DOCUMENT

IOAG

SERVICE CATALOG #3

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IOAG

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1 INTRODUCTION

1.1 Scope

The IOAG (Interagency Operations Advisory Group) provides a forum for identifying common needs across multiple international agencies for coordinating space communications policy, high-level procedures, technical interfaces, and other matters related to interoperability and space communications. To accomplish these goals, the IOAG has developed a series of service catalogs (see Figure 1-1). This document constitutes IOAG Service Catalog #3, complementing IOAG Service Catalog #1 [IC1] and IOAG Service Catalog #2 [IC2]. It identifies application-level Mission Operations Interoperability Services (MOIS) and data exchanges that should be provided by the IOAG member agencies contributing to the global interoperability of mission operations ground systems. (Note that CCSDS Mission Operations [MO] services may provide many of the capabilities identified as MOIS requirements.)

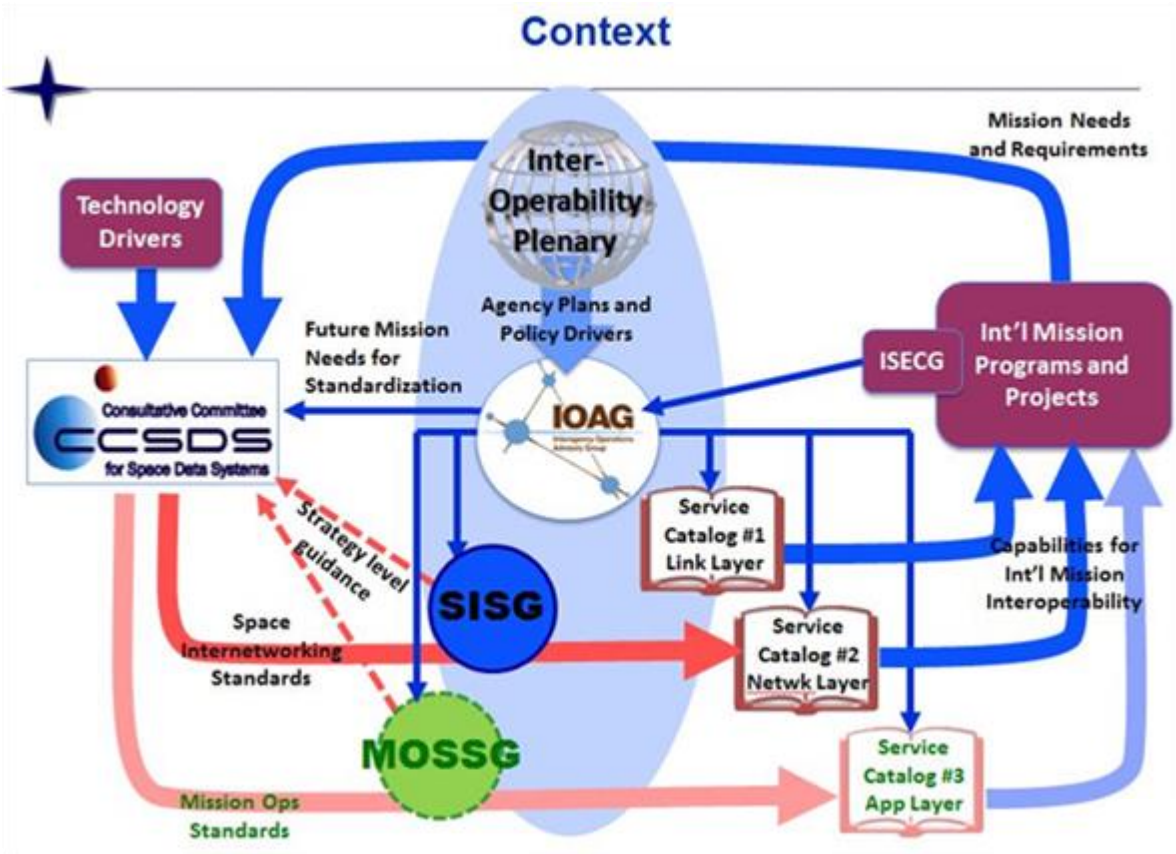

Figure 1-1 IOAG Service Catalogs

IOAG Service Catalog #1 services are limited to the provision of space communication and tracking capabilities for interaction between a spacecraft control center and a spacecraft directly reachable via a ground tracking asset. IOAG Service Catalog #2 defines services for in-space relay and networked cross-support scenarios. IOAG Service Catalog #3 addresses the services

relevant to operational teams in control rooms and may be used in conjunction with or independently from Service Catalogs #1 and #2.

MOIS are at the application level (International Organization for Standardization [ISO] stack), and directly concern operational teams on the ground and may extend to application-layer software/hardware systems onboard (and to the crew in manned systems). As such, the operational environment in which MOIS are used is highly variable and reflects various degrees of interoperability between agencies' systems and operations, depending on the needs of the different programs. Service Catalog #3 thus does not cover the full scope of MOIS that could be defined in a single multi-agency program, let alone across multiple programs. Rather, it aims at defining a minimum common set of services, which could be used by most programs where interoperability is a key factor.

This version of Service Catalog #3 addresses only the MOIS between ground segments of participating agencies. Space-to-ground and space-to-space services between agencies are not addressed. The definition of such services at the application level would require analysis by onboard systems architects and a better understanding of future programs such as solar system exploration missions to the Moon, Mars and beyond.

1.2 Agency Interactions

Figure 1-2 describes an example scenario involving two agencies where the service interface is exposed on the ground between the MOIS user and the MOIS provider. This scenario typically involves a payload of Agency A using a platform of Agency B, where the control center of Agency A's payload is connected to Agency B's control center. In this case, Agency B is most often the service provider and Agency A is the service user. Agency A, for example, may issue service requests to Agency B to obtain payload packet data, device temperatures, command histories, etc.

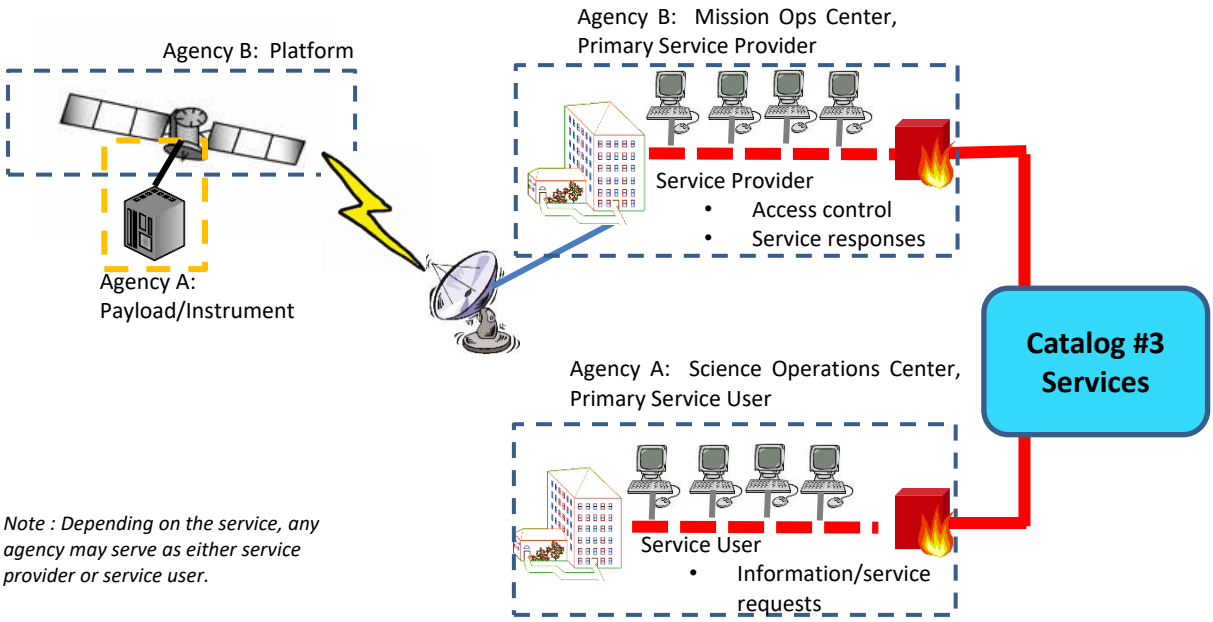

Figure 1-2. Notional Two-Agency Scenario

Multi-Agency interaction scenarios become more complex as functions are distributed and additional agency partners are included in the mission team. Many large programs are organized around a central entity, as illustrated by the scenario depicted in Figure 1-3. In this notional case, the Mission Operations Center (Agency B) manages the spacecraft and interacts with the payload operations centers belonging to Agencies A and C. As in the scenario shown in Figure 1-2, the payload operations centers request telemetry packets and parameters, command histories, etc. They also interact with the mission operations center for planning and scheduling. In such complex scenarios, one agency may provide a functional service for others. An agency may be a service user for some services and the service provider for others, depending on the service function. For example, in the scenario depicted in Figure 1-3, Agency D is a user of telemetry services and a provider of navigation services.

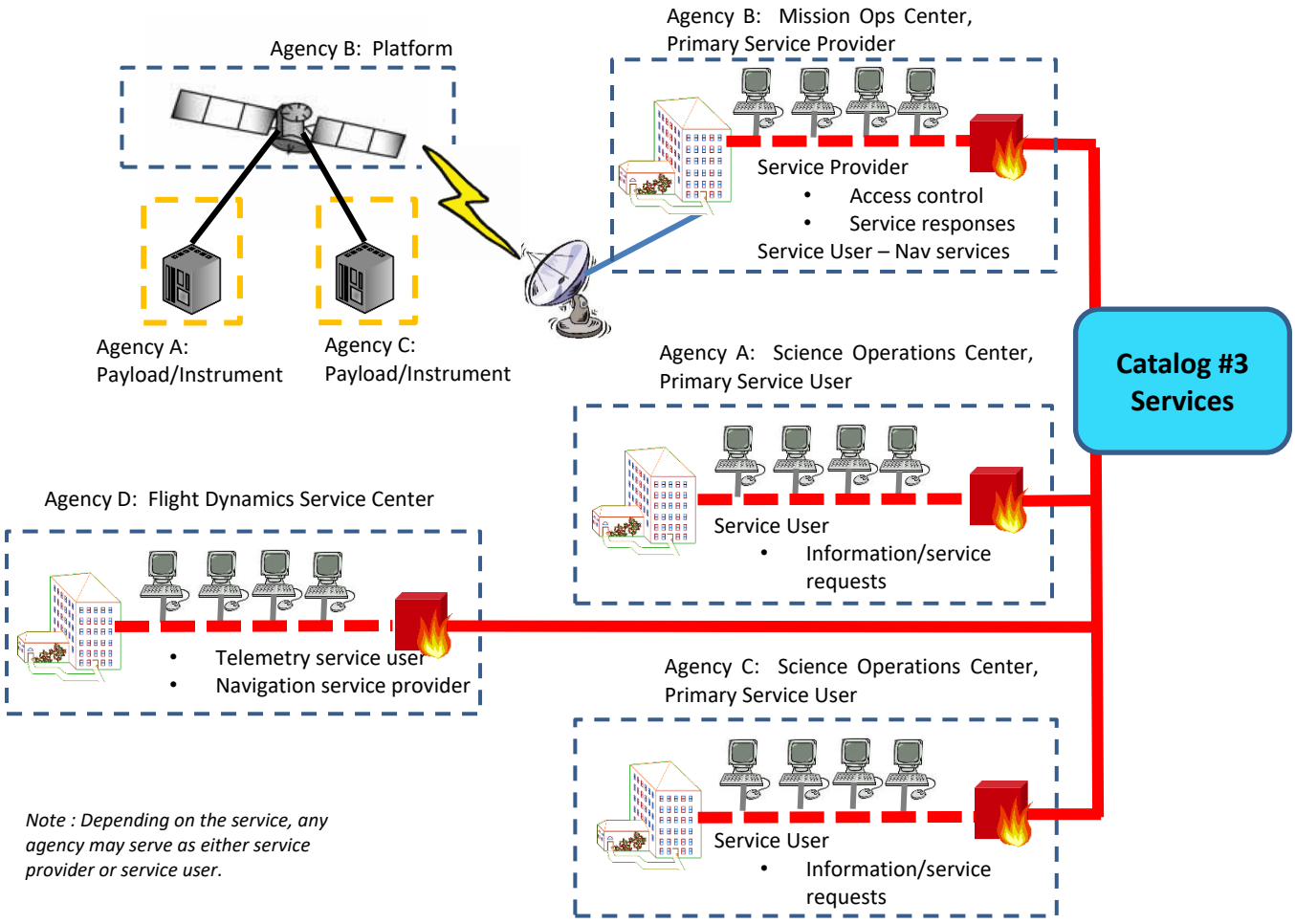

Figure 1-3. Notional Four-Agency Scenario

1.3 Definitions

The definitions of the following terms (Service, Service Interface, Service Provider System, Service User System) are identical to those in IOAG Service Catalog #2; however, in this service catalog, these definitions may also include people on operational teams.

Service

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

Service Interface

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

Service Provider System

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

Service User System

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

Interoperability Definition (From CCSDS Space Assigned Numbers Authority [SANA] Glossary)

- The technical capability of two or more systems or components to exchange information and to use the information that has been exchanged. Multiple degrees of interoperability are possible, ranging from basic physical layer (e.g., frequency, modulation and coding) compatibility up to full application layer information exchange.

The definition of the following term (Mission Operation Interoperability Services) is unique to IOAG Service Catalog #3.

Mission Operation Interoperability Services (MOIS)

- The services described in this catalog are a set of standard service types that support inter-Agency interoperability. Individual services may apply to some missions and not others. The individual services are distinguished from one another by the functions provided, level of processing involved, and/or the type(s) of source data.

1.4 Reference Documents

1.4.1 CCSDS STANDARDS

The latest set of CCSDS documents are available at https://public.ccsds.org/Publications/AllPubs.aspx.

[ADM]	CCSDS 504.0-B-1 Attitude Data Messages. Blue Book.
[ASDLP]	CCSDS 732.0-B-3 AOS Space Data Link Protocol. Blue Book.
[CDM]	CCSDS 508.0-B-1 Conjunction Data Message. Blue Book.
[COM]	CCSDS 521.1-B-1 Mission Operations Common Object Model. Blue Book.
[DPDS]	CCSDS [to be published] Mission Operations - Mission Data Product Distribution Services. Blue Book.
[ES]	CCSDS 133.1-B-2 Encapsulation Service
[IPCSL]	CCSDS 702.1-B-1 IP over CCSDS Space Links. Blue Book.
[MCS]	CCSDS 522.1-B-1 Mission Operations Monitor & Control Services. Blue Book.
[MOCS]	CCSDS [to be published] Mission Operations Common Services. Blue Book
[MPS]	CCSDS [to be published] Mission Planning and Scheduling. Blue Book.
[ODM]	CCSDS 502.0-B-2 Orbit Data Messages. Blue Book.
[PRM]	CCSDS 509.0-B-1 Pointing Request Message Blue Book.
[SPP]	CCSDS 133.0-B-1 Space Packet Protocol. Blue Book.
[TCF]	CCSDS 301.0-B-4 Time Code Formats. Blue Book.
[TDM]	CCSDS 503.0-B-1 Tracking Data Message. Blue Book.
[TMSDLP]	CCSDS 132.0-B-2 TM Space Data Link Protocol. Blue Book.
[XNDM]	CCSDS 505.0-B-1 XML Specification for Navigation Data Messages. Blue Book.
[XTCE]	CCSDS 660.0-B-1 XML Telemetric and Command Exchange. Blue Book.

1.4.2 IOAG DOCUMENTS

The latest set of IOAG documents are available at https://www.ioag.org.

[IC1]	IOAG Service Catalog #1
[IC2]	IOAG Service Catalog #2

1.5 Acronyms

ACKS	Acknowledgments
ADM	Attitude Data Messages
AOS	Advanced Orbiting Systems
APID	Application Process Identifier
ASCII	American Standard Code for Information Interchange
ASDLP	AOS Space Data Link Protocol
CCSDS	Consultative Committee for Space Data Systems
CDM	Conjunction Data Message
COM	Common Object Model
DPDS	Data Product Distribution Services
DTN	Delay/Disruption Tolerant Networking
ES	Encapsulation Service
FDIR	Fault Detection, Isolation, and Recovery
GVCID	Global Virtual Channel ID
HTTP	HyperText Transfer Protocol
IC1	IOAG Service Catalog #1
IC2	IOAG Service Catalog #2
ID	Identifier
IOAG	Interagency Operations Advisory Group
IP	Internet Protocol
IPCSL	IP over CCSDS Space Links
ISO	International Organization for Standardization
M&C	Monitor and Control
MCS	Monitor and Control Services
MO	Mission Operations

MOCS	Mission Operations Common Services
MOIS	Mission Operations Interoperability Services
MOSSG	Mission Operations Systems Strategy Group
MPS	Mission Planning and Scheduling
ODM	Orbit Data Messages
OMG	Object Management Group
PRM	Pointing Request Message
SANA	Space Assigned Numbers Authority
SCID	Spacecraft Identifier
SPP	Space Packet Protocol
TC	TeleCommand
TCF	Time Code Formats
TDM	Tracking Data Message
TM	Telemetry
TMSDLP	Telemetry Space Data Link Protocol
UTC	Coordinated Universal Time
VCID	Virtual Channel IDentifier
VPN	Virtual Private Network
XML	Extensible Markup Language
XNDM	XML Specification for Navigation Data Messages
XTCE	XML Telemetric and Command Exchange

2 SERVICE CATALOG #3 PRINCIPLES

2.1 Service Catalog #3 Approach

Service Catalog #3 was developed following the basic structure of Catalogs #1 and #2 and extends the scope of the Catalog services to the applications service level in support of inter-Agency interoperability for collaborative space missions. The development of any mission operations capability will rely on Catalog #1 and #2 services at the lower infrastructure layers in support of the specific applications identified in Catalog #3.

Common information exchanges between mission operations ground systems were identified and used as the basis for the list of Catalog #3 entries. A quick-look was then performed to identify existing CCSDS standards which cover Catalog #3 entries. The identified standards are provided for each service recommendation, although no claim is made that the existing standards fully meet the interoperability needs of this Catalog.

Service-based development is one valid approach for implementing interoperability functions. Many missions, however, have utilized a message-format approach to exchange information and use a variety of message delivery alternatives. The use of formats-based approaches may provide a simpler development process and could therefore speed adoption across Agencies. The full service-based approach provides additional behavioral capabilities and added functions such as service discoverability that are not in the formats approach, but the complexity is increased and deployment may be slowed. Existing CCSDS standards use a mix of service-based and formats-based standards. It is recommended that choices of both formats-based and service-based information exchange approaches should be available to support interoperability.

2.2 Functional Scope of Catalog #3

Service Catalog #3 is driven by shorter-term goals of current and known mid-term programs and can be considered as a minimum set of needed services.

Future missions may identify the need to extend Service Catalog #3. For example:

- Inventory management
- Medical data services
- Space situational awareness services
- Goal-oriented scheduling
- Data archive ingestion services
- Telerobotics services
- Onboard services to include Fault Detection, Isolation, and Recovery (FDIR) reporting; file management; process control; etc.

Figure 2-1 shows the common service groupings in the context of mission operations interoperability.

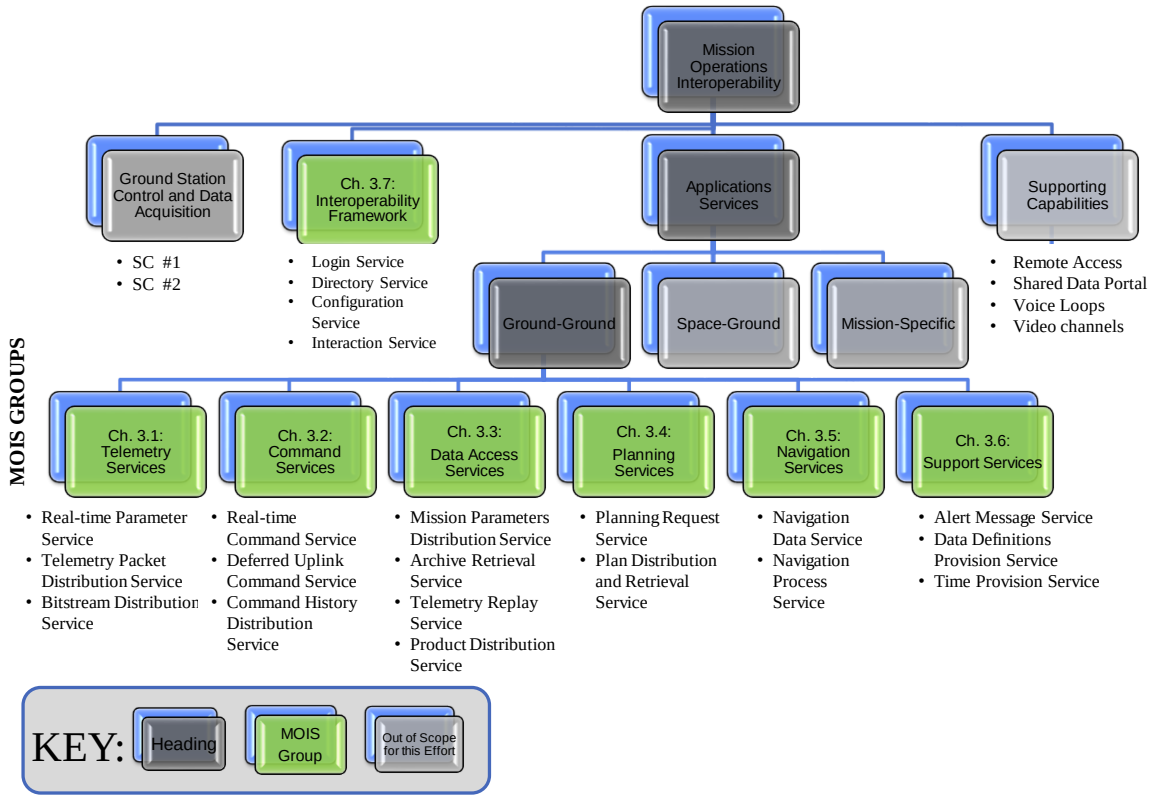

Figure 2-1: Mission Operations Interoperability

Service Catalog #3 MOIS groups are largely independent of one another and are provided mostly on a peer-to-peer basis. They do not require the overall, global management of a common resource like the Solar System Internetwork described in Service Catalog #2. Thus, a global Service Management Framework is not required. Service management is required for MOIS, however, and is supported via the Interoperability Framework. Supporting Capabilities in Figure 2-1 are essential to interoperability from an operations point of view, but are out of scope of Service Catalog #3.

Beyond functional services and frameworks, agreements are needed between agencies to specify network choices (private, Internet, etc.), use of Virtual Private Networks (VPN), protocols, security, and message encoding (American Standard Code for Information Interchange [ASCII], Extensible Markup Language [XML], HyperText Transfer Protocol (HTTP), etc.). These implementation and deployment decisions should be documented via formal agreements.

2.3 Catalog #3 Services Template

Each service is described using the template shown in Table 2-1.

Table 2-1 Service Description Template

Service ID	Service Name	Comments
Service Description	Description of the interface (service, data format, or both)	
Service Operations	Specifies the tasks that can be requested by the user or the provider E.g., ▪ Service request ▪ Service request status ▪ Service request modification	
Optional Services	Details the processing or added value that is provided E.g., command routing is a service of a command service	
Common Implementation Framework Services	Defines the management services that enable the functional services, including the service access E.g., ▪ Login service ▪ Directory service ▪ Configuration service ▪ Interaction service	
Implementation Required by Service User	Defines the minimum implementation expected from a service user	
Desirable Service Characteristics	Defines the set of service characteristics that would be desired from the proposed service	
Reference Standards	Specifies the applicable standard or states that the standard needs to be developed	

3 SERVICE CATALOG #3 MOIS GROUPS AND TYPES

The following sections describe in detail the following seven service groups included in Service Catalog #3. These service groups address interoperability between mission operations ground systems:

- Telemetry Services Group
- Command Services Group
- Data Access Services Group
- Planning Services Group
- Navigation Services Group
- Support Services Group
- Interoperability Framework

3.1 Telemetry Services Group

The Telemetry Services Group includes the services related to the provision of telemetry data in real time, either in raw format, such as packets, or in terms of calibrated and processed parameters (usually extracted from raw packets and processed).

3.1.1 REAL-TIME PARAMETER SERVICE

The service provides parameter values in raw or processed/calibrated format to the MOIS user in real time.

Typically, these values would include system parameters (such as temperatures, powers, modes, voltages, and rates as agreed between the agencies) for which suitable database information is available/provided.

This service provision is suitable for all scenarios. The only requirement is that the service provider has sufficient database information to be able to process the telemetry parameters correctly, and an agreement is in place between all involved agencies defining the parameter data that may be provided.

It is important for interoperability that the communicating systems utilize a common reference system for the parameters. Parameter mnemonics, as defined in the CCSDS and Object Management Group (OMG) standard XML Telemetric and Command Exchange (XTCE) standard, are recommended as this common reference identifier.

Telemetry-1	Real-time Parameter Service	Comments
Service Description	Parameters of relevance to an agency's telemetry system are provided in real time by the MOIS provider agency	Data Formats, transfer layer protocols, security aspects to be documented. Typically based upon the hosting agency infrastructure.
Service Operations	▪ Start and stop operations ▪ Add/suppress/update operations based on parameter IDs, aggregate IDs on-request ▪ Raw or calibrated values of parameters ▪ Parameter rate setting	
Optional Services	▪ Statistics service on data ▪ Parameters monitoring status delivery (out of limit, unavailability, alarm status…)	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session ▪ Directory service ▪ Configuration service: for support to parameter ID or aggregate ID selection, to obtain monitoring, out-of-limit, and unavailability definitions	
Implementation Required by Service User	▪ Access to parameter dictionary (e.g., XTCE file)	
Desirable Service Characteristics	▪ Scalability in case of very large parameter requests ▪ Exchange mode (complete and in sequence or expedited)	
Reference Standards	▪ CCSDS 522.1-B-1 Mission Operations Monitor & Control Services [MCS] ▪ CCSDS 660.0-B-1 XML Telemetric and Command Exchange [XTCE]	

3.1.2 TELEMETRY PACKET DISTRIBUTION SERVICE

The service provides the full raw telemetry packets to the MOIS user in real time.

Full decommutation of the packets is not needed; this service reads only the packet header to identify the packets for archive and distribution. This service must support CCSDS Space

Packet Protocol (SPP), and all information for the real-time forwarding of the raw packet must be included in the packet header. The use of the APID in the CCSDS SPP Header is assumed to be the basic identifier for packet forwarding; however, the Global Virtual Channel ID (GVCID) is also a common means of packet routing and forwarding that can be used.

Note that additional consideration needs to be taken when, for instance, SPP over Delay/Disruption Tolerant Networking (DTN) is used for transport.

Telemetry-2	Telemetry Packet Distribution Service	Comments
Service Description	MOIS provider provides the requested full raw telemetry packets to the MOIS user in real time	Implementation of this service to also support IP packets should be considered if IP packets become a more common form of telemetry transfer
Service Operations	▪ Start and stop operations, optional deferred delivery ▪ Add/suppress/update operations based on GVCID and/or Application Process Identifier (APID) and/or packet ID number on-request ▪ Provision of all packets or only "good" packets ▪ Setting of packet rate (distribute every n^{th} packet)	Distribution can be done on automated basis or in response to a request.
Optional Services	▪ Packet checksum check (for validating packet) ▪ Additional meta-data such as telemetry packet reception and transmission annotations (time tags, processing, etc.) ▪ IP packet decapsulation by MOIS provider agency (if encapsulation service is used on the downlink)	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session ▪ Directory service ▪ Configuration service: for support to APID, packet ID selection	
Implementation Required by Service User	Packet data definition agreed to (use XTCE definitions, as appropriate)	
Desirable Service Characteristics	Accountability of packet transmission delay in routing/transmission	

Telemetry-2	Telemetry Packet Distribution Service	Comments
Reference Standards	▪ CCSDS 133.0-B-1 Space Packet Protocol [SPP] ▪ CCSDS 702.1-B-1 IP over CCSDS Space Links [IPCSL] ▪ CCSDS 132.0-B-2 TM Space Data Link Protocol [TMSDLP] ▪ CCSDS 660.0-B-1 XML Telemetric and Command Exchange [XTCE] ▪ CCSDS [to be published] Mission Operations - Mission Data Product Distribution Services [DPDS]	

3.1.3 BITSTREAM DISTRIBUTION SERVICE

The service provides a bitstream to the MOIS user in real time, without any processing of the bitstream.

The bitstream is originally encapsulated in a transfer frame, with sufficient information in the frame header to identify the bitstream for forwarding and archiving. The bitstream could contain any type of information including voice or video from a space or ground asset.

CCSDS bitstream are defined in the CCSDS AOS Space Data Link Protocol. The MOIS bitstream distribution service could provide either the bitstream or an encapsulated bitstream to the end user. This service is often used by the mission operations center (MOIS provider) to provide science data to the science operations center (MOIS user), as shown in Figure 1-2 and Figure 1-3.

Telemetry-3	Bitstream Distribution Service	Comments
Service Description	Bitstream (e.g., via Transfer Frames) is provided by the MOIS provider to a MOIS user ground facility as bitstream optionally including the encapsulating transfer frame. This service can be used for science, voice, video, telemetry data, etc. of unknown format blindly forwarded from one agency to another.	In the case of ground equipment, non CCSDS AOS transfer frame mechanisms may be more appropriate, and so the service should be expandable to cover these protocols as appropriate.
Service Operations	▪ Start and stop operations ▪ Add/suppress/update operations based on virtual channel identifier (VCID) or other bitstream ID with or without transfer frame on-request	Distribution can be done on automated basis or in response to a request
Optional Services	▪ Deferred delivery ▪ Accountability of bitstream reception and delivery	Replay functions are addressed under support services (see section 3.3.3)
Common Implementation Framework Services	▪ Login service: to ensure authenticated session ▪ Directory service ▪ Configuration service: for support to virtual channel selection, include or exclude transfer frame.	
Implementation Required by Service User	▪ The provider agency must perform front-end processing for bitstream extraction and VCID or bitstream ID identification	
Desirable Service Characteristics	Scalability in case of very high rate (e.g., 1Gbps)	
Reference Standards	▪ CCSDS 132.0-B-2 TM Space Data Link Protocol. [TMSDLP] ▪ CCSDS 732.0-B-3 AOS Space Data Link Protocol [ASDLP] ▪ CCSDS 133.1-B-2 Encapsulation Service [ES]	

3.2 Command Services Group

The Command Services Group includes real-time, deferred commanding and a command history service (non-real-time).

Real-time command service when used in conjunction with the real-time telemetry services allows an agency to conduct real-time direct monitoring and control of a payload or another asset (commands being routed via another agency's control center).

3.2.1 REAL-TIME COMMAND SERVICE

This service accepts commands from the MOIS user, forwards them to the target destination in real time, and reports the status of the command execution.

The user should supply the command as either a basic hex string or as command mnemonic and parameter values, plus any necessary additional information to populate the command packet. The service puts the command into a packet, forwards it to the final destination onboard, and reports back the transfer and execution status. For the additional information needed for the transmission of the command, the command packet should be assumed to be CCSDS Space Packet Protocol (SPP). The MOIS provider may check the command integrity for security or against a list of allowed commands before releasing the commands.

This service provision is suitable, for example, in scenarios where a payload operations center of one agency (MOIS user) supplies command requests to the agency operating the platform (MOIS provider). The only requirement is that there is agreement on the assets that can be commanded from the various agencies (potentially a listed subset of commands).

It is important for interoperability that the communicating systems utilize a common reference system for the telecommands. Telecommand mnemonics, as defined in the CCSDS and OMG standard XML Telemetric and Command Exchange (XTCE) standard, are recommended as this common reference identifier.

Command-1	Real-time Command Service	Comments
Service Description	Command data sent from one agency to another for immediate uplink	Implementation of this service to also support IP packets should be considered if IP packets become a more common form of telecommand transfer
Service Operations	▪ Send command operation and report uplink or execution status ▪ Command can be raw values or provided as mnemonics and values	Command can be for immediate on-board execution or for onboard time-tagged execution
Optional Services	▪ Command validation (e.g., checksum if provided) ▪ Command identifier checked against allowed list. ▪ Security check of command packet Telecommand (TC) response/acknowledgments (ACKS) handling ▪ Storage (archiving) of TC packets handled ▪ Prioritization of commanding	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session of command sender ▪ Directory service ▪ Configuration service: for support to command identifier selection and checking and routing selection	
Implementation Required by Service User	▪ Access to telecommand dictionary (e.g., XTCE file) ▪ Routing information provided with command or part of the service binding	
Desirable Service Characteristics	Accountability of command rejection, delay in routing/transmission	
Reference Standards	▪ CCSDS 133.0-B-1 Space Packet Protocol [SPP] ▪ CCSDS 702.1-B-1 IP over CCSDS Space Links [IPCSL] ▪ CCSDS 522.1-B-1 Mission Operations Monitor & Control Services [MCS] ▪ CCSDS 660.0-B-1 XML Telemetric and Command Exchange [XTCE]	

3.2.2 DEFERRED UPLINK COMMAND SERVICE

This service accepts commands from the MOIS user, forwards them to the target destination, and reports back the status of the command uplink and execution. The control center (MOIS provider) places the command in its ground-queue and then uplinks the command to the target destination when a communication link is available and the specified time constraints are achieved.

Additional uplink timing information may be provided by the user. It may be absolute time specified in Coordinated Universal Time (UTC), relative time after a specific event, or options such as “do not uplink before absolute time” or “do not uplink after absolute time.”

The service request should contain the raw command or command mnemonic, plus parameters and packet information, and the deferred uplink timing information. As per the real-time command service, the command packet, built by the service provider, should be based on SPP.

This service provision is suitable, for example, in scenarios where a payload operations center of one agency (MOIS user) supplies timed command requests to the agency operating the platform (MOIS provider). The only requirement is that there is agreement on the assets that can be commanded from each agency (potentially a listed subset of commands only) and the routing information that needs to be confirmed.

Command-2	Deferred Uplink Command Service	Comments
Service Description	Command data sent from one agency to another for subsequent uplink at a future time	
Service Operations	▪ Uplink command at deferred time and report uplink or execution statuses	Command can be for immediate on-board execution or for onboard time-tagged execution
Optional Services	▪ Select uplink command from control center ▪ Cancel differed uplink ▪ Command identifier checking ▪ Command format checking ▪ Uplink timing information: o "Not before" and/or "before" uploading dates checked o Absolute time o Relative time after a specific event ▪ Time authentication of command packet ▪ Storage (archiving) of TC packets handled	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session of command sender ▪ Directory service ▪ Configuration service: for support command identifier selection and checking and command routing	
Implementation Required by Service User	▪ Access to telecommand dictionary (e.g., XTCE file)	
Desirable Service Characteristics	Accountability of packet rejection, delay in routing/transmission	
Reference Standards	▪ CCSDS 133.0-B-1 Space Packet Protocol [SPP] ▪ CCSDS 702.1-B-1 IP over CCSDS Space Links [IPCSL] ▪ CCSDS 522.1-B-1 Mission Operations Monitor & Control Services [MCS] ▪ CCSDS 660.0-B-1 XML Telemetric and Command Exchange [XTCE]	

3.2.3 COMMAND HISTORY DISTRIBUTION SERVICE

The MOIS user requests the command history and specifies a time frame and command history filter criteria. This service provides the user with a filtered list of requested commands including suitable metadata such as the time of uplink, time of execution, success or failure status of the command, as well as the command mnemonic or full command content, etc.

This service provision is suitable, for example, in scenarios where a payload operations center of one agency (MOIS user) requests a command history from the agency operating the platform (MOIS provider). Agreement is needed on the commands that are available to each user via this service, typically by permissible ranges of Spacecraft Identifier (SCID) and APID or time range.

Command-3	Command History Distribution Service	Comments
Service Description	MOIS provider provides the MOIS user with the requested command history	E.g., if Agency A and Agency B operate on the same asset, part of Agency B's command history is relevant to Agency A's payload
Service Operations	▪ Start and stop operations ▪ Add/suppress/update operations on requests based on SCID, APID, time range, Status (success, failure, etc.)	Distribution can be done on automated basis (i.e., After every pass) or in response to a request
Optional Services	▪ Command status provision ▪ Deferred delivery ▪ Detailed or summarized command history	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session ▪ Directory service ▪ Configuration service: for support to SCID, APID, packet ID selection	
Implementation Required by Service User	▪ Access to telecommand dictionary (e.g., XTCE file) ▪ Routing information must be provided with command or part of the service binding.	
Desirable Service Characteristics		
Reference Standards	▪ CCSDS 522.1-B-1 Mission Operations Monitor & Control Services [MCS] ▪ CCSDS 521.1-B-1 Mission Operations Common Object Model [COM] ▪ CCSDS 660.0-B-1 XML Telemetric and Command Exchange [XTCE]	

3.3 Data Access Services Group

The Data Access Services Group includes the services related to the provision of mission data from an archive or a system specialized in data distribution. Data exchange could include whole data products (e.g., a trend analysis, a set of observation data from an instrument session, etc.).

During real-time operations, Data Access Services may potentially overlap with Real-time Parameter Services (see section 3.1.1) and Telemetry Packet Distribution Services (see section 3.1.2), but those latter two services assume the data provider is a Monitor and Control (M&C) system, whereas with Data Access Services such an assumption is not made. From a service user point of view, M&C systems are no longer the only source of mission parameters in real time, because control centers have the need for other parameters (aggregates, ground system parameters, mission parameters) than those traditionally provided by M&C systems. Also, in large multi-lateral programs where various control centers interact with each other's M&C systems, centralizing data distribution proves more efficient overall (e.g., 1 to N distribution instead of M to N).

3.3.1 MISSION PARAMETERS DISTRIBUTION SERVICE

This service provides a central distribution capability for a network of sources/archives that provides parameter values (raw and calibrated) to the MOIS user.

The MOIS data distribution service provider receives data requests from multiple MOIS users and receives data from multiple sources (control centers of various agencies). The data distribution service acts as a broker between data users and data providers; i.e., it sends data requests to providers on behalf of users and provides a consistent parameter service interface to users.

The service implies the exchange of a common data catalog that defines the data that the service handles. The catalog is based on subsets of parameter databases from the various providers.

Data Access-1	Mission Parameters Distribution Service	Comments
Service Description	The service allows for distribution of available parameters (telemetry, ground system status, etc.) based on a catalog	Parameter mnemonic information based upon XTCE definitions
Service Operations	▪ Start/stop operations ▪ Add/suppress/update operations in response to requests based on parameter IDs	
Optional Services	▪ Application of parameter routing restrictions ▪ Application of parameter rates ▪ Parameter monitoring status delivery (out of limit, unavailability, alarm status, etc.) ▪ Deferred delivery	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session ▪ Directory service ▪ Configuration service: for support to parameters selection or pre-defined requests, routing restrictions (e.g., number of requests allowed by user), rates, to obtain monitoring, out of limit and unavailability definitions	
Implementation Required by Service User	Access to parameter dictionary (e.g., XTCE file)	
Desirable Service Characteristics	▪ Scalability of system to handle large requests, increased number of parallel requests, increased the number of nodes	
Reference Standards	▪ CCSDS 522.1-B-1 Mission Operations Monitor & Control Services [MCS] ▪ CCSDS 660.0-B-1 XML Telemetric and Command Exchange [XTCE]	

3.3.2 ARCHIVE RETRIEVAL SERVICE

This service provides the MOIS user with objects that have been stored in an archive.

It is applicable to any objects that could be archived (excluding parameters and commands whose retrieval are supported by other services described above). There is no dependency upon how the objects have been archived or their contents. For example, the objects could be packets, frames, files, acknowledgements, or logs.

In many scenarios multiple agencies may provide an archive retrieval service. This service requires that the definitions of the object types are available in the archive for retrieval, their metadata is available for filtering, and that agency access restrictions are followed. The archive could be fully distributed with the service provider acting as a broker, as well as a direct archive host, in the same way as the Mission Parameters Distribution Service.

Data Access-2	Archive Retrieval Service	Comments
Service Description	MOIS user requests and receives data from MOIS provider's archive	Data format of delivered archive objects is open.
Service Operations	▪ Start and stop operations ▪ Add/suppress/update operations on requests based on data type (packet ID, APID or parameter ID, orbital events, logs, etc.) time range, stream, file, etc. ▪ Automated archive gap detection	Data provision can be accomplished on an automated basis or in response to a request
Optional Services	▪ Archive content discovery ▪ Deferred delivery ▪ Automated archive gap completion ▪ Archive accountability (knowing what should be in archive)	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session) ▪ Directory service	
Implementation Required by Service User	Agreement must be reached with service provider on the data that is retrievable.	
Desirable Service Characteristics	Request accountability (logs)	
Reference Standards	▪ CCSDS 521.1-B-1 Mission Operations Common Object Model [COM]	

3.3.3 TELEMETRY REPLAY SERVICE

This service provides the MOIS user with a stream of replayed data containing all the telemetry that was provided in real time, in the same order and format as it was originally provided.

For example, a payload operations center (MOIS user) can request telemetry replay from a mission operations center (MOIS provider) to support a simulation or test. Agencies would follow the same agreements for data access and telemetry provision as are agreed for the Real-time Parameter, Telemetry Packet Distribution, and Bitstream Distribution services.

Data Access-3	Telemetry Replay Service	Comments
Service Description	MOIS user requests and receives an archived telemetry data stream from MOIS provider's archive	Archived telemetry data should be in the same time order and same format as were originally provided, including any associated metadata
Service Operations	▪ Request replay from a start time or during a time period ▪ Add/suppress/update operations on requests based on packet ID, APID, time range, stream, or file ▪ Replay control operations (play, pause, resume, speed up/down, stop)	
Optional Services	▪ Archive content discovery ▪ Deferred delivery	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session ▪ Directory service	
Implementation Required by Service User	Agreement must be reached with service provider on the data that is accessible.	
Desirable Service Characteristics	Request accountability (logs)	
Reference Standards	None	

3.3.4 PRODUCT DISTRIBUTION SERVICE

This service transfers data product files (including science data, navigation products, schedules, etc.) and product catalogs from an MOIS provider to an MOIS user. An agency could be both a provider and user of this service.

The service should confirm complete product reception at the target location.

Agencies must agree on the files to be transferred, and the distribution service requires security access at the target location site.

Data Access-4	Product Distribution Service	Comments
Service Description	MOIS user requests product catalogs and file distribution based on specified criteria	
Service Operations	▪ Add/suppress/update operations on distribution requests based on specified criteria ▪ Data distribution status alerts ▪ Accountability of product distribution ▪ Retrieve product catalogs	It is assumed that the transfer can be done on an automated basis or in response to a request
Optional Services	▪ Identify gaps in received file streams ▪ Resend corrupted or missing files (gaps) ▪ File data integrity check ▪ Exchange of metadata	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session ▪ Directory service ▪ Configuration service: to update product criteria	
Implementation Required by Service User	Suitable access (read/write) is needed at the target site for the distribution service.	
Desirable Service Characteristics	Inclusion of metadata to aid the accountability and add value by the service	
Reference Standards	CCSDS [to be published] Mission Operations - Mission Data Product Distribution Services [DPDS]	

3.4 Planning Services Group

This services group includes basic services related to the iterative and distributed planning processes. It allows multiple agencies to build shared plans and request information from each other about planning.

These services are applicable to any of a range of assets that are scheduled by agencies.

Two main services are identified to enable planning interoperability between agencies:

- The Planning Request Service used to provide inputs to a planning process
- The Plan Distribution and Retrieval Service to provide output of the planning process and feedback on plan execution

3.4.1 PLANNING REQUEST SERVICE

This service allows the MOIS user to provide inputs to the MOIS provider to support a planning process. The planning request service is required when multiple parties participate in the development of an overall operations plan or multiple plans.

Agency agreement on rules and timeliness of the planning cycle inputs is required in the setup of the service.

Planning-1	Planning Request Service	Comments
Service Description	MOIS user provides a planning request to MOIS provider	Data format is to be developed
Service Operations	▪ Add/update/cancel planning requests ▪ Provide request status feedback	
Optional Services	▪ Update planning events and resources	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session of command sender ▪ Directory service	
Implementation Required by Service User	None	
Desirable Service Characteristics	Planning request accountability	
Reference Standards	▪ CCSDS [to be published] Mission Planning and Scheduling. [MPS]	

3.4.2 PLAN DISTRIBUTION AND RETRIEVAL SERVICE

This service addresses the retrieval of plans and the update of plan contents (e.g., duration, dependencies, name, nature, resources, etc.).

For example, this service allows a payload operations center (MOIS user) to request copies of applicable portions of a mission schedule from the MOIS provider. Clear rules need to be agreed between agencies using this service regarding the activities and the range of activity parameterization that may be edited in a plan. Time frames for add/delete/update also need to be agreed.

Planning-2	Plan Distribution and Retrieval Service	Comments
Service Description	MOIS user can request schedules and edit schedules from the MOIS provider	
Service Operations	▪ Retrieve plan ▪ Retrieve plan status	Retrieval can be done on automated basis or in response to a request
Optional Services	▪ Add/edit/delete an activity in a plan ▪ Plan content execution status	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session of command sender ▪ Directory service	
Implementation Required by Service User	None	
Desirable Service Characteristics	Service accountability (were requests successfully executed)	
Reference Standards	▪ CCSDS [to be published] Mission Planning and Scheduling. [MPS]	

3.5 Navigation Services Group

The navigation services group concerns the generation and delivery of navigation data (e.g., ephemeris, reconstituted high precision orbit, attitude, predictions, maneuvers, collision predictions, swath data, etc.) between agencies.

3.5.1 NAVIGATION DATA SERVICE

The Navigation Data Service enables transfer of navigation data information from one agency to another.

It is assumed that navigation information is exchanged as files between control centers using the Product Distribution Service to control the file transfer. Use of a common configuration service is expected to allow the MOIS user to control the navigation data being provided.

For example, an independent flight dynamics and navigation center (MOIS provider) could accept requests for information from multiple MOIS users. The service supports the regular or on-request distribution of navigation product files. Agencies must agree on the types of files, data precision, and validity time of the file contents, in advance.

Navigation-1	Navigation Data Service (Flight Dynamics)	Comments
Service Description	MOIS user requests and receives flight dynamics data (a set of files) from the MOIS provider	
Service Operations	▪ Start/stop navigation files. ▪ Product availability alerts	Provision of files can be done on automated basis or in response to a request
Optional Services	▪ Accountability of delivered files ▪ Metadata assigned to each file ▪ Propagation delay	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session of command sender ▪ Directory service ▪ Configuration service: for support to file selection	
Implementation Required by Service User	None	
Desirable Service Characteristics	▪ Proposed standard minimum precision for each flight dynamics product type ▪ Current versions of systems, models used in the product generation	
Reference Standards	▪ CCSDS 502.0-B-2 Orbit Data Messages [ODM] ▪ CCSDS 503.0-B-1 Tracking Data Message [TDM] ▪ CCSDS 504.0-B-1Attitude Data Messages [ADM] ▪ CCSDS 505.0-B-1 XML Specification for Navigation Data Messages [XNDM] ▪ CCSDS 508.0-B-1 Conjunction Data Message [CDM] ▪ CCSDS 509.0-B-1 Pointing Request Message [PRM]	

3.5.2 NAVIGATION PROCESS SERVICE

The Navigation Process Service enables an MOIS user to request generation of navigation products.

The processing request will include the processing time period and the navigation data products to be generated.

For example, an MOIS user could request that an independent flight dynamics and navigation center (MOIS provider) perform specified product generation. This service supports both the regular or on-request generation of navigation product files. Agencies must agree on the navigation data products that can be generated in advance.

Navigation-2	Navigation Process Service (Flight Dynamics)	Comments
Service Description	MOIS user requests MOIS provider to generate navigation products	
Service Operations	▪ Generate and distribute product(s) ▪ Request status of product generation	Generation of products can be done on automated basis or in response to a request. The output products are generated over a defined time period from input data over another defined time period.
Optional Services	None	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session of command sender ▪ Directory service ▪ Configuration service: to support list of data product available for generation	
Implementation Required by Service User	None	
Desirable Service Characteristics	▪ Current versions of systems, models used in the product generation	
Reference Standards	▪ CCSDS 502.0-B-2 Orbit Data Messages [ODM] ▪ CCSDS 503.0-B-1 Tracking Data Message [TDM] ▪ CCSDS 504.0-B-1 Attitude Data Messages [ADM] ▪ CCSDS 505.0-B-1 XML Specification for Navigation Data Messages [XNDM] ▪ CCSDS 508.0-B-1 Conjunction Data Message [CDM] ▪ CCSDS 509.0-B-1 Pointing Request Message [PRM]	

3.6 Support Services Group

The support services group includes several functions useful in interoperability scenarios such as the broadcasting of alert messages (e.g., to warn of a contingency situation) and the exchange of data definitions (e.g., telemetry dictionaries).

3.6.1 ALERT MESSAGE SERVICE

This service provides a means of broadcasting alerts to MOIS users to inform them of the status of various activities or problems.

An “alert” is defined is an asynchronous notification, such as a nominal or non-nominal event that is of significance to mission operations. Alerts may include supporting information as a time stamp, criticality and type flags, and a text.

Note that in many scenarios each participating agency could be a provider of alert message services. Agencies must agree on the alerts that can be sent. Alerts can be filtered (e.g., for criticality, priority, or confidentiality).

Support-1	Alert Message Service	Comments
Service Description	MOIS users subscribe to alerts broadcast by an MOIS provider	Data format is to be developed
Service Operations	▪ Subscribe/unsubscribe to alerts ▪ Set filters for criticality, priority, confidentiality, or for specific alerts	
Optional Services	▪ Acknowledge message reception ▪ Re-send or defer delivery	Some alerts are sufficiently important to require a reception acknowledgement. In case of service unavailability, a user could request that all alerts in the last X hours are resent.
Common Implementation Framework Services	▪ Login service: to ensure authenticated session of command sender ▪ Directory service ▪ Configuration service: to define the list of alerts to be sent	
Implementation Required by Service User	None	
Desirable Service Characteristics	Accountability regarding sending and reception of messages	
Reference Standards	▪ CCSDS 522.1-B-1 Mission Operations Monitor & Control Services [MCS]	

3.6.2 DATA DEFINITIONS PROVISION SERVICE

This service provides for delivery of a data dictionary from one agency to another. XTCE is an example of a data dictionary that can be employed.

Support-2	Data Definitions Provision Service	Comments
Service Description	MOIS user requests and receives a data dictionary from the MOIS provider	
Service Operations	▪ Get master database version/metadata	
Optional Services	▪ Provide a subset of a full dictionary per specified criteria ▪ Provide a list of mnemonics per specified criteria ▪ Get data definition based on list of mnemonics	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session of command sender ▪ Directory service ▪ Configuration service: to define access restrictions per user	
Implementation Required by Service User	None	
Desirable Service Characteristics	Scalability (some missions may require several hundred thousand parameter and command definitions)	
Reference Standards	▪ CCSDS 660.0-B-1 XML Telemetric and Command Exchange [XTCE]	

3.6.3 TIME PROVISION SERVICE

This service enables mission operations ground systems to compare their respective time synchronization status, and to coordinate the time correlation.

This service shall provide messaging regarding the current time and time convention employed by the hosting system.

The time service shall provide the time couplets of ground systems time and the space systems time (already corrected for all known delays in the space systems, during propagation and in the ground stations). Metadata should be attached to the time couplets to provide additional information that could be applicable to the time couplet, such as the delays applied and ground station configuration used.

Support-3	Time Provision Service	Comments
Service Description	MOIS provider provides time and time correlation data to MOIS user.	
Service Operations	▪ Start/stop sending current time ▪ Request current time (Ping) ▪ Start/stop sending time couplets ▪ Request current time correlation	The Ping can also be used to calculate the two-way communications delay (plus processing)
Optional Services	▪ Metadata on current time and time couplets	
Common Implementation Framework Services	▪ Login service: to ensure authenticated session of command sender ▪ Directory service ▪ Configuration service: to change the frequency that the time is reported	
Implementation Required by Service User	Time correlation of the space/ground time couplets needs to be done at each agency.	
Desirable Service Characteristics		
Reference Standards	▪ CCSDS 301.0-B-4 Time Code Formats [TCF]	

3.7 Interoperability Framework

The functional services described above rely on the Interoperability Framework (see Figure 2-1).

3.7.1 INTEROPERABILITY FRAMEWORK SERVICES

Interoperability Framework services are common to all the groups described above. All services require Login, Directory, Configuration, and Interaction Services to connect the user to the provider. These management services enable interoperability at the service level.

These services are implemented at the service level and are in addition to any routine security interfaces; i.e., the login is purely a login to the service provider application and would occur after all the nominal security handshaking necessary to allow the communication between the user and provider applications. Security aspects will be based upon the hosting agency infrastructure and recorded via an interagency agreement.

Framework-1	Interoperability Framework Services	Comments
Service Description	▪ Login: provides authentication mechanism and the attribution of roles and privileges to the functional service user ▪ Directory: publishes the address of the requested functional services and the capabilities of each functional service ▪ Configuration: provides the information necessary to configure the functional service. ▪ Interaction: allows user entry in the functional service	These management services are not necessary when using formats-based approaches
Service Operations	▪ Login: login, logout, roles ▪ Directory: lookup, publish a new service, remove a service ▪ Configuration: lookup configuration, activate configuration ▪ Interaction: acknowledgment, confirmation, choice, value entry	
Desirable Service Characteristics	Logging/accountability	
Reference Standards	▪ CCSDS 521.1-B-1 Mission Operations Common Object Model [COM] ▪ CCSDS [to be published] Mission Operations Common Services [MOCS]	