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# IOAG

# SERVICE CATALOG #1

prepared by/*préparé par* Felix Flentge (Editor)

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| Initial version | 1 | 0 | 15 September 2009 |
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| Updated according to recently published CCSDS standards | 7-9 | 1.1 |
| Removed distinction between nominal, critical and emergency service modes as this distinction is not used in the remainder of the document | 14 | 3 |
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| Deletion of Forward Space Packet Service as CCSDS 912.3-B Space Link Extension – Forward Space Packet Service has been silverized by CCSDS | 16; 18 | 1.1.1<br>Table 3-1<br>4.1.3 |
| Added missing [TC-DLP] to Forward Frame Service Type | 18 | 4.1.2 |
| Update of Radio Metric Services<br>• Updated 'Validated Data Radiometric Service' to 'Tracking Data File Service'<br>○ updated from (non-existing) 'Offline Radio Metric Service' to use of Tracking Data Message [TDM] or XML Specification for Navigation Data Message [XNM]<br>○ added new file transfer options including sftp<br>• Updated 'Raw Data Radiometric Service' to 'Tracking Data Cross Support Transfer Service'<br>○ explicitly added Tracking Data Message [TDM] as Ground Link Interface Standard<br>• Updated 'Delta DOR Service' to 'Delta DOR File Service'<br>○ updated from (non-existing) CSTS DDOR Service to Delta-DOR Raw Data Exchange Format [DDRXF]<br>○ added new file transfer options including sftp | 17; 21-22 | Table 3-1<br>4.3 |
| Restructuring of Service Management Functions Group into<br>• Trajectory Data File Service<br>• Service Agreement Development<br>• Communication Resource Booking (Station Scheduling)<br>• Planning Information<br>• Published Schedule and Unallocated Times | 23-27 | 5.1 |
| Update of paragraph on Service Management in 2 according to restructured service management | 11 | 2 |
| Removed references<br>• CCSDS 902.8-B Cross Support Service Management: Service Accounting<br>• CCSDS 902.7-M Cross Support Service Management: Service Catalog. Magenta Book. | 7 | 1.1.1 |

| | | |
|---|---|---|
| Renamed:<br>• Engineering Monitoring Data Delivery to Service Execution Functions Group<br>• Engineering Monitoring Data Delivery to Monitored Data Delivery | 27 | 5.2 |
| Added reference to SANA Functional Resource Model | 7; 27 | 1.1.1 / 5.2 |
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# TABLE OF CONTENTS

# 1 INTRODUCTION

This document constitutes the IOAG Service Catalog #1 that describes the cross-support services that will be provided by the ground tracking assets[1] operated by the IOAG member agencies.

The IOAG Service Catalog #1 services provide space communication and navigation capabilities for interaction between a spacecraft control center and a spacecraft directly reachable via a ground tracking asset as shown in Figure 2-1. Measurements using the radio signal are provided as Radio Metric Services for the purpose of spacecraft navigation and communication operation in space.

Related to the provision of the above Space Communication and Radio Metric 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.

IOAG Service Catalog #1 is structured into "core" and "extended" services with the understanding that "core" services will be implemented by all IOAG Agencies, while "extended" services will be considered for bi-lateral cross supports. The IOAG agencies current capabilities are documented in the IOAG Communications Asset Table [XSCA].

The definition of IOAG Service Catalog #1 is likely to generate associated guidance of CCSDS work for those standards that are either in progress or to be started. 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.

The IOAG Service Catalog #2 defines space communication services for in-space relay and network cross support scenarios which would enable future Solar System Internetworking. That catalog comprises typically DTN and/or IP technologies.

A future IOAG Service Catalog #3 is planned to define services at application level for end-to-end cross support scenarios or for interoperability within a Space and/or Ground system with contributions by several independent Agencies. That catalog will comprise typically Mission Operations software technologies.

Some agencies are currently implementing on their Ground Systems, the Mission Operation services that will be addressed in IOAG Service Catalog #3. There is on-going analysis for future implementations in Space assets.

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

## *1.1 Applicable Documents*

### 1.1.1 GROUND LINK STANDARDS

[CLTU] CCSDS 912.1-B Space Link Extension – Forward CLTU Service Specification. Blue Book.

[CFXS] CCSDS 927.1-B Terrestrial Generic File Transfer. Blue Book.

[CRTRM] CCSDS 922.2-B Cross Support Transfer Service – Tracking Data Service. Blue Book.

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

[FF] CCSDS 922.3-B Cross Support Transfer Service – Forward Frame Service. Blue Book.

[FRM] Functional Resources, SANA Registry, https://sanaregistry.org/r/functional_resources/

[RAF] CCSDS 911.1-B Space Link Extension – Return All Frames Service Specification. Blue Book.

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

[ROCF] CCSDS 911.5-B Space Link Extension – Return Operational Control Fields Service Specification. Blue Book.

[SCC] Cross Support Transfer Service – Service Control Blue Book. TBW

[SFTP] https://datatracker.ietf.org/doc/html/draft-ietf-secsh-filexfer-02

[SM] CCSDS 910.11-B Space Link Extension – Service Management. Blue Book.

[SACP] CCSDS 902.5-B Cross Support Service Management: Service Agreement and Service Configuration Profile Data Formats. Blue Book. TBW

[SCAT] CCSDS 902.7-M Cross Support Service Management: Service Catalog. Magenta Book. TBW

[EVSQ] CCSDS 902.6-B Cross Support Service Management: Event Sequence Data Format. Blue Book. TBW

[CPIF] CCSDS 902.2-B Cross Support Service Management: Communications Planning Information Format: Planning Data Formats. Blue Book. TBW

[SPDF] CCSDS 902.4-B Cross Support Service Management: Service Package Data Formats. Blue Book - to be published

[SSF] CCSDS-902.1-B Cross Support Service Management: Simple Schedule Format Specification. Blue Book. TBW

[SMURF] CCSDS 902.9-B Cross Support Service Management: Service Management Utilization Request Format. Blue Book - to be published

### 1.1.2 SPACE LINK STANDARDS

[AOS] CCSDS 732.0-B AOS Space Data Link Protocol. Blue Book.
Including the specifications to support the Space Data Link Security Protocol [SDLP].

[ENC] CCSDS 133.1-B Encapsulation Packet Protocol. Blue Book.

[OPT] Optical Coding and Modulation, i.e. the collection of[2]:[2]

CCSDS 142.0-B Optical Communications Coding & Synchronization. Blue Book.

CCSDS 141.0-B Optical Communications Physical Layer. Blue Book.

[PNR] CCSDS 414.1-B Pseudo-Noise (PN) Ranging Systems. Blue Book.

[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.
NOTE: IOAG Agencies integrated this document with the IOAG Report on Preferred Coding and Modulation Schemes [PC&M].

[SDLP] CCSDS 355.0-B Space Data Link Security Protocol. Blue Book.

CCSDS 355.1-B Space Data Link Security Protocol: Extended Procedures. Blue Book.
NOTE: As implementation of security measures are normally left to bilateral agreements, the security options for Space Data Link Protocols are optional for core services.

[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.
Including the specifications to support the Space Data Link Security Protocol [SDLP].

[TC-S&C] CCSDS 231.0-B TC Synchronization and Channel Coding. Blue Book.
NOTE: IOAG Agencies integrated this document with the IOAG Report on Preferred Coding and Modulation Schemes [PC&M].

[TM-DLP] CCSDS 132.0-B TM Space Data Link Protocol. Blue Book.
Including the specifications to support the Space Data Link Security Protocol [SDLP].

[2] The standards for Optical Coding and Modulation plan to eventually cover a number of different scenarios, namely High Photon Efficiency (HPE), Optical On Off Keying (O3K), and High Data Rate (HDR). As for other standards, Agencies may decide to support only a subset of those scenarios.

[TM-S&C] The collection of:

CCSDS 131.0-B TM 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.

CCSDS 431.1-B Variable Code and Modulation (VCM) Systems for CCSDS

NOTE: IOAG Agencies integrated these documents with the IOAG Report on Preferred Coding and Modulation Schemes [PC&M].

[USLP] CCSDS 732.1-B Unified Space Data Link Protocol. Blue Book.
Including the specifications to support the Space Data Link Security Protocol [SDLP].

### 1.1.3 DATA STRUCTURES STANDARDS

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

[DDORO] CCSDS 506.0-M Delta-Differential One Way Ranging (Delta-DOR) Operations. Magenta Book.

[DDRXF] CCSDS 506.1-B Delta-DOR Raw Data Exchange Format – Blue Book.

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

[SLID] "Registries." Space Assigned Number Authority. http://sanaregistry.org/r/.

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

[XNM] CCSDS 505.0-B XML Specification for Navigation Data Messages. Blue Book.

Note: The XML Specification for Navigation Data Messages Recommended Standard is providing a different representation than [TDM] and [ODM] that define ASCII formats.

### 1.1.4 IOAG DOCUMENTS

[XSCA] (IOAG) RF Communication Assets, SANA Registry, https://sanaregistry.org/r/service_sites_apertures/

[PC&M] IOAG Report: Recommendations on Preferred Coding and Modulation Schemes –Issue 1.0, 18 April 2016.

## *1.2 Acronyms*

| | |
|---|---|
| AOS | Advanced Orbiting Systems |
| CCSDS | Consultative Committee for Space Data Systems |
| CLTU | Communication Link Transmission Unit |
| COP | Command/Communication Operation Procedure |
| CSTS | Cross Support Transfer Services |
| DOR | Differential One-Way Ranging |
| DTN | Delay/Disruption Tolerant Network |
| HDR | High Data Rate |
| HPE | High Photon Efficiency |
| IOAG | Interagency Operations Advisory Group |
| IOP | Inter-Operability Plenary |
| IP | Internet Protocol |
| LEO | Low Earth Orbit |
| O3K | Optical On Off Keying |
| PN | Pseudo Noise |
| RF | Radio Frequency |
| SLE | Space Link Extension |
| SP | Space Packet |
| SSI | Solar System Internetworking |
| TBW | To Be Written (or to be published in case work is already ongoing) |
| TC | TeleCommand |
| TDM | Tracking Data Message |
| TM | TeleMetry |
| USLP | Unified Space data Link Protocol. |

# 2 SCOPE OF CATALOG #1

Catalog #1 includes the ground based cross-support services currently available or envisaged in short time for supporting the scenario described in Figure 2-1. Such a scenario is sometimes referred to as an ABA scenario to show that an Agency B is providing services to Agency A Control Center for accessing an Agency A spacecraft.

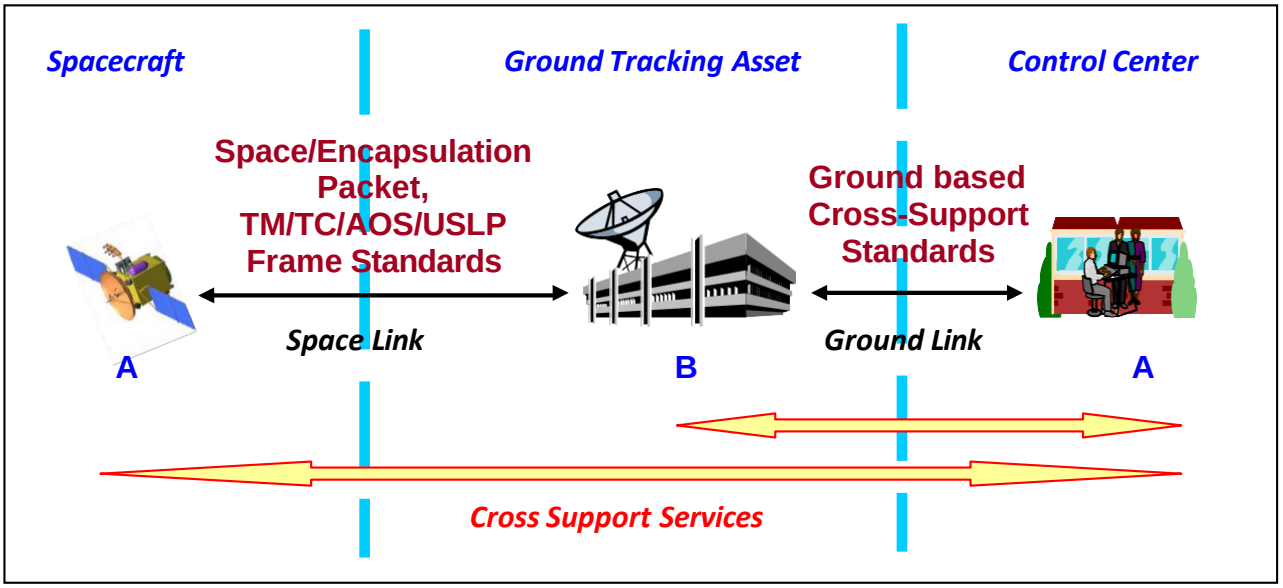


**Figure 2-1 ABA Scenario for Catalog #1**

As depicted in Figure 2-1, there are two kinds of links (and then two types of interfaces) involved in this scenario: 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.

On the Space Link, services are based on a set of standards applicable to the transfer of data over this connection, while on the Ground Link the services are defined by a set of standards defining a set of Cross Support Transfer Services (named Space Link Extension services in their simplest form). In addition, both kinds of links (and then two types of interfaces) rely on a set of other standards for data structures. The relevant standards are defined by CCSDS.

For the Space Link Interface, a very comprehensive list of CCSDS Recommendations is available covering RF and Modulation, Coding and Synchronization and Link Layer Protocols. However, those Recommendations are not necessarily fully supported by the plurality of the IOAG agencies (e.g. GMSK modulation, turbo codes, regenerative ranging, forward AOS).

The Cross Support Transfer Services provide the Control Center either with access to information traveling on the Space Link or with access to other information not traveling on the Space Link (but possibly derived from/related to the space link). Therefore, the IOAG Service span either between

the Control Center and the Spacecraft or between the Control Center and the Ground Tracking Asset as shown by the yellow arrows in the figure.

The Ground Link Interface services fall into the following categories:

1. Cross Support Transfer Services / Space Link Extension Services.
2. "Service Management" Functions.

The Cross Support Transfer Services (CSTS) and the Space Link Extension (SLE) Services define ground link interfaces between a Control Center and a Ground Tracking Asset.

The "Service Management" functions include

a. the exchange of trajectory information,
b. the development of a Service Agreement between service user and provider, including Configuration Profiles to execute the supports,
c. the booking of communication resources,
d. the exchange of planning information, and
e. the publishing of scheduling information.

## *2.1 Definition of Service*

A service is a self-contained function, which accepts one or more requests and returns one or more responses through a well-defined, standard interface. A service does not depend on the context or state of other services or processes (although it may utilize other services via their interfaces). Services are specified from the user's point of view, i.e., in terms of "what it provides" rather than "how it is performed" or "what does the job". Therefore, a service is solely specified in terms of its behavior and performance without reference to a particular implementation.

The services described in this catalog are those services supporting mission operations and relevant to an operational context where a service provider (e.g., a tracking station or a communications network) exists and it provides communications and tracking supports to a service user, i.e., a flight project's mission control center. Figure 2-2 describes the "service provider – service user" relationship in the service paradigm.

The service is the "whole job" in the operations sense. It will thus typically involve 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. The design, implementation, integration, verification and validation activities needed to supply the service are an inherent part of it.

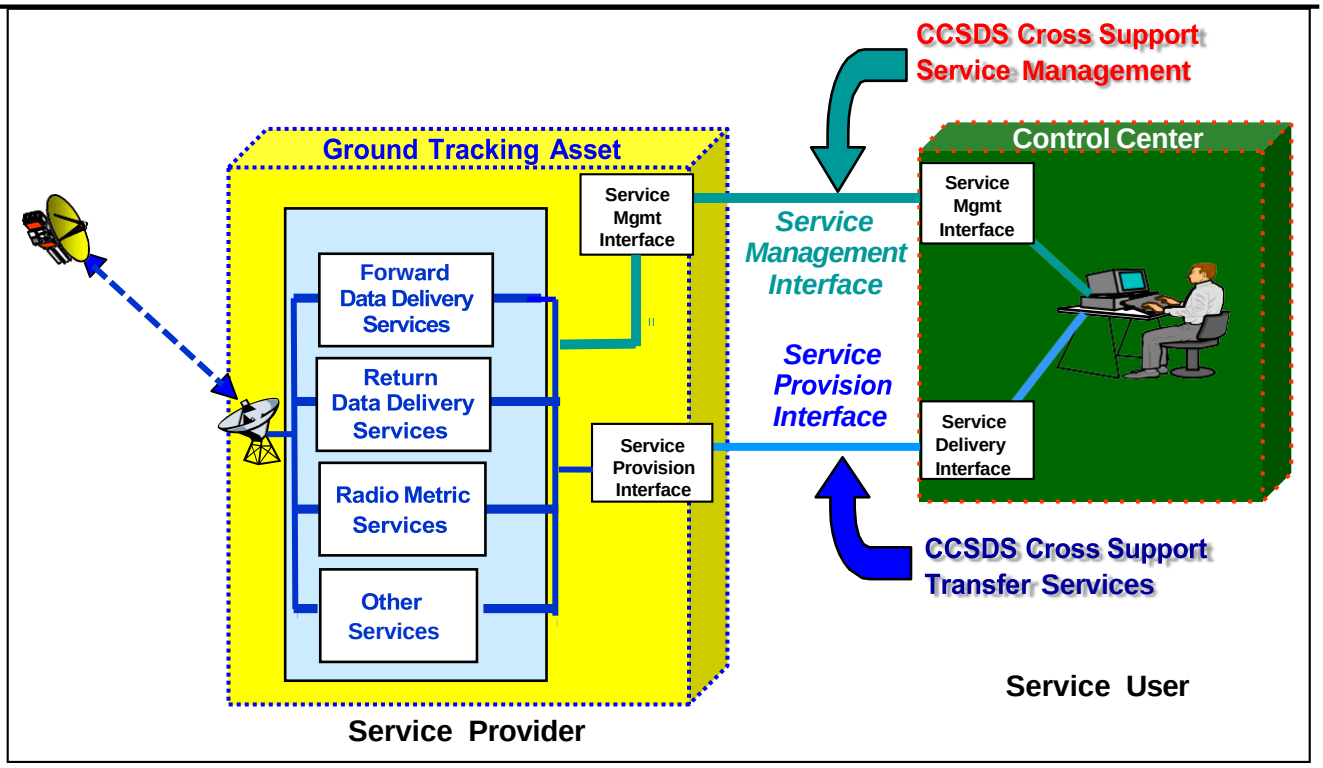


**Figure 2-2 Context of the Cross Support Services**

This catalog describes a set of standard service types provided by the IOAG member agencies for cross support purposes. 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. Of these service types a few that are minimally required of all member agencies are considered "Core Services", whereas those to be provided only on a voluntary, bi-lateral agreement basis are "Extended Services".

# 3 CATALOG #1 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 as shown in Table 3-1. Both types of standards rely on Data Structure standards that are not shown in the table.

The following groups of IOAG Services have been identified within IOAG Service Catalog #1. Each 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.

In addition, Service Management functions are defined. They allow for interaction between the space agencies in order to coordinate the provision of the above space communications and radio metric services. Moreover, these functions allow the results of radio link status to be provided to a control center.

The rows marked by light green shadow in Table 3-1 indicate core services for IOAG Service Catalog #1 while the white rows indicate extended services.

| IOAG Service Group | IOAG Service Types | Space Link Interface Standards | Ground Link Interface Standards |
|---|---|---|---|
| Forward Data Delivery Services | Forward CLTU Service | • Radio Frequency and Modulation [RFM][3]<br>• TC Synchronization and Channel Coding [TC-S&C] | • SLE Forward CLTU Service [CLTU] |
| | Forward Frame Service | • Radio Frequency and Modulation [RFM][3]<br>• TC Synchronization and Channel Coding [TC-S&C]<br>• TM Synchronization and Channel Coding [TM-S&C][4]<br>• TC Space Data Link Protocol [TC-DLP]<br>• AOS Space Data Link Protocol [AOS]<br>• Unified Space Data Link Protocol [USLP] | • CSTS Forward Frame Service [FF] |
| | Forward Frame Optical Service | • Optical Coding and Modulation [OPT]<br>• AOS Space Data Link Protocol [AOS]<br>• Unified Space Data Link Protocol [USLP] | • CSTS Forward Frame Service [FF] |

[3] 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".
[4] With respect to the use of AOS and fixed-length USLP frames on the uplink.

| IOAG Service Group | IOAG Service Types | Space Link Interface Standards | Ground Link Interface Standards |
|---|---|---|---|
| Return Data | Return All Frames Service | • Radio Frequency and Modulation [RFM][5]<br>• TM Synchronization and Channel Coding [TM-S&C] | • SLE Return AllFrames [RAF] |
| | Return All Frames Optical Service | • Optical Coding and Modulation [OPT] | • SLE Return AllFrames [RAF] |
| | Return Channel Frames Service | Those for "Return All Frames Service" plus:<br>• TM Space Data Link Protocol [TM-DLP]<br>• AOS Space Data Link Protocol [AOS]<br>• Unified Space Data Link Protocol [USLP] | • SLE Return Channel Frames [RCF] |
| | Return Channel Frames Optical Service | Those for "Return All Frames Optical Service" plus:<br>• TM Space Data Link Protocol [TM-DLP]<br>• AOS Space Data Link Protocol [AOS]<br>• Unified Space Data Link Protocol [USLP] | • SLE Return Channel Frames [RCF] |
| | Return Operational Control Field Service | • Those for "Return Channel Frames Service" | • SLE Return Operational Control Field [ROCF] |

[5] 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 |
|---|---|---|---|
| Radio Metric Services | Tracking Data File Service | • Radio Frequency and Modulation [RFM][6] [6]<br>• Pseudo-Noise (PN) Ranging Systems [PNR] | • Tracking Data Message [TDM] or XML Specification for Navigation Data Message [XNM] over<br>• file transfer[7] [7] |
| | Tracking Data Cross-Support Transfer Service | • Those for "Tracking Data File Service"[8] [8] | • Tracking Data Message [TDM] over<br>• Tracking Data Cross Support Service [CRTRM] |
| | Delta DOR File Service | • Radio Frequency and Modulation [RFM][9] [9] | • Delta-DOR Raw Data Exchange Format [DDRXF] over<br>• file transfer[6] |

**Table 3-1 Catalog #1 Services**

[6] With respect to Radio Metric IOAG Service(s), the applicability of this recommendation is limited to the sections for the recommendations about "Radio Metric".
[7] Terrestrial file transfer to be agreed between agencies depending on security policies. Maybe be based on SSH File Transfer Protocol [SFTP], Cross Support Terrestrial Generic File Transfer [CFXS] or any other protocol including cloud-based delivery.
[8] With respect to the "Tracking Data Cross Support Transfer Service", the Delta DOR recommendation of [RFM] is not applicable.
[9] With respect to Radio Metric IOAG Service(s), the applicability of this recommendation is limited to the Delta DOR related sections for the recommendations about "Radio Metric".

# 4 DESCRIPTION OF CATALOG #1 SERVICE GROUPS AND TYPES

Catalog #1 includes three groups of Services:

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

## *4.1 Forward Data Delivery Services Group*

The Forward Data Delivery services allow a Control Center to forward messages to a remote spacecraft as shown in Figure 2-1.

### 4.1.1 FORWARD CLTU SERVICE TYPE

This Service enables a mission to send Communications Link Transmission Units (CLTUs) to a spacecraft. It relies on the following Space Link Interface Standards and Ground Link Interface 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]
- SLE Forward CLTU Service [CLTU]

### 4.1.2 FORWARD FRAME SERVICE TYPE

This Service enables a mission to send fixed length AOS or USLP Transfer Frames to a spacecraft. It relies on the following Space Link Interface Standards and Ground Link Interface 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]
- TM Synchronization and Channel Coding [TM-S&C][10]
- TC Space Data Link Protocol [TC-DLP]
- AOS Space Data Link Protocol [AOS]
- Unified Space Data Link Protocol [USLP]
- CSTS Forward Frame Service [FF]

### 4.1.3 FORWARD FRAME OPTICAL SERVICE TYPE

This Service enables a mission to send fixed length AOS or USLP Transfer Frames to a spacecraft over an optical link. It relies on the following Space Link Interface Standards and Ground Link Interface Standards.

- Optical Coding and Modulation [OPT] limited to the parts for Earth-to-Space (Forward) Link
- AOS Space Data Link Protocol [AOS]
- Unified Space Data Link Protocol [USLP]
- CSTS Forward Frame Service [FF]

[10] With respect to the use of AOS and fixed-length USLP frames on the uplink.

## *4.2 Return Data Delivery Services Group*

The Return Data Delivery services allow a Control Center to receive messages that a remote spacecraft sent to a supporting Ground Tracking Asset as shown in Figure 2-1.

### 4.2.1 RETURN ALL FRAMES SERVICE TYPE

This Service enables a mission to send Telemetry Frames received over an RF link (formatted according to Packet Telemetry or AOS standards or privately formatted) to a Control Center. It relies on the following Space Link Interface Standards and Ground Link Interface Standards.

- Radio Frequency and Modulation [RFM] limited to modules for "Space-to-Earth Radio Frequency (Return Link)" and "Telemetry (Return Link)"
- TM Synchronization and Channel Coding [TM-S&C]
- SLE Return All Frames [RAF]

NOTE: IOAG Agencies are expected to consider also the IOAG Report on Preferred Coding and Modulation Schemes [PC&M].

### 4.2.2 RETURN ALL FRAMES OPTICAL SERVICE TYPE

This Service enables a mission to send Telemetry Frames received over an Optical link (formatted according to Packet Telemetry or AOS standards or privately formatted) to a Control Center. It relies on the following Space Link Interface Standards and Ground Link Interface Standards.

- Optical Coding and Modulation [OPT] limited to the parts for Space-to-Earth (Return) Link
- SLE Return All Frames [RAF]

### 4.2.3 RETURN CHANNEL FRAMES SERVICE TYPE

This Service enables a mission to send Telemetry Frames received over an RF link (formatted either according to Packet Telemetry or AOS standards) to a Control Center. It relies on the same Space Link Interface Standards applicable to "Return All Frames Service" (see 4.2.1) plus the following Space Link Interface Standards and Ground Link Interface Standards.

- TM Space Data Link Protocol [TM-DLP]
- AOS Space Data Link Protocol [AOS]
- Unified Space Data Link Protocol [USLP]
- SLE Return Channel Frames [RCF]

### 4.2.4 RETURN CHANNEL FRAMES OPTICAL SERVICE TYPE

This Service enables a mission to send Telemetry Frames received over an Optical link (formatted either according to Packet Telemetry or AOS standards) to a Control Center. It relies on the same Space Link Interface Standards applicable to "Return All Frames Optical Service" (see 4.2.1.1) plus the following Space Link Interface Standards and Ground Link Interface Standards.

- TM Space Data Link Protocol [TM-DLP]
- AOS Space Data Link Protocol [AOS]
- Unified Space Data Link Protocol [USLP]
- SLE Return Channel Frames [RCF]

### 4.2.5 RETURN OPERATIONAL CONTROL FIELD SERVICE TYPE

This Service enables a mission to send Operational Control Fields (extracted from frames formatted either according to Packet Telemetry or AOS standards) to a Control Center. It relies on the same Space Link Interface Standards applicable to "Return Channel Frames Service" (see 4.2.2) plus the following Space Link Interface Standards and Ground Link Interface Standards.

- SLE Return Operational Control Field [ROCF]

## *4.3 Radio Metric Services Group*

The Radio Metric services allow a Control Center to receive data involved in orbit computation for a remote spacecraft.

### 4.3.1 TRACKING DATA FILE SERVICE TYPE

This Service enables a Control Center to receive the data involved in orbit computation as received and potentially validated by a Ground Tracking Asset. Data include range, Doppler, and Pseudo-Noise ranging results as well as correlated Delta-DOR data. Such data are provided to a Control Center within files assembled by the Ground Tracking Asset. This Service relies on the following Space Link Interface Standards and Ground Link Interface Standards.

- Radio Frequency and Modulation [RFM] limited to module for "Radio Metric"
- Pseudo-Noise (PN) Ranging Systems [PNR]
- Tracking Data Message [TDM] or XML Specification for Navigation Data Message [XNM] over
- file transfer

Remark - The [DDORO] Recommended Practice addresses Delta-DOR aspects as e.g., configuration requirements for interagency Delta-DOR measurement; interagency exchange of measurement data; parameters that are necessary in order to correlate and process the data at one of the agencies; interagency transfer of the generated observables; and the end-to-end flow of control.

Remark – Details of file transfer are to be agreed between agencies depending on security policies. It may be based on SSH File Transfer Protocol [SFTP], Cross Support Terrestrial Generic File Transfer [CFXS] or any other protocol including cloud-based delivery.

### 4.3.2 TRACKING DATA CROSS-SUPPORT TRANSFER SERVICE TYPE

This Service enables a Control Center to receive the data involved in orbit computation as soon as they are received/built by a Ground Tracking Asset. Such data are provided to a Control Center via streaming interface sending CSTS messages embedding the TDM formatted data received by the Ground Tracking Asset. It relies on the same Space Link Interface Standards applicable to "Tracking Data File Service Type" (See 4.3.1) – with the exception of the Delta DOR recommendation of [RFM] - plus the following Space Link Interface Standards and Ground Link Interface Standards:

- Tracking Data Cross Support Transfer Service [CRTRM]

### 4.3.3 DELTA DOR FILE SERVICE TYPE

This Service enables a Control Center to receive Delta-DOR raw data[11] or Open Loop Recording data[12] acquired by a Ground Tracking Asset. Such data are provided to a Control Center within files assembled by the Ground Tracking Asset. It relies on the following Space Link Interface Standards and Ground Link Interface Standards.

- Radio Frequency and Modulation [RFM] limited to Delta DOR related sections in the module for "Radio Metric"
- Delta-DOR Raw Data Exchange Format [DDRXF] over
- file transfer

[11] Note that this service only provides Delta-DOR raw data while Delta-DOR correlated data are provided via the "Tracking Data File Service".

[12] In fact, the data format defined in [DDRXF] can also be used to store Open Loop Recording data.

Remark - The [DDORO] Recommended Practice addresses Delta-DOR aspects such as:

- configuration requirements for interagency Delta-DOR measurement;
- interagency exchange of measurement data;
- parameters that are necessary in order to correlate and process the data at one of the agencies;
- interagency transfer of the generated observables;
- and the end-to-end flow of control.

Remark – Details of file transfer are to be agreed between agencies depending on security policies. It may be based on SSH File Transfer Protocol [SFTP], Cross Support Terrestrial Generic File Transfer [CFXS] or any other protocol including cloud-based delivery.

# 5 SERVICE MANAGEMENT FUNCTIONS

Services provided by an IOAG member agency are requested and controlled via standard Service Management functions. Service Management by itself is not a service as such, but rather a collection of functions and management services which may be called or ordered via standardized information entities and interface. Its function is 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:

- Allocation and scheduling of space and ground communication resources and assets during the service commitment and planning phases.
- Configuring, monitoring, and controlling the communication assets during the service provision phase (i.e., before, during, and after a communication contact).
- Reporting of service execution results.

The service management interfaces and information entities (formats) employed by the above tasks will consist of various combinations of the standards of the CCSDS Cross Support Service Management Specifications; i.e. Service Agreement and Configuration Profile [SACP], Service Management – Management Services [SMMS], Event Sequence [EVSQ], Service Package Data Format [SPDF], Simple Schedule Format [SSF], Communications Planning Information Format and Service Management Utilization Request Formats [SMURF]. For configuring of the tracking asset in terms of antenna pointing the [ODM] or [XNM] standards are applied. In addition, Service Execution Functions can deliver the status of the space link or of the related processing equipment in near real time to the users [EDM]. A service control function is planned to cover configuration and control during service execution [SCC].

## *5.1 Service Management Functions Group*

The Service Management functions allow a Control Center to agree, to plan and to execute the services required from a Ground Tracking Asset provider, as shown in Figure 2-2.

| | **IOAG Service Function** | **Service Management Standards** |
|---|---|---|
| **Service Management Functions** | Trajectory Data File Service | • Orbit Data Message [ODM] or [XNM][13]<br>• Utilization Request Format [SMURF] - Submission Request<br>OVER:<br>• file transfer<br>OR<br>• Management Services [SMMS] |
| | Service Agreement Development | • Service Agreement and Configuration Profile [SACP]– Service Agreement<br>OVER:<br>• file transfer<br>OR<br>• Management Services [SMMS] |

[13]This includes the ASCII and XML file formats. It also allows to use, as bilaterally agreed, different types of ODM: OPM, OEM or OMM.

| | | |
|---|---|---|
| | Communication Resource Booking (Station Scheduling) | • Service Management Utilization Request Format [SMURF] – Service Package Request<br>• Service Package Data Formats [SPDF]<br>• Orbit Data Messages [ODM] or [XNM][14]<br>• Service Agreement and Configuration Profile [SACP] – Configuration Profile<br>• Space Link Event Sequence Data Format [EVSQ]<br>OVER:<br>• file transfer<br>OR<br>• Management Services [SMMS] |
| | Planning Information | • Service Management Utilization Request Format [SMURF] – Planning Information Request<br>• Communications Planning Information Formats [CPIF]<br>• Service Agreement and Configuration Profile [SACP] – Configuration Profile<br>• Orbit Data Messages [ODM] or [XNM][12]<br>OVER:<br>• file transfer<br>OR<br>• Management Services [SMMS] |
| | Published Schedule and Unallocated Times | • Utilization Request Format [SMURF] – Report Request<br>• Simple Schedule Format Specification [SSF]<br>OVER:<br>• file transfer<br>OR<br>• Management Services [SMMS] |

*Table 5-1 Catalog #1 Service Management Functions*

Remark – The Service Management - Management Services (Automation) [SMMS] are intended to help automate the exchange of the various kinds of information in the different data formats (such as [SMURF], [SPDF] and [SACP]). The management services shall describe the possible exchange patterns, definition of data states and their state changes and ideally the binding to specific implementation API allowing the integration into existing systems and enable full automation. For the time being, all services can also be based on the exchange of information via standard file transfer.

[14] This includes the ASCII and XML file formats. It also allows to use, as bilaterally agreed, different types of ODM: OPM, OEM or OMM.

### 5.1.1 TRAJECTORY DATA FILE SERVICE

This service function allows a service user to provide up-to-date trajectory information, which enables the service provider to execute its services. This information exchange is in most cases an integral part of further services (see below) however it can be also used separately, outside of any specific Service Agreement scope, or as a third-party ancillary service. The example of such support is provision of trajectory data by a third-party Flight Dynamics Facility, which itself is not part of the User-Provider bilateral agreement.

It is expected the trajectory data will be provided in one of the [ODM] variants, i.e., OPM, OEM or OMM in either ASCII text [ODM] or XML format [XNM]. The de-facto industry standard TLE (Two Line Element) can be accepted here as a specific case of OMM compatible information. The information can be provided via standard file transfer or by Management Services [SMMS] if the corresponding API is implemented on the service provider and the service user side.

To improve the cross referencing of the specific trajectory data to concrete service packages, the Trajectory Submission Request of [SMURF] can be used to wrap the [ODM].

### 5.1.2 SERVICE AGREEMENT DEVELOPMENT

This service function enables a service user to establish a Service Agreement with a service provider for specific mission phases. Such agreements may contain the Configuration Profiles for expressing the configuration of cross supported services. Agreed Configuration Profiles will be used for Communications Resource Booking or Planning Information services. Therefore, the [SACP] (Service Agreement and Service Configuration Profile Data Formats) define the data formats for expressing the agreed mission setup and the configuration of cross supported Telemetry, Tracking, and Commanding services.

The Service Agreement information shall be exchanged between User and Provider to iterate on details of the agreement and finalize all information and parameters. Initial version of Service Agreements may be created by the user, based on its mission requirements and information from the provider. The provider in turn, may refine the agreement, limiting for example requested usage of its assets, upon their availability or other constraints. The Service Agreement shall be than returned to user for further iteration. In the final state, both user and provider shall have the same version of Service Agreement.

Additionally, to the Service Agreement, user shall provide at least one Configuration Profile dataset corresponding to the specific spacecraft configuration for communication during the tracking pass. The Configuration Profiles shall include all parameters required to bilaterally configure the communication path and enable successful support under the specific Service Agreement.

In case user and provider support the Functional Resource Model [FRM], the Configuration Profile definitions shall be expressed in terms of functional resources.

Service Agreement and Configuration Profile [SACP] can be exchanged via standard file transfer or by Management Services [SMMS] if the corresponding API is implemented on the service provider and the service user side.

### 5.1.3 COMMUNICATIONS RESOURCE BOOKING (STATION SCHEDULING)

This service function enables service users and service providers to exchange the information required to book communication assets or resources in order to support contacts with the space assets of the user.

The Service Package Request [SMURF] defines the data format to request scheduling of service packages. These requests shall contain all information (either directly or via referencing of ancillary information) required to allow a provider to assess the request, and respectively confirm or reject it. In case of confirmation, the information available to the provider must be sufficient to execute the actual support and to provide the service. This includes information like time of support, required configuration, trajectory of tracked spacecraft, etc.

It is expected that at a time of issuing the utilization request, user and provider have an active Service Agreement, with accompanying Configuration Profiles [SACP]. The user sends a Service Package request referring to the Configuration Profile and trajectory information ([ODM] or [XNM]). Optionally, depending on mission needs, the user may provide an Event Sequence [EVSQ] beforehand and refer to it respectively in its Service Package request.

Upon request processing, the provider shall produce a dataset reflecting the confirmed resource booking in form of Service Package Data Format [SPDF]. The Service Package Request [SMURF], Configuration Profile [SACP], Service Package [SPDF] and Event Sequence [EVSQ] can be exchanged via standard file transfer or by Management Services [SMMS] if the corresponding API is implemented on the service provider and the service user side.

### 5.1.4 PLANNING INFORMATION

This service function enables a service user to inform a service provider about constraints which affect the planning activities of the support, including constraints on the communication geometry.

The Planning Information Request [SMURF] is used for requesting planning information from the provider. That request shall contain all information (either directly or via referencing of ancillary information) required to allow a provider to assess the request, and respectively generate provisional planning information, which can be used by user to better assess suitability for actual service bookings in future. The planning information is provided using the Communication Planning Information Format [CPIF]] considering the user's and the provider's own constraints (like unavailability of communication assets due to conflicts or maintenance).

It is expected that at a time of issuing the Planning Information Request, user and provider have an active Service Agreement, with accompanying Configuration Profiles [SACP]. A user shall send to Provider a Planning Information Request, formatted according to [SMURF]. The Planning Information Request shall refer to existing (provided beforehand) Configuration Profile [SACP] and trajectory information ([ODM] or [XNM]).

The Planning Information Request [SMURF], Service Agreement and Configuration Profile [SACP] and Planning Information [CPIF] can be exchanged via standard file transfer or by Management Services [SMMS] if the corresponding API is implemented on the service provider and the service user side.

### 5.1.5 PUBLISHED SCHEDULE AND UNALLOCATED TIMES

This service function enables a service provider to describe the resources that are scheduled as well as the unallocated times that remain free for utilization. Such information includes the start / stop times of the activities in the service packages, used frequency bands and reserved ground asset. The Simple Schedule Format Specification [SSF] defines a data format to exchange such information and also to indicate unallocated times. The information may be distributed at regular times to users. user may also explicitly request generation of schedule information by sending a Report Request [SMURF] to the provider. Providers answers to this request with schedule or unallocated time information according to users' constraints.

The Simple Schedule [SSF] and the Report Request [SMURF] can be exchanged via standard file transfer or by Management Services [SMMS] if the corresponding API is implemented on the service provider and the service user side.

## *5.2 Service Execution Functions Group*

IOAG Service Catalog #1 foresees a link monitoring function (see Table 5-2) to allow a Control Center to receive data monitoring the status of the space link between a Ground Tracking Asset and a remote spacecraft. Such monitoring data are not limited to the status of the space link and they may also include information about space link related status and/or processing of the equipment at the Ground Tracking Asset. Such data is expressed by the means of the Functional Resource Model [FRM] providing abstract representations of the functionality needed to provide space communication and navigation services.

IOAG Service Catalog #1 also foresees a control function (see Table 5-2) that provides a Control Center with the capabilities to request execution of control directives at a ground station and/or to perform configuration changes in near-real time in response to unplanned events involving the spacecraft.

The Service Execution Functions rely on the following Ground Link Interface Standards:

- Monitored Data - Cross Support Transfer Service [EDM]
- Service Control - Cross Support Transfer Service [SCC]
- Functional Resource Model [FRM]

| | IOAG Service Function | Space Link Interface Standards | Ground Link Interface Standards |
|---|---|---|---|
| **Service Execution Functions** | Monitored Data Delivery | • N/A | • Monitored Data - Cross Support Transfer Service [EDM]<br>• Functional Resource Model [FRM] |
| | Service Control | • N/A | • Service Control - Cross Support Transfer Service [SCC]<br>• Functional Resource Model [FRM] |

**Table 5-2 Catalog #1 Service Execution Functions**