	Licklider Transmission Protocol
MOC	Mission Operations Center
OCM	Optical Coding and Modulation
PDU	Protocol Data Unit
PN	Pseudo Noise
RF	Radio Frequency
SLE	Space Link Extension
SP	Space Packet
SSI	Solar System Internetworking
TBW	To Be Written
TCP	Transmission Control Protocol
TC	TeleCommand
TDM	Tracking Data Message
TM	TeleMetry

[7] In this document it is used only with the meaning of “SSI ISP” and not in the sense of terrestrial ISP.

2 SCOPE OF CATALOG #2

2.1 Overview

Catalog #1 includes the ground based cross-support services for supporting the scenario described in Figure 2-1, where two kinds of links (and then two types of interfaces) are involved: the Space Link (Interface) between the Spacecraft and a Ground Tracking Asset and the Ground Link (Interface) between the Ground Tracking Asset and the Spacecraft Control Center. Such a scenario is sometimes referred as an ABA scenario to show that an Agency B is providing services to an Agency A Control Center for accessing an Agency A Spacecraft.

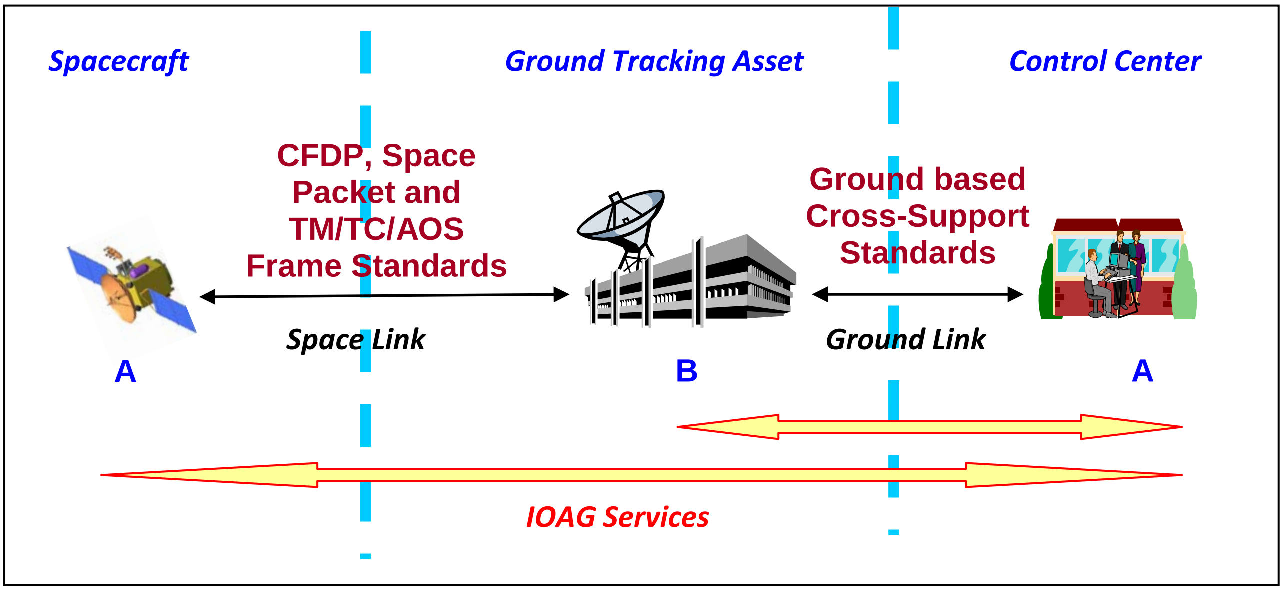

Figure 2-1 ABA Scenario for Catalog #1

Figure 2-1 also shows, as yellow arrows, the "IOAG Services" generally intended as the end-to-end services made available to the requesting "user" Agency to access its peer asset across several domains often with different administrations and technical characteristics. For Catalog #1, the crossed domains are clearly very limited.

Catalog #2 shall include the IOAG Services envisaged for supporting the scenario described in Figure 2-2 showing the case of a Lander belonging to Agency A and accessed by its "Lander Control Center" through an Agency B "Orbiter Control Center" using an Agency C Ground Tracking Asset communicating with the Orbiter belonging to Agency B. Figure 2-2 is usually described as an ABCBA configuration.

In the future more complex communications topologies are expected to evolve encompassing more intermediate nodes, thus offering alternate communication paths. The services are provided to the

Agency A Control Center for accessing an Agency A Spacecraft (Lander or Orbiter) through a Ground Tracking Asset and a set of relay Spacecraft possibly belonging to various agencies.

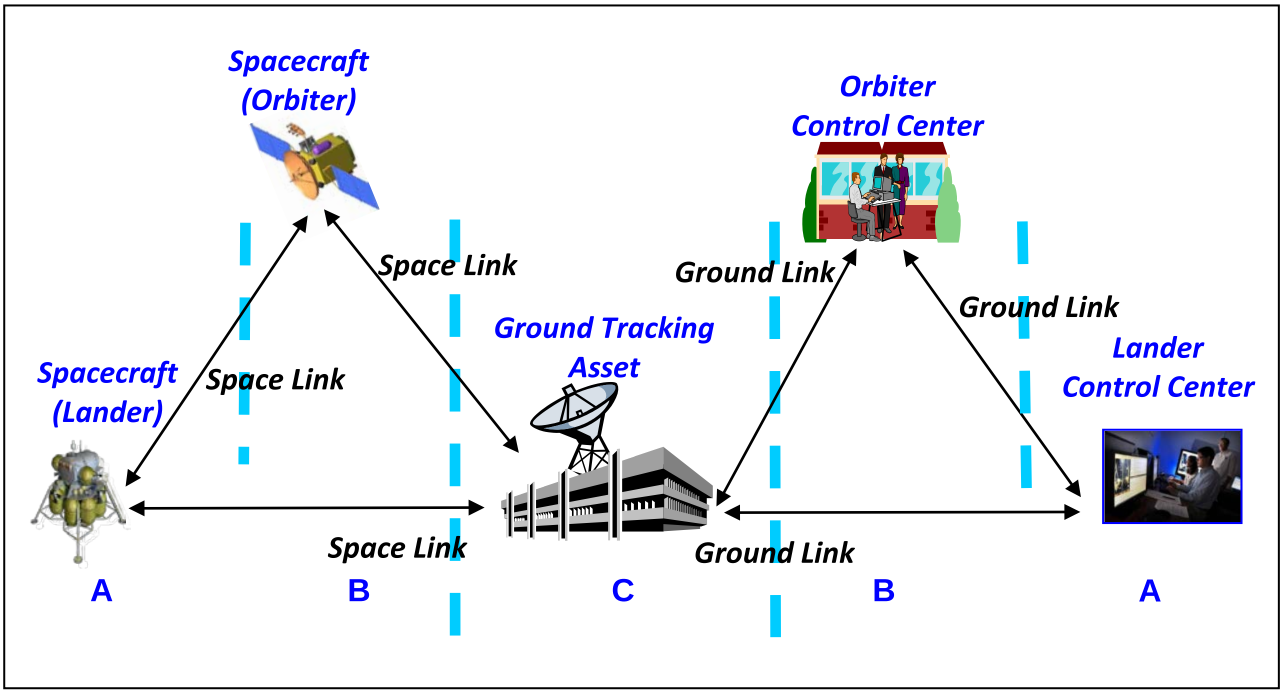

Figure 2-2 Example ABCBA Scenario for Catalog #2

Similar to what applies to Catalog #1, also in Catalog #2 there are two kinds of links (and then two types of interfaces): the Space Link Interface and the Ground Link Interface. However for Catalog #2, while the Ground Link Interface still operates between the Ground Tracking Asset and a spacecraft Control Center (or between Control Centers), there may be several different Space Link Interfaces. The space link can be between an Orbiter and a Ground Tracking Asset or between a Lander and an Orbiter or between two Orbiters/Landers. Whenever the Space Link Interface implies space-to-space [8] communications, in this document communications based exclusively on the Proximity-1 [PR1] set of standards [9] are considered.

The Space Link Interfaces are based on a very comprehensive list of CCSDS Recommendations covering RF and Modulation, Coding and Synchronization and Link Layer Protocols. The Ground Link Interface is defined by a set of CCSDS Recommendations, called Cross Support Transfer

[8] For simplicity, space to space links also include communications with non-flight platforms, e.g. landers.
[9] In future final elements may not be using the Proximity-1 protocol stack; e.g.
1. Connection on planet surface may be using IP. This is very likely to apply to the Moon and possibly to Mars as well.
2. Optical Coding and Modulation (OCM) techniques and alternative (new) protocols may be used.

The former case has been ignored because it is not considered to be an issue as it is anyway introducing reliable network hops. The latter case has been ignored because no real assumption can be made for the time being.

Services (named Space Link Extension services in their simplest form). In Catalog #2, IOAG Services are using also Internetworking Standards such as DTN and IP.

The Ground Link Interface can further be categorized as follows:

1. Service provision interface: This is the interface between a Control Center and a Ground Tracking Asset via Cross Support Transfer Services / Space Link Extension Services standards.
2. Service Management interface: This is the interface between a Control Center and a Ground Tracking Asset for the two parties to conduct the service management functions cooperatively.

To take into account the new communications topologies with several SSI nodes to be configured and operated, the Ground Link Interface of Catalog #2 needs an additional SSI Service Management interface that refers to the 'configuration' aspect of the underlying services (connectivity) used to construct the SSI. SSI Missions and SSI Service Management work together to establish the underlying connectivity and nominal routing plan. This additional SSI Service Management interface can be further categorized as follows:

3a. Link Layer Service Management is in charge of planning, requesting and configuring the connectivity at link layer, i.e. the hops between individual SSI nodes in accordance with agreed contact plans.

3b. SSI Network Management refers to the activities, methods, procedures, and tools that pertain to the operation, administration, maintenance, and provisioning of SSI network layer resources.

- Operation deals with keeping the network (and the services that the network provides) up and running smoothly. It includes monitoring the network to spot problems as soon as possible, ideally before users are affected.
- Administration deals with keeping track of resources in the network and how they are assigned. It includes all the "housekeeping" that is necessary to keep the network under control.
- Maintenance is concerned with performing repairs and upgrades. Maintenance also involves corrective and preventive measures to make the managed network run "better", such as adjusting device configuration parameters.
- Provisioning is concerned with configuring resources in the network to support a given SSI service.

The Service Management and Network Management Interfaces are shown in Figure 2-3 where blue arrows show management flows and green arrows show data flows. The dashed yellow boxes indicate the location of the different kinds of interfaces. The green rectangles on the left are the major protocol stack elements and the rounded boxes on the right represent the major organizational elements involved in these exchanges.

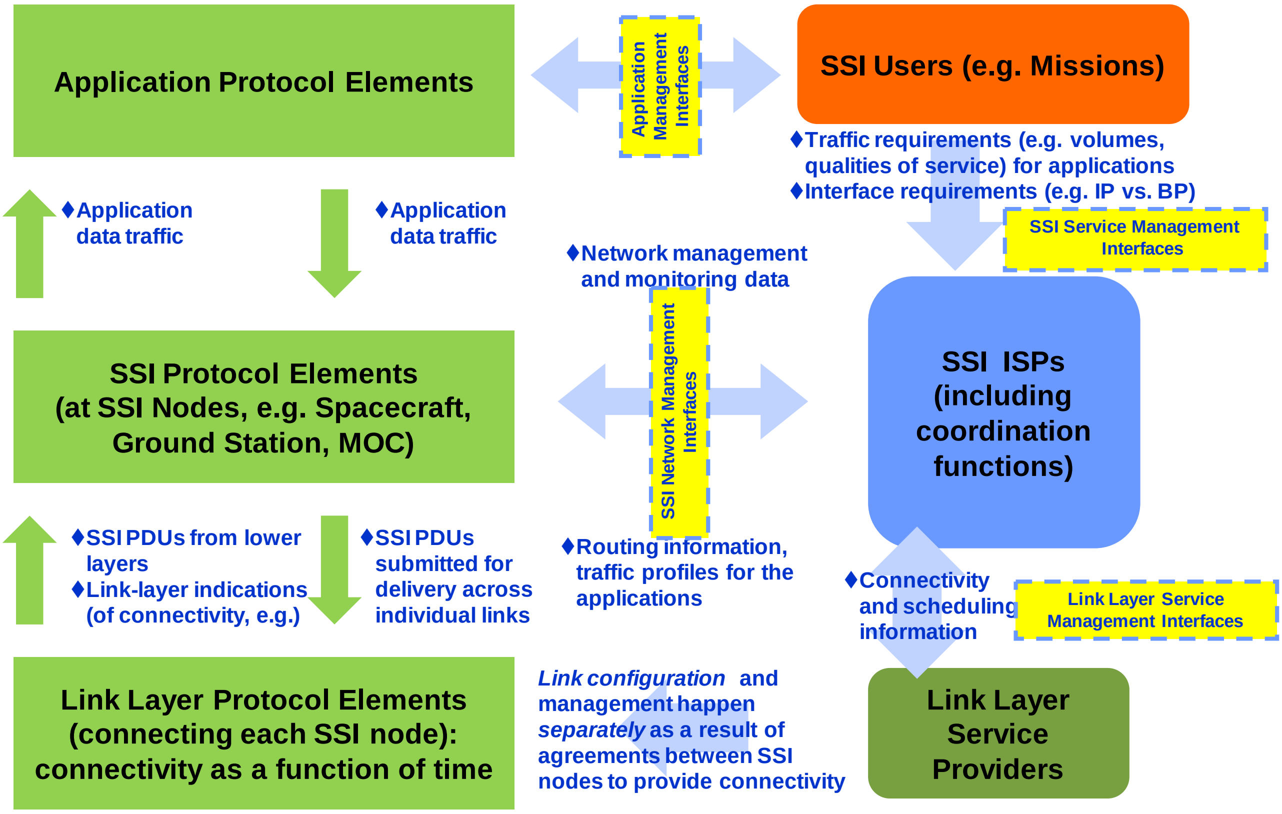

Figure 2-3 Service Management and Network Management Interfaces

3 CATALOG #2 SERVICES

A given IOAG Service can be built on top of a number of combinations of Space Link Interface standards and Ground Link Interface standards. Both types of standards rely on Data Structure standards that are not shown in the table. In Catalog #2, IOAG Services are using also Internetworking Standards such as DTN and IP.

The following IOAG Service groups are relevant within IOAG Service Catalog #2. Each service group includes several service types.

- Forward Data Delivery Services Group. These services allow transfer of data from a control center to a spacecraft.
- Return Data Delivery Services Group. These services allow transfer of data from a spacecraft to a control center.
- Radio Metric Services Group. These services allow the results of radio metric measurements to be provided to a control center. [10]
- Time Services Group. These services allow the calculation of time correlation elements and synchronization by means of time distribution.[11]

In addition Service Management and SSI Network Management functions are defined. They allow for interaction between the space agencies in order to coordinate the provision of the above listed services. Moreover, these functions allow the status of the execution of a service to be provided to a control center.

All IOAG Services defined in Catalog #1 [IC1] can still be used by Agencies, with the understanding that their applicability is limited to ABA scenarios. In addition, Agencies can use in ABA scenarios all the services defined in Catalog #2. IOAG Services defined in Catalog #1 are repeated here below for convenience.

- **Forward Data Delivery Services**
  - Forward CLTU Service (Core Service)
  - Forward Space Packet Service
  - Forward Synchronous Encoded Frame Service
  - Forward File Service
- **Return Data Delivery Services**
  - Return All Frames Service (Core Service)
  - Return Channel Frames Service (Core Service)
  - Return Operational Control Field Service
  - Return Unframed Telemetry Service
  - Return File Service

[10] As explained in section 4, no new IOAG Service is added to this group by Catalog #2. Nevertheless, with respect to Catalog #1 IOAG Services, some additional results of radio metric measurements may be provided via First Hop Delivery Service.

[11] As explained in section 4, this new group of Catalog #2 includes only one IOAG Service. Nevertheless, some additional time measurements may be provided via Last/First Hop Delivery Services.

- **Radio Metric Services**
  - Validated Data Radio Metric Service (Core Service)
  - Raw Data Radio Metric Service
  - Delta DOR Service

The services defined for IOAG Service Catalog #2 are shown in the following summary table and explained in detail in Section 4. The rows marked by light green shadow in the following table indicate core services for IOAG Service Catalog #2 while the white rows indicate extended services.

As mentioned in Section 2, the term “Link” as used in table column headers does not refer to the Link Layer (layer 2) of the ISO/OSI reference model. Rather the term Space Link refers to any connectivity between elements of which at least one of the peer entities is space borne, While Ground Link refers to a connection between entities that are both on ground.

All applicable standards are identified in the following table, but any given implementation will only use a sub-set of these in appropriate combinations.

IOAG Service Group	IOAG Service Types	Space Link Interface Standards	Ground Link Interface Standards
Forward Data Delivery Services	Forward Internetworking for DTN	• Radio Frequency and Modulation [RFM] [12] • TC Synchronization and Channel Coding [TC-S&C] • TC Space Data Link Protocol [TC-DLP] • Communications Operation Procedure-1 [TC-COP] • Space Packet Protocol [SPP] • Encapsulation Service [ENC] • TM Synchronization and Channel Coding [TM-S&C] • AOS Space Data Link Protocol [AOS] • Proximity-1 Space Link Protocol [PR1] • DTN Protocol [DTN-S]	• DTN Protocol [DTN-S] • CSTS Forward Frame Service [FF] • SLE Return Channel Frames [RCF]
	Forward Internetworking for IP	Those for "Forward Internetworking for DTN" except [DTN-S] but plus: • Internet Protocol [IP] • IP over CCSDS Space Links [IPOC]	• Internet Protocol [IP] • CSTS Forward Frame Service [FF] • SLE Return Channel Frames [RCF]
	Forward Last Hop Delivery Service	Those for "Forward Internetworking for DTN" and "Forward Internetworking for IP" plus: • CCSDS File Delivery Protocol [CFDP] • CCSDS Delivery Agent [CDA]	Those for "Forward Internetworking for DTN" and "Forward Internetworking for IP" plus: • CSTS Forward File Service [CFFS] (only when the user is not DTN enabled)

[12] With respect to Forward IOAG Service(s), the applicability of this recommendation is limited to the sections for the recommendations about "Earth to Space RF" and "Telecommand".

IOAG Service Group	IOAG Service Types	Space Link Interface Standards	Ground Link Interface Standards
Return Data Delivery Services	Return Internetworking for DTN	• Radio Frequency and Modulation [RFM] [13] • TM Synchronization and Channel Coding [TM-S&C] • TM Space Data Link Protocol [TM-DLP] • AOS Space Data Link Protocol [AOS] • Space Packet Protocol [SPP] • Encapsulation Service [ENC] • Proximity-1 Space Link Protocol [PR1] • DTN Protocol [DTN-S]	• DTN Protocol [DTN-S] • SLE Return Channel Frames [RCF] • CSTS Forward Frame Service [FF]
	Return Internetworking for IP	Those for "Return Internetworking for DTN" except [DTN-S] but plus: • Internet Protocol [IP] • IP over CCSDS Space Links [IPOC]	• Internet Protocol [IP] • SLE Return Channel Frames [RCF] • CSTS Forward Frame Service [FF]
	Return First Hop Delivery Service	Those for "Return Internetworking for DTN" and "Return Internetworking for IP" plus: • CCSDS File Delivery Protocol [CFDP] • CCSDS Delivery Agent [CDA]	Those for "Return Internetworking for DTN" and "Return Internetworking for IP" plus: • CSTS Return File Service [CRFS] (only when the user is not DTN enabled)

[13] With respect to Return IOAG Service(s), the applicability of this recommendation is limited to the sections for the recommendations about "Space to Earth RF" and "Telemetry".

IOAG Service Group	IOAG Service Types	Space Link Interface Standards	Ground Link Interface Standards
Time Services	Time Synchronization Service	• Time Transfer [TT]	• Clock Correlation [CC] • Time Synchronization [TS]

Table 3-1 Catalog #2 Services

4 DESCRIPTION OF CATALOG #2 SERVICE GROUPS AND TYPES

The following sections describe in detail the four service groups included in Catalog #2. They are:

- Forward Data Delivery Services Group
- Return Data Delivery Services Group
- Radio Metric Services Group
- Time Services Group

4.1 Forward Data Delivery Services Group

The Forward Data Delivery services allow a Control Center to forward data to a remote spacecraft.

4.1.1 FORWARD INTERNETWORKING FOR DTN

[DTN-S] defines the end-to-end protocol (suite) and services for the exchange of bundles in Delay/Disruption Tolerant Networking. Once the network of DTN nodes is established, the user at the sending end invokes this IOAG service by requesting the DTN node at the sending end to forward bundles (possibly via multiple hops) to the receiving end.

Each node will provide the necessary interfaces to the underlying link layer protocols; e.g. for a terrestrial hop a node will simply send Bundles over a TCP/IP based link [TCP], but for a long haul hop a node will encapsulate the Bundles in LTP PDUs, which in turn get wrapped into CCSDS Encapsulation Packets. Depending on the type of forward link, Encapsulation packets may be carried by TC frames (version number 1, asynchronous uplink) or AOS frames (version number 2, synchronous uplink) or Proximity-1 frames (version number 3, asynchronous transmission).

Each node will know which necessary conversions, including address mapping, shall be performed regarding the underlying protocol layers. The configuration will be established by SSI Network Management functions [see section 6.1].

Forward Internetworking for DTN relies on the following standards:

- Radio Frequency and Modulation [RFM] limited to modules for “Earth-to-Space Radio Frequency (Forward Link)” and “Telecommand (Forward Link)”
- TC Synchronization and Channel Coding [TC-S&C]
- TC Space Data Link Protocol [TC-DLP]
- Communications Operation Procedure-1 [TC-COP]
- Space Packet Protocol [SPP]
- Encapsulation Service [ENC]
- TM Synchronization and Channel Coding [TM-S&C]
- AOS Space Data Link Protocol [AOS]
- Proximity-1 Space Link Protocol [PR1]

- DTN Protocol [DTN-S]

There are cases where a DTN enabled Ground Tracking asset will be required to support a non-DTN enabled data flow concurrently with the DTN data flows supporting this IOAG Service [14]. In this case, the IOAG service relies also on the following Ground Link Interface Standard:

- CSTS Forward Frame Service [FF]

Additionally, there are cases where a non-DTN enabled Ground Tracking asset has to support a DTN enabled Agency A Lander Control Center together with a non-DTN enabled Agency B Orbiter Control Center [15]. In this case, the IOAG service relies also on the following Ground Link Interface Standards:

- CSTS Forward Frame Service [FF]
- SLE Return Channel Frames [RCF] [16]

NOTE - The CSTS Forward Frame Services above is “to be written”. It is assumed that this Service will provide a forward frame service for [AOS] and [TC-DLP] implementing multiplexing, frame fill and coding in the provider and implementing the full stack down to the physical layer.

NOTE – In some special cases an Agency may still access a Ground Tracking Asset through [CLTU] or [FSEF] (e.g. when frame multiplexing is not required, when frames are encrypted, etc.). However [CLTU] or [FSEF] are not regarded as components of the IOAG Service Forward Internetworking for DTN.

4.1.2 FORWARD INTERNETWORKING FOR IP

The user at the sending end invokes the Forward Internetworking IP Service by requesting the IP node at the sending end to forward IP datagrams (possibly via multiple hops) to the receiving end.

Each node will provide the necessary interfaces to the underlying link layer protocols; e.g. for a terrestrial hop the provider may send datagrams over an IP based ground link: for a hop over the space link, IP datagrams will be wrapped into CCSDS Encapsulation Packets. Depending on the type of forward link, these packets may be carried by TC frames (version number 1, asynchronous uplink) or AOS frames (version number 2, synchronous uplink) or Proximity-1 frames (version number 3, asynchronous transmission).

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[14] With reference to the example scenario of Figure 2-2, a possible case for this is where the Agency B Orbiter supports also DTN, but it uses standard TC/TM/AOS link layer services for controlling purposes. In such a case, the DTN enabled Agency A Lander Control Center communicates to its Lander via an Agency B Orbiter through an Agency C Ground Tracking Asset that also must support the non-DTN enabled Agency B Orbiter Control Center. Therefore the Ground Tracking Asset must support the Orbiter TT&C using non-DTN data flow via SLE/CSTS services as well as accepting the DTN flows from the Lander Control Center. Consequently the Ground Tracking Asset shall multiplex the data flows at frame level.

[15] With reference to the example scenario of Figure 2-2, a possible case for this is where the Agency C Ground Tracking Asset has to support a DTN enabled Agency A Lander Control Center together with a non-DTN enabled Agency B Orbiter Control Center. However Agency A Lander Control Center cannot rely directly on DTN because the Ground Tracking Asset is not DTN enabled. The DTN data flow will be invisible to the Ground Tracking Asset.

[16] This is required to allow the DTN enabled Agency A Lander Control Center to close the LTP protocol.

Users have to take into account that this service works only if end-to-end connectivity to the final destination can be established, if it will be continuously available during the transmission, and if the round-trip delay is less than 10 seconds. These are fundamental limitations imposed by the design of the Internet Protocol Suite.

Forward Internetworking for IP relies on the same standards applicable to "Forward Internetworking for DTN" (see 4.1.1), except [DTN-S], plus the following standards:

- IP over CCSDS Space Links [IPOC]
- IP Protocol [IP]

For the cases where an IP enabled Ground Tracking asset must support a non-IP enabled data flow concurrently with the IP data flows, Forward Internetworking for IP relies also on the following Ground Link Interface Standard to do frame multiplexing:

- CSTS Forward Frame Service [FF]

Additionally, for cases where the IP enabled Control Center needs "IP feedback" from a non-IP ground tracking asset [17], this IOAG Service also relies on the following Ground Link Interface Standard:

- SLE Return Channel Frames [RCF]

4.1.3 FORWARD LAST HOP DELIVERY SERVICE

This IOAG service provides a standardized "last hop" delivery service in the forward direction to support "essential commanding", legacy (non-networked) mission commanding, and Proximity link time distribution. A standard file format is assumed as the means for the user (i.e. the Control Center of the spacecraft being the last node n) to transmit both the data to be delivered and the metadata such as instructions about how to deliver it in a consistent way, proximity-1 configuration, etc.

The service is designed to operate over SSI networked end-to-end services, and it will enable a user (in node 1) to transfer data to a spacecraft (identified as end node "n") via multi-hop relaying of a file through a sequence of "n-1" either DTN or IP nodes. This service uses the CFDP application to transfer a file as described in 4.3 on top of the Forward Internetworking Services for either DTN or IP extending up to node "n-1". In node "n-1", an application referred as Delivery Agent resides and provides the data delivery to the last node. The last hop from node "n-1" to end node "n" does not rely on SSI networked services.

The file transmitted from the user to the node "n-1" contains all the information needed by the Delivery Agent that is in charge of satisfying the request, by interpreting the delivery instructions (e.g. timing, link configuration etc.) and transmitting the data over the last hop. The Forward Delivery Agent extracts data according to instructions and configures the "last hop" node to deliver those data over the link to the end node.

[17] This may be required e.g. for an address resolution protocol to work or in case additional protocols run on top of IP.

For the forward direction, the CCSDS Delivery Agent will provide 2 functions that will impact the file format:

- Essential commanding (e.g. Proximity-1 UDD or Packet SAP, BCH data or Packets, etc.);
- Proximity-1 Timing Services.

The file formats will be subject to the Delivery Agent standardization by CCSDS.

In this case, this service relies on the same standards applicable to Forward Internetworking Services for either DTN or IP, plus the following Space Link Interface standards:

- Proximity-1 Space Link Protocol [PR1]
- CCSDS File Delivery Protocol [CFDP]
- CCSDS Delivery Agent [CDA]

For cases when the Lander Control Center is not DTN enabled, the file can be passed from the user to the Orbiter Control Center using the CSTS Forward File Service [CFFS], which in essence asks the Orbiter Control Center to transmit the file up to node "n-1" using CFDP[18]. In this case, it relies on the same standards applicable to Forward Internetworking Services for either DTN or IP, plus the following standards:

- Proximity-1 Space Link Protocol [PR1]
- CCSDS File Delivery Protocol [CFDP]
- CSTS Forward File Service [CFFS]
- CCSDS Delivery Agent [CDA]

The Delivery Agent will also report back status of the delivery service to the user of the SSI networked services mentioned above by returning to the user a file still using the CFDP application described in 4.3. Also this file format will be subject to the Delivery Agent standardization by CCSDS.

4.2 Return Data Delivery Services Group

The Return Data Delivery services allow a Control Center to use a supporting Ground Tracking Asset to receive data sent from a remote spacecraft.

4.2.1 RETURN INTERNETWORKING FOR DTN

All the considerations for the forward direction of this IOAG service apply to the return direction as well, while (part of) the set of applicable Space Link Interface Standards clearly changes according to the changed direction.

Return Internetworking for DTN relies on the following standards:

- Radio Frequency and Modulation [RFM] limited to modules for "Space-to-Earth Radio Frequency (Return Link)" and "Telemetry (Return Link)"

[18] For the CSTS service defined in Catalog #1 the fact that CFDP runs over DTN or IP or SPP will be irrelevant.

- TM Synchronization and Channel Coding [TM-S&C]
- TM Space Data Link Protocol [TM-DLP]
- AOS Space Data Link Protocol [AOS]
- Space Packet Protocol [SPP]
- Encapsulation Service [ENC]
- Proximity-1 Space Link Protocol [PR1]
- DTN Protocol [DTN-S]

In the cases where a DTN enabled Ground Tracking asset must support a non-DTN enabled data flow concurrently with the DTN data flows, this IOAG Service relies also on the following Ground Link Interface Standard.

- SLE Return Channel Frames [RCF]

In the cases where a non-DTN enabled Ground Tracking asset has to support concurrently DTN and non-DTN data flows, this IOAG service relies also on the following Ground Link Interface Standards:

- SLE Return Channel Frames [RCF]
- CSTS Forward Frame Service [FF] [19]

4.2.2 RETURN INTERNETWORKING FOR IP

All the considerations for the forward direction of this IOAG service apply to the return direction as well, while (part of) the set of applicable Space Link Interface Standards clearly changes according to the changed direction.

Return Internetworking for IP relies on the same standards applicable to "Return Internetworking for DTN" (see 4.2.1) plus the following standards:

- IP over CCSDS Space Links [IPOC]
- IP Protocol [IP]

In the cases where a Ground Tracking asset shall support a non-IP enabled data flow concurrently with the IP data flows supporting this IOAG Service, it relies also on the following Ground Link Interface Standard.

- SLE Return Channel Frames [RCF]

Additionally, for cases where the IP enabled Control Center needs to send "IP feedback" to a non-IP ground tracking asset [20], this IOAG Service relies also on the following Ground Link Interface Standard.

- CSTS Forward Frame Service [FF]

[19] This is required to allow the DTN enabled Agency A Lander Control Center to close the LTP protocol.
[20] This may be required by e.g protocols running on top of IP.

4.2.3 RETURN FIRST HOP DELIVERY SERVICE

This IOAG service provides a standardized “first hop” delivery service in the return direction to support “essential” telemetry, legacy (non-networked) mission telemetry, open-loop recording (EDL & emergency), Proximity link tracking & time data return.

The data flows from the delivery agent to the user (i.e. the Control Center of the spacecraft being node 1) are nominally designed to operate over SSI networked end-to-end services. This service will enable the spacecraft hosting the service (identified as node 2) to transfer data to the end user (identified as end node “n”) via multi-hop relaying of a file through a sequence of “n-1” either DTN or IP nodes.

This service uses the CFDP application to transfer a file as described in 4.3 on top of the Return Internetworking Services for either DTN or IP extending from node 2 up to node n. In node 2, an application referred to as Delivery Agent resides and collects the data from node 1. The data transfers over the first hop (i.e. from node 1 to node 2) do not rely on SSI networked services, but instead use link or physical layer capabilities.

The request to support this service (e.g. when to collect radio metric measurements), together with the relevant delivery instructions, originates from the user and is sent in a file of standard format to the Delivery Agent using the CFDP application mentioned before. Opposite to the case of the forward direction there will be two files involved:

- the first file, traveling from the user to the Delivery Agent, contains metadata needed by the Delivery Agent such as details about which data shall be collected, configuration and delivery instructions;
- the second file, traveling from the Delivery Agent to user, contains the requested data including Delivery Agent generated annotations.

The Delivery Agent is responsible for accepting the request, interpreting the instructions (e.g. collection and delivery timing, link configuration etc.), receiving the data over the first hop and relaying them. The Delivery Agent configures node 2 to acquire the data as requested, packages the data as instructed, and returns the data and any associated metadata as a file through the SSI networked (return) services mentioned above.

For the return direction, the CCSDS Delivery Agent will provide several functions that will impact the file format:

- Essential telemetry (e.g. Proximity-1 UDD or Packet SAP, raw data or Packets, etc.);
- Open-loop recording;
- Proximity-1 radio metric data (Doppler and range);
- Proximity-1 Timing Services.

The file formats will be subject to the Delivery Agent standardization by CCSDS.

In this case, it relies on the same standards applicable to “Return Internetworking Services for either DTN or IP” plus the following Space Link Interface Standards:

- Proximity-1 Space Link Protocol [PR1]

- CCSDS File Delivery Protocol [CFDP]
- CCSDS Delivery Agent [CDA]

In a situation where the Lander Control Center is not DTN enabled, the file can be passed from the Orbiter Control Center to Lander Control Center (i.e. from node "n-1" to the end user node) using the CSTS Return File Service [CRFS] capable of receiving the file via CFDP[21]. In this case, it relies on the same standards applicable to "Return Internetworking Services for either DTN or IP" plus the following standards:

- Proximity-1 Space Link Protocol [PR1]
- CCSDS File Delivery Protocol [CFDP]
- CSTS Return File Service [CRFS]
- CCSDS Delivery Agent [CDA]

4.3 Additional Forward and Return Applications

Once the SSI is established, additional forward and return applications can run on top of the Forward/Return Internetworking Services for either DTN or IP in a way that is actually invisible to intermediate SSI nodes.

The most important example for such applications is CFDP that will enable users to transfer files to/from a spacecraft via multi-hop relaying through a sequence of either DTN or IP nodes. The user at the sending end simply uses a CFDP protocol entity to send CFDP Protocol Data Units to the receiving end (possibly via multiple hops) embedding them either within bundles or IP datagrams.

Similarly, the Asynchronous Message Service [AMS], can run on top of the Forward/Return Internetworking Services for either DTN or IP in a way that is actually invisible to intermediate SSI nodes.

4.4 Radio Metric Services Group

No new IOAG Service is added to this group by IOAG Catalog #2. Nevertheless, with respect to IOAG Catalog #1 Services, some additional results of radio metric measurements, that are collected by the lander, the orbiter or both , may be provided via First Hop Delivery Service, i.e.:

- Open-loop Recording, and
- Proximity-1 radio metric data (Doppler and range).

4.5 Time Services Group

This new group of Catalog #2 services includes only the Time Synchronization Service.

[21] For the CSTS service defined in Catalog #1 the fact that CFDP runs over DTN or IP or SPP will be irrelevant.

In an attempt to reduce ambiguity, in this section a specific terminology is used that may differ from common practice used in some space flight organizations. The term “**clock**” means some instrument used to indicate, measure, keep, and/or co-ordinate time (on spacecraft this is most often a counter driven by some accurate, but free running, oscillator) while the term ”**time**” means a reading of such counter at a point in time and, in particular, also to relate that time to a specific universal timescale. Formalized definition of all of these terms is the province of the standardization organizations.

Up until now missions have typically used private means for doing clock correlation between a free-running spacecraft clock and “Earth time”, by computing the relationship between the spacecraft local clock and some universal timescale such as UTC. Typically this is done by recording time data at specific events that are observable both on the spacecraft and on ground (e.g., leading edge of the first bit of the Attached Sync Marker of a clearly identifiable telemetry frame) and then noting the time-tags both at transmission from the spacecraft and at reception on ground. A clock correlation process is used on the ground to establish the relationship between the spacecraft clock and Earth time. This process requires precise knowledge of the position spacecraft at the observed event so that the propagation delay induced by the signal path can be compensated.

More formally: ”**time transfer**” is performed by exchanging time data formatted according to some agreed ”**time code**”, while ”**clock correlation**” uses the data exchanged by ”**time transfer**” in order to determine the offset between the clocks at the sending and receiving ends. Clock correlation does not imply alignment of clocks, but it may require knowledge of clock stability, skew, and drift and most importantly the propagation delay induced by the signal path(s) involved in the time transfer. Clock correlation may also involve comparison of local clock times to some standard high precision clock that accurately reflects a common timescale such as UTC.

Synchronization of activities on multiple spacecraft may require time synchronization of their clocks to the same universal timescale, e.g. UTC. Depending upon the application and the environment, various means may be applied to either update the local clock (clock synchronization) or just to maintain knowledge of the offsets between the spacecraft clock and the universal timescale (clock correlation).

The essential process for time synchronization relies on time transfer. The time data are used to calculate the offset between the two clocks with or without eventually performing clock synchronization. A generalized diagram for this is shown in Figure 4-1.

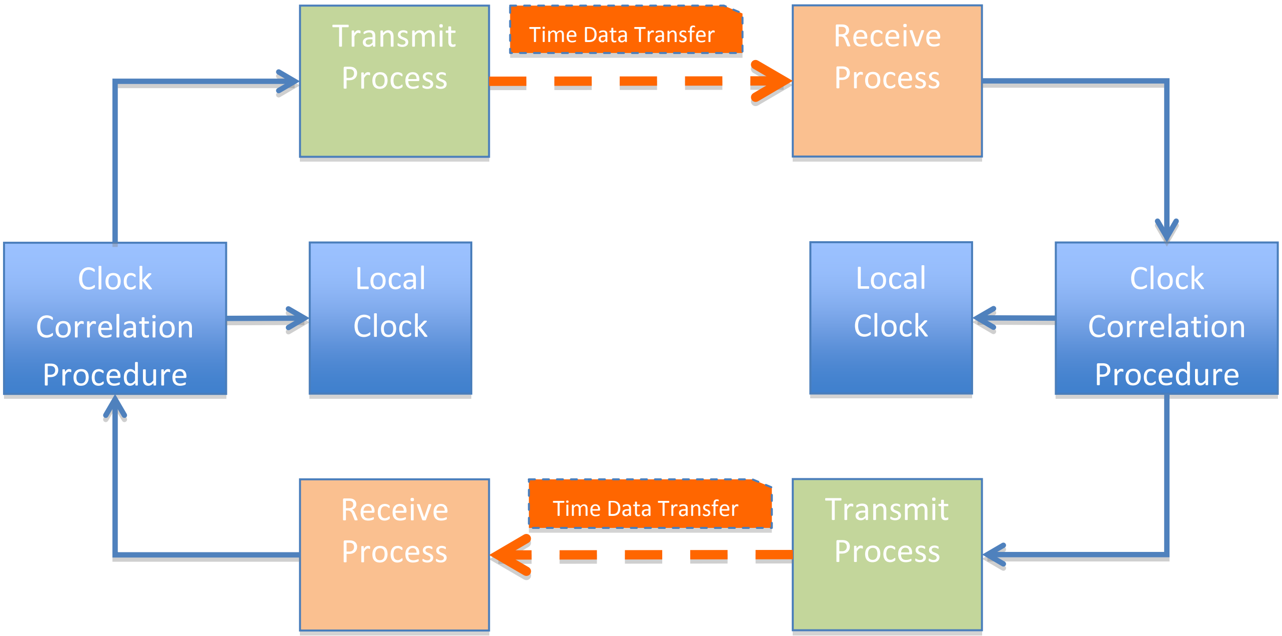

Figure 4-1 Generalized Time Synchronization Procedure

4.5.1 TIME SYNCHRONIZATION SERVICE

The IOAG Time Synchronization Service will allow aligning clocks to a common timescale, such as UTC and it requires both *clock correlation* and *time transfer* be performed.

For transferring timing information one of the formats defined in [TCF] standard shall be used.

The Time Synchronization Service relies on the following standards:

- Clock Correlation Procedures [CC]
- Time Transfer [TT]
- Time Synchronization [TS].

5 SERVICE MANAGEMENT FUNCTIONS

Services provided by an IOAG member agency are requested and controlled via a standard service management function. Service management by itself is not a service. It is a function performed cooperatively by both the tracking network (on the service provider's side) and the mission operations center (on the service user's side). It includes, but it is not limited to:

- Allocation and scheduling of space communication resources and assets during the service commitment and planning phases. This does not include allocation and scheduling of the resources managed by the SSI Network Management functions described in section 6.
- Configuring, monitoring, and controlling the communication assets during the service provision phase (i.e., before, during, and after a communication contact) as far as the individual point to point connections are concerned.
- Reporting of service execution results.

Service Management Functions described in this section do not deal with the SSI Network Nodes resources for which the SSI Network Management functions described in section 6 are used.

The service management interfaces employed for some of the above will be in compliance with the CCSDS Cross Support Service Management Specification [SM]. For transferring the spacecraft tracking information to the ground communications asset the CCSDS Orbit Data Message [ODM] standard shall be used.

The Service Management Functions defined in IOAG Service Catalog #1 can still be used by Agencies, including the monitoring function for Engineering Monitoring Data Delivery relying on CSTS Engineering Data Monitoring [EDM].

The introduction in Catalog #2 of space communication services for in-space relay and networked cross support scenarios creates a number of new requirements on the CCSDS standard for cross support service management [SM]. A tentative list of new requirements and issues is included here together with the functionality to be supported.

- Forward/Return DTN Internetworking
  - Mapping of multiple SSI and/or TT&C data streams into specific virtual channels
  - Specification of Ground Station functionality for framing, encoding, and fill insertion.
- Forward/Return IP Internetworking
  - whether the CCSDS Encapsulation Packets (wrapping IP datagrams) shall be carried by AOS frames (version number 2, synchronous uplink) or TC frames (version number 1, asynchronous uplink);
  - in the latter case whether COP shall be used or not (i.e. AD or BD service).
  - Mapping of multiple SSI and/or TT&C data streams into specific virtual channels
  - Specification of Ground Station functionality for framing, encoding, and fill insertion.
- Forward Essential Command

    - Specification of the proximity radio link layer configuration (Port, Rate, SAP, COP-P)
    - How to interpret the data file (CLTUs, BCH code blocks, TC frames, space packets)
    - Scheduling times for data transmission via Proximity-1 and any retransmission instructions or termination conditions
    - Required reporting and its scheduling and configuration
- Return Essential Telemetry
    - Specification of the proximity radio link layer configuration (Port, Rate, SAP, COP-P)
    - Scheduling times for receiving the data via Proximity-1
    - Configuration instructions to package the relevant data
    - Required reporting/confirmation about the handling of the request
- Open-loop Recording
    - Receiver physical layer configuration (channels' center frequency, sampling rate, sample resolution)
    - Scheduling times for recording the data
    - Configuration instructions to package the relevant data
    - Required reporting/confirmation about the handling of the request
- In-situ radiometric data collection
    - Link Layer Instructions (Time tagging of egress and ingress of Proximity-1 frames, Doppler shift measurement)
    - Scheduling times for receiving the data via Proximity-1
    - Configuration instructions to package the relevant data
    - Required reporting/confirmation about the handling of the request
- Time Synchronization
    - Configuration instructions for time synchronization service and data exchange
- Multiplexing to address bandwidth allocation control on the space link when several TC/AOS/TM streams are flowing concurrently on different VCs.
    - Configuration of the Multiplexing in Ground Station or in the Orbiter Control Center for the forward link. [22]
    - Configuration of the Multiplexing in the Orbiter for the return link may not be addressed by SM. Despite the applied multiplexing is always subject to agreement among agencies, cannot be controlled by a standardized service management mechanism as it is part of Spacecraft configuration.
- Resource management.

The presence of objects in-space needing to be managed implies another important addition to the CCSDS Cross Support Service Management Specification [SM] that will have to address the resource management of some in-space entities. As such, the mechanism to be used for conveying SSI network management information to these entities will have to be addressed.

[22] Multiplexing is always subject to agreement among agencies; however the real need for Service Management only rises when Orbiter MOC and Ground Asset belong to different agencies. If the multiplexing is performed in the Orbiter MOC or when Orbiter MOC & Ground Asset belong to same agency, then management of the multiplexing is a private matter that still must be specified (but even in the latter case the owner may want to use Service Management).

6 SSI NETWORK MANAGEMENT FUNCTIONS

DTN networks will consist of a combination of “connected systems with wide-bandwidth, low-delay links” (e.g. on ground) and “disconnected systems with low-bandwidth, noisy, and perhaps long-delay links” (e.g. in space), Thus DTN network management will be more complex than managing a connected system. The SSI Network Management functions are responsible for the management of the SSI Network layer entities (i.e. those related to the DTN protocol suite[23]). This implies that SSI Network Management does not address things such as antenna pointing, modulation scheme, data rates and frequencies etc. as all that is handled by conventional Service Management Functions (see section 5) or by lower layer elements responsible for configuring individual hops. To operate correctly and timely, SSI Network Management requires knowledge of what Service Management Function have established in terms of connectivity and associated characteristics.

Since SSI can work satisfactorily only when the appropriate amount of resources can be guaranteed by the nodes and they are functioning nominally, there is a tight dependency between these two sets of functions; e.g. the configuration of a SSI node in space can only be achieved by configuring some items by means of Service Management.

Among the aspects related to the management of the SSI Network, two main classes, and therefore two functions, can be identified:

1. the configuration of DTN parameters that are properly a part of the DTN protocol suite, and
2. the configuration of parameters concerning planning and opportunities for carrying out the DTN communications.

6.1 Bundle Protocol Network Management

Within DTN, the configuration of the individual nodes will be a key issue for achieving the expected performances and efficiency.

A tentative list of items to be managed includes, but may not be limited to:

- routing tables and address mapping,
- naming services,
- setting for the connections and inter-process communications between the DTN bundle layer and the underlying transport protocol required by the application (e.g. DTN running on top of IP or CCSDS Link Layer protocols),
- priorities to use multiple communication links [24],

[23] Actually the SSI network includes also IP nodes and they will need to be configured and properly managed. The management of the IP nodes as needed in the cross support context is assumed to be carried out by the existing standard means and this is therefore not addressed in this document.

[24] This is addressing the case of several physical links among two DTN nodes (i.e. visibility of several nodes).

- priorities and multiplexing of bundles over a single communication link [25],
- time distribution within SSI/DTN, and
- other configuration parameters.

The SSI Network Management Service also addresses the monitoring of the DTN nodes.

DTN distinguishes between Local and Remote DTN Network Management:

- The term "Local Management" is used when the “manager” can access the device by being physically at the devices (i.e. console port) or via real-time access such as via a connected IP network. Here we assume high bandwidth, no disruption and insignificant delay.
- The term "Remote Management" implies managing a DTN node over a DTN network. This assumes that the systems may experience one or more of the following: long propagation delays, long periods of disruption, long periods of disconnection and operate over low bandwidths.

Within SSI, the second type is the most relevant one.

The DTN management aspects of SSI Network are defined in [DTN-M].

6.2 SSI Contact Planning

Another very important task of SSI Network Management is the distribution of contact opportunities so that the individual nodes are in the position to route the data (e.g. SSI bundles) accordingly. SSI Network Management faces the challenge of managing resources contributed by various confederated ‘networks’ and this service has to overcome the complexity and operations cost for scheduling and setting up individual hops as it is done today.

The service planning aspects of SSI Network Management are defined in [SSI-CP].

[25] This is addressing the case of only one physical link among two DTN nodes and the Bundle multiplexing shall be managed to support traffic from several DTN users.