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# 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](#_bookmark0) 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.](#_bookmark46) 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 by 2020, 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].](#_bookmark44)

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 are 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.

## Applicable Documents

### 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. |
| [FSP] | CCSDS 912.3-B Space Link Extension – Forward Space Packet Service Specification. Blue Book. |
| [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. |
| [RFM] | Functional Resources, SANA Registry, <https://sanaregistry.org/r/functional_resources/> |
| [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. |
| [SM-ACC] | CCSDS 902.8-B Cross Support Service Management: Service Accounting. Blue Book. TBW |

|  |  |
| --- | --- |
| [SM-ACP] | CCSDS 902.5-B Cross Support Service Management: Service Agreement and Service Configuration Profile Data Formats. Blue Book. TBW |
| [SM-AUT] | CCSDS 902.10-B Cross Support Service Management: Management Services (Automation) . Blue Book. TBW |
| [SM-CAT] | CCSDS 902.7-M Cross Support Service Management: Service Catalog. Magenta Book. TBW |
| [SM-ESF] | CCSDS 902.6-B Cross Support Service Management: Event Sequence Data Format. Blue Book. TBW |
| [SM-PDF] | CCSDS 902.2-B Cross Support Service Management: Communications  Planning Information Format. Blue Book. |
| [SM-SPF] | CCSDS 902.4-B Cross Support Service Management: Service Package Data Formats. Blue Book. TBW |
| [SM-SSF] | CCSDS-902.1-B Cross Support Service Management: Simple Schedule Format Specification. Blue Book. |
| [SM-URF] | CCSDS 902.9-B Cross Support Service Management: Service Management Utilization Request Format. Blue Book. TBW |

### 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 Protoco[l [SDLP]](#_bookmark32). |
| [CFDP] | CCSDS 727.0-B CCSDS File Delivery Protocol (CFDP). Blue Book. |
| [ENC] | CCSDS 133.1-B Encapsulation Packet Protocol. Blue Book. |
| [OPT] | Optical Coding and Modulation, i.e. the collection of:[2](#_bookmark30)  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. |

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.

|  |  |
| --- | --- |
| [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]](#_bookmark45). |
| [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 Protoco[l [SDLP]](#_bookmark32). |
| [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]](#_bookmark45). |
| [TM-DLP] | CCSDS 132.0-B TM Space Data Link Protocol. Blue Book.  Including the specifications to support the Space Data Link Security Protoco[l [SDLP]](#_bookmark32). |

|  |  |
| --- | --- |
| [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]](#_bookmark45). |
| [USLP] | CCSDS 732.1-B Unified Space Data Link Protocol. Blue Book.  Including the specifications to support the Space Data Link Security Protoco[l [SDLP]](#_bookmark32). |

### 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/.](http://sanaregistry.org/r/) This replaces CCSDS 135.0-B Space Link Identifiers. Silver Book. |
| [TDM] | CCSDS 503.0-B Tracking Data Message. Blue Book. |
| [XNM] | CCSDS 505.0-BXML Specification for Navigation Data Messages. Blue Book.  Note: The XML Specification for Navigation Data Messages  Recommended Standard is providing a different representation than [[TDM]](#_bookmark42) and [[ODM]](#_bookmark41) that define ASCII formats. |

### 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. |

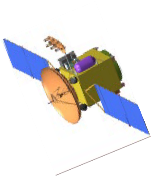
## Acronyms

|  |  |
| --- | --- |
| AOS | Advanced Orbiting Systems |
| CCSDS | Consultative Committee for Space Data Systems |
| CFDP | CCSDS File Delivery Protocol |
| 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. |

# 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.](#_bookmark46) 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.



***Spacecraft***

***Ground Tracking Asset***

***Control Center***

**CFDP, Space/Encapsulation Packet, TM/TC/AOS/USLP**

**Frame Standards**

**Ground based Cross-Support Standards**

**A**

***Space Link***

**B**

***Ground Link***

**A**

***Cross Support Services***

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

As depicted in [Figure 2-1,](#_bookmark46) 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 informa tion 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 interface between a Control Center and a Ground Tracking Asset.

The “Service Management” functions include

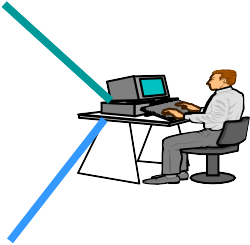
* 1. assessment of service suitability by verification of the Provider’s Service Catalog,
  2. the establishment of a Service Agreement between User and Provider of Cross Support, possibly including configuration profiles to execute the supports,
  3. the Service Planning and Scheduling
  4. the Service Execution, and
  5. the Service Accounting

## 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](#_bookmark47) 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.



**CCSDS Cross Support**

**Service Management**

**Ground Tracking Asset**

**Service Mgmt Interface**

**Control Center**

**Forw ard**

**D y**

**ata Deliver Services**

***Service***

***Management Interface***

**Return Data Delivery**

**Services**

***Service Provision Interface***

**Radio Metric Services**

**Service Provision Interface**

**Other Services**

**CCSDS Cross Support**

**Transfer Services**

**Service User**

**Service Provider**

**Service Mgmt Interface**

**Service Delivery Interface**

**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”.

# 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.](#_bookmark51) 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](#_bookmark51) 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]](#_bookmark31) [3](#_bookmark48)   * TC Synchronization and Channel Coding [[TC-](#_bookmark36)   [S&C]](#_bookmark36) | * SLE Forward CLTU   Service [[CLTU]](#_bookmark1) |
| Forward Frame Service | * Radio Frequency and   Modulation [[RFM]](#_bookmark31) [4](#_bookmark49)   * TC Synchronization and Channel Coding [[TC-](#_bookmark38) [S&C]](#_bookmark38) * AOS Space Data Link Protocol [[AOS]](#_bookmark25) * Unified Space Data Link Protocol [USLP] | * CSTS Forward   Frame Service [FF] |
| Forward Frame Optical Service | * Optical Coding and Modulation [[OPT]](#_bookmark28) * AOS Space Data Link Protocol [[AOS]](#_bookmark25) * Unified Space Data Link Protocol [USLP] | * CSTS Forward Frame Service [FF] |
| Forward Space Packet Service | Those for “Forward CLTU  Service” plus:   * TC Space Data Link Protocol [[TC-DLP]](#_bookmark35) * Unified Space Data Link Protocol [USLP] * Communications Operation Procedure-1 [[TC-COP]](#_bookmark34) | * SLE Forward Space Packet Service [[FSP]](#_bookmark9) |

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 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 All Frames Service | * Radio Frequency and   Modulation [[RFM]](#_bookmark31) [5](#_bookmark50)   * TM Synchronization and Channel Coding [[TM-](#_bookmark38)   [S&C]](#_bookmark38) | * SLE Return All   Frames [[RAF]](#_bookmark10) |
| Return All Frames  Optical Service | * Optical Coding and   Modulation [[OPT]](#_bookmark28) | * SLE Return All   Frames [[RAF]](#_bookmark10) |
| Return Channel Frames Service | Those for “Return All Frames  Service” plus:   * TM Space Data Link Protocol [[TM-DLP]](#_bookmark37) * AOS Space Data Link Protocol [[AOS]](#_bookmark25) * Unified Space Data Link Protocol [USLP] | * SLE Return Channel Frames [[RCF]](#_bookmark11) |
| Return Channel Frames Optical Service | Those for “Return All Frames  Optical Service” plus:   * TM Space Data Link Protocol [[TM-DLP]](#_bookmark37) * AOS Space Data Link Protocol [[AOS]](#_bookmark25) * Unified Space Data Link Protocol [USLP] | * SLE Return Channel   Frames [[RCF]](#_bookmark11) |
| Return Operational Control Field Service | * Those for “Return Channel   Frames Service” | * SLE Return   Operational Control Field [[ROCF]](#_bookmark13) |

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]](#_bookmark31) [6](#_bookmark52)   * Pseudo-Noise (PN) Ranging Systems [[PNR]](#_bookmark29) | * Tracking Data Message [TDM] or XML Specification for Navigation Data Message [XNM] over * file transfer [7](#_bookmark52) |
| Tracking Data Cross-Support Transfer Service | * Those for “Tracking Data File Service” [8](#_bookmark53) | * Tracking Data Message [TDM] over * Tracking Data Cross Support Service [CRTRM] |
| Delta DOR File Service | * Radio Frequency and Modulation [[RFM]](#_bookmark31) [9](#_bookmark54) | * Delta-DOR Raw Data Exchange Format [[DDRXF]](#_bookmark5) over * file transfer [7](#_bookmark52) |

**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 “Validated Data Radio Metric Service”, the Delta DOR recommendation of [[RFM]](#_bookmark31) is not applicable to “Raw Data Radio Metric Service”.

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”.

# 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

## 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.](#_bookmark46)

### 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]

### FORWARD SPACE PACKET SERVICE TYPE

This Service enables a mission to send Space Packets to a spacecraft, possibly with the benefits give n by the Communications Operation Procedure-1. It relies on the same Space Link Interface Standards applicable to “Forward CLTU Service” (see [4.1.1)](#_bookmark55) plus the following Space Link Interface Standards and Ground Link Interface Standards.

* TC Space Data Link Protocol [TC-DLP]
* Unified Space Data Link Protocol [USLP]
* Communications Operation Procedure-1 [TC-COP]
* SLE Forward Space Packet Service [FSP]

### 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)”
* TM Synchronization and Channel Coding [TM-S&C]
* AOS Space Data Link Protocol [[AOS]](#_bookmark25)
* Unified Space Data Link Protocol [USLP]
* CSTS Forward Frame Service [FF]

### 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]](#_bookmark28) limited to the parts for Earth-to-Space (Forward) Link
* AOS Space Data Link Protocol [[AOS]](#_bookmark25)
* Unified Space Data Link Protocol [USLP]
* CSTS Forward Frame Service [FF]

## 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.](#_bookmark46)

### 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]](#_bookmark10)

NOTE: IOAG Agencies are expected to consider also the IOAG Report on Preferred Coding and Modulation Schemes [[PC&M]](#_bookmark45).

#### 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]](#_bookmark28) limited to the parts for Space-to-Earth (Return) Link
        + SLE Return All Frames [[RAF]](#_bookmark10)

### 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](#_bookmark58)) plus the following Space Link Interface Standards and Ground Link Interface Standards.

* TM Space Data Link Protocol [[TM-DLP]](#_bookmark37)
* AOS Space Data Link Protocol [[AOS]](#_bookmark25)
* Unified Space Data Link Protocol [USLP]
* SLE Return Channel Frames [[RCF]](#_bookmark11)

#### 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](#_bookmark59)) plus the following Space Link Interface Standards and Ground Link Interface Standards.

* + - * + TM Space Data Link Protocol [[TM-DLP]](#_bookmark37)
        + AOS Space Data Link Protocol [[AOS]](#_bookmark25)
        + Unified Space Data Link Protocol [USLP]
        + SLE Return Channel Frames [[RCF]](#_bookmark11)

### 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](#_bookmark60)) plus the following Space Link Interface Standards and Ground Link Interface Standards.

* SLE Return Operational Control Field [[ROCF]](#_bookmark13)

## Radio Metric Services Group

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

### 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]](#_bookmark29)
* Tracking Data Message [[TDM]](#_bookmark3) or XML Specification for Navigation Data Message [XNM] over
* file transfer

Remark - The [[DDORO]](#_bookmark39) 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.

### 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](#_bookmark63)) – with the exception of the Delta DOR recommendation of [[RFM]](#_bookmark31) - plus the following Space Link Interface Standards and Ground Link Interface Standards.

* Tracking Data Cross Support Transfer Service [[CRTRM]](#_bookmark4)

### DELTA DOR FILE SERVICE TYPE

This Service enables a Control Center to receive Delta-DOR raw data [10](#_bookmark64) or Open Loop Recording data [11](#_bookmark65) 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

Remark - The [[DDORO]](#_bookmark39) 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.

10 Note that this service only provides Delta-DOR raw data while Delta-DOR correlated data are provided via the “Tracking Data File Service”.

11 In fact, the data format defined in [[DDRXF]](#_bookmark40) can also be used to store Open Loop Recording data.

# 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:

* Allocation and scheduling of space 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 employed by some of the above tasks will be following any of the standards in the set of the CCSDS Cross Support Service Management

Specifications; i.e. [[SM],](#_bookmark15) [[SCAT],](#_bookmark16) [[SACP]](#_bookmark17), [[SMMS],](#_bookmark18) [[SCAT],](#_bookmark19) [[EVSQ],](#_bookmark20) [[SPDF]](#_bookmark21), [[SSF],](#_bookmark22) [[CPIF],](#_bookmark22)[[SMURF].](#_bookmark24)

In addition, an engineering data delivery service is planned in IOAG Service Catalog # 1, to deliver in near real time to the users, the status of the space link or of the related processing equipment.

For configuring of the tracking asset in terms of antenna pointing the [[ODM]](#_bookmark41) or [[XNM]](#_bookmark43) standards will be applied.

## 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.](#_bookmark47)

|  |  |  |
| --- | --- | --- |
|  | **IOAG Service Function** | **Service Management**  **Standards** |
| **Service Management Functions** | Trajectory Data File Service | * Orbit Data Message [**ODM**]\* * Utilization Request Format [**SMURF**] - Submission Request   OVER:   * Management Services (**SMMS**)   OR   * file transfer |
| Assessment of service suitability | * Service Catalog (**SCAT**) |
| Service Agreement Development | * Service Agreement and Configuration Profile [**SACP**] – Service Agreement   OVER:   * Management Services (**SMMS**)   OR   * file transfer |
| Communication Resource Booking (Station Scheduling) | * Utilization Request Format [**SMURF**] – Service Package Request * Service Package Data Formats [**SPDF**] * Orbit Data Messages **[ODM]\*** * Service Agreement and Configuration Profile [**SACP**] – Configuration Profile * Space Link Event Sequence Data Format [**EVSQ**]   OVER   * Management Services (**SMMS**)   OR   * file transfer |
|  | Planning Information | * Utilization Request Format [**SMURF**] – Planning Information Request * Communications Planning Information Formats **[CPIF]** * Service Agreement and Configuration Profile [**SACP**] – Configuration Profile * Orbit Data Messages **[ODM]\***   OVER   * Management Services (**SMMS**)   OR   * file transfer |
|  | Published Schedule and Unallocated Times | * Utilization Request Format [**SMURF**] – Report Request * Simple Schedule Format Specification **[SSF]**   OVER   * Management Services (**SMMS**)   OR   * file transfer |
|  | Service Accounting | * Service Accounting [SACC]   OVER   * Management Services (**SMMS**)   OR   * file transfer |

Table 5‑1 Catalog #1 Service Management Functions

\***ODM** here includes its ASCII or XML file formats. It also allows to use, as bilaterally agreed, different types of ODM: OPM, OEM or OMM.

**Service Management - Management Services** are intended to help automate the way the information provided in different data formats (SMURF; SPDF, SACP, etc…) is being exchanged. These services shall describe the possible exchange patterns, definition of data states and their state changes and ideally the binding to specific implementation API allowing to integration into existing systems and enable full automation.

### TRAJECTORY DATA FILE SERVICE

This service function enables a User of services to provide the up-to-date trajectory information, which enables the Provider to execute its services. This information exchange is also 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 third-party Flight Dynamics Facility, which itself is not part of the User-Provider bilateral setup.

It is expected the trajectory data will be provided in one of the [ODM] variants, i.e. OPM, OEM or OMM in either simple text or XML file format. The de-facto industry standard TLE (Two Line Element) is accepted here as a specific case of OMM compatible information.

The [ODM] shall be provided in form of the file, in simplest case via file transfer.

To improve the cross referencing of the specific trajectory data, it is expected, that the Submission Request of [SMURF] will be used to wrap the [ODM].

Assuming both sides of User and Provider implement respective automated Management Services [SMMS], it is expected that the [ODM] will be provided over the means of that services and according to its API.

### ASSESSMENT OF SERVICE SUITABILITY

This service function enables a User of services to evaluate the suitability of a Provider of Cross Support Services, to provide the required services, based on the study of its Service Catalog. The Service Catalog is used before the Service Agreement development phase. Therefore, it is expected that the [[SCAT]](#_bookmark19) (Service Catalog Recommended Standard) will define the set of obligatory parameters or information, which every Provider shall expose.

The file format or, in wider sense, presentation of Service Catalog is left to the best method the Provider finds effective (i.e. web page, PDF document or printed flyer).

### SERVICE AGREEMENT DEVELOPMENT

This service function enables a User of services to establish an agreement with a Provider of Cross Support Services data for a specific phase of a mission. Such agreement 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 it is expected that the [[SACP]](#_bookmark17) (Service Agreement and Service Configuration Profile Data Formats) will define the data formats for expressing the agreed mission setup and agreement wide configuration of cross supported Telemetry, Tracking, and Commanding services.

The Service Agreement information shall be exchanged between User and Provider in order to iterate on details of the agreement and finalize all information and parameters. Initial version of Service Agreement may be created by the User, based on its mission requirements and the Service Catalog of the Provider. The Provider may refine in turn the agreement, limiting for example requested usage of its assets, upon their availability or whatever intrinsic constraints. The Service Agreement shall be than returned to User in order to give them feedback. In final state, both User and Provider shall have exacted the same version of Service Agreement.

Additionally, to the Service Agreement, User shall provide at least one Configuration Profile dataset corresponding to specific spacecraft configuration which is required to communicate with it during the tracking pass. The Configuration Profiles shall include all parameters required to bilaterally configure the communication path and enable successful support, where the term required is to be understood in the scope of User – Provider cooperation and under the specific Service Agreement.

In case User and Provider enabled the support of Functional Resources, the Configuration Profile definitions shall follow that Functional Resources.

The [SACP] shall be provided in form of the file, in simplest case via file transfer.

Assuming both sides of User and Provider implement respective automated Management Services [SMMS], it is expected that the [SACP] will be exchanged over the means of that services and according to its API.

### COMMUNICATIONS RESOURCE BOOKING

This service function enables a User of services and a Provider of Cross Support Services to exchange the information required to book the communication assets or resources in order to support specific contact or contacts with the space assets of the User.

Therefore, it is expected that the [[SMURF]](#_bookmark24) (SM Utilization Request Formats) will define the data format to indicate requests for requesting the schedules (to reserve resources). That request shall contain all information (either directly or via referencing of ancillary information) required to allow Provider to assess the request, and respectively confirm or reject it. In case of confirmation, the information available to Provider must be sufficient to execute the actual support / provide the service. This includes information like time of support, required configuration, trajectory of tracked spacecraft, etc.

It is expected that User and Provider have an active Service Agreement, with accompanying Configuration Profiles.

A User shall send to Provider a Service Package Request, formatted according to [SMURF].

The Service Package Request shall refer to existing (provided beforehand) Configuration Profile [SACP] and Trajectory information [ODM].

Optionally, depending on mission needs, User may provide an Event Sequence [EVSQ] beforehand and refer 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]. This dataset may be used to transport the status of the request, however in existence of additional Management Services such status information may be exchanged with other means as well.

The [SMURF], [SACP], [SPDF] and [EVSQ] shall be provided in form of the files, in simplest case via file transfer.

Assuming both sides of User and Provider implement respective automated Management Services [SMMS], it is expected that the abovementioned information will be exchanged over the means of that services and according to its API.

### PLANNING INFORMATION

This service function enables a User of services to give a Provider of Cross Support Services information that will constrain the planning activities of the support. Such information will include the constraints on the communication geometry.

Therefore, it is expected that the [[SMURF]](#_bookmark24) (SM Utilization Request Formats) will define the data format to indicate requests for requesting the planning information. That request shall contain all information (either directly or via referencing of ancillary information) required to allow Provider to assess the request, and respectively generate provisional planning information, which can be used by User to better asses its requests for actual service bookings in future.

It is also expected, that the [CPIF] (Communication Planning Information Format) will define the data format to indicate provisional planning of Provider resources according to Users provided constraints and considering Provider own constraints (like unavailability of communication assets due to conflicts or maintenance).

It is expected that User and Provider have an active Service Agreement, with accompanying Configuration Profiles.

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].

Upon request processing, the Provider shall produce a dataset reflecting the result of provisional planning in form of Communication Planning Information Format [CPIF]. This dataset may be used by User to generate requests for actual service bookings in future.

The [SMURF], [SACP] and [CPIF] shall be provided in form of the files, in simplest case via file transfer.

Assuming both sides of User and Provider implement respective automated Management Services [SMMS], it is expected that the abovementioned information will be exchanged over the means of that services and according to its API.

### PUBLISHED SCHEDULE AND UNALLOCATED TIMES

This service function enables a Provider of Cross Support Services to describe the resources that are scheduled in support of a mission 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. Therefore, it is expected that the [[SSF]](#_bookmark23) (Simple Schedule Format Specification) will define such data format to indicate schedule of services for missions relative to an agency tracking assets and also to indicate unallocated times.

The provider may distribute schedule information [SSF] on regular base to service User.

User may also request generation of schedule information arbitrarily, triggering it by providing Report Request [SMURF] to Provider. Provider answers to this request with schedule or unallocated time information in the format of [SSF] according to Users constraints.

The [SMURF] and [SSF] shall be provided in form of the files, in simplest case via file transfer.

Assuming both sides of User and Provider implement respective automated Management Services [SMMS], it is expected that the abovementioned information will be exchanged over the means of that services and according to its API.

### SERVICE ACCOUNTING

This service function enables a Provider of Cross Support Services to report on the volumes and the quality of the services provided to a User of such services. The Service Accounting is used after the provision of the services phase. Therefore, it is expected that the [[SACC]](#_bookmark16) (Service Accounting) will define the data format for providing accounting of services rendered.

The provider shall deliver Accounting Report information [SACC] to User after each pass or regularly as agreed in Service Agreement, without User being required to ask for such report each time.

The [SACC] shall be provided in form of the files, in simplest case via file transfer.

Assuming both sides of User and Provider implement respective automated Management Services [SMMS], it is expected that the abovementioned information will be exchanged over the means of that services and according to its API.

## Service Execution Functions Group

IOAG Service Catalog #1 foresees a link monitoring function (see [Table 5-2)](#_bookmark66) 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].

IOAG Service Catalog #1 also foresees a control function (see [Table 5-2](#_bookmark66)) 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 Engineering Monitoring Data Delivery relies on the following Ground Link Interface Standards.

* Monitored Data - Cross Support Transfer Service [[EDM]](#_bookmark6)
* 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]](#_bookmark6)   * Functional Resource Model [FRM] |
| Service Control | * N/A | * Service Control -   Cross Support Transfer Service [SCC]   * Functional Resource Model [FRM] |

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