

Report Concerning Space Data System Standards

MISSION OPERATIONS SERVICES CONCEPT

INFORMATIONAL REPORT

CCSDS 520.0-G-1

GREEN BOOK

May 2005

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1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This CCSDS Report presents a set of concepts, reference architecture, and service framework for spacecraft monitoring and control. It has been prepared by the Spacecraft Monitoring and Control working group of the CCSDS Mission Operations and Information Management Systems (MOIMS) area.

In this context, Spacecraft Monitoring and Control (SM&C) refers to end-to-end services between onboard or remote applications and ground-based functions responsible for mission operations.

The scope of SM&C includes:

- a) Operational Concept: definition of an operational concept that covers a set of standard operations activities related to the monitoring and control of both ground and space segments.
- b) Common Monitor & Control Services: definition of a common monitor and control pattern that can be applied on the ground and in space, a common monitor and control protocol for interoperability, and a core monitor and control application service. This includes an information base describing interfaces and functionality of controlled devices and components.
- c) Core Set of Mission Operations Services: definition of an extensible set of services to support the operational concept together with its information model and behaviours. This includes (non-exhaustively) ground systems such as Automatic Command and Control, Data Archiving and Retrieval, Flight Dynamics, Mission Planning, and Performance Evaluation.
- d) Application-layer information: definition of the standard information set to be exchanged for SM&C purposes.

1.2 DOCUMENT STRUCTURE

Following this introduction, the document has the following main sections:

2. Context and Overview of Spacecraft Monitoring and Control (SM&C) services. Provides a brief description of the architecture and key concepts.
3. Reference Architecture for SM&C services using the Reference Architecture for Space Data Systems methodology (RASDS). Outlines the context of the SM&C services with respect to the system users.
4. Operational Concept that forms a basis for the services identified later in the Report. Detailed description of the operational concepts and driving forces behind the specified services.

5. Service Framework for subsequent definition of an extensible set of SM&C services and specification of common protocols, mechanisms, and concepts to be used in such services. Primarily a section focussing on the mechanisms used to define and specify the services.
6. Services Identified: lists and provides a brief description of a potential set of services to be defined as CCSDS Recommended Standards, using the Service Framework described. The set of services identified is not intended to be exhaustive, but does indicate a priority for standardisation.

1.3 DEFINITION OF TERMS

Adapter	A component that adapts from one protocol/interface to another.
Alert	Operationally significant event.
Atomic	Something that cannot be split into subcomponents and cannot be interrupted. For example, it may be possible to stop an atomic operation before it has started but once it has it cannot be stopped.
Directive	Low-level instruction.
Event	Change of state notification.
Proxy	Component that acts as a remote agent for some other component, representing it in the remote system.

1.4 DEFINITION OF ACRONYMS

AOS	Acquisition of Signal
APES	Antenna Pointing Element Set
CFDP	CCSDS File Delivery Protocol
CORBA	Common Object Request Broker Architecture
ECSS	European Cooperation for Space Standardisation
LOS	Loss of Signal
MIB	Management Information Base
MOIMS	Mission Operations and Information Management Systems
PDU	Protocol Data Unit
PUS	Packet Utilisation Standard
QoS	Quality of Service

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RASDS	Reference Architecture for Space Data Systems
SAP	Service Access Point
SEA	Systems Engineering Area
SLE	Space Link Extension
SLS	Space Link Services
SM&C	Spacecraft Monitor and Control
SMP	Service Message Protocol
SMS	Small Message Service (mobile phone text messaging)
SOAP	Simple Object Access Protocol.
SOIS	CCSDS Spacecraft Onboard Interface Services
TAI	Temps Atomique International
TC	Telecommand(ing)
TM	Telemetry
UML	Universal Modelling Language
UTC	Universal Time Coordinated
WG	Working Group
XML	eXtensible Markup Language

1.5 REFERENCES

The following documents are referenced in the text of this Report. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this Report are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS Documents.

- [1] *Reference Architecture for Space Data Systems*. Draft Specification Concerning Space Data Systems, CCSDS 800.0-M-0.8a. Draft Recommended Practice. Issue 0.8a. n.p.: n.p., November 2004.
- [2] *Space Link Extension—Return Channel Frames Service Specification*. Recommendation for Space Data System Standards, CCSDS 911.2-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, December 2004.

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- [3] *Space Link Extension—Return All Frames Service Specification*. Recommendation for Space Data System Standards, CCSDS 911.1-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, December 2004.
- [4] *Space Link Extension—Return Operational Control Fields Service Specification*. Recommendation for Space Data System Standards, CCSDS 911.5-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, December 2004.
- [5] *Space Link Extension—Forward CLTU Service Specification*. Recommendation for Space Data System Standards, CCSDS 912.1-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, December 2004.
- [6] *Space Link Extension—Forward Space Packet Service Specification*. Recommendation for Space Data System Standards, CCSDS 912.3-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, December 2004.
- [7] *Telemetry and Telecommand Packet Utilization*. ECSS Standard, E-70-41A. Noordwijk, The Netherlands: ECSS, January 2003.
- [8] J. Case, et al. *A Simple Network Management Protocol (SNMP)*. RFC 1157, May 1990. <<http://ietf.org/rfc/rfc1157.txt>>

2 CONTEXT AND OVERVIEW

This Report outlines a framework for a set of end-to-end Mission Operations and Spacecraft Monitoring and Control (SM&C) services that support interaction between distributed SM&C functions (or applications) that may reside onboard spacecraft or within an associated ground segment. These services are aimed at the support of spacecraft mission operations and, as they have been conceived within the context of the CCSDS Mission Operations and Information Management Systems (MOIMS) area, they are also referred to as MOIMS Services. It defines the approach to be used in the subsequent service definition itself and prioritises the identified services in terms of the perceived interoperability benefits.

Where the corresponding service crosses the boundary between operating agencies, missions, or systems, then the adoption of a standard would offer interoperability between infrastructures. When the corresponding service crosses the boundary between software systems, then the adoption of a standard would permit the development of ‘plug-and-play’ components from various organisations and the capability of rapid integration into a mission-specific system.

The Report elaborates the basic operations and interactions of each of the Application-layer services and through this is able to identify common interaction patterns, services, and protocols. These common services and protocols are the initial focus of the work of the Recommended Standards, as the Application-layer services build on them and are expected to be implemented in terms of them.

2.1 SERVICES MODEL

Service-based architecture is gradually replacing monolithic architecture as the main design principle for new applications in both private and distributed systems. It is one of the fundamental design principles of network distributed applications where the interfaces (both operations and data objects) must be well defined, as the clients are often heterogeneous.

The architecture is essentially a design that starts with an interface definition and builds the entire application based around the interfaces, interface semantics (state machines of the interface), and interface calls (operations allowed and data objects passed). Whilst there are no universally recognised standards for service-based architecture, the concepts and terminology used are nevertheless well developed and consistent, having evolved in line with their wide utilisation. Comparison shows that these are analogous to the service model conventions used for the ECSS PUS (reference [7]) and SLE (references [2-6]).

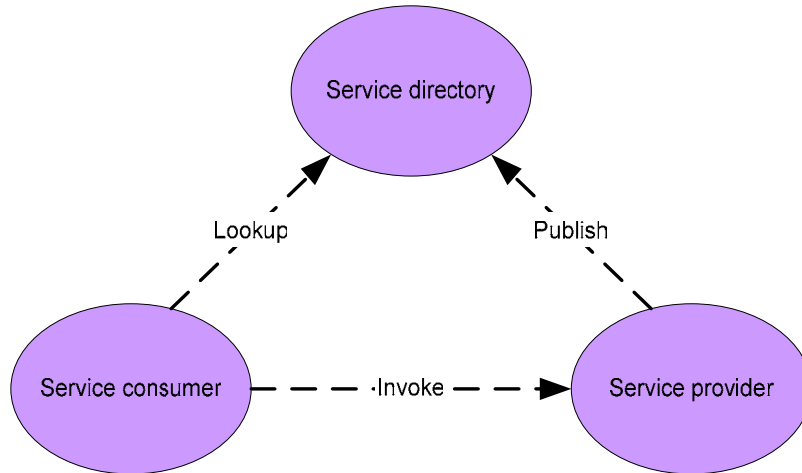


Figure 2-1: Service Model

Service:

A service is an operation, or set of operations, that is well defined, self-contained, and does not depend on the state or context of another service. A service may be implemented in terms of, or use, another service, but interaction with other services should not be apparent to a consumer of the service.

Service provider:

A service provider is an entity that implements a service, equivalent to the target in a controller and target pattern. A service provider may also be a service consumer of lower-level services; however, interaction with other services should be transparent to the consumers of the service (i.e., it is an implementation detail).

Service consumer:

A service consumer is an entity that uses a service being supplied by a service provider, equivalent to the controller in a controller and target pattern. A service consumer may also be a service provider to higher-level service providers; however, interaction with other services would and should be transparent to the lower-level service being invoked (i.e., it is an implementation detail).

Service directory:

A service directory is an entity that provides publish and lookup facilities to service providers and consumers. Strictly speaking a directory is not required if a well known service is to be used; however, in most circumstances a directory provides required flexibility in the location of services. The service directory is in itself a service by definition.

Service adapter:

An adapter is a device used to match the characteristics of two different things so that a connection may be made between them. In the context of services a service adapter is a component that matches the interface of one service to another (platform specific) service. For example, a service adapter could enable a Data Management service provider to use a specific file transfer protocol.

The preference of the terms 'provider' and 'consumer' with respect to the service architecture is driven by the fact that they reflect the use of the service. An entity provides a service, whereas another entity consumes the service. An alternative to consumer is user, i.e., 'service user'; however, this usage can conflict with the generic term 'user', which often means a person involved in the system.

The terms service provider and service consumer are also predominantly used in the distributed web application domain.

2.2 IDENTIFICATION OF SM&C SERVICES

The set of services identified in this document are split into two service layers:

- Application layer, containing the core services and the other Application-layer mission operations services;
- common layer, containing the common services and protocols.

A single service specification is assumed for the common layer, while there will be a set of Application-layer service specifications as listed in the table 2-1.

The table lists the proposed services, together with a brief description summarising the principal objects and the operations that can be performed on them. The final column of the table highlights where the proposed service requires coordination with other CCSDS working groups and areas to ensure overall consistency.

Within each service specification, sub-services will be grouped into capability sets. The service specification will indicate the minimum capability set required for compliance and may also include a set of optional capability sets to support advanced interaction. For example, with a time service the basic capability might be time correlation, whereas an optional capability might be time adjustment.

Table 2-1: Application-Layer Service Summary

Service	Description	Related Area
Core	Parameters: calibration, monitoring, aggregation, configuration, statistics, ... Actions: send, validate, verify, ... Alerts: notify, ...	SOIS
Time	Time correlation, set time, ...	SOIS
Data Product Management	File management and transfer, both ground-based and onboard	SIS
Location	Tracking, ranging, and onboard position determination, ...	Navigation WG CSS
Scheduling	Schedule: managing (e.g., load, clear, shift, ...), control (e.g., start, suspend, resume, ...)	
Flight Dynamics	Orbit/attitude determination/propagation, manoeuvre preparation, ...	Navigation WG
Planning	Plan: managing (e.g., add/delete/modify activity, ...), control (e.g., validate/generate plan, allocate authority...)	
Software Management	Software versioning, patching, dumping and releasing, ...	
Automation	Automated procedure/functions: control (e.g., start, stop), progress reporting, ...	
Interaction	Asynchronous (human) operator: notification and interaction, ...	

Table 2-2: Common Layer Service Summary

Service	Description	Related Area
Protocol	Directives, Events, Reports	SOIS
Common Service	Common interactions, History, Security, Configuration, Service Directory	Security

2.3 SM&C SERVICE CONCEPT

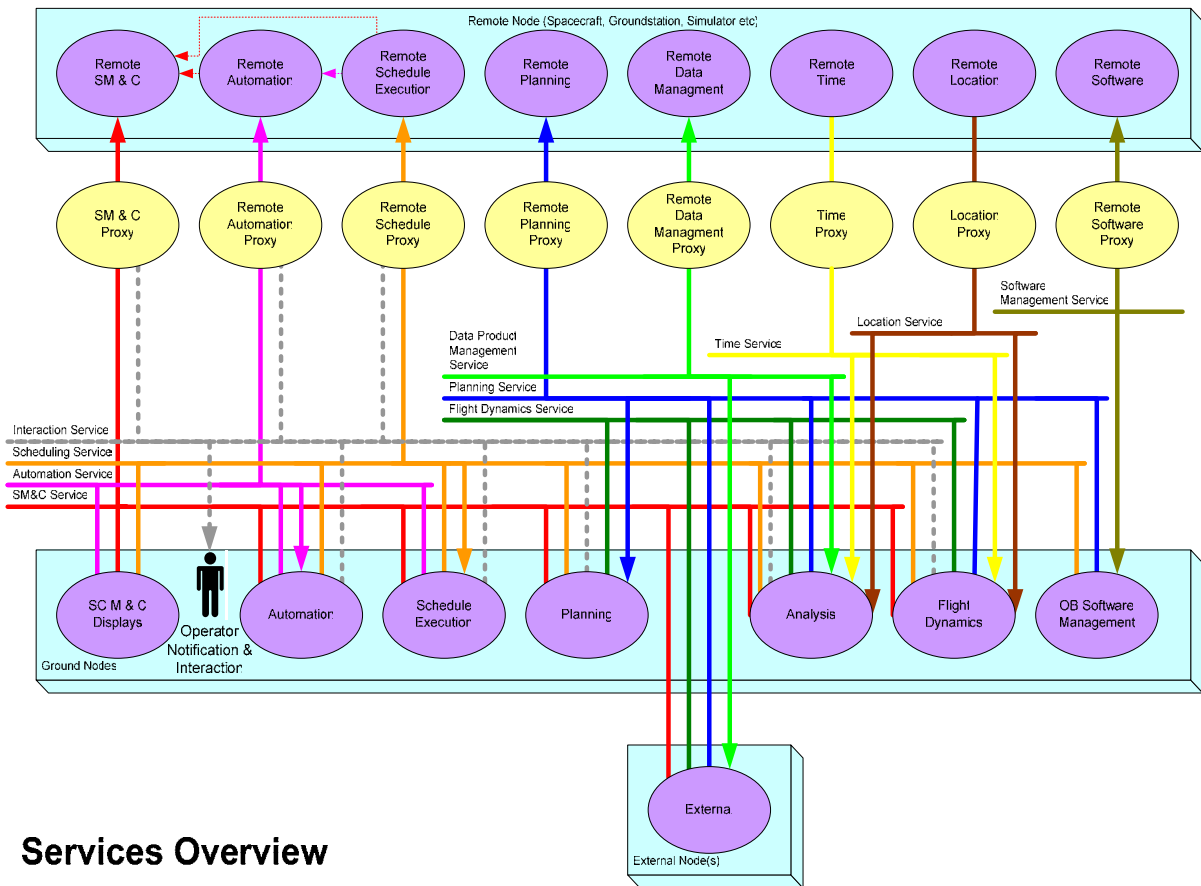


Figure 2-2: Mission Operations Services Overview

Figure 2-2 illustrates the concept of a set of Application-layer mission operations services for the Monitoring and Control of spacecraft. This core set of operational functions are ones that exist, or may exist, in many current and future spacecraft control systems. These functions may be distributed between organisations and physical entities in many different ways, as increasingly functions are being deployed onboard spacecraft. The intention is to identify services that allow different distributions of operational functions to be adopted by individual organisations or missions.

The basic monitor and control service is architecturally one of the Application-layer mission operations services shown in the figure, but has a key role as it provides the most basic core services for monitoring and controlling various system elements.

Underlying this set of mission operations services is a monitor and control protocol which provides the basic communications and control services and hides the details of underlying communications infrastructure from the upper-layer applications. This protocol is a key element of the interoperability infrastructure.

Another key part is an information base that defines the capabilities of the various devices and components that are managed by these services. This information base defines the objects that are exposed by the services, together with their associated attributes and actions.

2.4 SERVICE LAYERS

The Application-layer services relate to the end-to-end operation of spacecraft (and potentially other remote systems) and are logically independent of underlying transport protocols.

An adapter provides a standard interface to the applications whilst hiding the currently used protocol. By utilising a different Transport-layer adapter an Application-layer service can then be used to operate over CCSDS Space Link Services, SIS transport services, onboard SOIS services, or various ground-based middleware standards, such as WSDL, SOAP or CORBA.

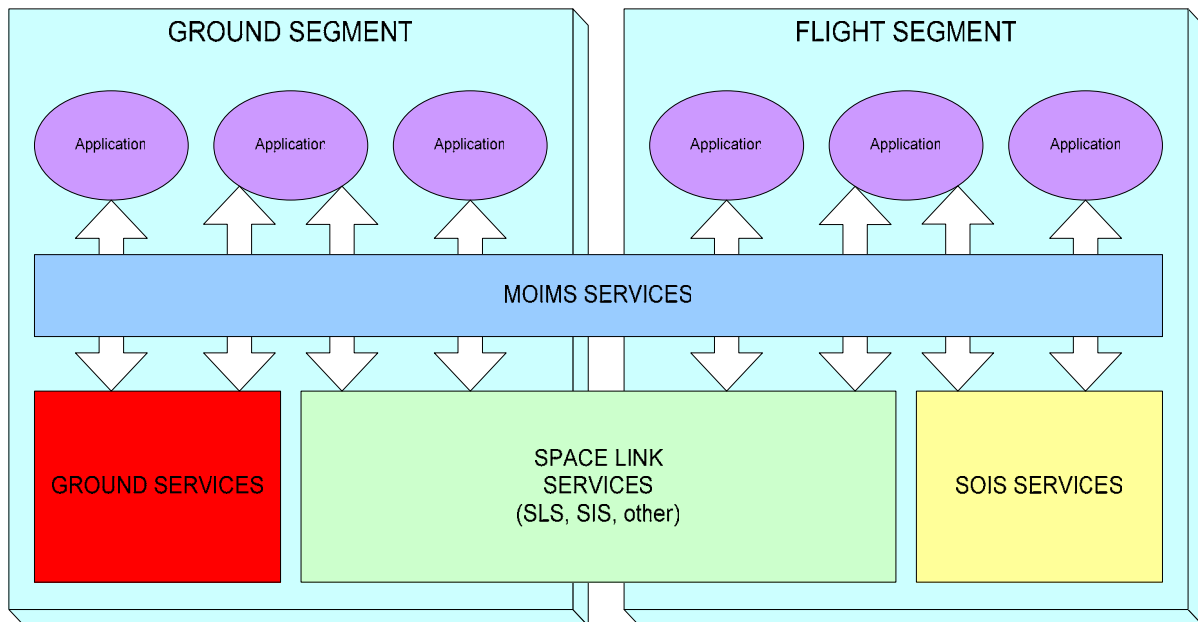


Figure 2-3: MOIMS Service Transports

Mapping each high-level Application-layer service directly to the underlying transport protocol would require implementation of multiple service adapters, one to map each Application-layer service to the underlying transport service used.

To avoid this, common interactions that provide the basis for all Application-layer services have been identified. This common service layer isolates the Application-layer services and enables the implementation of a single transport service adapter to support all high-level Application-layer services, as illustrated in figure 2-4.

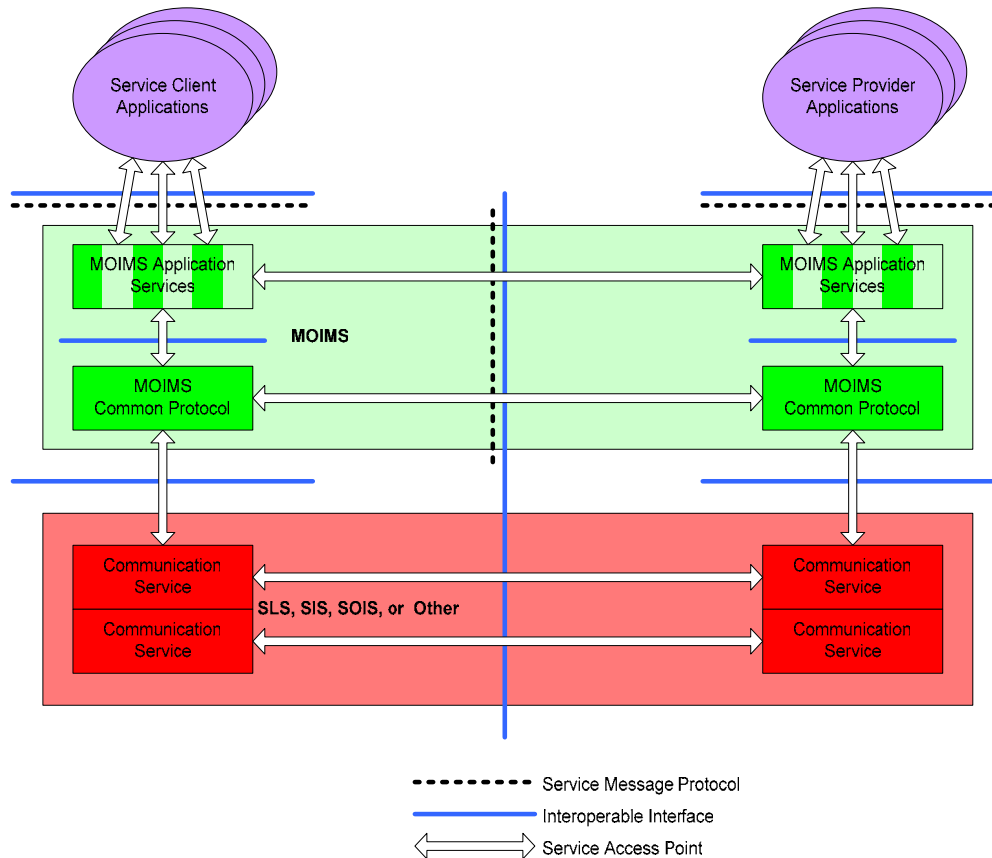


Figure 2-4: MOIMS Service Layering

The advantage of this layered service architecture is that these same services may be deployed over a protocol stack that uses CCSDS Packet TM/TC space link services for space-ground connections (or alternatives such as SCPS-TP/TCP), relevant SOIS protocol stacks for onboard-to-onboard functions, while being used over TCP/IP to control an equivalent ground-based function by only changing the common service adapter. This layering enables functions to be migrated from ground to space without impacting client functions within the ground segment.

Legacy systems can be incorporated through the use of adapter components that present a service façade to clients. The adapter provides the translation required and also supplements

the missing functionality of the legacy system. Proxies can also be used for missions where space-ground contact is intermittent; the proxy hides the intermittent nature of the space-ground link from the client.

Figure 2-5 presents another way of viewing this layering, wherein the high-level Application-layer services are transported through pipes provided by the underlying transport protocol. The common service provides an end-to-end pipe, which itself is transported via the transport protocol, such as that provided by Space Link Services.

For example, Space Link Extension (SLE) services extend the space link services to control centres by providing a pipe through which both SLS and other services terminating at the ground station can be transported.

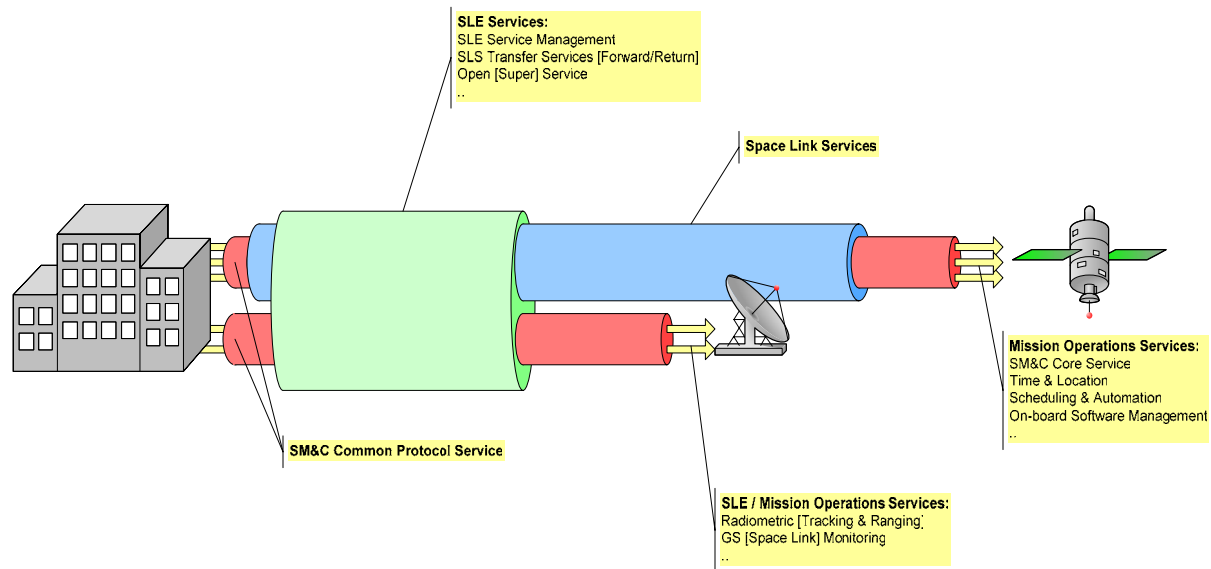


Figure 2-5: Service Tunnelling

2.5 INTEROPERABILITY

One of the main goals of standardisation is to provide avenues for interoperability. Two main types of interoperability will be provided from the standards identified in this Report:

- inter-enterprise interoperability: the use of a standard allows cooperating enterprises to interoperate;
- software interoperability: the use of a standard allows software components to interoperate.

The SM&C services provide interoperability at a number of interfaces, as shown in figure 2-4. These include the service interfaces and the service protocols.

Service interfaces are the platform independent specifications which have to be mapped to platform dependant implementations of Application Programmer Interfaces (APIs).

Service protocols define the messages that flow between service layers at either end of a communications link.

Service interface standardisation supports plug-and-play architectures, re-usable software components, and interoperability via adapters. Service protocol standardisation supports interoperability between enterprises irrespective of their infrastructure implementation.

It should be noted that the underlying transport service is assumed also to provide interoperable protocols and interfaces, but this capability is outside the scope of SM&C standardisation. These are typically implementation and operating-environment specific, but the use of a standard SM&C protocol hides these details from other Application-layer services.

Adoption of the full stack of protocols, the common services, and the core SM&C Application-layer services will ensure interoperability between diverse implementations. Other approaches are possible to provide interoperability of varying degrees at a specific interface point for legacy missions through the use of adapters.

Specialised adapters can enable a ground systems infrastructure compatible with SM&C services to be used to support legacy spacecraft. The following diagrams illustrate two potential implementations. In the first case, the legacy spacecraft supports interoperable Transport-layer protocols but has no equivalent of the SM&C Application-layer services. Mission specific adapter(s) are required to map the SM&C services to the mechanisms used to provide the equivalent of those services in the legacy context; see figure 2-6.

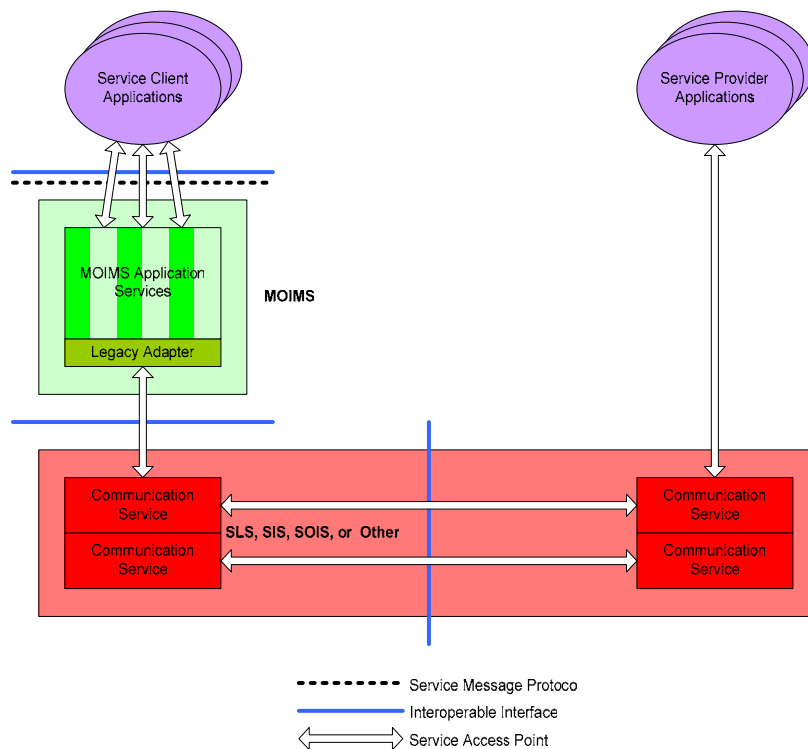


Figure 2-6: Legacy Protocol Adapter

In the case of these legacy applications the use of an adapter can permit the use of new mission operations services on a legacy spacecraft. This may require the development of a number of adapters. Clearly such an approach does not give interoperability among diverse agencies or implementations at the protocol or at the common layer, where these are not supported by the legacy system. However, interoperability can still be achieved if:

- The co-operating agencies are compliant with the service interfaces at the Application-layer service level (i.e., the core SM&C Application-layer services, or other Mission Operations Services).
- The communications layer adheres to a common interoperable standard.
- The owner or manufacturer of the legacy system provides the (set of) legacy adapter(s) required to the co-operating agency. It is noted that such an adapter may be common to an entire series of spacecraft, corresponding to a manufacturer's production line or a historical standard. This is conceptually similar to the provision of device drivers to support peripherals offering a standard Application-layer service.

The second case shows how a 'private' Service Message Protocol can be used where this has already been standardised within an agency or mission. The European Packet Utilisation Standard (PUS) is used as an illustration. Adapters map the SM&C services to the corresponding PUS message protocols that are bound to underlying CCSDS Space Link Services:

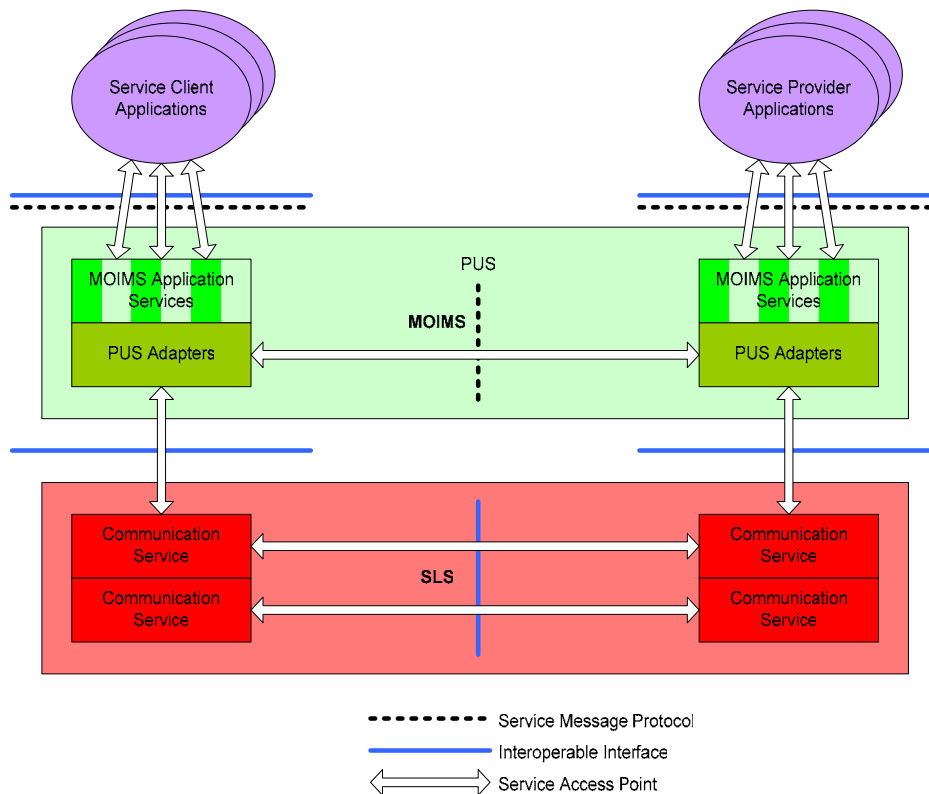


Figure 2-7: PUS Protocol Adapter

In the case of the PUS, the use of an adapter can permit the use of new mission operations services, written to a common set of service interfaces, to be used with a PUS-compliant spacecraft. As shown, the PUS combines the elements of the mission operations interfaces and the SM&C protocol PDUs into one set of packet definitions.

This approach will support PUS-compliant spacecraft but, as before, does not provide interoperability among diverse agencies or implementations at the protocol interface or at the SM&C Common layer. Interoperability at the Application-layer service interface can be achieved in the same way through the use of a protocol adapter.

3 REFERENCE ARCHITECTURE

3.1 INTRODUCTION

The RASDS methodology provides the ability to represent a system using five primary views and a number of secondary combined views. For more information on the RASDS methodology, including detailed descriptions of the purpose of each view, see reference [1].

This section details a model of a representative space system and is used to provide a context for the services outlined in later sections. Each view provides one or more diagrams to illustrate the types of objects involved and also the context that they are used in. These diagrams should not be considered definitive; alternatives should still be supported, as the actual details are expanded in later sections.

3.2 ENTERPRISE VIEW

The enterprise view shows the various high-level entities that are involved in the use of the system.

It is a model of the companies, organisations, spacecraft, and networks contained in the system. The relationships shown are logical ones and the information exchanged includes such things as agreements, plans, contracts, support requests, policies, and ICDs. Requirements and Use Cases also belong to the enterprise view (see figure 3-1).

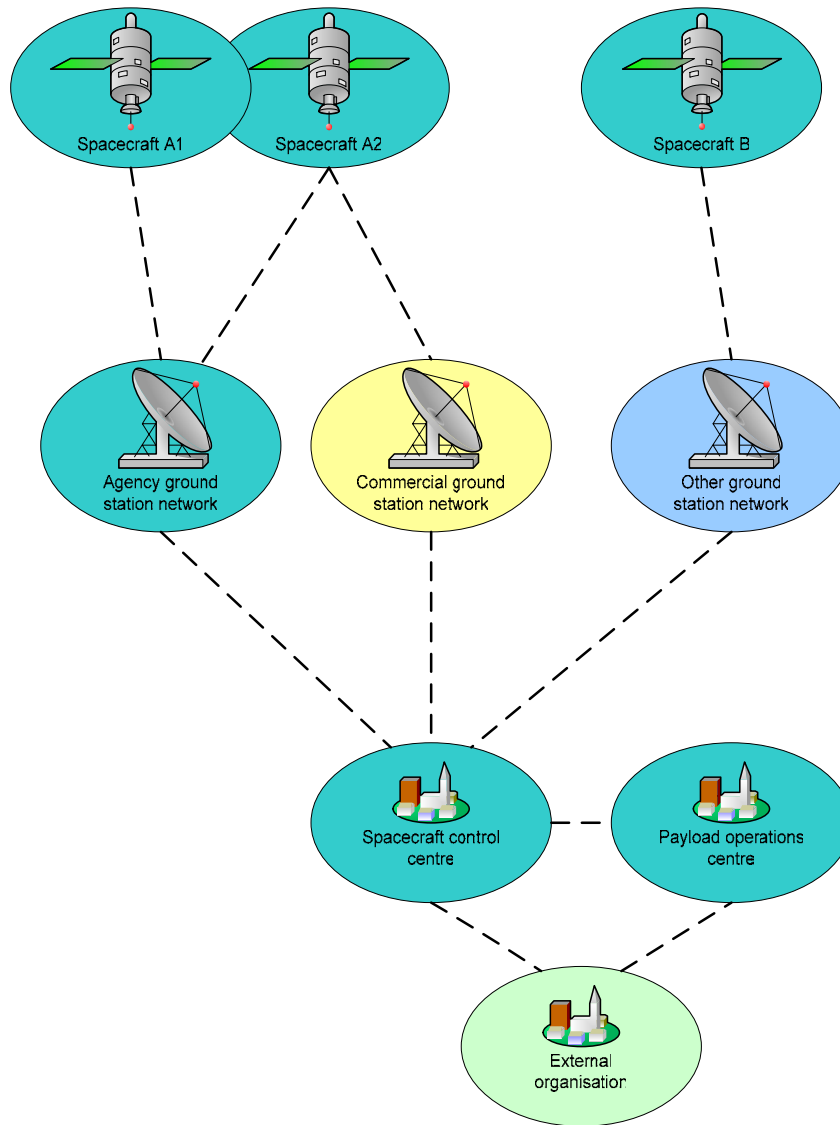


Figure 3-1: Enterprise View

The enterprise view does not attempt to show any particular agency or commercial operation, but is instead intended to be a more generic layout. For this reason the term payload has been used rather than specific terms such as science. It is also possible that the spacecraft and payload operations would be run from the same control centre, even by the same operator, but because they are separate functions they have been split on the diagram to show them as separate enterprises; see table 3-1.

Table 3-1: Enterprise View Entities

Enterprise entity	Description
Spacecraft	The enterprise of the onboard systems.
Ground station network	Enterprise responsible for communications with, and possibly tracking of, the spacecraft. May be one of several.
Spacecraft control centre	Entity that is responsible for operation and control of a spacecraft.
Payload operations centre	Enterprise that is responsible for some component of the spacecraft which is possibly separate from the main control centre.
External organisation	Catchall for all other agencies, manufacturer authorities, data clients, organisations, principle investigators or third-party clients of the system.

The enterprise view also illustrates how the use of standard services and protocols allows the use of different entities in an interoperable way, where different agencies and commercial enterprises are involved in the link between the spacecraft and the control centre.

3.3 CONNECTIVITY VIEW

The connectivity view (see figure 3-2) details the various physical entities of the system and their physical connections (including hardwired and RF) to other entities. The connectivity view can also detail physical attributes of these entities including their location, performance, motion and the characteristics of the links that connect them.

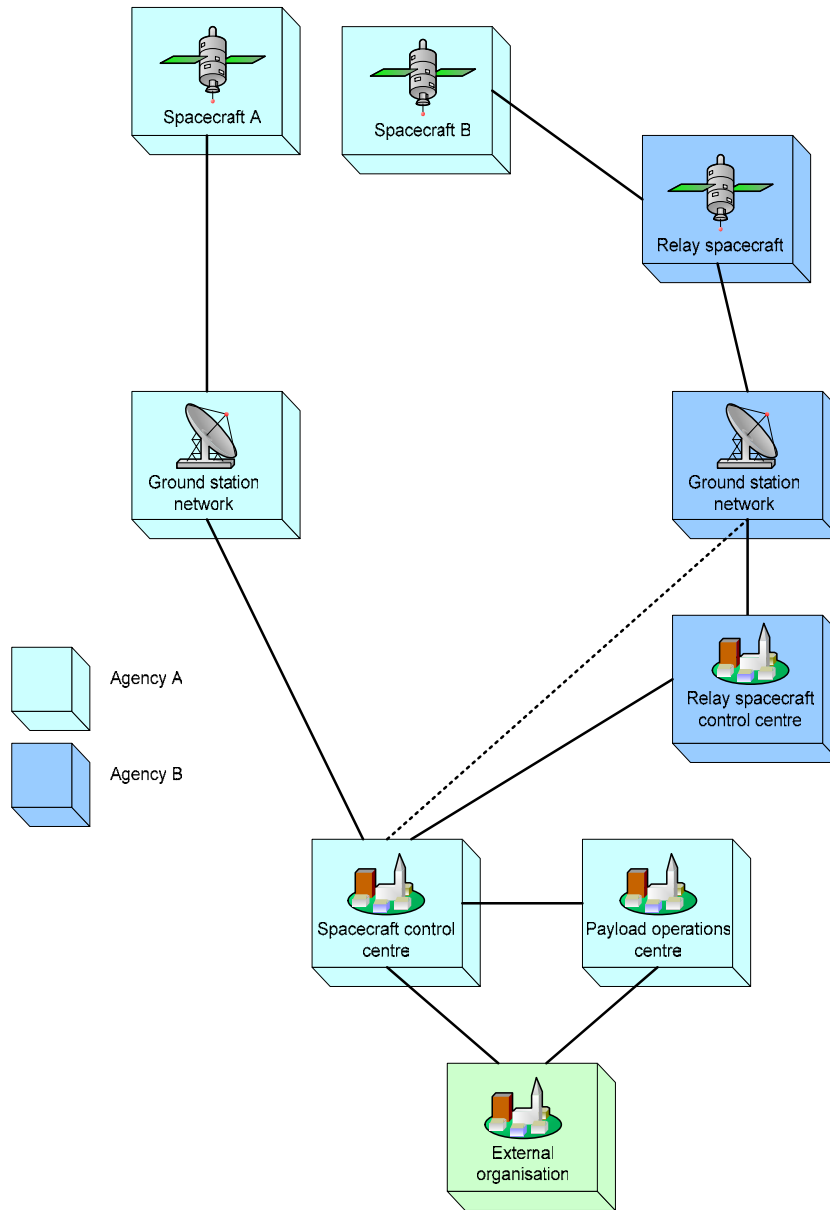


Figure 3-2: Connectivity View

Figure 3-2 shows the physical relationship between installations. It does not show any particular spacecraft setup or agency distribution but attempts to illustrate a more generic view.

Table 3-2: Connectivity View Nodes

Connectivity node	Description
Spacecraft	The physical onboard systems.
Relay spacecraft	The physical onboard systems of a spacecraft used to relay to the desired spacecraft. In the figure it is part of a different agency.
Ground station network	Physical network responsible for communications with, and possibly tracking of, the spacecraft. May be one of several.
Spacecraft control centre	Primary installation that is responsible for operation and control of a spacecraft.
Relay spacecraft control centre	Installation that is responsible for operation and control of the relay spacecraft. In the figure it is part of a different agency.
Payload operations centre	Possibly separate installation that is responsible for some component of the spacecraft.
External organisation	Catch all for all other agencies, manufacturer authorities, data clients, organisations, principle investigators or third-party clients of the system.

Figure 3-2 makes the point of demonstrating that more than one company/agency may be involved in the SM&C loop, when using a relay craft for example. In the figure a dotted line illustrates that the primary spacecraft control centre may also have a direct connection to the relay spacecraft ground station network. Note that this connection is neither enforced nor required; it is purely an example.

3.4 FUNCTIONAL VIEW

The functional view (see figure 3-3) details functional entities rather than the physical entities shown in the Connectivity view. It shows the functional objects and the logical connections/relationships between them. The attributes of these Functional entities include what they do, their interfaces, the information that is exchanged amongst them, their support requirements, and possibly constraints on their use or operation. The functional view does not specify where these functions execute, but a mapping of the functions onto physical entities, using the Connectivity view, can provide that view of actual deployment.

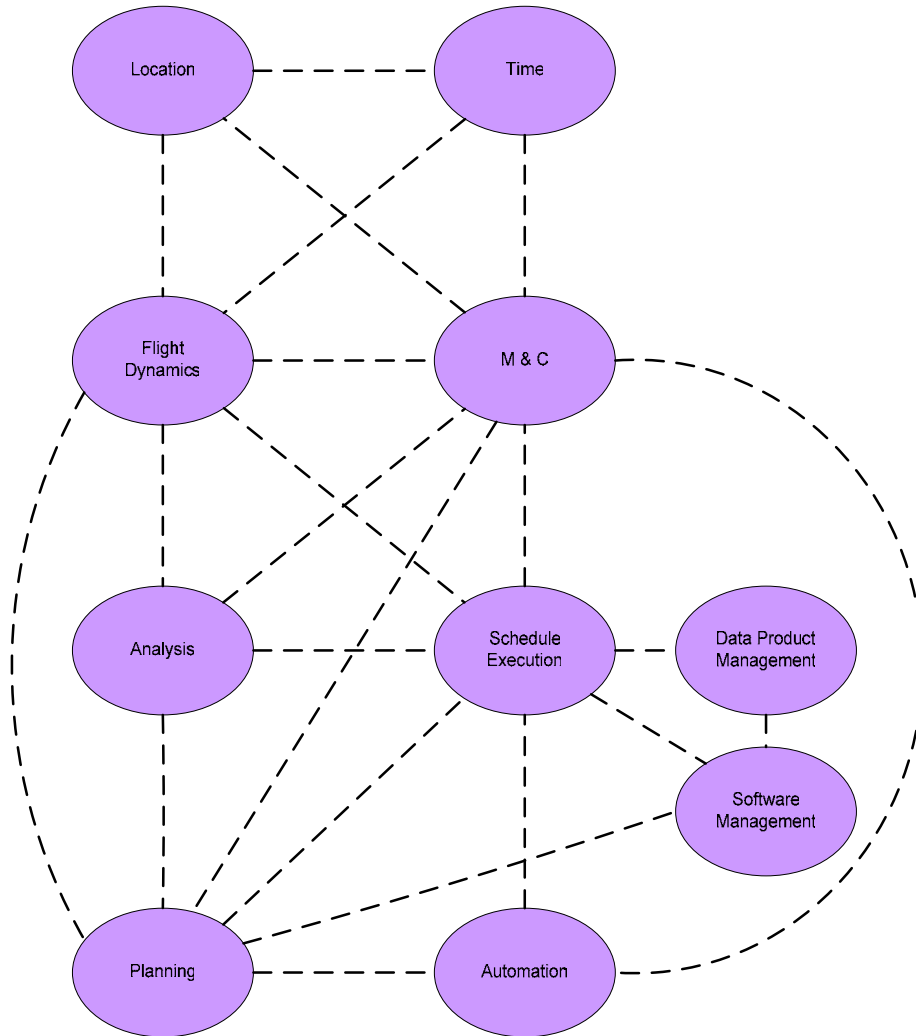


Figure 3-3: Functional View

This view shows the separate areas of functionality that are involved in the operation of a spacecraft. The connections shown between functions are logical ones; they use underlying communication protocols running over actual physical links to transfer data. The character of the data items that are exchanged over these logical links is an aspect detailed in the information views.

Table 3-3: Functional View Areas

Functional area	Description
M&C	Core Monitor and Control functions.
Automation	Concerned with control and management of the automation task.
Schedule Execution	Component responsible for executing the schedule generated by the planning component.
Planning	Component responsible for the planning of future events in the system, schedule generation, and validation.
Software Management	Software version control, patching and release.
Flight Dynamics	Orbit vector determination, event schedule production, etc.
Time	Responsibilities cover time correlation and time management.
Location	Responsibilities include ranging, tracking, and position determination.
Analysis	Trending and analysis.
Data Product Management	Control, management, and transfer of the data products produced by the other components.

Figure 3-3 attempts to show the different areas of functionality in a generic setup; one or more components may not be present in any particular system. For example, onboard planning, schedule execution, and onboard automation are unlikely to be present in a simple near-Earth communication satellite, as most operations will either be manual or performed by ground-based automation; see figure 3-4.

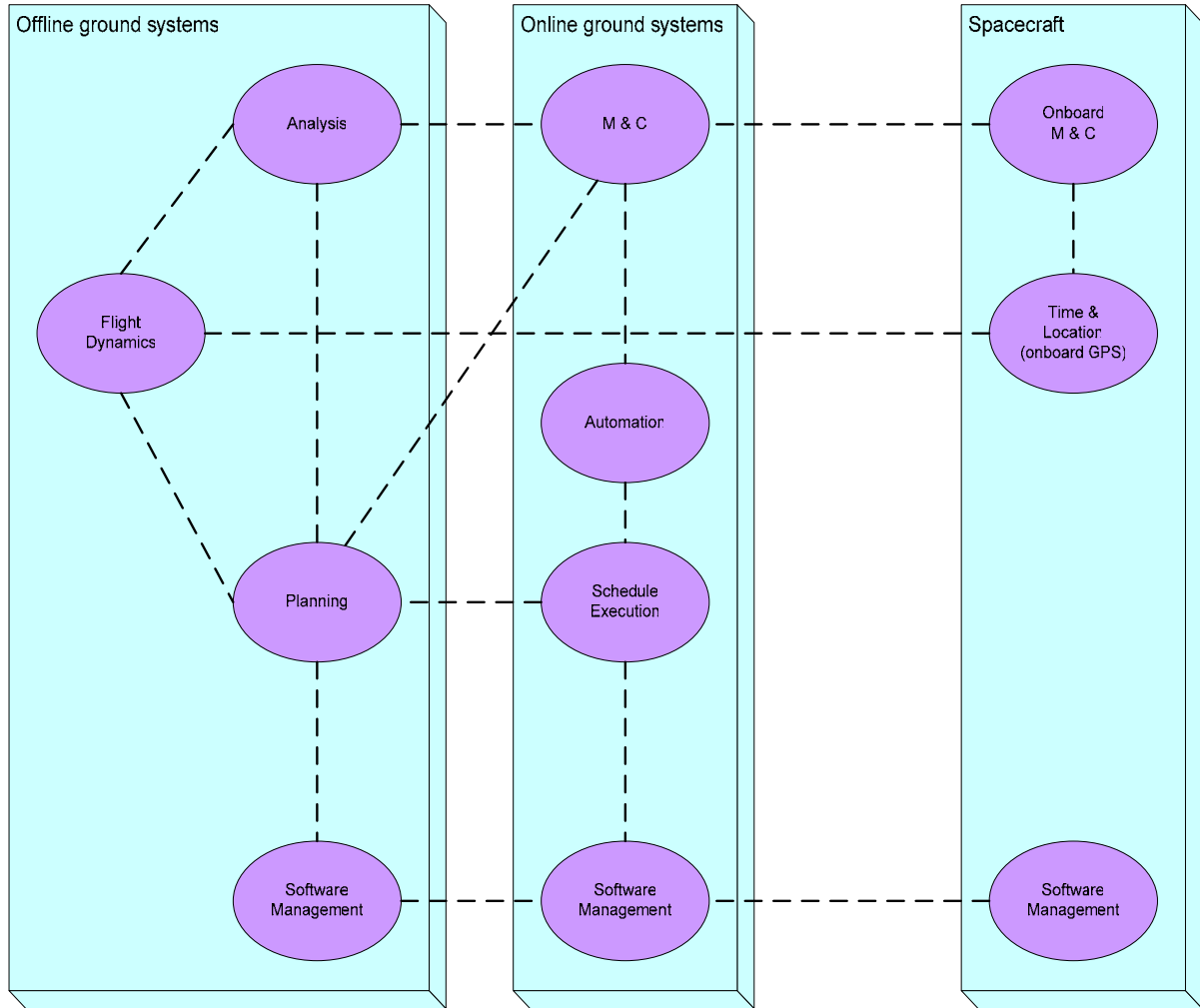


Figure 3-4: Simple Satellite Functional Example

However, for a deep-space craft these onboard automation functions may be present, and the ground-based systems would only acquire status data from these autonomous systems in order to monitor and guide their operation; see figure 3-5. These guidance systems would use high-level goals (e.g., ‘take an observation of Quasar 3C273’, or ‘drive to that rocky outcropping’) rather than low-level commands (e.g., ‘turn on power’, ‘open shutter’, ‘take 1 min exposure’, ‘close shutter’, ‘dump data’, etc.) to direct onboard activities.

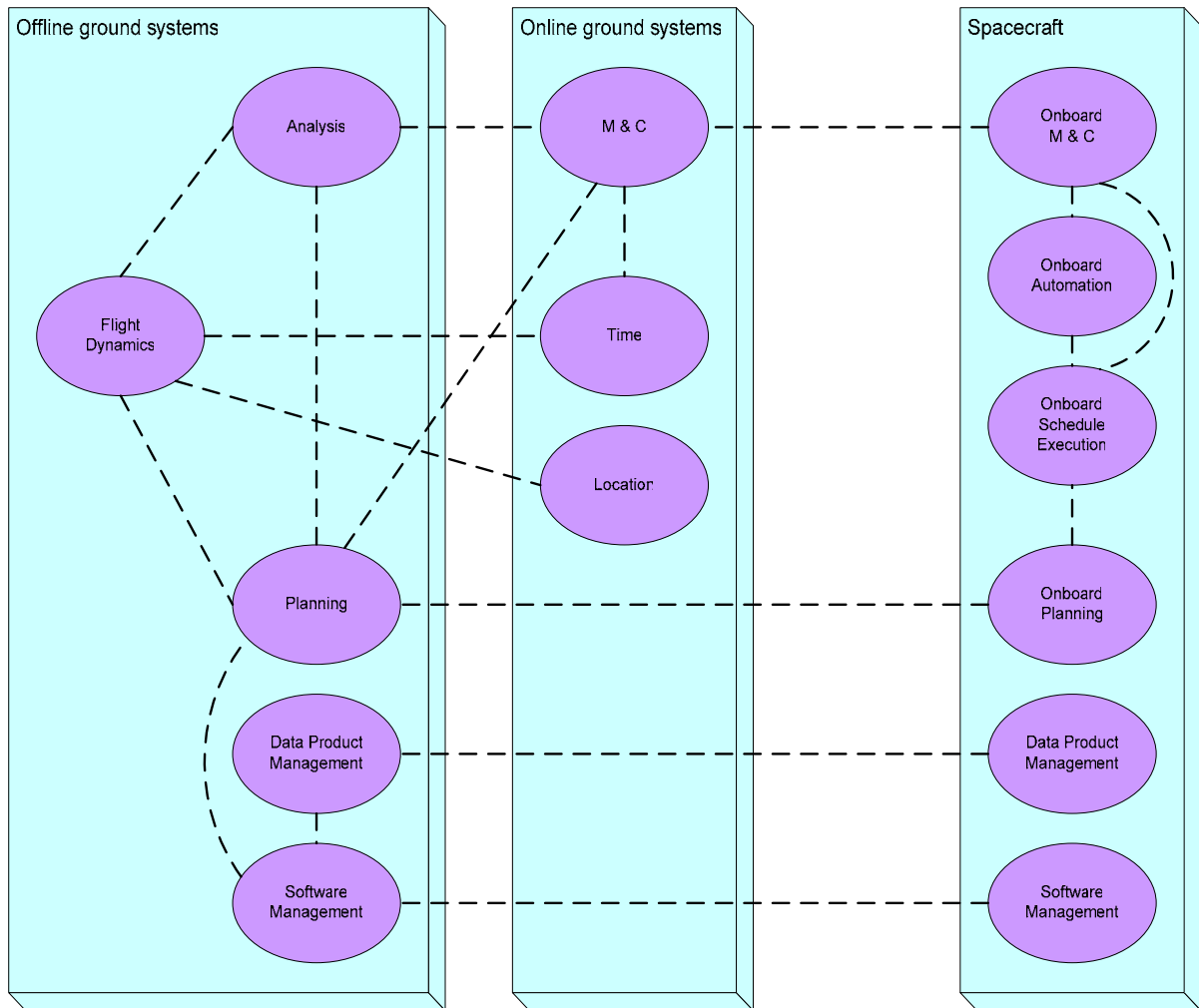


Figure 3-5: Advanced Spacecraft Functional Example

Communication between ground functions and those onboard the spacecraft is likely done via low-level communication services. The services are responsible for delivering data items (commands, goals, files, etc.) to the onboard system and responses to the ground system.

3.5 INFORMATION VIEW

The information view identifies the information objects that are exchanged between functional objects. It also shows the relationship between information objects and the functional objects which manipulate and exchange them.

To illustrate this view a number of scenarios have been selected, and the functional objects are shown with the information objects required for the scenarios. In the diagrams which illustrate these scenarios the functional objects are represented by coloured/shaded objects and the information objects are represented by non-coloured/unshaded objects.

The arrows in the diagram indicate the principle direction of the data flow for an information object; in many cases there will be a data flow in both directions. For example, when Automation requests M&C to execute an action, the principle direction is from Schedule Execution to Automation; there will, however, be a data flow in the opposite direction when M&C reports the status of the action.

The diagram below shows the functional objects and information objects for the scenario in which the Flight Dynamics issues a Planning Request, such as a request for a manoeuvre.

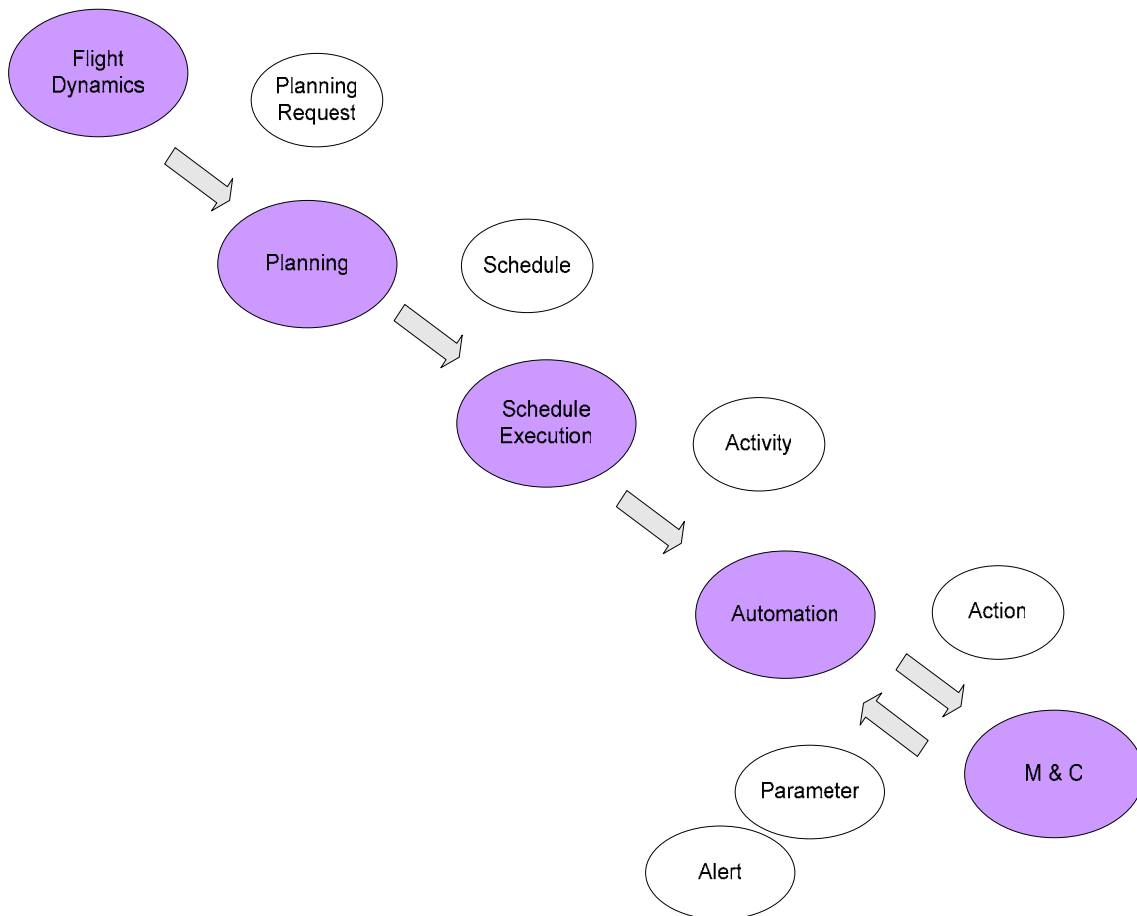


Figure 3-6: Information Objects in Flight Dynamics Planning Request

Table 3-4: Information Objects in Flight Dynamics Planning Request

Information Object	Description
Planning Request	<p>A request to the Planning system for the inclusion of an item in the plan.</p> <p>In this scenario the request is from Flight Dynamics for the execution of a Flight Dynamics operation such as a manoeuvre.</p>
Schedule	<p>Consists of a timeline of activities and actions for execution either locally within the ground control system or within the remote system.</p> <p>In this scenario the schedule includes the activities required to execute the Flight Dynamics operation.</p>
Activity	<p>An extended operation performed autonomously. <i>Activities</i> can correspond to automated operations procedures and software functions that execute within the remote system or within the ground control system.</p> <p>In this scenario the activities are those required to execute the Flight Dynamics operation.</p>
Action	<p>An atomic control directive to the ground control system or the remote control system.</p> <p>In this scenario a number of <i>Actions</i> will be executed to perform the <i>Activities</i> required for the Flight Dynamics operation. An <i>Action</i> is atomic, whereas an <i>Activity</i> is not.</p>
Parameter	<p>A predefined element that contains status information.</p> <p>In this scenario it will be necessary to monitor a number of <i>Parameters</i> to perform the <i>Activities</i> required for the Flight Dynamics operation.</p>
Alert	<p>A timestamped notification of an unexpected or non-nominal condition.</p> <p>In this scenario it may be necessary to respond a number of Alerts during the execution of <i>Activities</i> required for the Flight Dynamics operation.</p>

Figure 3-7 shows the functional objects and information objects for the scenario in which a software image update is performed; note that the software management update would most probably be triggered initially by a human operator.

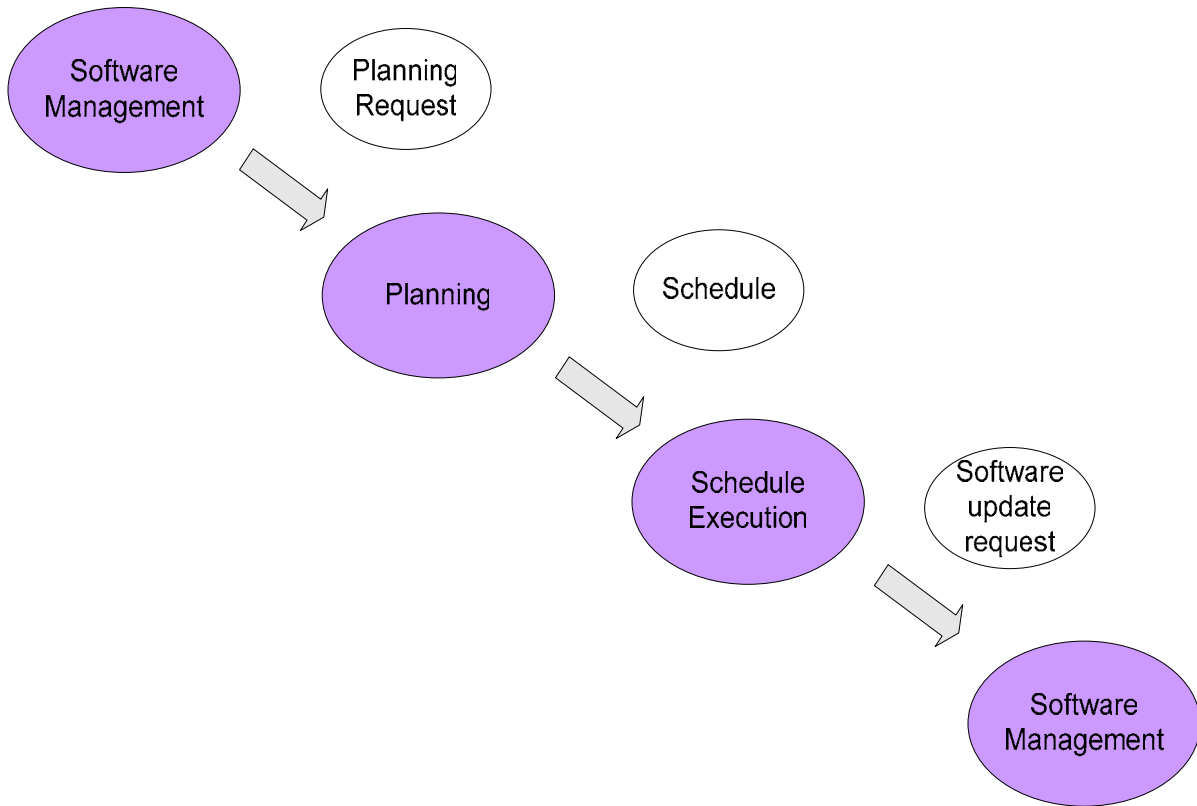


Figure 3-7: Information Objects in Software Image Update

Table 3-5: Information Objects in Software Image Update

Information Object	Description
Planning Request	A request is issued by Software Management for the update of a software image.
Schedule	The schedule includes the request to upload the software image.
Software update request	Object representing the request to start the update of a software image.

Figure 3-8 shows the functional objects and information objects for the scenario in which Flight Dynamics provides Planning with Orbit Vectors.

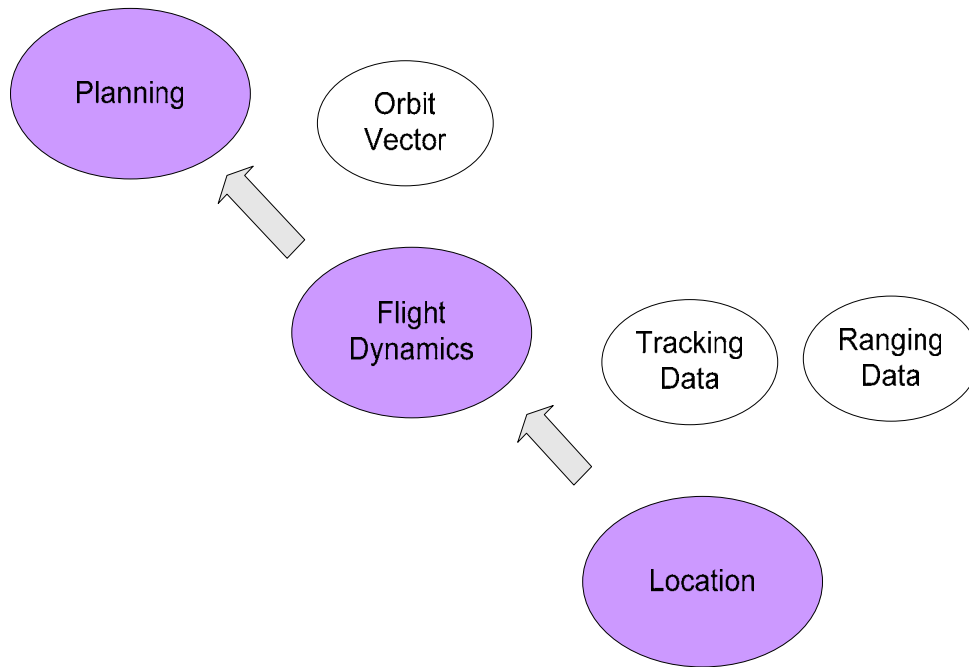


Figure 3-8: Information Objects in Orbit Vector Provision

Table 3-6: Information Objects in Orbit Vector Provision

Information Object	Description
Orbit Vector	Predicted spacecraft trajectory.
Tracking Data	Ground Station tracking data.
Ranging Data	Ground Station ranging and Doppler data.

3.6 COMMUNICATIONS VIEW

The communications view defines the layered set of protocols that support communication amongst the functional elements. Communication objects are protocol entities. While Functional objects are used to transform data, the actions of Communication objects are to transport data, and any transformation (such as packet fragmentation and re-assembly) is incidental to the intended function of moving data from point A to point B.

In the communications view, the system is modelled using communication objects, which are often shown mapped onto nodes, and may be shown with associated functional objects.

It is envisaged that a standard low-level service is requested to transfer the data objects used by the high-level services to the destination, whether that is space or ground based. This SM&C Common Protocol service hides the underlying communications protocols from the higher-level services. Data objects that are likely to be required to be transported are:

- Directive;
- Event.

Supported operations of the SM&C Common Protocol service on the data objects would be:

- Send Directive or Event.

The diagram below shows an example of the communication objects being used in a layered way. The high-level service consumer application communicates through the high-level services to the high-level service provider on the spacecraft. The high-level mission operations service uses the SM&C Common Protocol service (and potentially others) to communicate with its peer and uses appropriate Network layers to provide this link. Different common service implementations or adapters would most likely be required for space-ground and ground-ground interfaces if different underlying communications protocols were used.

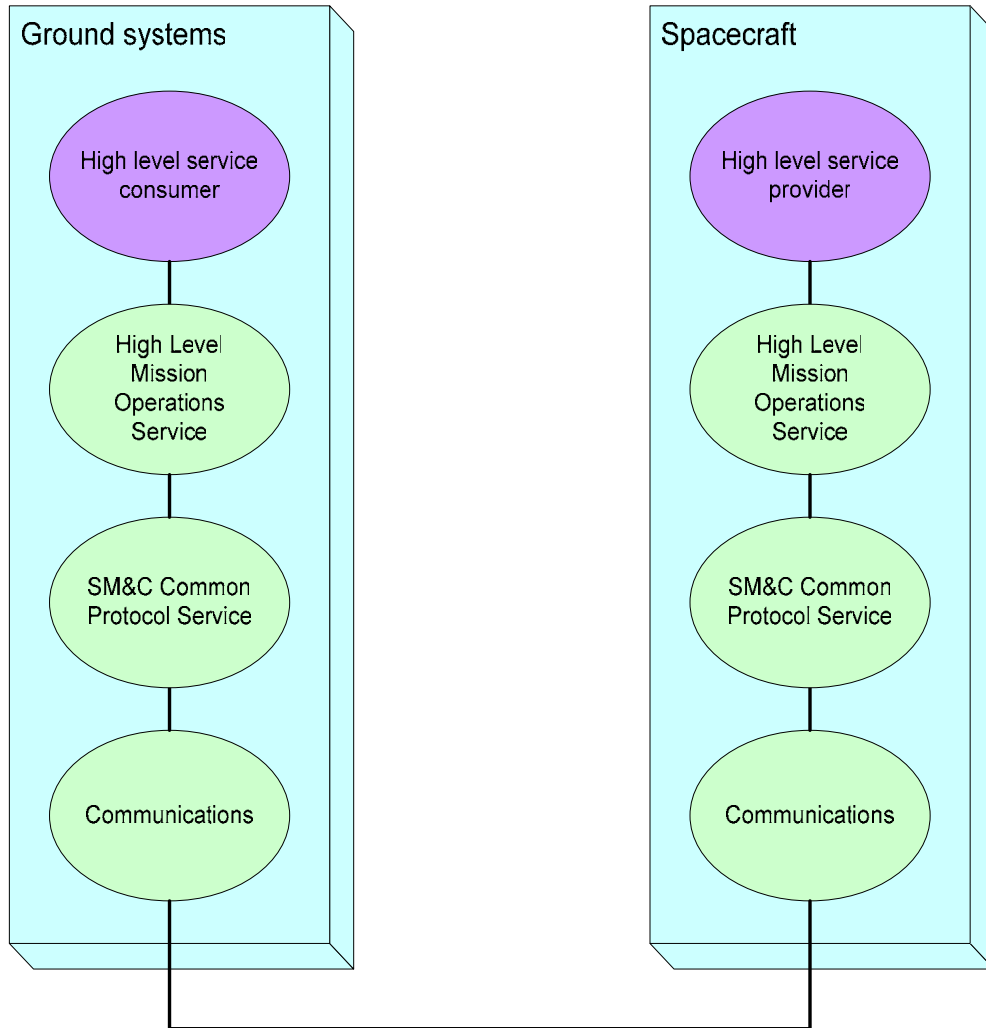


Figure 3-9: High-Level Service Concept Communications View

The definition of a standard interface and protocol allows the details of low-level communication protocol to be hidden from the higher-level applications and services. Figure 3-10 demonstrates this layer of communication adapter in place.

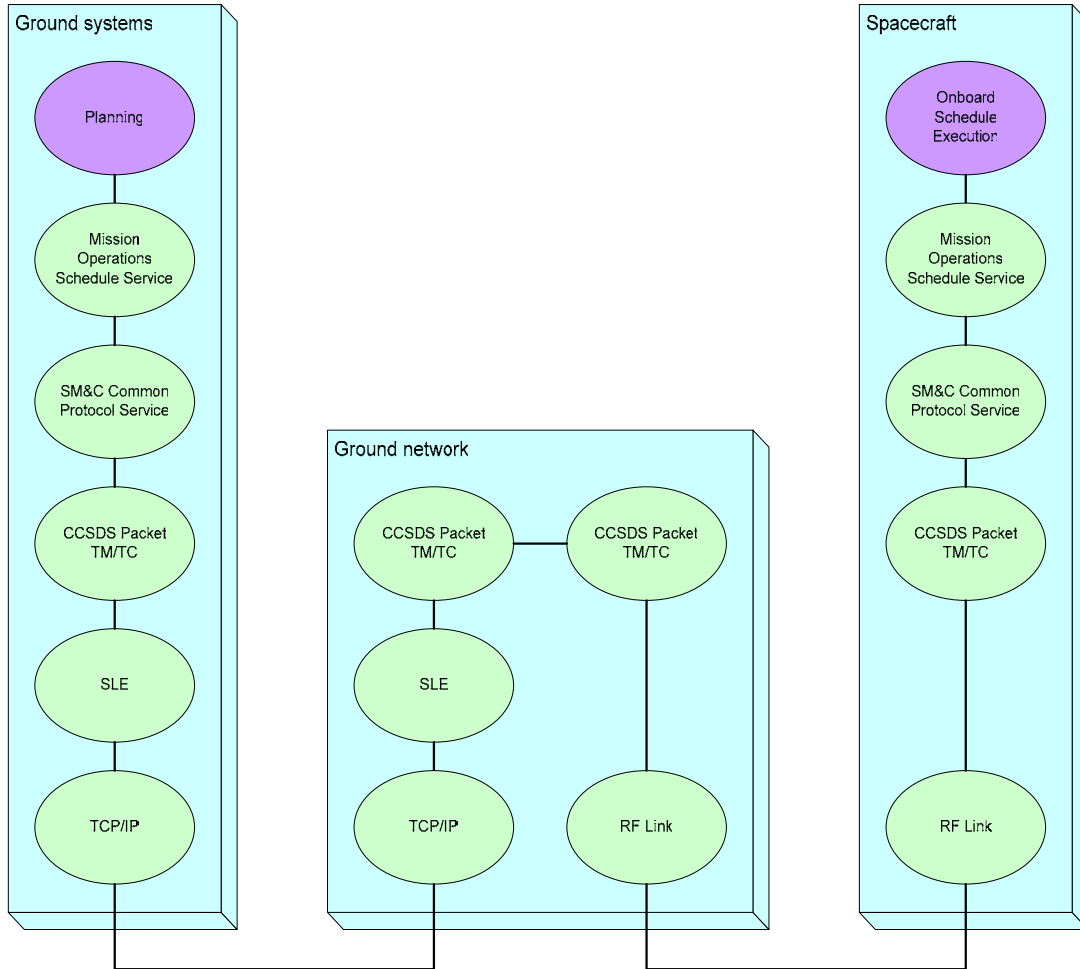


Figure 3-10: Onboard Schedule Execution Service Communications View

On the ground system node the Schedule Service communication object provides an interface which allows the Planning functional object to communicate with the Schedule Execution functional object. This interface is independent of the lower-level communication protocols required to provide the interface. The Schedule Service uses the SM&C Common Protocol service communication object to provide the communication link.

On the spacecraft the (Onboard) Schedule Execution functional object interfaces with other functional objects via relevant communication objects. Again the interface provided by the communication objects are independent of the lower-level communication protocols required to provide the interface.

Figure 3-11 shows the communication objects required for the Planning functional object to communicate with the Schedule Execution functional object, where both these functional objects are located in the ground system. The use of a standard service allows the previous functional objects to be reused, yet allows the underlying communication objects to be replaced with ones more appropriate for the ground-to-ground communication.

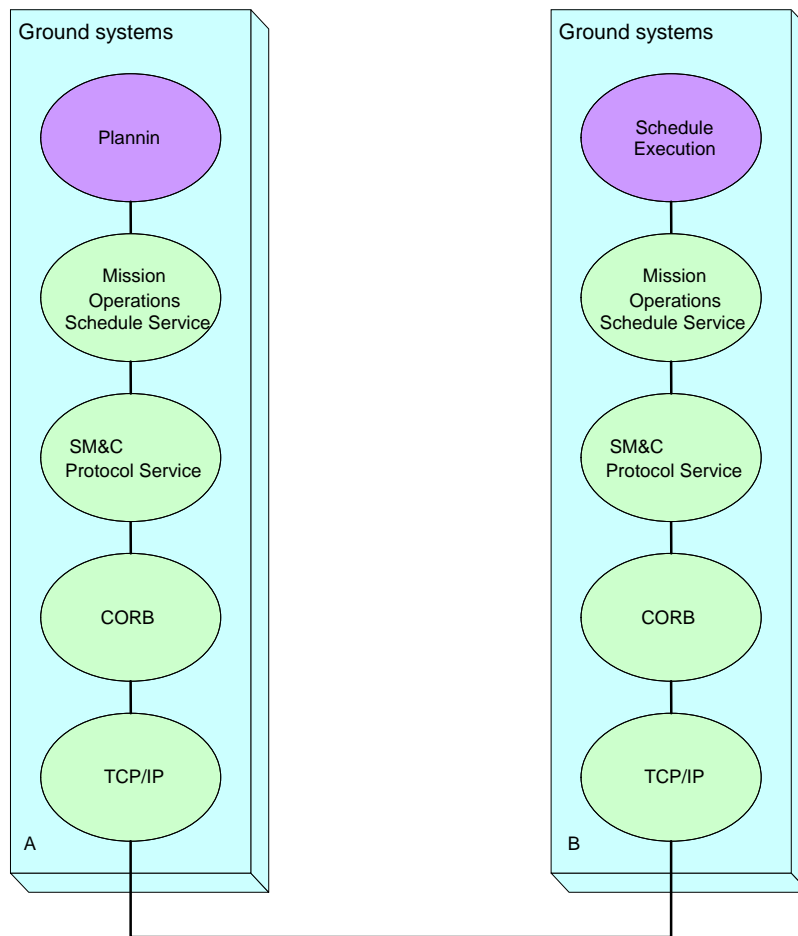


Figure 3-11: Ground-Based Schedule Execution Communications View

On the ground system node ‘A’, the Planning functional object uses the Schedule Service communication object to communicate with the Schedule Execution functional object on the ground system node ‘B’. The Schedule Service provides an identical interface to the Schedule Service in the onboard view shown in figure 3-10. The Schedule Service then communicates via the SM&C Common Protocol service, which in this view uses a different underlying implementation that provides the communication via appropriate ground middleware. In this example, CORBA is used to illustrate a middleware communications layer that is appropriate for ground-to-ground communications; others are equally appropriate, such as XML, SOAP, UNIX RPC, or even a proprietary protocol. Of course, all applications in a given deployment will have to use the same underlying infrastructure, or build adapters among diverse ones, if interoperability is to be achieved.

On the ground system node ‘B’ the Schedule Execution functional object interfaces with other functional objects via the Schedule Service communication object. Again the interface provided by the Schedule Service is independent of the lower-level communication protocols required to provide the interface.

The two communications views presented above illustrate the major benefits provided by the layered communications architecture. In both cases presented, the Planning functional object uses the standard interface provided by the Schedule Service to communicate with the Schedule Execution functional object. This approach means that the location and implementation of the Schedule Execution function object is transparent to the Planning functional object.

This layered architecture approach provides interoperability between the elements in the system and also allows selection of the underlying communications objects that are relevant to the environment infrastructure. It is possible to extend the concept further, where a communication protocol such as SCPS-TP/TCP is used both on the ground and onboard, in this case it would be possible to migrate both the applications and the adapters.

4 OPERATIONAL CONCEPT

4.1 INTRODUCTION

This section contains the definition of the operational concept for SM&C services. This definition draws upon the approach used in the ECSS PUS standard to describe a set of topics within an overall operational concept for monitoring and control. It is presented as a hierarchy of operational topics, with closely related operational aspects being grouped.

Following this introduction, the section is structured as follows:

- subsection 4.2 contains an overview of generic concepts applicable to all or multiple operations topics;
- subsection 4.3 provides a summary of the Spacecraft M&C Common Protocol, introduced in section 2, above, that is common to all subsequent operational topics;
- subsection 4.4 describes the operations concept for core Spacecraft Monitoring and Control operational topic;
- subsections 4.5-4.11 describe the operations concepts for other Mission Operations topics, as listed below.

A key driver for the identification of the operational topic, and subsequently for the identification of associated services, is where the corresponding interactions between functions supporting the operational topic may be distributed across agencies, missions, physical entities/sites, or (software) systems. Standardisation of such service interfaces will therefore be a key enabler for interoperability at two levels:

- interoperable infrastructures;
- interoperable components capable of rapid and cost-effective configuration into mission specific infrastructures: ‘plug-and-play’ architectures.

Within each operational topic, individual operations are categorised as constituting Routine, Configuration, and History functions:

- routine operations are those that are used to initiate functions and receive active information;
- configuration operations are those associated with setup of routine operations, and may include access to, or update of, a common information model between a function and its clients;
- historical operations are those associated with persistence of routine operations and the retrieval of historical data or logs.

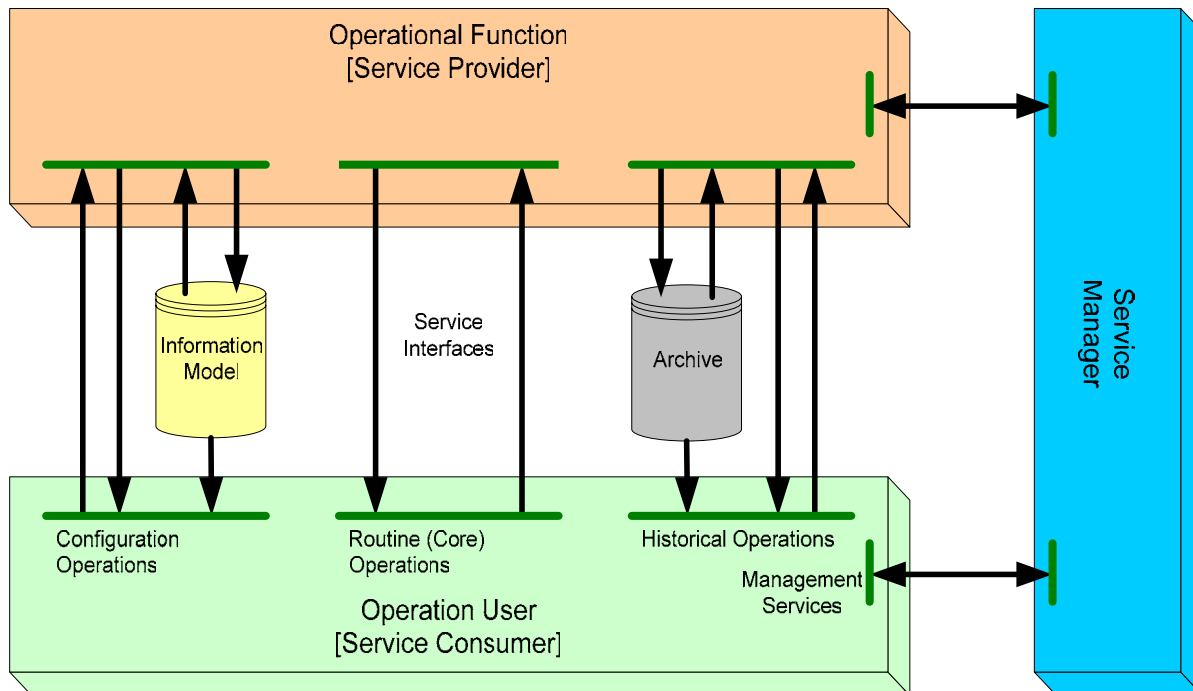


Figure 4-1: Routine, Configuration, and Historical Operations

The following operational topics are identified:

- Core Monitoring & Control:
 - Status Monitoring,
 - Action Invocation,
 - Alert Notification,
 - Historical Data Operations;
- Operations Automation;
- Operations Scheduling;
- Operations Planning;
- Guidance, Tracking and Synchronisation:
 - Time and Location Reporting,
 - Flight Dynamics;
- Remote Software Management;
- Payload Data Product Management;
- Operator Interaction.

Correlation with ECSS PUS services is provided in footnotes for information purposes only. It is the intention that the resultant M&C service definitions will be at a more abstract and transport protocol-independent level than PUS.

4.2 GENERIC CONCEPTS

4.2.1 M&C SESSIONS

For a given M&C operational function it may be possible to observe both current (live) data and also (initiated via a historical data replay service) data replayed from stored history. In a given system it may be possible to observe both live and historical data in parallel. It may also be possible to observe data originating from a simulator or test configuration in parallel with that originating from the live operational system.

The entities being controlled in the live, simulated, or test cases (and monitored in both these and historical replay cases) are the same. In order to distinguish these parallel operational scenarios, it is necessary to partition M&C data by operational *session*. While partitioning can be achieved physically, in a distributed network environment it is preferable that operational services be defined in such a way that *session* is explicit, to avoid any possibility of confusion, and to enable data to be combined in a single system.

Table 4-1: Summary of Potential Session Timeframes and Rates

Data Source	Timeframe and Rate	
	Live	Replay
Operational	Present Real-time Rate	Past Variable Rate
Test Configuration	Present Real-Time Rate	Past Variable Rate
Simulation	Past Present Future Variable Rate	Past Present Future Variable Rate

It should be noted that in some circumstances the real-time rate might itself be variable.

In the context of this document, the term *session* is used to refer to a coherent data source, relating to:

- a) the Operational System subject to M&C;
- b) the Controlled System in Test Configuration;
- c) a Simulation of the Controlled System;
- d) dynamic Replay of Historical Data from the Controlled System.

It is noted that multiple *sessions* may exist in parallel (particularly for cases c and d).

4.2.2 M&C DOMAINS

M&C does not always simply relate to the control of a single spacecraft. Many existing space agencies and missions require the control of multiple remote assets (spacecraft fleets and constellations, ground stations, etc.).

In order to ensure that unique referencing of operational entities and data items is possible, the concept of a hierarchy of system components or operational *domains* is required. This concept is used to scope the frame of reference of monitoring and control (e.g., agency>mission>satellite>subsystem). It provides a framework for the control of *namespaces for operational data*, such as telemetry monitoring parameters and telecommands.

Hence commands are represented with a full referential context. Command C1234, 'Heater C On', becomes:

AgencyY.MissionA.SatB.C1234 *or even* AgencyY.MissionA.SatB.HeaterC.ON

which cannot inadvertently be sent to AgencyY.MissionX.SatY and executed.

Within a specific detailed operation, the *domain* may be contextually implicit to allow generic (multi-domain) operations to be defined and to ensure that the specification of operations is not unduly verbose.

4.2.3 SECURITY AND ACCESS CONTROL

To ensure that only authorised operational clients have access to M&C functions, it is critical that some form of client authentication be an integral part of M&C service definitions. To avoid the need for a client to support multiple authentication methods, it is highly desirable that all M&C services use the same mechanism and that client authentication is required only once per client 'login', even if multiple services are used.

It is expected that the concept of roles and associated privileges would also be required where the operations of the services would require a certain privilege or role to be held by the operator. In multi-user environments there is often the support for privilege transfer, and this should also be taken into consideration. This information would be a configuration controlled aspect of the system.

Where services are supported over open or public communications paths, a level of security is required to avoid unauthorised access or intrusion. Services must be defined in such a way as to allow them to make use of secure communications channels. These security services are expected to adhere to the recommendations made by the SEA Security Working Group.

4.2.4 OPERATIONAL RESPONSIBILITY

The concept of operational responsibility supports the notion of nominated user (or operator) roles with responsibility to deal with asynchronous M&C decision points, alarms, or failure conditions.

Where an automated system function must asynchronously alert the responsible 'user' to an issue that requires resolution, there is a need for a responsibility model that allows these interactions to be directed to the appropriate user. The mechanism would not define the set of responsibilities associated with user roles (that is a mission specific configuration issue), but would make it possible to assign a responsibility to an asynchronous service message and have it routed appropriately.

There is also a need for the routing of these messages to have an appropriate fallback mechanism, where an alternative route, operator, or action is taken if the required 'user' is not present in the system at that time.

It may be that this mechanism is entirely encapsulated within the proposed Operator Interaction service, although it could also be supported within Alert Notification. Responsibility is also likely to be coupled to the M&C *domain* hierarchy.

4.2.5 QUALITY OF SERVICE

Quality of Service relates to the provision of different levels of service or performance guarantee that an operational function or service may offer. Issues that fall within this topic include:

- prioritisation—methods by which support for service clients can be prioritised in order to guarantee control actions (e.g., commanding) for critical applications, or a minimum delay for monitoring data provision;
- bandwidth management;
- delivery guarantee;
- error management—retransmission, etc.

A given service provider need not offer all QOS levels, or may provide a restricted set over restricted bandwidth communications paths. Means must be provided to determine available QOS levels and to negotiate for required levels of service during connection establishment.

4.3 COMMON SM&C PROTOCOL

The high-level mission operations services are used by a service consumer to monitor and control a service provider in an interactive or non-interactive fashion, depending upon the mission operations environment. The services may also include management and control of information (e.g., schedules) stored at the service provider.

The mission operations services defined in this document (e.g., automation, scheduling, etc.) are expected to be provided over the SM&C Common Protocol service. For example, a schedule may be represented in a report format, the capabilities of the SM&C Common Protocol can be utilised for the transport of schedules, and the control directives of the service can be provided using the control directives of the SM&C Common Protocol.

Monitor & Control (M&C) functions are typically performed by a string (or a network) of elements. These elements are not necessarily physically separated.

A typical example shown in figure 4-2.

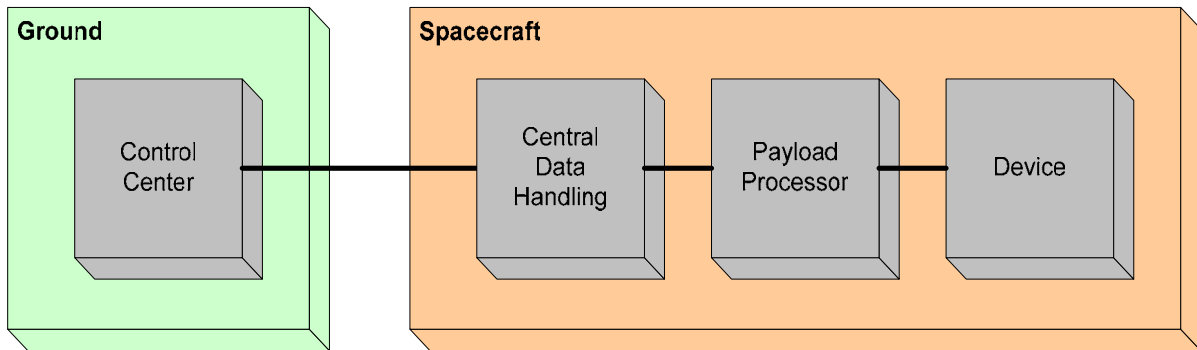


Figure 4-2: SM&C Common Protocol Context

In the string, each pair of adjacent elements can be considered as a pair of controller and target elements:

- Controller—the element that controls and monitors the target, also known as a service consumer;
- Target—the element that is controlled and monitored by the controller, also known as a service provider.

A controller can be a ground control system, an onboard data handling subsystem, or a processor of a payload/subsystem. A target can be a device, a subsystem, or even an entire spacecraft. This target/controller pattern can be applied recursively.

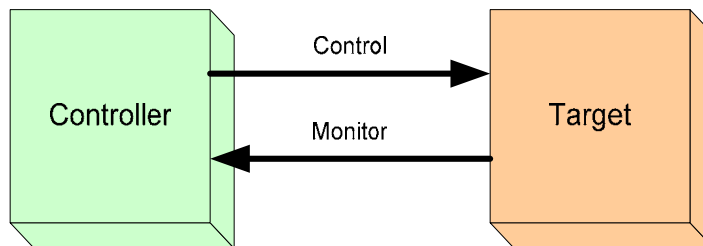


Figure 4-3: Controller and Target Pattern

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

There is a standard set of operations that the SM&C Common Protocol provides and that may be used to transfer directives from any controller to any target and similarly to transfer reports from any target to any controller. This standard pattern of interaction may be used to implement any of the following standard operations:

- Trigger Execution of Target;
- Send Directive to Target:
 - Confirmed or Unconfirmed,
 - Immediate, triggered, or timed;
- Read State of Target:
 - Confirmed or Unconfirmed;
- Send Indication to Controller:
 - Confirmed or Unconfirmed;
- Send Event to Controller:
 - Confirmed or Unconfirmed.

The following lists the operations that the SM&C Common Protocol service provides; this list is not exhaustive and will be defined in detail in the relevant standard.

The *controller* (or service consumer) can send the following messages to the *target* (or service provider):

- Directives to trigger execution of the target;
- Directives to control an operation of the target:
 - Start/Stop/Suspend/Resume an operation;
- Directives to read the value of an attribute or a set of attributes of the service provider;
- Directives to change the value of an attribute.

The *target* (or service provider) can send the following messages to the *controller* (or service consumer):

- Reports containing the value of an attribute or a set of attributes, issued in response to a read directive from the consumer;
- Reports containing the value of an attribute or a set of attributes, issued according to a predetermined interval (the interval is contained in an attribute);
- Reports containing the value of an attribute or a set of attributes, issued in response to a change of an attribute (the trigger condition is contained in an attribute);

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

- Reports about asynchronous events in the target;
- Reports about the execution status of an operation:
Operation started/stopped/suspended/resumed in response to a directive, or error detected for some reason.

The SM&C Common Protocol also provides support for bulk data transfers such as files or complex reports which cannot be represented using the simpler report mechanism.

It should be noted that the SM&C Common Protocol service should not, and does not, make any assumptions about the implementation of the controller and target. Specifically, any assumptions about data structures being used by the high-level services are not made.

The SM&C Common Protocol effectively provides a pipe, through which each of the higher-level services supporting the operational topics described in the subsections below can be tunnelled. This effective pipe isolates the high-level services from the underlying transport protocols used to exchange data between controller and target. The SM&C Common Protocol must be generic enough to support all the high-level concepts and operations of the SM&C high-level Application-layer services. The outline for the service is shown in A6 and the mapping from the high-level services is given in A5.1.

There should be a standard method for describing the characteristics of targets (which may be spacecraft, subsystems, processors, operational concepts, or devices) as objects, abstracting those characteristics that are relevant to monitor and control. In order to develop such a method, there should be a model for characterising the behaviour of targets (including interactions of the objects with controllers). Objects described with the standard method will be able to be used by any piece of software that can monitor and control the targets, but they shall be managed independently of the software that uses them. Controllers should also be described as objects using the same method for describing targets, if they are controlled by other controllers higher in the control architecture.

These standard interface descriptions may be thought of as a Management Information Base (MIB). The MIB may be constructed and managed externally to any of the services that control the targets. It may also be populated, in part or completely, by information that is embedded in the components themselves.

In order to preserve the layering of high-level Application-layer services running over a SM&C Common Protocol service, it is important that this MIB, or Information Model, be similarly layered. Each high-level service will have an associated information model that describes the set of associated objects and operations that exist at the service interface. Each information model for a high-level service may also refer to the information model of other high-level services and to that of the common protocol service.

Service objects may be:

- Run-time instantiations of object classes fully defined by the service definition:
Objects of this type are fully defined by the service specification and require no mission information by the client. Time service is an example.
- Mission definition-time instantiations of object classes fully defined by the service definition:
Objects of this type are fully defined by the service but have information specific to that mission. Examples are TM/TC services, where the access to them is standard but the information they represent is mission specific.
- Run-time instantiations of mission definition-time specialisations of object classes defined by the service definition:
Objects of this type are extended to provide mission specific features over ones provided by the standard service. Additional operations supported by Flight Dynamics are examples.

Objects and classes defined on a per mission basis correspond to traditional spacecraft TM/TC databases or MIBs. The proposed service model would require these databases or MIBs to follow the same structure as the services.

The SM&C Common Protocol service, as a carrier for an extensible set of high-level Application-layer services, should have a minimal MIB associated with it, with the majority of objects being fully defined by the service definition, such that the information models of the high-level Application-layer services that rely upon it can be standardised.

The MIB that captures target characteristics and behaviour for basic monitoring and control is that associated with the core SM&C Application-layer services, described in the next subsection.

4.4 CORE MONITORING & CONTROL OPERATIONS

The core Monitoring & Control operations topic corresponds to generic monitoring and control of a remote system (e.g., a spacecraft or ground system component) in terms of three fundamental mechanisms and associated data items:

- Status Monitoring: *Monitoring Parameters*;
- Action Invocation: *Actions*;
- Alert Notification: *Alerts*.

The communication of status information allows the remote system to be monitored. In principle, the remote system publishes its status to a number of active or passive observers, or *clients*, which may subscribe to a selective subset of available status, action and alert data.

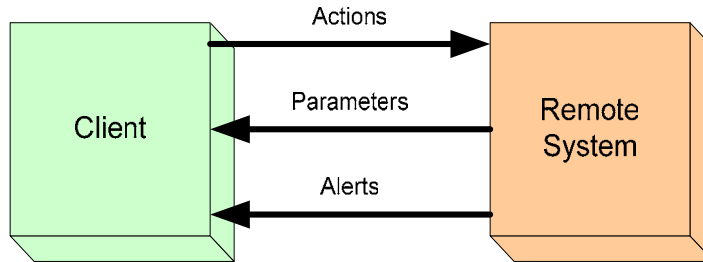


Figure 4-4: Core M&C Operations

Examples of M&C client functions include:

- Manual M&C (Status Display and Manual Control Applications);
- Automated Operations (Automated Procedures, Schedules, and Contingency Response);
- Flight Dynamics;
- Operations Analysis and Performance Reporting;
- Fault Diagnosis;
- External M&C Operations (e.g., Payload Control centres).

The invocation of actions upon the remote system enables an active client to effect control over it.

The ability of the remote system (or other clients) to raise alert notifications provides a mechanism by which undefined actions or responses can be asynchronously elicited from clients.

The term *Event* is used to refer to any time-stamped notification of change of state or asynchronous response, and as such may relate to *Monitoring Parameters*, *Actions* and *Alerts*. The term *Alert* is used to differentiate the notification of operationally significant asynchronous events, such as anomalies or threshold transitions, from routine events such as nominal monitoring parameter value change.

The point in the system at which the timestamp is applied may have a notable step in the clock used to perform the timestamping difference; a one-second resolution may be typical. Therefore the resolution and accuracy required of the ‘timestamp’ may leave ambiguity to alarm order if just the crude timestamp is used. For situations like this, a secondary time sequence counter could be used where clients of a clock request a time sequence number with the timestamp; the count would be reset each specified interval. The sequence counter would have to be shared between all clients of a particular clock, and would provide the required event sequencing.

Timestamping should be done as soon as possible, especially before any buffering by asynchronous data busses, to ensure the correct timestamp is applied.

The M&C concept includes both basic and advanced mechanisms. Basic mechanisms correspond to those typical in the majority of existing spacecraft systems. Advanced mechanisms correspond to optional features which nevertheless relate to the same fundamental data items.

The operations concept is intentionally independent of the location of the processes required to service it. In this regard, it may be that all aspects of processing associated with *monitoring parameters*, *actions*, and *alerts* are located within the remote system itself, or it may be that some of the associated processing is performed within a ground-based proxy component that provides client access to these data items. For example, status monitoring (the evaluation of predefined status checks) may be performed onboard a spacecraft or on the ground, but operationally the client sees the result of these checks irrespective of where they are performed.

The use cases for this are given in A5.2.

4.4.1 STATUS MONITORING

Status monitoring¹ is performed by publishing the status of a set of predefined *monitoring parameters* that contain status information.

Monitoring parameters have an evolving status represented by a chronological sequence of status update *events* over an unbounded lifetime. Status update events may be periodic, change-based, or a mixture of the two.

Operationally, a *monitoring parameter* may be considered to have multiple status attributes or fields, including:

- Value, of various data types and of specific units for numeric data types;
- Raw data: uncalibrated binary data;
- Results of any monitoring or ‘limit’ checks;
- Associated quality/validity/availability states.

Monitoring parameters may be simple or compound. Simple *monitoring parameters* comprise a single status item as described above. Compound *monitoring parameters* correspond to a defined structure of *sub-parameters* that are not separately notifiable. An example of a compound monitoring parameter is a telemetry word or channel containing a four-bit integer followed by twelve single bit status flags, which can be selected or telemetered only as a whole, but each element of which can be considered an independent status value or *monitoring parameter*.

¹ Status Monitoring correlates to the ECSS PUS services 3 (Housekeeping and Diagnostic Data Reporting), 4 (Parameter Statistics Reporting) and 12 (On-board Monitoring).

Monitoring parameters may be referenced individually, or in terms of predefined or dynamically defined *Monitoring Parameter Groups* that may be used by clients in subscribing to status data. *Monitoring Parameter Groups* correspond to an abstract set of *monitoring parameters* with an associated identity and fall into three categories:

- Predefined, fixed groups the membership of which is known to both remote system and clients. An example is a housekeeping telemetry packet containing a fixed set of *monitoring parameters*.
- Groups for which the membership is dynamically defined by a client or the service provider. An example is a diagnostic telemetry packet containing a dynamically defined set of *monitoring parameters*.
- Groups that are dynamically maintained by the (remote) system and whose membership is not known in advance to the client. An example is the limit violation list.

Monitoring parameters may be

- directly sensed and telemetered by the remote system;
- derived from other *monitoring parameters* through the evaluation of a defined expression or algorithm;
- asserted by a client to reflect an operational status or configuration option.

Monitoring parameters may be subjected to a range of monitoring checks specific to the data type, and the resultant check status is then associated with the monitoring parameter. A list of monitoring parameters currently violating checks may also be maintained, together with the time of initial violation. It should be noted that some classes of check may have multiple threshold sets (e.g., upper and lower limits, expiration timeouts and value absence checks).

Monitoring parameters may also be subjected to statistical evaluation and the resultant statistical data (e.g., min, max, mean, standard deviation) provided to clients.

4.4.1.1 Routine Operations

Routine status monitoring operations provide for:

- the delivery of selected status monitoring data to M&C clients;
- the update of *monitoring parameter* values by M&C clients.

The basic delivery mechanism forwards status *monitoring parameters* or *monitoring parameter groups* to subscribing M&C clients. Routine monitoring (housekeeping) data and diagnostic monitoring data are treated identically. The delivered monitoring parameter data includes calibration or interpretation into engineering values or states, evaluation of associated validity states, and monitoring check results if available.

At the most basic level, all such data generated by the remote system is delivered to the client, but a range of mechanisms for selecting a subset of data is also foreseen as part of the subscription process. These include:

- the referential scope of the data (system, subsystem, etc.);
- a nominated set of *monitoring parameters* and/or *monitoring parameter groups*;
- sub-sampling or changes-only notification;
- filtering by attribute value.

Where monitoring parameter monitoring is supported, the following additional data may also be forwarded to the client:

- monitoring check transition events;
- check violation list.

Where monitoring parameter statistics are supported, they may also be forwarded to the client.

The monitoring parameter assertion mechanism enables an authorised client to set the value of a nominated attribute of a nominated *monitoring parameter*, subject to its being defined as assertable.

4.4.1.2 Configuration Operations

Configuration operations for status monitoring include the following:

- enabling or disabling the generation and/or notification of *monitoring parameter* or *monitoring parameter group* status and selecting the mode of status reporting (periodic, change-based or filtered change-based);

NOTE – Filtered change-based reporting allows for suppressing insignificant change in ‘noisy’ analogue monitoring parameters.

- controlling remote status buffering and routing;
- managing the definition of dynamic *monitoring parameter groups* for diagnostic reporting purposes;
- managing the set of *monitoring parameters* subject to monitoring and configuration of the associated checks;
- managing the set of *monitoring parameters* subject to statistical evaluation and associated configuration data.

4.4.2 ACTION INVOCATION

Action invocation² operations include both the issuing of action directives by an authorised M&C client to the remote system and the subsequent monitoring of the evolving execution status of that action by both the initiator and other M&C client functions.

Actions correspond to any symbolic control directive, to the remote system (spacecraft or other controlled systems) or even to the ground control system itself. *Actions* are characterised by an ID, a set of arguments, and current status. *Actions* have an evolving status represented by a chronological sequence of *events*, over a limited lifetime, for each invocation of the action.

An authorised M&C client invokes an action by submitting an action request (referring to a predefined action definition and providing a populated argument set) to the remote system (or ground-based bridge) for immediate execution. This results in the creation of a new action instance, which is assigned a unique identity that is returned to the initiator.

Action status is delivered to subscribing M&C clients. For each action instance, there may be a series of status change *events* corresponding to various stages of action execution, e.g.:

- action invocation (instance creation);
- pre-execution validation (pre-transmission or onboard);
- transmission to/acknowledgement by uplink system;
- verification of receipt and/or execution by remote system;
- post-execution verification (on the ground or onboard, based on *monitoring parameter* status).

As with status monitoring, all such data generated by the remote system is delivered to the client, but mechanisms for selecting a subset of data are also foreseen as part of the subscription process. These include:

- the referential scope of the data (system, subsystem, etc.);
- a nominated set of *action* definitions (all instances);
- a nominated set of *action* instances (nominated instances);
- filtering by state (e.g., final state only);
- filtering by action argument value.

² *Action Invocation correlates to the ECSS PUS services 2 (Device Command Distribution) and corresponding usage of service 1 (Telecommand Verification).*

With most existing systems there are no associated configuration operations. Should pre-execution validation and post-execution verification conditions be evaluated within the remote system rather than within the ground control system, however, configuration of the associated check conditions would be required.

4.4.3 ALERT NOTIFICATION AND AUTOMATED ACTIONS

*Alerts*³ are raised asynchronously to report a significant occurrence or anomaly. They may originate within the remote system (spacecraft or other controlled system) itself or an associated ground-based proxy process in response to a transition in some monitored status. *Alerts* may also be injected by an authorised M&C Client. Alerts are characterised by an ID and a set of arguments. A single *event* represents each Alert occurrence.

Automated Actions offer an extension to *alert* notification and certain other classes of *event* reporting (e.g., telemetry check transition events, *activity* execution status and progress events).

In response to the occurrence of a defined *alert* (or other supported *event*), one or more *actions* are automatically initiated. An alert-action trigger definition identifies the class of *alert*, optionally with argument value filters, and associates it with a class of *action* to be initiated. Any *action* arguments must also be defined, either in terms of literal values or *alert* arguments. The associated *action* may be one of:

- an atomic *action*;
- initiation of an *activity* (procedure, function);
- operator interaction (see 4.11);
- others (TBD).

4.4.3.1 Routine Operations

Routine alert notification operations provide for:

- the delivery of selected *alert* notifications to M&C clients;
- the injection of *alert* notifications by M&C clients.

³ *Alert Notification correlates to the ECSS PUS service 5 (Event Reporting Service) although it is noted that an equivalent mechanism to this generic service could also be used to support event reporting required by other operational tasks.*

Automated Actions correlate to the ECSS PUS service 19 (Event-Action).

As with action status, at the most basic level all *alerts* generated are delivered to the client, but mechanisms for selecting a subset of data are also foreseen as part of the subscription process. These include:

- the referential scope of the data (system, subsystem, etc.);
- a nominated set of *alert* definitions (all instances);
- filtering by *alert* argument value.

No routine operations are specifically associated with automated actions, as these are already reported via both *alert* notification and *action* status delivery.

4.4.3.2 Configuration Operations

Configuration operations for alert notification include the following:

- enable and disable the delivery of alert notifications for each *alert* definition;
- control of remote alert buffering and routing.

Configuration operations for automated actions include:

- manage the definitions of alert-action triggers (dump, add, delete);
- enable and disable individual triggers.

4.4.4 BUFFERED DATA OPERATIONS

Buffered data⁴ principally relates to the buffering of core M&C routine operations data in a remote system, and applies equally to status monitoring, action invocation, and alert notifications. However, it is noted that buffered data operations may also apply to observable data relating to other operational topics, e.g., payload data products.

Buffered data is concerned only with observable data, i.e.:

- *Monitoring parameter* or *Monitoring parameter Group* status delivery;
- *Action* status delivery;
- *Alert* notification.

⁴ *Buffered Data Operations* includes the operational function covered by the ECSS PUS service 15 (on-board storage and retrieval).

Such data may be buffered or stored for a limited period within the remote system itself or at an intermediate node such as a ground station. While there are specific issues associated with storage within the remote system, there are nevertheless commonalities in the access and management of buffered data from any source.

Buffered data operations require support in the following areas:

- Buffered Data Delivery;
- Buffer Control;
- Buffer Management/Configuration.

The delivery mechanism for buffered data is assumed to be common with 'live' status delivery.

A retrieval request mechanism is required to initiate retrievals, which essentially constitute request-response transactions.

Buffer management operations include:

- configure the subset of observable data to be buffered (e.g., enable/disable the storage of individual *monitoring parameters* or *monitoring parameter groups*);
- report the content or *catalogue* of buffered data;
- delete data from the buffer store or configure its automatic deletion based on predefined retention times or buffer size.

4.4.5 HISTORICAL DATA OPERATIONS

Historical data principally relates to the persistence of core M&C routine operations data, and applies equally to status monitoring, action invocation, and alert notifications. However, it is noted that historical data operations may also apply to observable data relating to other operational topics, e.g., payload data products.

Historical data is concerned only with observable data, i.e.:

- *Monitoring parameter* or *Monitoring Parameter Group* status delivery;
- *Action* status delivery;
- *Alert* notification;
- *Data Product* history.

Data insertion (monitoring parameter assertion, action invocation, or alert injection) is not possible in a historical context.

While there are specific issues associated with storage within the remote system, there are nevertheless commonalities in the access and management of historical data from any source. Consequently this operational topic addresses generally:

- Data Archiving and Retrieval.

An M&C client function may use a number of different data retrieval methods:

- snapshot, in which the status at a given point in time is extracted from history;
- trend, in which all *events* (monitoring parameter, action, or alert) relating to a time period are extracted from history and delivered to the client as a single archive product or block of data;
- replay, in which historical events are retrieved and played back sequentially to the client.

Historical data operations require support in the following areas:

- historical data delivery;
- retrieval control;
- archive management/configuration.

The delivery mechanism for replay is assumed to be common with ‘live’ status delivery, but additional mechanisms are required for trend and possibly snapshot delivery.

A retrieval request mechanism is required to initiate static retrievals (snapshot and trend), which essentially constitute request-response transactions.

A more complex interaction is required to support replay control. As well as specifying the initial retrieval condition, the replay *session* can be controlled in a similar way to a video player (play, pause, fast forward, rewind, single step, etc.).

Both static and replay retrievals may also be subject to the same selection or filtering methods as for live data delivery.

Archive management operations include:

- configure the subset of observable data to be stored (e.g., enable/disable the storage of individual *monitoring parameters* or *monitoring parameter groups*);
- report the content or *catalogue* of stored data;
- delete data from the historical store or configure its automatic deletion based on predefined retention times or sizes.

4.5 OPERATIONS AUTOMATION

The Operations Automation concept⁵ in this context allows for system functions that are capable of autonomously executing a predefined operation or *activity* of greater complexity than a single discrete *action*. Operations Automation is itself a user of the previously described core M&C mechanisms to observe status and execute control.

An *activity* is an extended operation performed autonomously. *Activities* can correspond to configurable automated operations procedures and software functions that execute within the remote system, or within a ground-based Operations Automation function. The remote system may also provide built-in test capabilities that can also be considered *activities*.

Actions constitute atomic elements of control, the execution of which is effectively instantaneous (although it may take a while to observe the result). In comparison, *Activities* may invoke multiple atomic *actions*, be executed over an extended period of time, have behaviour conditional upon observed status, report intermediate stages of execution, and be subject to control during execution.

It should be noted that this service covers only *action* and *activity* automation and not direct automation of ground functions such as planning and scheduling. However, any operation that can be expressed in terms of *actions* and *activities* is a candidate for implementation-specific automation.

In current systems, distinct methods of activity monitoring and control can apply to onboard procedures or macro-commands, ground-based automated procedures, predefined command sequences, and custom software functions. A common operational approach to all these classes of *activity* would simplify the integration of automated operations and enable interoperability of systems at the level of automated functions.

Built-in tests may also be considered to be special cases of *activities* that generate a test report in prescribed format in response. This concept may be generalised to the provision of summary results by any *activity*.

Automated functions may be located within the remote system, or locally within the ground control system. Both can act as the service provider, which may itself make use of core M&C operations to observe and control the remote system. Potential client functions of Activity Control include:

- manual M&C (*activity* level Status Display and Manual Control Applications);
- automated schedule execution (remote and local);
- automated contingency recovery (remote and local);
- other automated procedures (remote and local – nested calls).

⁵ Activity Control correlates to ECSS PUS services 18 (on-board procedure), 8 (function management) and 19 (test service), and usage of service 5 (event reporting) for activity status change and progress reporting.

Routine activity control operations include:

- high-level *activity* control (Start, Stop, Abort, Suspend, Resume);
- reporting of *activity* execution status and progress *events*;
- reporting of the list of active *activity* instances;
- reporting of *activity* (test) results.

Note that the start *action* is assumed to include the provision of input arguments to the procedure or software function.

Configuration operations for activity control include:

- reporting of catalogue of remote procedure definitions (identity, version, and argument list);
- management of remote procedure definitions (load, dump, delete).

The use cases for this are given in A5.3.

4.6 OPERATIONS SCHEDULING

The Operations Scheduling concept⁶ applies to missions where operations are executed in accordance with a pre-planned schedule or operational timeline.

A *schedule* constitutes a timeline of executable *activities* and *actions* for automatic (or manual) execution, either locally within the ground control system or within the remote system itself. Typically a schedule may have interrelated remote and local components. For example, the remote (onboard) component is locally loaded during contact for autonomous execution remotely, in or out of ground contact. The local component identifies the operations to be performed locally to support the out-of-contact command uplink or executed immediately within the remote system during contact.

Both remote (onboard) and local (ground-based) schedule execution functions act as service provider in the context of this operational topic. Potential client functions for Operations Scheduling include:

- mission planning as the generator of schedules;
- manual M&C (*schedule* level Status Display and Control Applications);
- automated procedures (*schedule* level control).

⁶ Operations Scheduling correlates to ECSS PUS service 11 (on-board scheduling) and usage of service 5 (event reporting) for schedule status change and progress reporting.

For schedules that are autonomously executed by the remote system, the operations concept covers the synchronisation of the remote schedule with a local image of it (onboard schedule image) and supports intermittent connectivity between the remote system and ground control system with respect to transfer of the schedule to the remote system and update of schedule image status.

Routine operations scheduling operations include:

- transfer of executable *schedules* to schedule execution function (merge/append/replace active schedule with update);
- management of active schedule (clear schedule; time shift schedule or part thereof);
- modification of scheduled *activities/actions* (add, modify, delete);
- reporting of *schedule* execution status and progress *events*;
- reporting of current schedule (complete schedule or changes only);
- control of execution of the current schedule (suspend, resume).

No configuration operations are currently identified. The use cases for this are given in A5.4.

4.7 OPERATIONS PLANNING

Operations Planning requests may originate from a wide range of sources. It is the role of the (Mission) Operations Planning function to schedule activities in response to the current set of planning requests.

Within the ground control system, Operations Planning may be an off-line function that generates a predetermined *schedule* of executable activities, that schedule then being transferred using Operations Scheduling. The planning service may involve a hierarchical planning that is driven by the ‘schedule of authority’.

Alternatively it may be a reactive goal-oriented function, embedded within the remote system or hosted locally within the ground control system, that directly initiates *activities* or discrete *actions* in accordance with strategies elaborated in near–real time by reference to current observable status. The use cases for this are given in A5.5.

The Operations Planning concept supports the transfer of Operations Planning requests (or goals) to the planning process for incorporation into the current plan. Planning request sources include:

- system users;
- Flight Dynamics (for manoeuvres);
- performance analysis (for housekeeping operations);
- onboard software management (for onboard software loads);
- manual M&C (*planning* level Status Display and Control Applications).

To allow for hierarchical planning systems, the approach should allow for both single planning transactions and block transfers of pre-scheduled operations.

The operation is transactional, in that for each Operations Planning request or block of requests (input to Planning Process) there is an associated response providing the planned operations status report to provide feedback to the user or higher-level planning process. The updates are asynchronous and are generated when the status of a planned operation changes, for example, at the start of a re-planning request or the completion of the plan generation.

Routine Operations Planning operations include:

- modification of planned *operations* (add, modify, delete);
- modification of planned *constraints* (add, modify, delete of inter-operation and intra-operation *constraints*);
- controlling of generation of a *plan* (start, stop, suspend, resume);
- reporting of *plan* generation status and progress *events*;
- reporting of current *plan* or others (complete *plan* or changes only).

4.8 GUIDANCE, TRACKING, AND SYNCHRONISATION

Guidance, Tracking, and Synchronisation concerns the management of spacecraft orbit and attitude dynamics. It may be considered to compose the following principal functions:

- the reporting of the position and time reference of the remote systems (spacecraft);
- correlation of onboard clocks to UTC/TAI;
- orbit determination and the generation of an associated orbit vector product;
- orbit propagation and the generation of orbit prediction products including:
 - ground station visibilities (AOS-LOS),
 - antenna steering data,
 - other predicted geometric events (sensor blindings, eclipses, etc.);
- attitude determination, monitoring, and prediction;
- physical state determination and prediction;
- manoeuvre planning and the associated generation of detailed manoeuvre control products.

Historically, onboard clocks have been correlated with UTC through precise reception time-stamping of an onboard time signal or report. With an increasing number of missions making use of onboard position and even orbit determination through receipt of satellite navigation signals, the reporting of time and position together is an implementation-specific issue.

The remaining functions are traditionally grouped together within a ground-based Flight Dynamics function, although it is noted above that this may increasingly be distributed between onboard and ground-based components. To maximise the scope for interoperability of future systems, standardisation of the key functional interactions in this area is considered critical.

The use cases for this are given in A5.6.

4.8.1 TIME REPORTING

Functions which are potential clients for time reporting⁷ include:

- Flight Dynamics (both single, constellation, and formation flying);
- core M&C;
- onboard software management (for analysis of process timings, etc.).

The principal client function for time reporting is Flight Dynamics, specifically for orbit prediction and manoeuvre planning.

Remote time correlation is typically required to synchronise M&C functions and is hence linked to the core M&C operations topic. For earth-orbiting missions this will increasingly be unnecessary as onboard time is synchronised remotely through the receipt of navigation signals. It will continue to be necessary for deep space missions.

The topic includes the following operations:

- remote (onboard) time reporting;
- remote (onboard) time correlation;
- remote (onboard) time shifting.

Of these, the first corresponds to passive delivery of status data to the client function. This has similar characteristics to status monitoring data delivery and could be implemented using common mechanisms. Standardisation of the corresponding ‘monitoring parameter’ data is recommended to ensure interoperability, as many implementation variations of complex data items would be possible using a generic monitoring parameter delivery mechanism.

Associated configuration operations include:

- configuration of the time report generation rate.

⁷ Time Reporting includes the operational function covered by the ECSS PUS service 9 (time management).

4.8.2 LOCATION REPORTING

Functions which are potential clients of location reporting include:

- Flight Dynamics.

The principal client function for location reporting is Flight Dynamics, specifically for orbit prediction and manoeuvre planning.

The topic includes the following operations:

- remote position reporting;
- ground station tracking data reporting: antenna azimuth and elevation when in autotrack mode;
- ground station ranging and Doppler (range rate) measurement; including both the initiation of the ranging operation and the reporting of the measurement.

Of these, the first two correspond to passive delivery of status data to the client function. This has similar characteristics to status monitoring data delivery and could be implemented using common mechanisms. Standardisation of the corresponding ‘monitoring parameter’ data is recommended to ensure interoperability, as many implementation variations of complex data items would be possible using a generic monitoring parameter delivery mechanism.

Ranging operations can be initiated by the client function in a simple request-response transaction. Alternatively, ranging may be performed automatically and reported in a similar manner to the other time and location data classes.

NOTE – Ground station tracking and ranging operations may be defined in the context of Space Link Extension services.

Associated configuration operations include:

- configuration of the position report generation rate.

4.8.3 FLIGHT DYNAMICS

Flight Dynamics constitutes a range of services associated with spacecraft orbit, attitude and physical state determination and prediction, and manoeuvre planning.

With the advent of onboard positioning via satellite navigation signals, the migration of traditionally ground-based functions such as orbit determination to the spacecraft becomes increasingly probable.

Potential Flight Dynamics client functions include:

- mission planning;
- core M&C;
- analysis.

The Flight Dynamics function is tightly coupled to Time and Location Reporting, whose services are required to support it. It is also a user of core M&C mechanisms for access to status monitoring data and Mission Planning mechanisms for the submission of manoeuvre planning requests.

The Flight Dynamics function should support the concept of multiple scenarios where alternative configurations can be examined.

Routine Flight Dynamics operations include:

- Flight Dynamics task control and status reporting;
- provision of orbit vector (note that this could be provided by an onboard or ground-based function);
- provision of ground station visibilities (AOS-LOS periods);
- provision of antenna steering data (APES);
- provision of predicted events, geometric and others;
- provision of attitude data;
- provision of physical state data;
- provision of manoeuvre control data;
- provision of fuel budget assessment;
- provision of End of Life prediction.

A standardised approach is proposed to enable Flight Dynamics tasks to be initiated by client functions using a mechanism equivalent to that of Activity Control. Standardisation of Flight Dynamics products will greatly improve interoperability between agencies, missions, and systems.

4.9 REMOTE SOFTWARE MANAGEMENT

Remote Software Management concerns the management of the software loaded into the remote system.⁸ The Software Management function may include the maintenance of the onboard software through direct modification of the onboard image, or through updates supplied to it from an external source, such as the spacecraft or payload manufacturer.

The remote Software Management function can be itself a user of Mission Planning mechanisms for the submission of remote Software Management planning requests; however, in some instances it may not be. Potential client functions of remote Software Management operations include:

- Operations Scheduling;
- Operations Automation;
- manual Software Management (Software Management status display and control applications).

It is purely a configuration function that includes the following operations:

- loading of software image (directly or from file);
- dumping of software image (directly or to file);
- checking of software image.

Depending on the spacecraft design, different methods of software image load may be supported. It may be necessary to load software directly to absolute or relative memory locations. Alternatively a file transfer approach may be used to transfer a locally installable image.

The use cases for this are given in A5.7.

4.10 DATA PRODUCT MANAGEMENT

Many classes of spacecraft mission generate sizeable payload data products such as images and other observation data from onboard instrumentation.

Such observation data may be stored on the remote system using various bulk storage mechanisms, including onboard or remote file systems. This service is separate from the archive and retrieval concept in 4.4.5.

⁸ Remote Software Management correlates to ECSS PUS service 6 (memory management).

Operationally, mechanisms are required to:

- obtain explorer-style directory tree listings of the content of the onboard data product store;
- transfer products in both directions;
- perform data product store management operations, such as delete, move, rename, etc.;
- provide information about changes to the onboard data product store, such as new file events, etc.

It is anticipated that these mechanisms can be supported by a standard file transfer mechanism, such as CFDP. The SM&C Common Protocol service will provide common file transfer mechanisms to support Data Product Management and other file services.

The use cases for Data Product Management are given in A5.8.

4.11 OPERATOR INTERACTION

Most spacecraft control systems are staffed by human operators. User interfaces provided by various functions allow these operators to monitor current status and initiate control actions. With increasing automation, however, there are occasions where the local or remote system needs to notify the human operator of a significant occurrence, or solicit his/her input or operational decision. Such notification constitutes an asynchronous operator interaction, where the system is invoking the operator, rather than the other way round. In this context, the Operator Interaction function is a proxy for the operator.

Standardisation of an Operator Interaction service would allow any automatic function to initiate interactions in the same way, irrespective of the local implementation of the mechanisms to achieve interaction initiation (audible alarms, pop-up dialogues, pagers, etc.).

System routing of operator interactions to the appropriate person requires a responsibility model that identifies to which operator workstation an interaction should be directed. To allow for dynamic login/logout of human operators and workstation failures, such interactions may need to be re-routed in the event that the original user session is closed/lost before a required response has been received. Information about fallback operators/systems/actions would also be part of the responsibility model.

It is plausible that the human operator could be substituted in part (or fully) by an intelligent system, but the primary intent of this service is the interface to a human operator.

The following classes of interaction are identified:

- notification (message displayed to operator, no action required);
- paging of operator/engineer (variant of above where message is delivered via external messaging service [SMS, pager or e-mail]);
- request acknowledgement (message displayed to operator, acknowledgement is required);
- raising of alarm (variant of above where audible alarm is sounded at operator's console or control room, cancellation response is required);
- request for input data (question displayed to operator with data entry box, response with valid input value is required);
- request for option selection (question displayed to operator with multiple option buttons, response with selection of an option is required).

The use cases for Operator Interaction are given in A5.9.

5 SERVICE FRAMEWORK

5.1 INTRODUCTION

This section details the definition approach, the terms used, and the rational behind the service grouping given in section 6.

5.2 SERVICE IDENTIFICATION APPROACH

An analysis of the previous sections, 3 and 4, using the steps listed below will identify the services. The services will then be elaborated on to provide the UML use cases for them and also the semantics of their operation.

5.2.1 IDENTIFICATION OF CONSUMERS

An analysis of the various RASDS views will help identify the various consumers of the system. The main driver of the model is what the users (consumers) of the system require it to support. This information will be taken from section 3. This will provide the list of UML use case actors.

5.2.2 IDENTIFICATION OF CONSUMERS' REQUIREMENTS

A more detailed approach then will examine each consumer in turn to identify what each consumer requires of the system. This is the elaboration phase of the design. This information will be taken from section 4 and combined with the results of the previous step. This will produce a list of UML use cases per actor.

5.2.3 RATIONALISATION OF REQUIREMENTS

Once a list of requirements has been created it is then important that they are examined to identify common requirements and also to identify areas that require more analysis. After this step there should exist a consistent set of simple requirements. As a result of this step the previous list of use cases, which were separated by actor and possibly duplicated, will be merged into a single list of use cases.

5.2.4 GROUPING OF REQUIREMENTS INTO SERVICES

The requirements will most probably fall into several distinct areas and will therefore be easily grouped. It is also likely that several will not fall into clean-cut categories, and it may be necessary to split requirements and also to create groups that contain only the single requirement. The UML use cases would now be grouped into sets.

5.2.5 HARMONISATION OF SERVICES

Once the service groups have been identified it is then possible to look at these service areas in a more generic way. This generic view allows the extraction of common support services as well as identification of the relationships between the services. It is then possible to extract the data objects used by the services. Finally it will be possible to ensure that the mid- and lower-level services such as the SM&C Common Protocol service provide the necessary functionality needed to support the high-level services.

5.3 SERVICE DEFINITION APPROACH

Once the services and the operations of those services have been identified it is then possible to start formally specifying the service semantics. To ensure interoperability between different systems the high-level semantics of the service must be fully defined using UML sequence, collaboration, and state diagrams.

In each specific blue book, for each service, the standardisation work will cover:

- definition of the service operational concept;
- definition of the service operations to achieve the operational concept;
- define capability sets with the aim of making the service extensible and consistent;
- definition of the service dynamics (sequence of service operations);
- definition of the information model, i.e., the set of information that is required to fulfil the operation;

NOTE – The information model will also have to be tied to the capability sets.

- definition of the messages exchanged between the service provider and consumer;
- definition of the error handling of the service.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

To facilitate this a template shall be designed to help expand and detail the individual services and the operations (sub-services) of them.

Template for overall service:

Name	
Description	
Pre/post conditions for use	
Quality of service	
List of sub-services/methods	
High-level UML use case diagram	
High-level UML sequence diagrams	
High-level UML state diagrams	

Template for individual sub-services/methods:

Name	
Service member of	
Description	
Pre/post conditions	
Access restrictions	
Message structures	
UML use case diagram	
UML sequence diagrams	
UML state diagrams	

6 SERVICES IDENTIFIED

6.1 INTRODUCTION

This section lists the services identified from section 4.

Annex A applies the process for identification of the services given in 5.2 to the context given in sections 3 and 4. Once each service has been identified it is then elaborated using the approach and templates given in section 5.3 in a separate Blue Book.

6.2 SERVICES OVERVIEW

Table 6-1 lists services identified from section 4; the priorities are the development priorities.

Table 6-1: List of Services

Service	Priority	Description
SM&C Protocol	1	SM&C Common protocol
SM&C Common Services	1	SM&C Common services
SM&C Core	1	Core Monitoring and Control service
Time	2	Time correlation and management service
Data Product Management	3	File management and transfer, both ground-based and onboard
Location	4	Tracking, ranging, and onboard position determination services
Scheduling	5	Activity scheduling
Flight Dynamics	6	Orbit determination, flight plan generation, and manoeuvre generation
Planning	7	Constraint and resource planning
Interaction	8	Operator notification and interaction
Automation	9	Activity automation management
Software Management	10	Software versioning, patching, and release

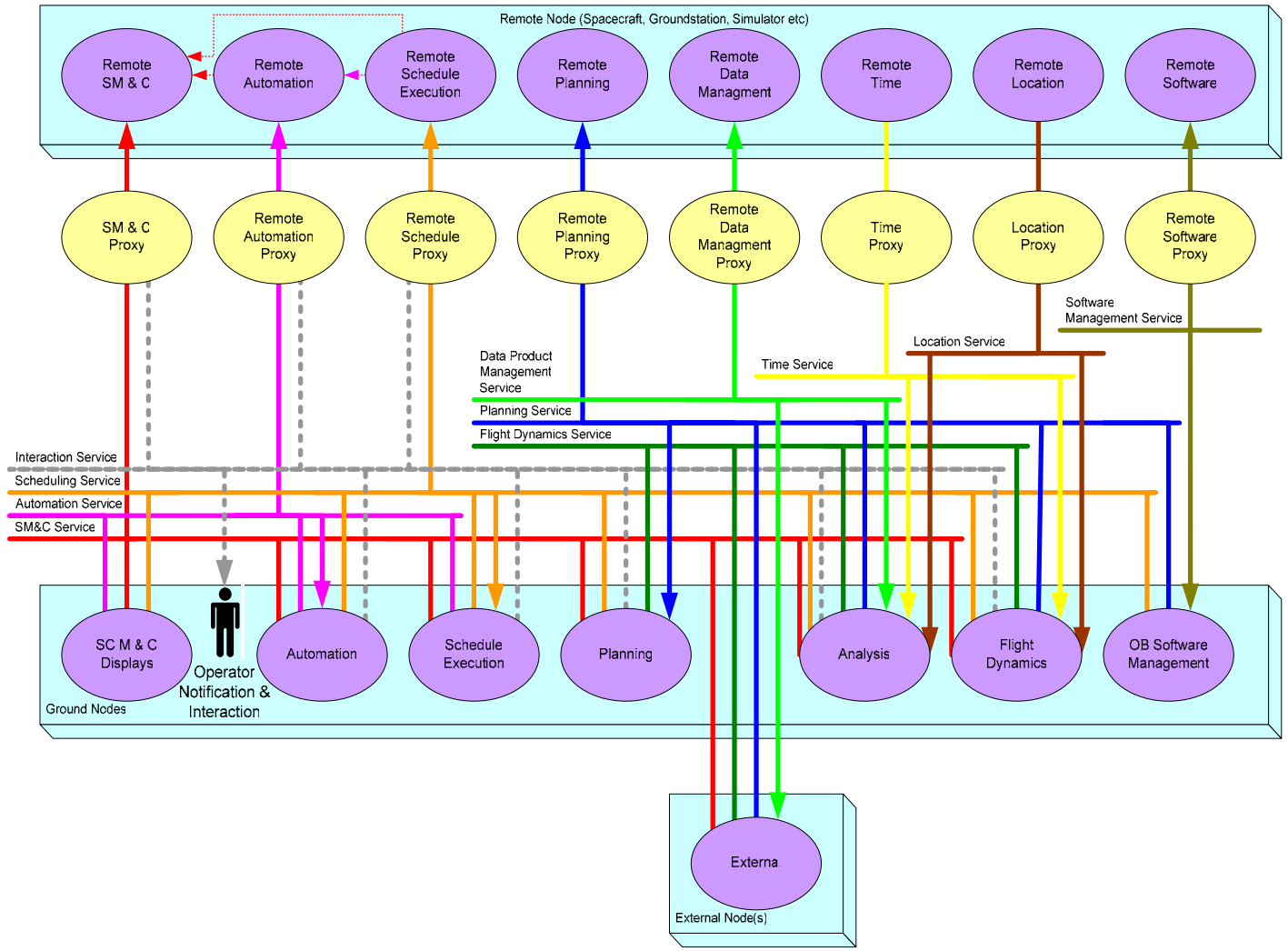


Figure 6-1: Service Overview

ANNEX A

USE CASE ANALYSIS

For each of the operational topics identified in section 4, a UML use case analysis is performed and documented using predominantly use case diagrams, supported by high-level type and interaction/sequence diagrams as necessary. This list is not exhaustive, as the service standard Blue Books provide the full detail.

In the Use Case Analysis, the system being modelled is the Space Monitor & Control System.

Subsequent refinement and definition of services in terms of UML use case templates, type diagrams, state charts, and interaction/sequence diagrams would form part of a service definition itself and are not detailed within this document.

A1 NOTATION AND TERMINOLOGY

A *Use Case* is a model element that describes how a user of the proposed system will interact with the system to perform a discrete unit of work.

An *Actor* is a user of the system: either a human user, a machine, or even another system. Anything that interacts with the system from the outside of the system *boundary* is termed an actor.

An *Actor* may specialise another *Actor*. An *Actor* that specialises another *Actor* is fully consistent with it (it has all of its properties, members, and relationships) and may contain additional information.

In this annex *Use Cases* are described with UML *Use Case Diagrams* and description templates.

A *Use Case Diagram* captures *Use Cases* and Actor interactions. It describes the functional requirements of the system and how outside things (actors) interact at the system boundary, and what the system does in response.

The *Boundary* box in the diagram identifies the system boundary.

The diagram below describes the notation used in the *Use Case Diagrams*.

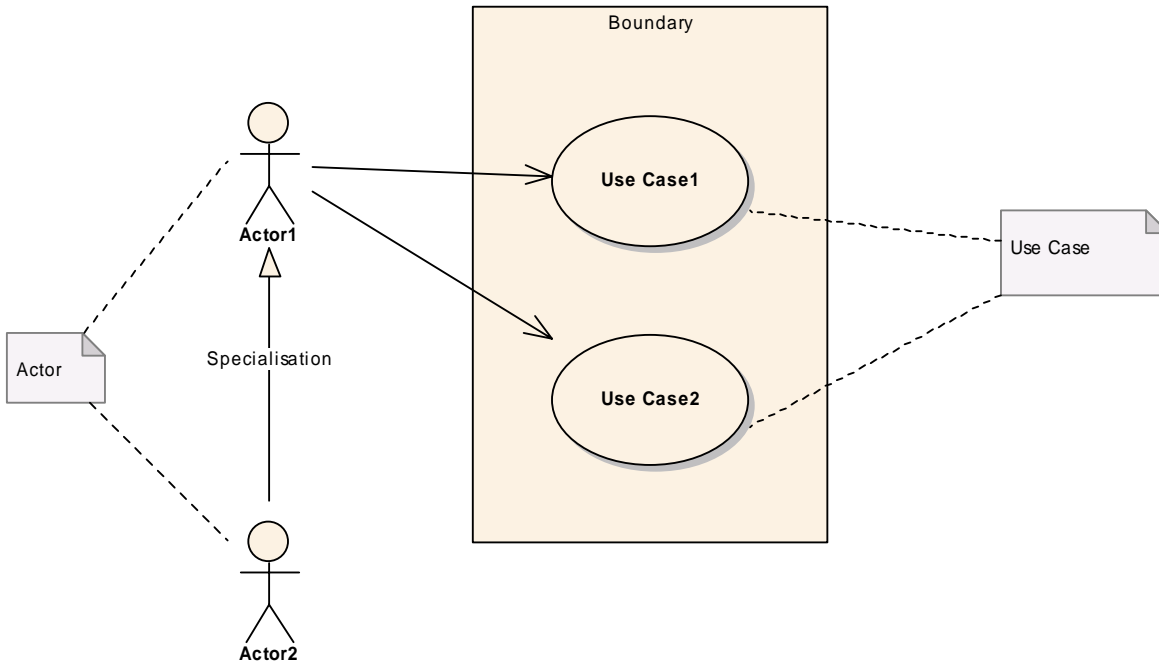


Figure A-1: Use Case Diagram Notation

Use Case Templates are used to describe each Use Case. The table below describes the template.

Use Case	The name of the use case
Brief Description	A high-level description of the use case.
Primary Actor	The actor which calls on the system to deliver one of its services.
Preconditions	A condition which must be true before the use case can be started.
Main Success Scenarios	A typical scenario in which the primary actor's goal is delivered and the interests of all other actors are satisfied.

A2 IDENTIFICATION OF CONSUMERS

This section maps to the analysis stage given in 5.2.1.

The diagram below shows the actors which represent the operators of the various Space Subsystems.

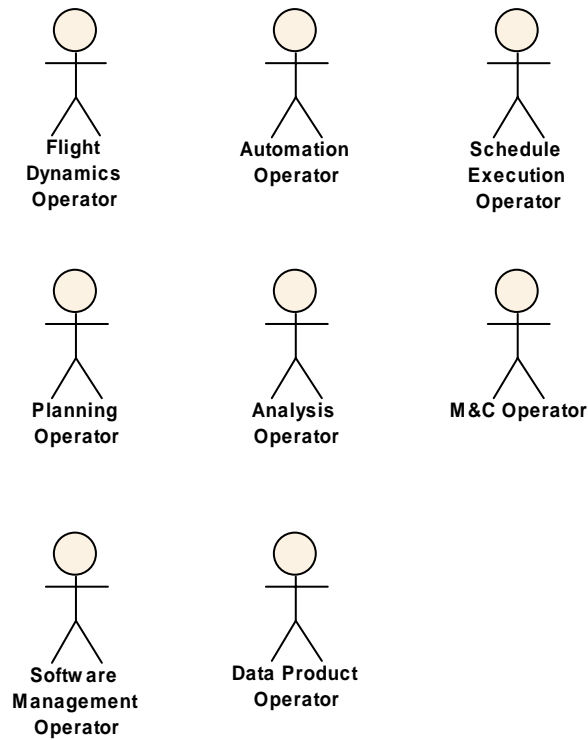


Figure A-2: Operator Actors

The diagram below shows the actors which represent the various Space Subsystems.

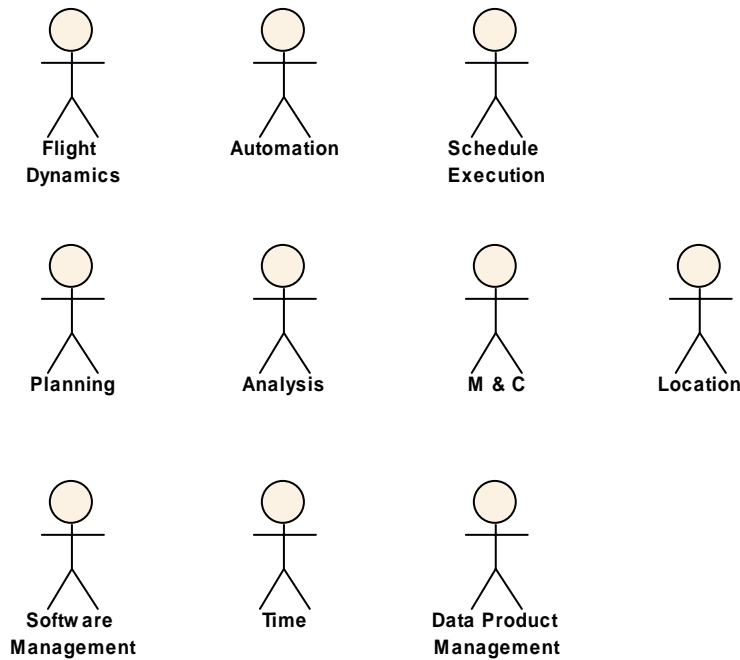


Figure A-3: Subsystem Actors

A3 IDENTIFICATION OF CONSUMERS' REQUIREMENTS

This section maps to the analysis stage given in 5.2.2.

Section 4 provides the consumers requirements of the functional areas and therefore their requirements on the services.

A4 RATIONALISATION OF REQUIREMENTS

This section maps to the analysis stage given in 5.2.3.

The rationalisation of the requirements is achieved by the definition of the Common Services and Protocol.

A5 GROUPING OF REQUIREMENTS

This section maps to the analysis stage given in 5.2.4.

A5.1 COMMON SM&C USE CASES

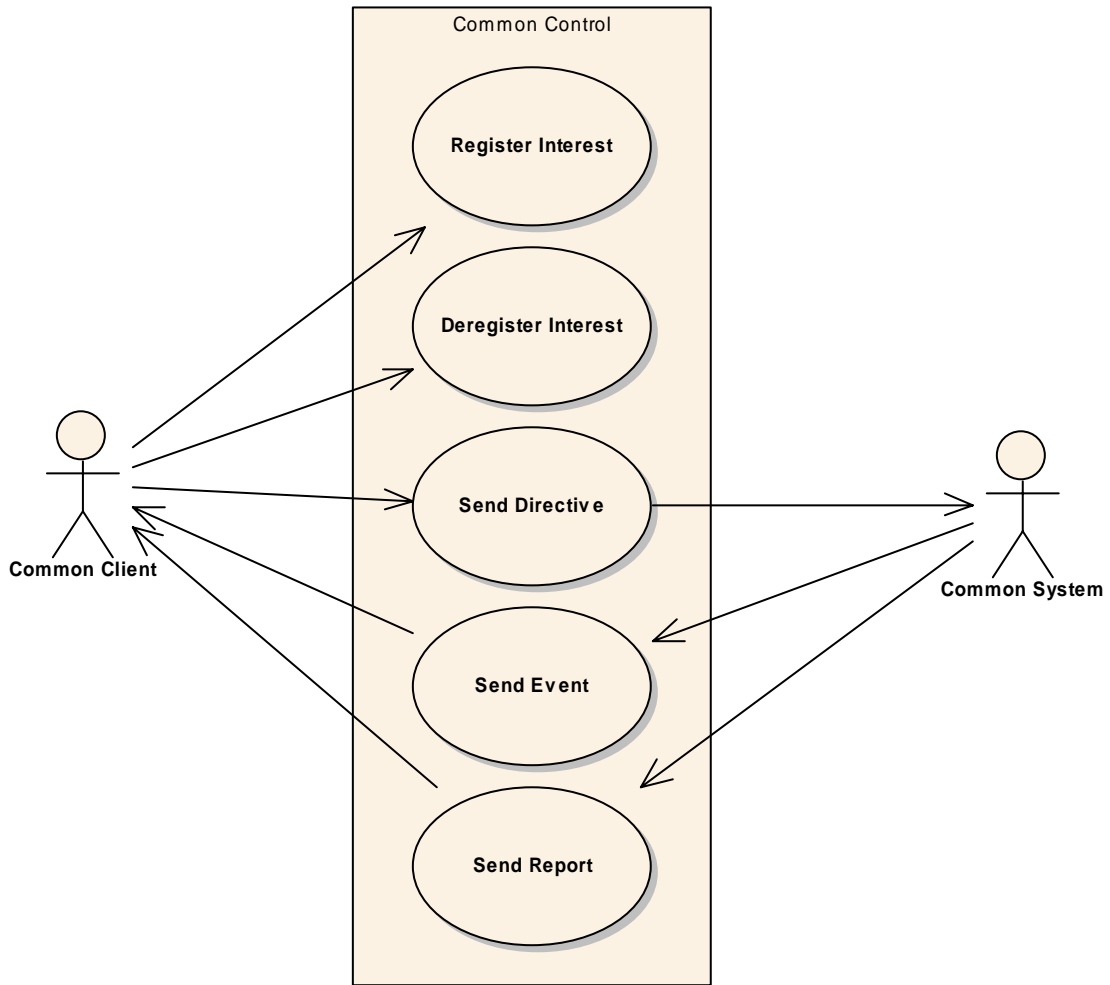


Figure A-4: Common SM&C Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Register Interest
Brief Description	<p>Use case allows a user to register to receive updates.</p> <p>It is expected that the registering of interest would involve the sending of some kind of filter and would also require some kind of privilege.</p> <p>The request may also specify that only the current state should be supplied (single shot), or that the current state and subsequent changes in the state should be supplied (continuous).</p>
Primary Actor	Client
Preconditions	<p>The subsystem which provides the updates must be available.</p> <p>Client must have appropriate privileges to perform this.</p>
Main Success Scenarios	<ul style="list-style-type: none"> • The filter provided by the Client is validated. • The Client is provided with the current state of all the items they have referenced in the request. • The Client is registered with the subsystem to receive updates.

Use Case	Deregister Interest
Brief Description	Use case allows a client to deregister interest in one or more items it previously registered for.
Primary Actor	Client
Preconditions	Was previously registered.
Main Success Scenarios	<ul style="list-style-type: none"> • The registration between the Client and the referenced items is removed.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Send Directive
Brief Description	<p>Use case allows a client to send a directive to the subsystem.</p> <p>The directive may have associated with it attributes related to its execution such as:</p> <ul style="list-style-type: none"> • Execution Time (immediate, relative, or absolute) • Response required (uplink, acceptance, start, success, etc.).
Primary Actor	Client
Preconditions	Client must have appropriate privileges to perform this operation.
Main Success Scenarios	<ul style="list-style-type: none"> • The subsystem receives the directive.

Use Case	Send Event
Brief Description	Use case allows a subsystem to report a change for an item.
Primary Actor	Subsystem
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • The new state is reported to all clients that have registered for the update.

Use Case	Send Report
Brief Description	<p>Use case allows a subsystem to report a set of changes for one or more items.</p> <p>This use case differs from the previous in that it sends a set of changes as a single entity (a report) rather than a set of changes as a set of events which might arrive out of order.</p>
Primary Actor	Subsystem
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • For each item the new states are to all clients which have registered for the update.

A5.2 CORE SM&C USE CASES

A5.2.1 Status Monitoring

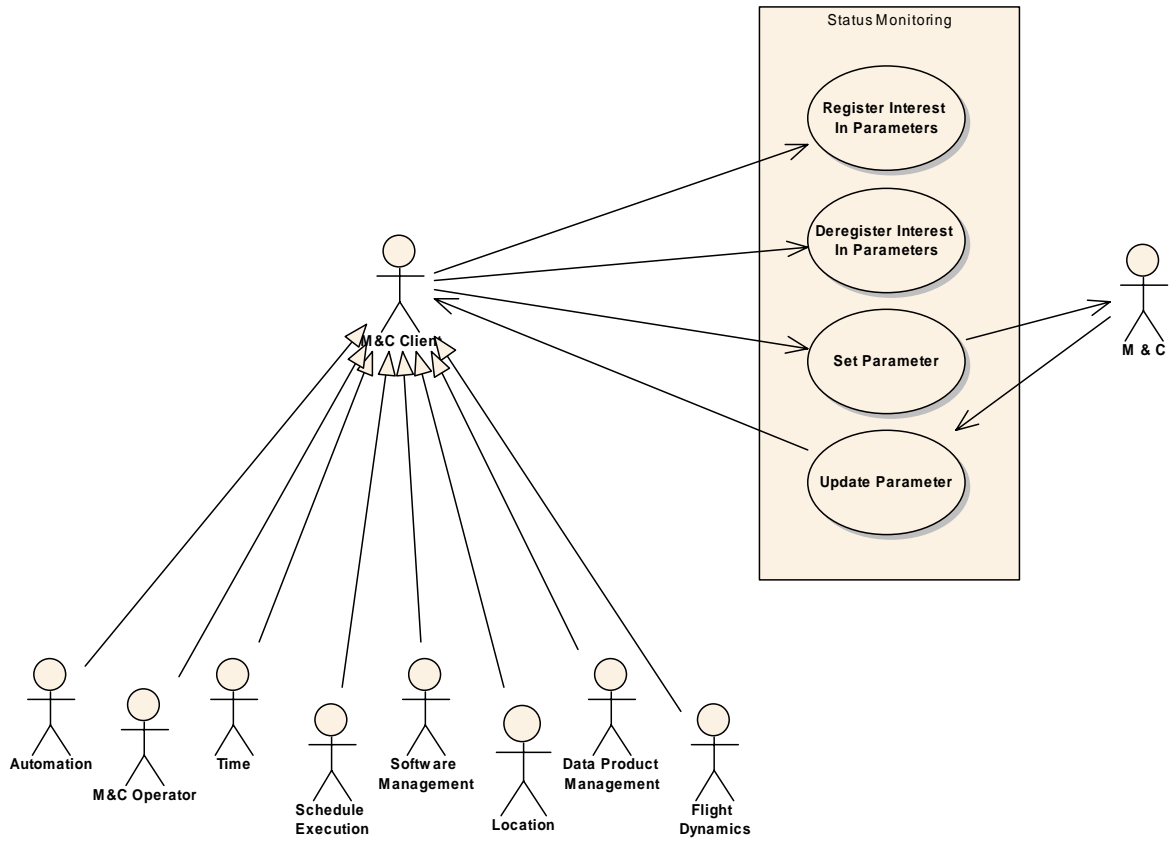


Figure A-5: Status Monitoring Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Register Interest In Parameters
Brief Description	<p>Use case allows a user to register to receive updates reporting the state of one or more parameters.</p> <p>In this context the state of the parameter consists of all its dynamic attributes (e.g., value, status, raw data, quality flags)</p> <p>The request can specify that only the current parameter state should be supplied (single shot), or that the current parameter state and subsequent changes in the state should be supplied (continuous).</p>
Primary Actor	M&C Client
Preconditions	The M&C Subsystem which provides the Parameter values must be available.
Main Success Scenarios	<ul style="list-style-type: none"> • All the parameter references provided by the M&C Status Client are validated. • The M&C Status Client is provided with the current state of all the parameters he has referenced in the request. • The M&C Status Client is registered with the Parameters.

Use Case	Update Parameter
Brief Description	Use case allows a M&C Subsystem to report an attribute change for one or more Parameters.
Primary Actor	M&C (Subsystem)
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • All the parameter references provided by the M&C Subsystem are validated. • For each Parameter the new state is reported to all clients which have registered for the Parameter.

Use Case	Deregister Interest In Parameters
Brief Description	Use case allows a user to deregister interest in one or more parameters.
Primary Actor	M&C Client
Preconditions	None
Main Success Scenarios	<ul style="list-style-type: none"> The registration between the M&C Status Client and the referenced Parameters is removed.

Use Case	Set Parameters
Brief Description	Use case allows a Client to set a Parameter.
Primary Actor	M&C Client
Preconditions	The M&C Subsystem which maintains the Parameter values must be available.
Main Success Scenarios	<ul style="list-style-type: none"> The Set request is forwarded to the M&C Subsystem.

A5.2.2 Action Invocation

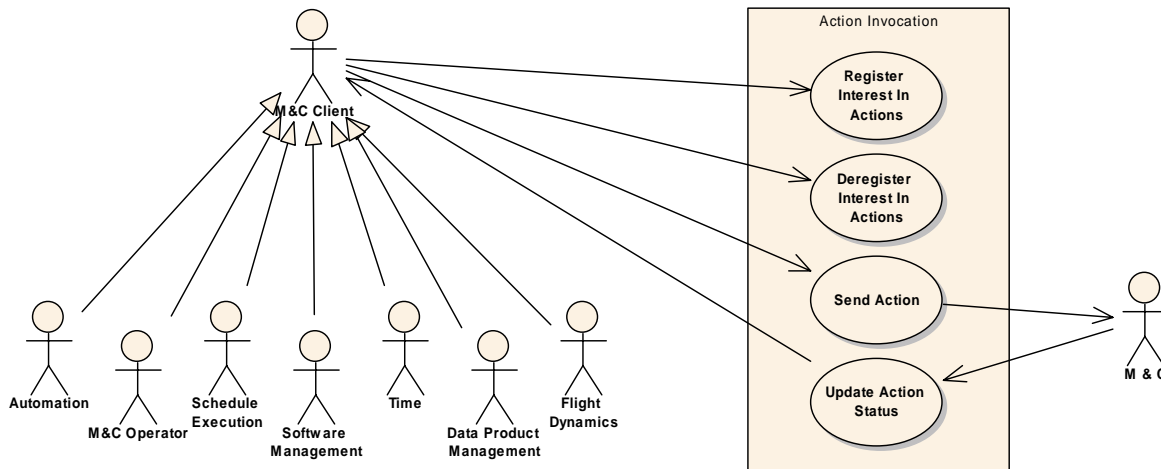


Figure A-6: Action Invocation Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Send Action
Brief Description	Use case allows a client to invoke an action (a symbolic control directive) by submitting an action request. The action request results in the creation of a new action instance, which is assigned a unique identifier. The action may be tagged for immediate execution, or tagged with an execution time.
Primary Actor	M&C Client
Preconditions	The target of the action must be available. The pre-transmission verification, if any, must be successful.
Main Success Scenarios	<ul style="list-style-type: none"> • The action is validated. • An action instance is created, and a unique identifier allocated to it. • The action is forwarded to the M&C Subsystem. • The action is registered with the initiating client, so that the client will receive updates reporting changes in the action status. • The action identifier is returned to the initiating client.

Use Case	Update Action Status
Brief Description	Use case allows a M&C System to report an update in the status of an Action.
Primary Actor	M&C (Subsystem)
Preconditions	The action must have been sent by a M&C Client.
Main Success Scenarios	<ul style="list-style-type: none"> • The action is validated. • The action status is reported all clients registered with the Action.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Register Interest In Actions
Brief Description	<p>Register to receive updates reporting status change of Actions.</p> <p>The Actions for which updates are required can be specified by any of the following methods :-</p> <p>Providing the instance identifiers - of the Actions for which updates are required.</p> <p>Providing the definition identifiers - of the Actions for which updates are required.</p> <p>Providing the Domain - updates are supplied for Actions executing in the Domain.</p>
Primary Actor	M&C Client
Preconditions	None
Main Success Scenarios	<ul style="list-style-type: none"> • The Client is registered with the identified Actions. • For all Actions identified - report their current status to the client.

Use Case	Deregister Interest In Actions
Brief Description	Use case allows a Space System to deregister for Action updates.
Primary Actor	M&C Client
Preconditions	None
Main Success Scenarios	<ul style="list-style-type: none"> • The registration between the Client and the Action is removed.

A5.2.3 Alert Notification

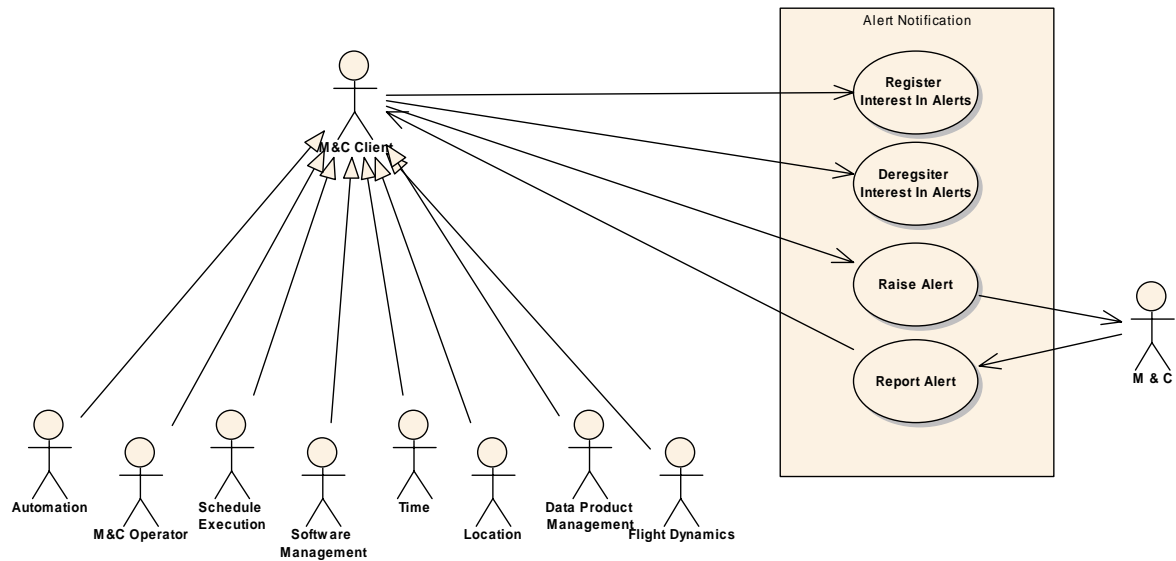


Figure A-7: Alert Notification Use Case Diagram

Use Case	Raise Alert
Brief Description	Use case allows an M&C Client to Raise an Alert.
Primary Actor	M&C Client
Preconditions	None
Main Success Scenarios	<ul style="list-style-type: none"> The Alert is forwarded to the M&C Subsystem.

Use Case	Report Alert
Brief Description	Use case allows the M&C Subsystem to report the existence of the alert.
Primary Actor	M&C (Subsystem)
Preconditions	Alert is enabled for reporting.
Main Success Scenarios	<ul style="list-style-type: none"> The Alert is validated. The Alert is forwarded to all Clients that have registered to receive notifications of the Alert.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Register Interest In Alerts
Brief Description	Register to receive notification of Alerts. The Alerts for which notifications are required can be specified by any of the following methods : Providing the definition identifiers - of the Alerts for which updates are required. Providing the Domain - notifications are supplied for Alerts raised in the Domain.
Primary Actor	M&C Client
Preconditions	None
Main Success Scenarios	<ul style="list-style-type: none"> • The Client is registered with the Alert definition.

Use Case	Deregister Interest In Alerts
Brief Description	Use case allows a Space System to deregister for Alerts.
Primary Actor	M&C Client
Preconditions	None
Main Success Scenarios	<ul style="list-style-type: none"> • The registration between the Client and the Alert definition is removed.

A5.3 OPERATIONS AUTOMATION USE CASES

A5.3.1 Activity Control Use Cases

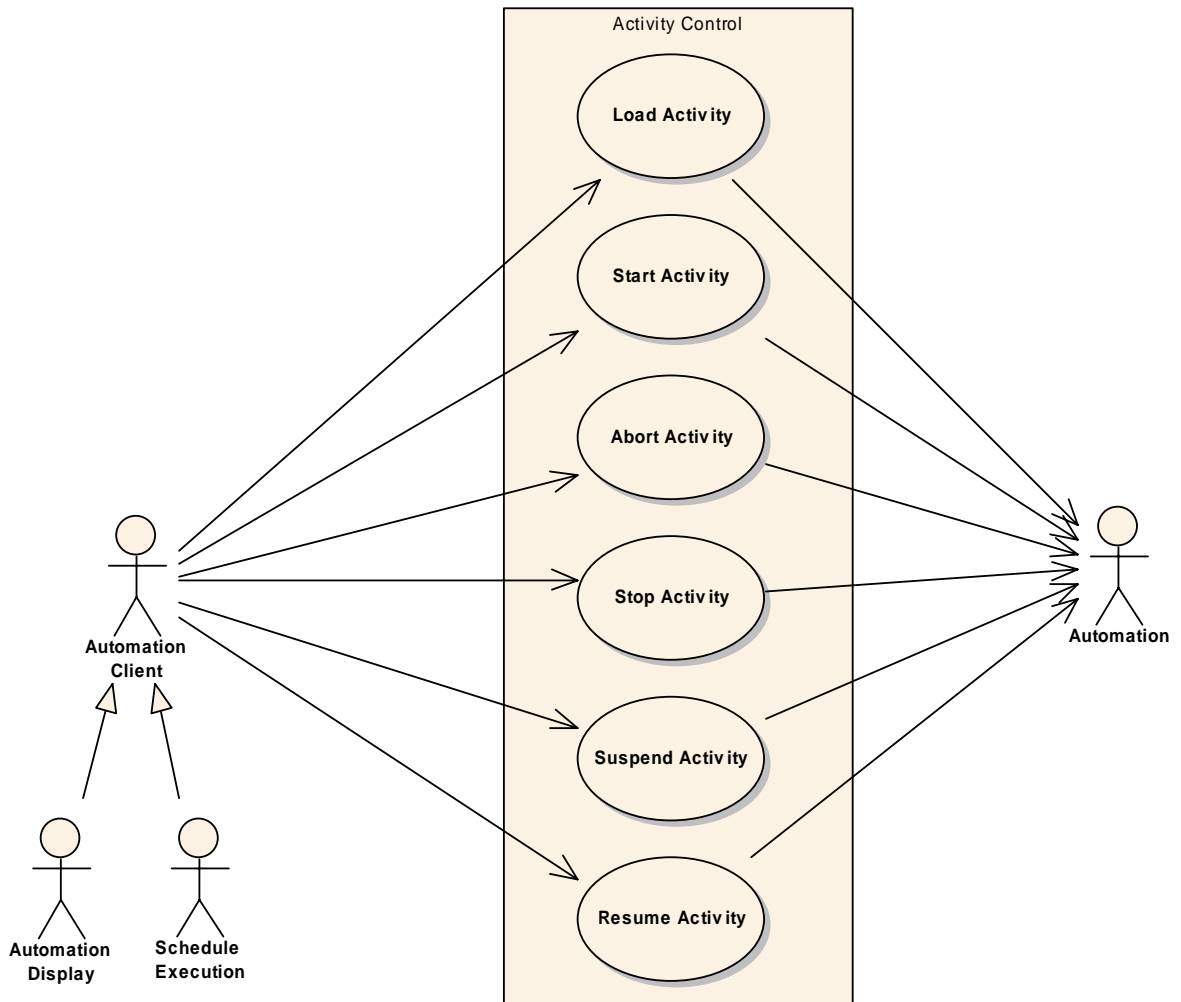


Figure A-8: Activity Control Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Load Activity
Brief Description	Loads an activity, so that it is ready for execution. An activity is an extended Operation performed autonomously.
Primary Actor	Automation Client
Preconditions	The activity exists in the Automation Execution Subsystem
Main Success Scenarios	<ul style="list-style-type: none"> • Forward load request to the Automation Execution Subsystem

Use Case	Start Activity
Brief Description	Initiates the execution of an Activity. The Start request includes the activity arguments.
Primary Actor	Automation Client
Preconditions	The Activity has been loaded. Any activity start conditions have been satisfied.
Main Success Scenarios	<ul style="list-style-type: none"> • Forward the 'Start' request to the Automation Execution Subsystem

Use Case	Stop Activity
Brief Description	Stops the execution of the Activity, at the next breakpoint.
Primary Actor	Automation Client
Preconditions	The Activity is executing.
Main Success Scenarios	<ul style="list-style-type: none"> • Forward the 'Stop' request to the Automation Execution Subsystem

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Abort Activity
Brief Description	Immediately aborts execution of the Activity.
Primary Actor	Automation Client
Preconditions	The Activity is executing.
Main Success Scenarios	<ul style="list-style-type: none"> • Forward the 'Abort' request to the Automation Execution Subsystem

Use Case	Suspend Activity
Brief Description	Suspends execution of an activity.
Primary Actor	Automation Client
Preconditions	The Activity is executing.
Main Success Scenarios	<ul style="list-style-type: none"> • Forward the 'Suspend' request to the Automation Execution Subsystem

Use Case	Resume Activity
Brief Description	Resume execution of an activity.
Primary Actor	Automation Client
Preconditions	The Automation is suspended.
Main Success Scenarios	<ul style="list-style-type: none"> • Forward the 'Resume' request to the Automation Execution Subsystem

A5.3.2 Activity Monitoring Use Cases

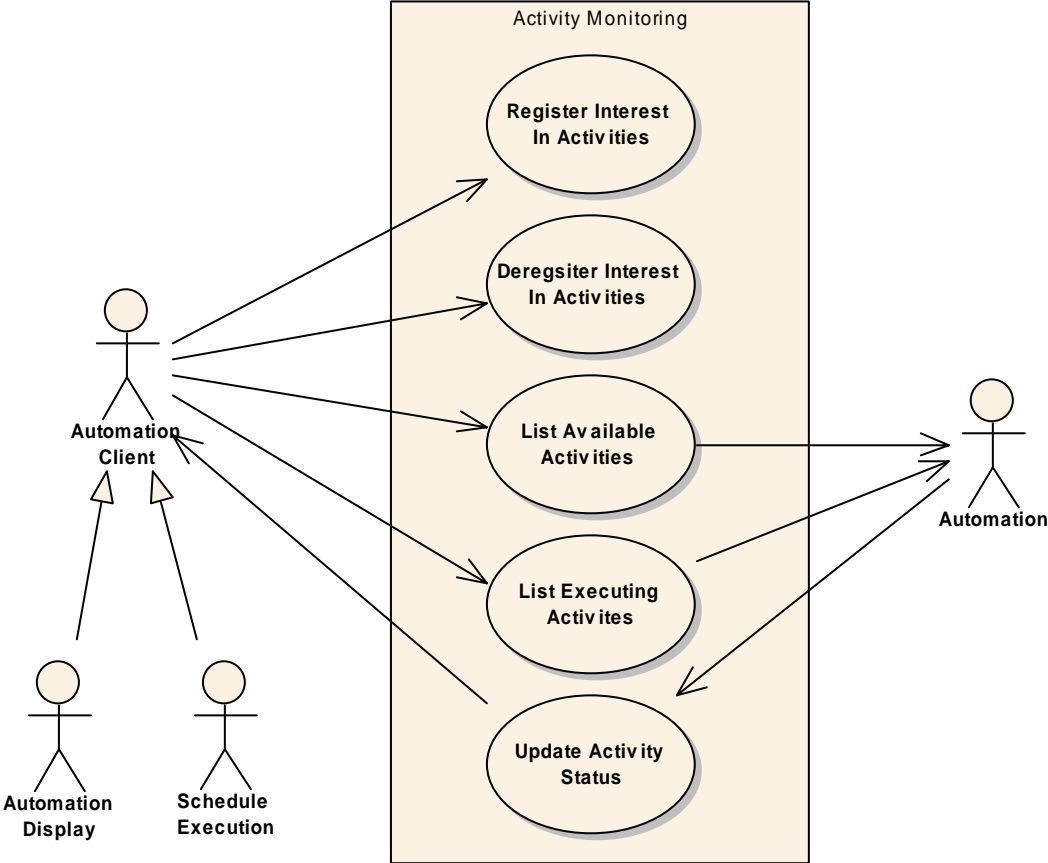


Figure A-9: Activity Monitoring Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Register Interest In Activities
Brief Description	<p>Register to receive updates reporting status change of Activities.</p> <p>The activities for which updates are required can be specified by any of the following methods :</p> <p>Providing the instance identifiers - of the activities for which updates are required.</p> <p>Providing the definition identifiers - of the activities for which updates are required.</p> <p>Providing the Domain - updates are supplied for activities executing in the Domain.</p>
Primary Actor	Automation Client
Preconditions	None
Main Success Scenarios	<ul style="list-style-type: none"> • The Client is registered with the identified activities. • For all activities identified - report their current status to the client.

Use Case	Deregister Interest In Activities
Brief Description	Deregister to receive updates reporting status change of Activities.
Primary Actor	Automation Client
Preconditions	Client has registered for the specified activities
Main Success Scenarios	<ul style="list-style-type: none"> • The registration between the Client and the activities is removed.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	List Available Activities
Brief Description	List available activities.
Primary Actor	Automation Client
Preconditions	None
Main Success Scenarios	<ul style="list-style-type: none"> • Provide the Client with a list of all Activities that are available for execution.

Use Case	List Executing Activities
Brief Description	List executing activities.
Primary Actor	Automation Client
Preconditions	None
Main Success Scenarios	<ul style="list-style-type: none"> • Provide the Client with a list of all Activities that are currently executing.

Use Case	Update Activity Status
Brief Description	Update the execution status of an activity
Primary Actor	Automation (Subsystem)
Preconditions	None
Main Success Scenarios	<ul style="list-style-type: none"> • Report the Activity Status to all Clients which have registered to receive updates for the Activity

A5.4 OPERATIONS SCHEDULING USE CASES

A5.4.1 Schedule Level Control Use Cases

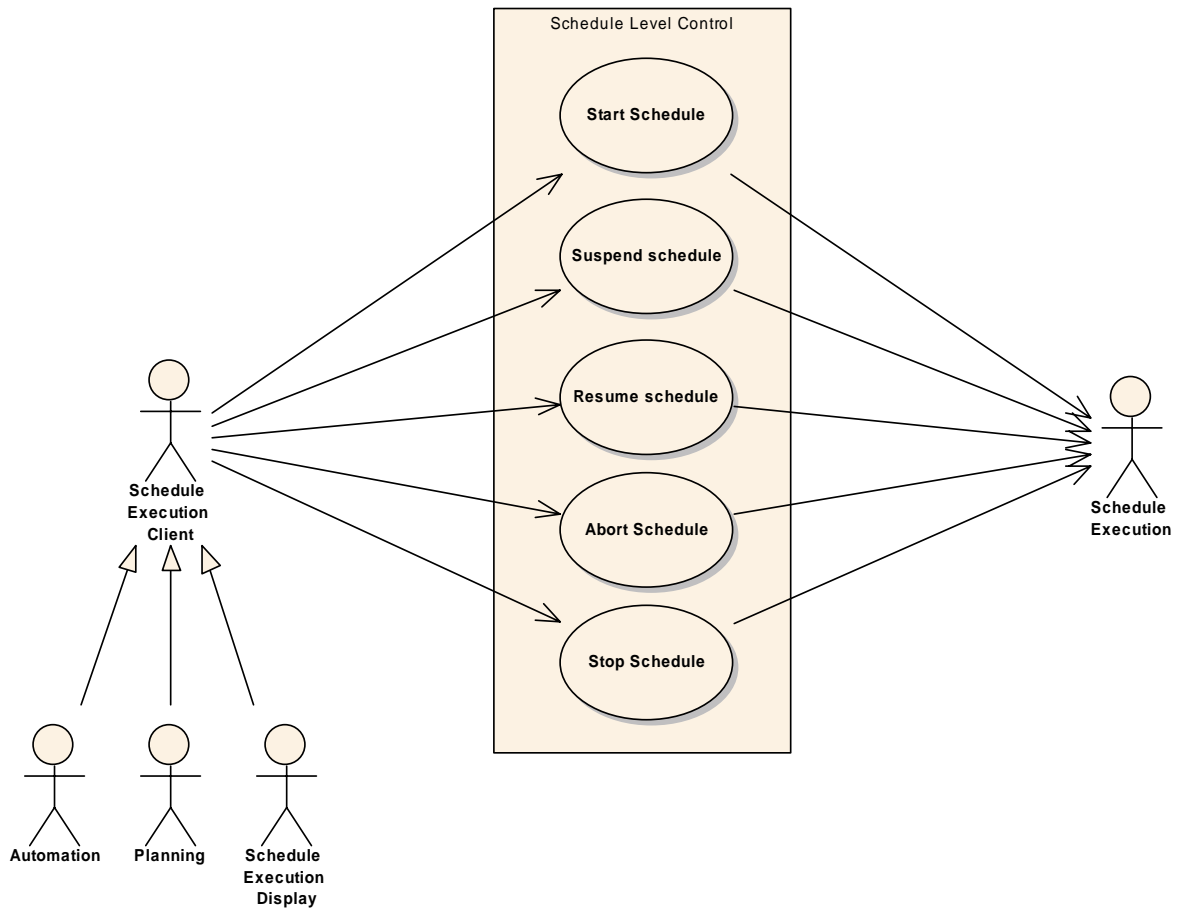


Figure A-10: Schedule Level Control Use Case Diagram

Use Case	Start Schedule
Brief Description	Initiates the execution of a schedule.
Primary Actor	Schedule Execution Client
Preconditions	No other schedule is active.
Main Success Scenarios	<ul style="list-style-type: none"> Forward the 'Start' request to the Schedule Execution Subsystem

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Suspend Schedule
Brief Description	Further execution of elements on the active schedule is suspended.
Primary Actor	Schedule Execution Client
Preconditions	The schedule is currently active.
Main Success Scenarios	<ul style="list-style-type: none"> • The active schedule is suspended.

Use Case	Resume Schedule
Brief Description	Resume execution of elements on the suspended schedule.
Primary Actor	Schedule Execution Client
Preconditions	The schedule is suspended.
Main Success Scenarios	<ul style="list-style-type: none"> • The suspended schedule is resumed.

Use Case	Stop Schedule
Brief Description	Stops the execution of the schedule, at the next breakpoint.
Primary Actor	Schedule Execution Client
Preconditions	The schedule is executing.
Main Success Scenarios	<ul style="list-style-type: none"> • Forward the 'Stop' request to the Schedule Execution Subsystem

Use Case	Abort Schedule
Brief Description	Immediately aborts execution of the schedule.
Primary Actor	Schedule Execution Client
Preconditions	The schedule is executing.
Main Success Scenarios	<ul style="list-style-type: none"> Forward the 'Abort' request to the Schedule Execution Subsystem

A5.4.2 Schedule Maintenance



Figure A-11: Schedule Maintenance Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Create Schedule
Brief Description	Creates a new blank schedule inside the schedule system.
Primary Actor	Schedule Execution Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Blank schedule is created.

Use Case	Copy Schedule
Brief Description	Copies an existing schedule into a new schedule.
Primary Actor	Schedule Execution Client
Preconditions	Schedule to be copied exists.
Main Success Scenarios	<ul style="list-style-type: none"> • New schedule created which is a duplicate of existing one.

Use Case	Delete Schedule
Brief Description	Deletes an existing schedule from the schedule system.
Primary Actor	Schedule Execution Client
Preconditions	Schedule exists.
Main Success Scenarios	<ul style="list-style-type: none"> • Schedule is deleted.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Merge Schedule
Brief Description	Merge provided schedule with currently active schedule.
Primary Actor	Schedule Execution Client
Preconditions	The schedules exist. The time period of the schedule to merge is in the future.
Main Success Scenarios	<ul style="list-style-type: none"> Active schedule is updated to include new items.

Use Case	Append Schedule
Brief Description	A provided schedule is appended to the end of the active schedule.
Primary Actor	Schedule Execution Client
Preconditions	The schedules exist. The time period of the schedule to append is in the future.
Main Success Scenarios	<ul style="list-style-type: none"> Active schedule is appended to.

Use Case	Replace Schedule
Brief Description	A provided schedule is used to replace the active schedule.
Primary Actor	Schedule Execution Client
Preconditions	The schedules exist. The time period of the new schedule is in the future.
Main Success Scenarios	<ul style="list-style-type: none"> The active schedule is cleared and the provided schedule is inserted in its place.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Clear Schedule
Brief Description	The active schedule is cleared of all items.
Primary Actor	Schedule Execution Client
Preconditions	The schedule exists.
Main Success Scenarios	<ul style="list-style-type: none"> • The active schedule is cleared.

Use Case	Time Shift Schedule
Brief Description	The execution times of the elements in the active schedule are time shifted by the desired amount. This can be a positive or negative amount.
Primary Actor	Schedule Execution Client
Preconditions	The elements in the schedule exist.
Main Success Scenarios	<ul style="list-style-type: none"> • The required elements are shifted by the correct amount.

A5.4.3 Schedule Activity Level Control Use Cases

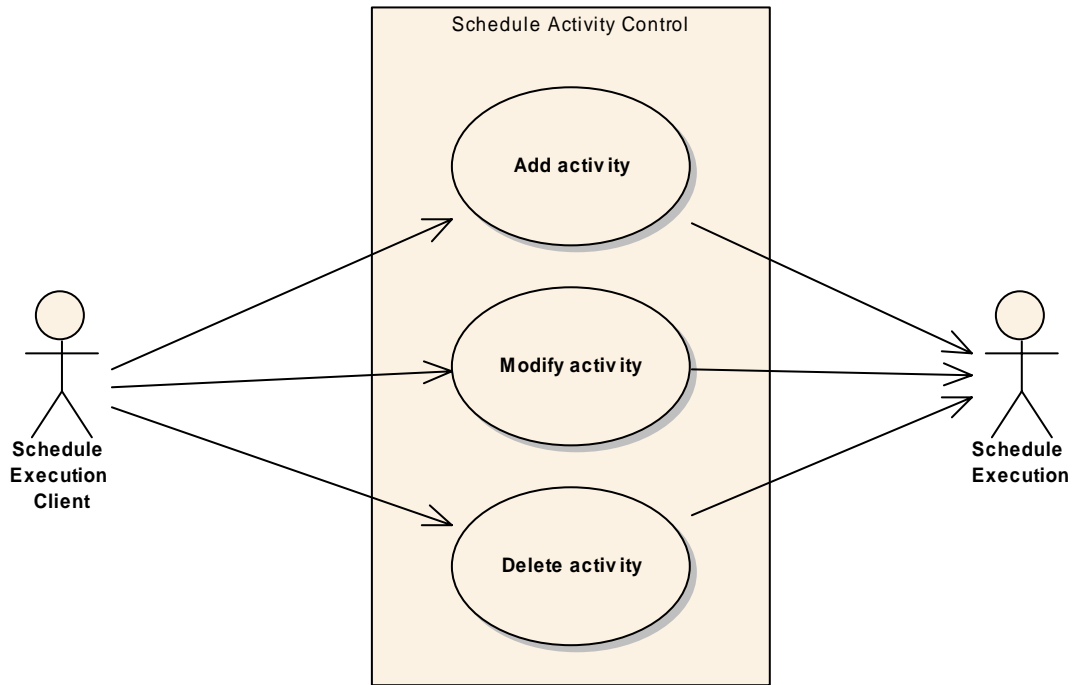


Figure A-12: Schedule Activity Control Use Case Diagram

Use Case	Add Activity
Brief Description	Adds an activity to the current active schedule.
Primary Actor	Schedule Execution Client
Preconditions	Activity does not already exist in schedule.
Main Success Scenarios	<ul style="list-style-type: none"> Activity is inserted into the schedule.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Modify Activity
Brief Description	Modify an activity in the schedule.
Primary Actor	Schedule Execution Client
Preconditions	Activity exists in the schedule.
Main Success Scenarios	<ul style="list-style-type: none"> • Activity is modified.

Use Case	Delete Activity
Brief Description	Removes from the schedule a particular activity.
Primary Actor	Schedule Execution Client
Preconditions	Activity exists in the schedule.
Main Success Scenarios	<ul style="list-style-type: none"> • Activity is deleted.

A5.4.4 Schedule Monitoring Use Cases

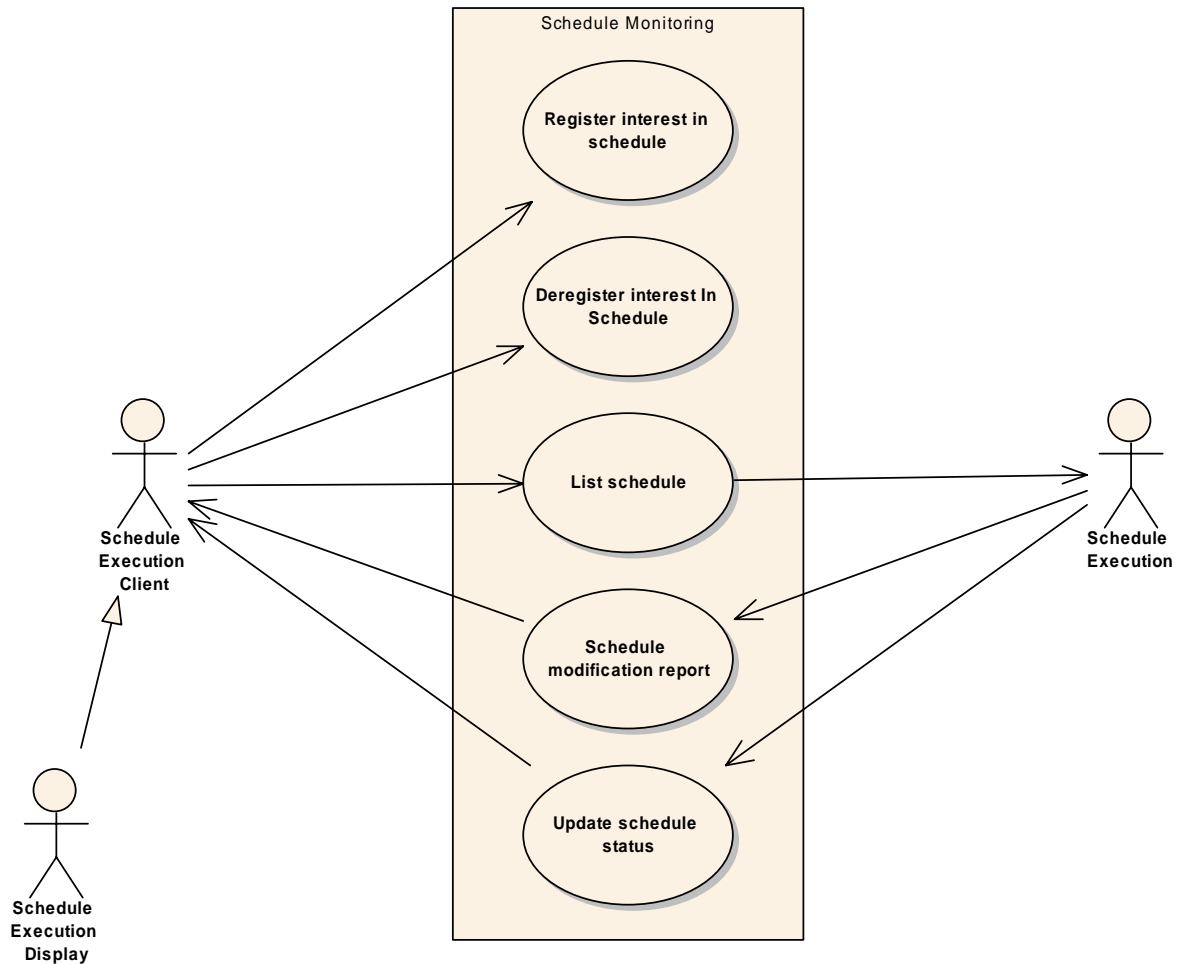


Figure A-13: Schedule Monitoring Use Case Diagram

Use Case	Register Interest In Schedule
Brief Description	Register to receive updates reporting status change of schedule.
Primary Actor	Schedule Execution Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • The Client is registered with the schedule. • Report the current status to the client.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Deregister Interest In Schedule
Brief Description	Deregister to receive updates reporting status change of schedule.
Primary Actor	Schedule Execution Client
Preconditions	Client has registered.
Main Success Scenarios	<ul style="list-style-type: none"> The registration between the Client and the schedule is removed.

Use Case	List Schedule
Brief Description	List the schedule.
Primary Actor	Schedule Execution Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> Provide the Client with a list of all Activities that are currently contained in the schedule.

Use Case	Schedule Modification Report
Brief Description	Update the client with a notification of a modification of the schedule.
Primary Actor	Schedule Execution
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> Report the modification to all Clients which have registered to receive modification reports.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Update Schedule Status
Brief Description	Update the execution status of the schedule.
Primary Actor	Schedule Execution
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none">• Report the Schedule Status to all Clients which have registered to receive updates for the Schedule.

A5.5 OPERATIONS PLANNING USE CASES

A5.5.1 Planning Control Use Cases

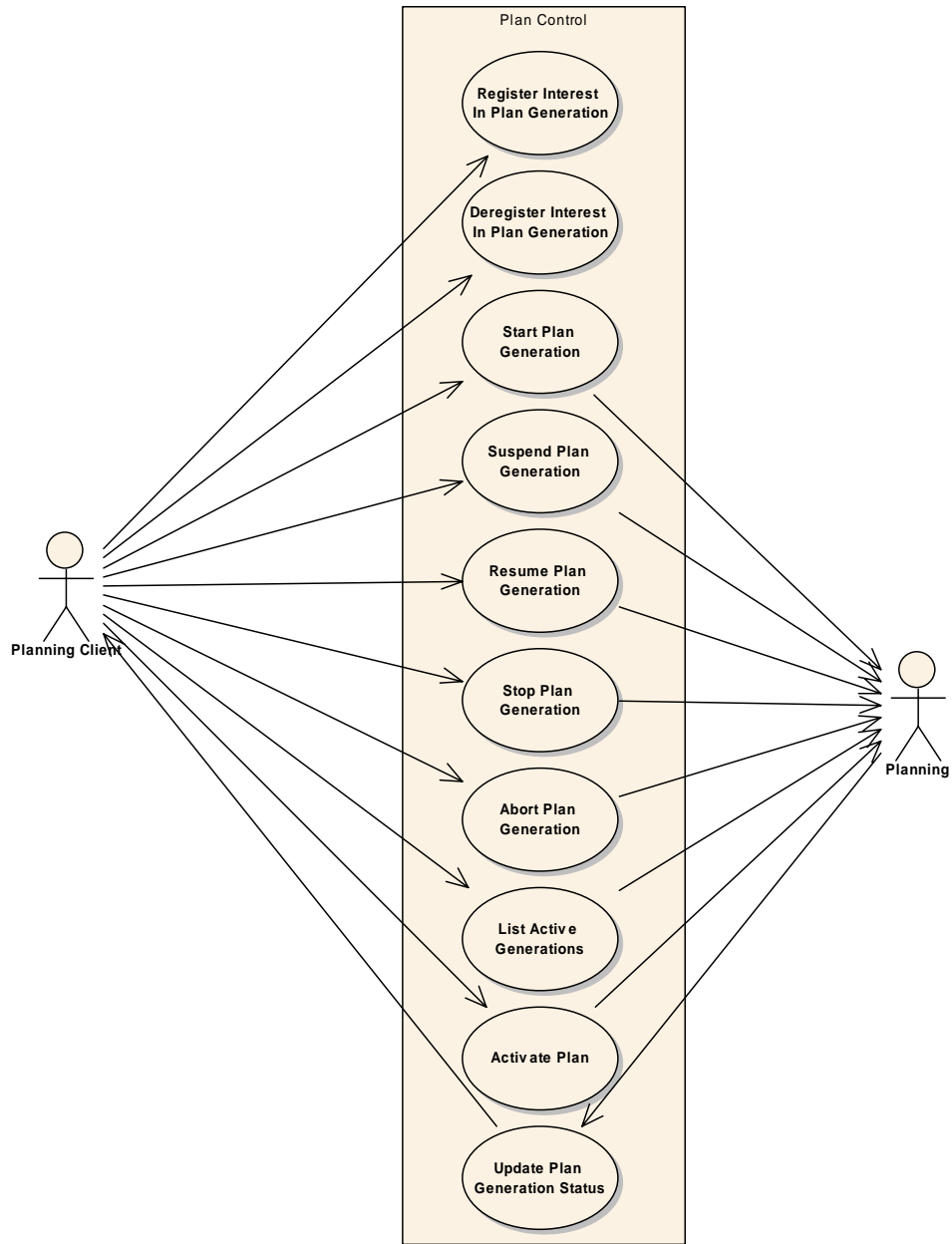


Figure A-14: Planning Control Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Register Interest In Plan Generation
Brief Description	Allows the client to register for status updates for selected plan generation events.
Primary Actor	Planning Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Client is registered for plan generation events. • Report the current status to the client.

Use Case	Deregister Interest In Plan Generation
Brief Description	Allows a client to remove themselves from the list of clients to be notified of plan generation events.
Primary Actor	Planning Client
Preconditions	The client is previously registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Client is no longer notified of plan generation events.

Use Case	Start Plan Generation
Brief Description	Initiates the generation of a plan.
Primary Actor	Planning Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • The generation is started.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Suspend Plan Generation
Brief Description	Further generation of elements on the plan is suspended.
Primary Actor	Planning Client
Preconditions	The generation is currently active.
Main Success Scenarios	<ul style="list-style-type: none"> • The active generation is suspended.

Use Case	Resume Plan Generation
Brief Description	Resume generation of elements on the suspended plan.
Primary Actor	Planning Client
Preconditions	The generation is suspended.
Main Success Scenarios	<ul style="list-style-type: none"> • The suspended generation is resumed.

Use Case	Stop Plan Generation
Brief Description	Stops the generation of the plan, at the next breakpoint. Could possibly allow the generation to be started again from this point.
Primary Actor	Planning Client
Preconditions	The generation is currently active or suspended.
Main Success Scenarios	<ul style="list-style-type: none"> • The generation is stopped.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Abort Plan Generation
Brief Description	Immediately aborts generation of the plan. No restart of the generation is possible unless it is completely restarted.
Primary Actor	Planning Client
Preconditions	The generation is currently active or suspended.
Main Success Scenarios	<ul style="list-style-type: none"> • The generation is aborted.

Use Case	List Active Plan Generations
Brief Description	Returns the complete list of active plan generations.
Primary Actor	Planning Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • The list is returned.

Use Case	Update Plan Generation Status
Brief Description	Notification to the client of a status change in the generation.
Primary Actor	Planning
Preconditions	Client has registered for updates.
Main Success Scenarios	<ul style="list-style-type: none"> • All registered client receive the update.

A5.5.2 Plan Level Maintenance Use Cases

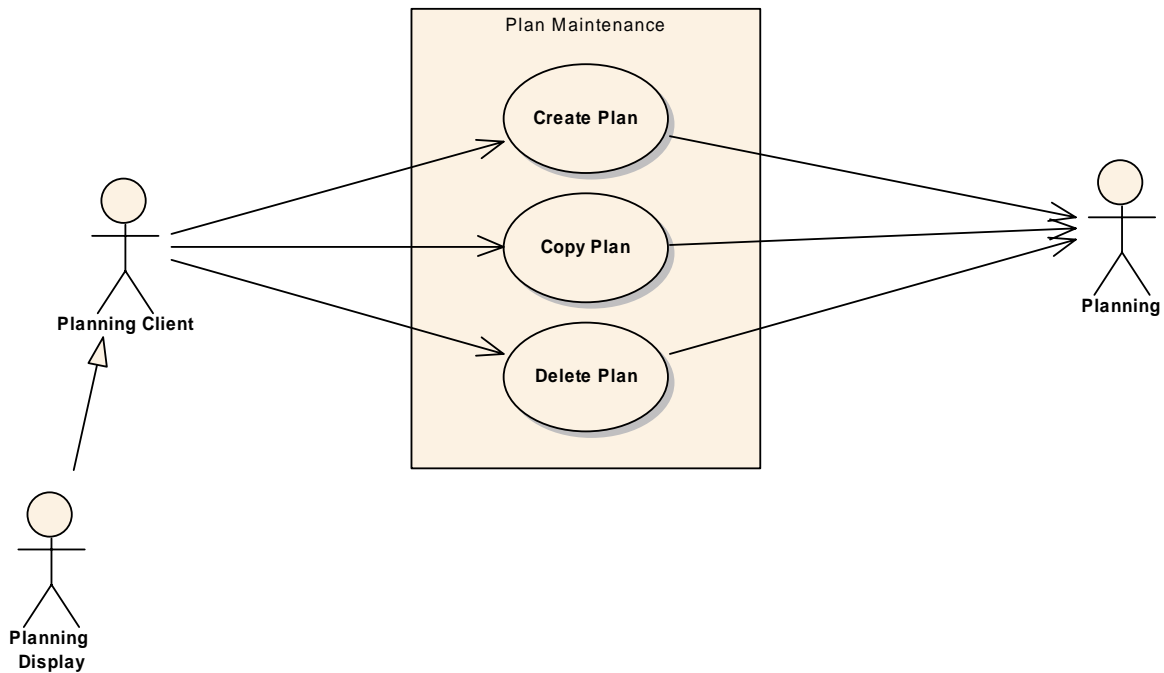


Figure A-15: Plan Maintenance Use Case Diagram

Use Case	Create Plan
Brief Description	Creates a new blank plan inside the planning system.
Primary Actor	Planning Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> Blank plan is created.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Copy Plan
Brief Description	Copies an existing plan into a new plan.
Primary Actor	Planning Client
Preconditions	Plan to be copied exists.
Main Success Scenarios	<ul style="list-style-type: none"> • New plan created which is a duplicate of existing one.

Use Case	Delete Plan
Brief Description	Deletes an existing plan from the planning system.
Primary Actor	Planning Client
Preconditions	Plan exists.
Main Success Scenarios	<ul style="list-style-type: none"> • Plan is deleted.

A5.5.3 Plan Task Level Maintenance Use Cases



Figure A-16: Planning Task Maintenance Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Register Interest In Element Status
Brief Description	Allows the client to register for status updates for selected plan elements. Plan elements include: Plans Tasks <ul style="list-style-type: none"> ▪ Activities ▪ Actions Constraints
Primary Actor	Planning Client
Preconditions	Elements exist.
Main Success Scenarios	<ul style="list-style-type: none"> • Client is registered for updates. • Report the current status to the client.

Use Case	Deregister Interest In Element Status
Brief Description	Removes the client from receiving updates about the selected elements.
Primary Actor	Planning Client
Preconditions	Client is already registered to receive updates.
Main Success Scenarios	<ul style="list-style-type: none"> • Client is deregistered for updates.

Use Case	Add Task
Brief Description	A task is added to a plan.
Primary Actor	Planning Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Task is added.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Modify Task
Brief Description	An existing task is modified.
Primary Actor	Planning Client
Preconditions	Task exists.
Main Success Scenarios	<ul style="list-style-type: none"> • Task is modified.

Use Case	Delete Task
Brief Description	Deletes a task from an existing plan.
Primary Actor	Planning Client
Preconditions	Task exists.
Main Success Scenarios	<ul style="list-style-type: none"> • Task is removed from the plan.

Use Case	Add Constraint
Brief Description	Adds a constraint to a plan. A constraint can be on a element or between elements.
Primary Actor	Planning Client
Preconditions	Element being constrained exists.
Main Success Scenarios	<ul style="list-style-type: none"> • Constraint is inserted in plan.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Modify Constraint
Brief Description	Modify an existing constraint.
Primary Actor	Planning Client
Preconditions	Constraint exists.
Main Success Scenarios	<ul style="list-style-type: none"> • Constraint is modified.

Use Case	Delete Constraint
Brief Description	Delete an existing constraint from a plan.
Primary Actor	Planning Client
Preconditions	Constraint exists.
Main Success Scenarios	<ul style="list-style-type: none"> • Constraint is removed from the plan.

Use Case	Update Element Status
Brief Description	Send notification of an update to an element to all registered clients.
Primary Actor	Planning
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • All registered clients are notified of update.

A5.5.4 Plan Monitoring Use Cases

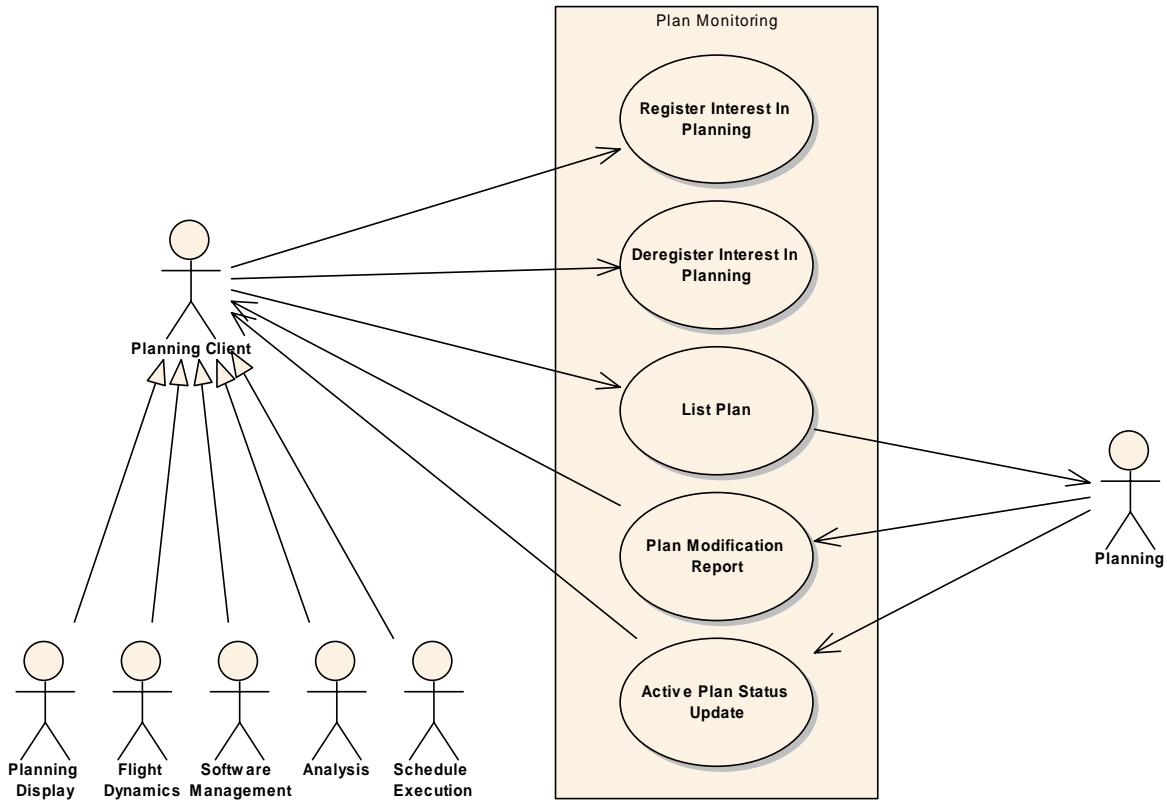


Figure A-17: Plan Monitoring Use Case Diagram

Use Case	Register Interest In Planning
Brief Description	Allows the client to register for status updates for selected planning events.
Primary Actor	Planning Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Client is registered for planning events. • Report the current status to the client.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Deregister Interest In Planning
Brief Description	Allows a client to remove themselves from the list of clients to be notified of planning events.
Primary Actor	Planning Client
Preconditions	The client is previously registered.
Main Success Scenarios	<ul style="list-style-type: none"> Client is no longer notified of planning events.

Use Case	List Plan
Brief Description	Returns the complete plan, or a subsection of, the plan to the client.
Primary Actor	Planning Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> The requested plan is returned.

Use Case	Plan Modification Report
Brief Description	Summary report of any modification made to the active plan.
Primary Actor	Planning
Preconditions	Client had registered for updates.
Main Success Scenarios	<ul style="list-style-type: none"> All registered clients receive the update.

Use Case	Active Plan Status Update
Brief Description	Notification to the client of a status change in the active plan.
Primary Actor	Planning
Preconditions	Client has registered for updates.
Main Success Scenarios	<ul style="list-style-type: none"> All registered client receive the update.

A5.6 GUIDANCE, TRACKING AND SYNCHRONISATION USE CASES

A5.6.1 Time use cases

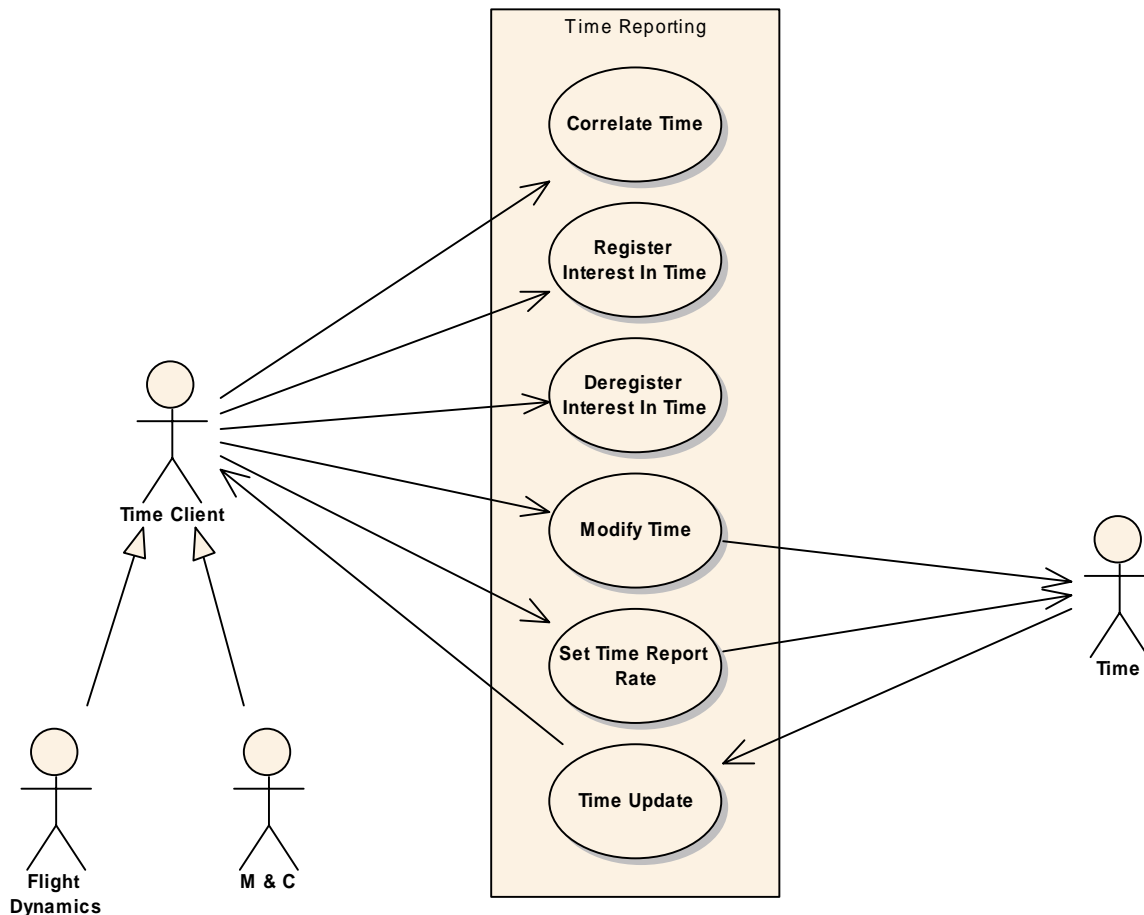


Figure A-18: Time Reporting Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Correlate Time
Brief Description	Converts time between UTC and onboard time when not using onboard time synchronisation.
Primary Actor	Time Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Time is converted.

Use Case	Register Interest In Time
Brief Description	Allows a client to register interest in time reports.
Primary Actor	Time Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Client is registered for time reports.

Use Case	Deregister Interest In Time
Brief Description	Allows a previously registered client to stop receiving time reports.
Primary Actor	Time Client
Preconditions	Client was previously registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Client no long receives time reports.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Modify Time
Brief Description	<p>Allows a client to adjust the remote time. Several methods of time update may be supported such as:</p> <ul style="list-style-type: none"> • Relative values, i.e., add/subtract x milliseconds. • Absolute time reset at absolute time, i.e., at time X reset time to time Y • Specification of a creep rate, i.e., add/subtract one cycle every 10 million cycles
Primary Actor	Time Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Time is updated.

Use Case	Set Time Report Rate
Brief Description	Set the time reporting rate.
Primary Actor	Time Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Time reporting rate is modified.

Use Case	Time Update
Brief Description	Time update is sent.
Primary Actor	Time
Preconditions	Client has registered for updates.
Main Success Scenarios	<ul style="list-style-type: none"> • All registered client receive a time update.

A5.6.2 Location Reporting use cases

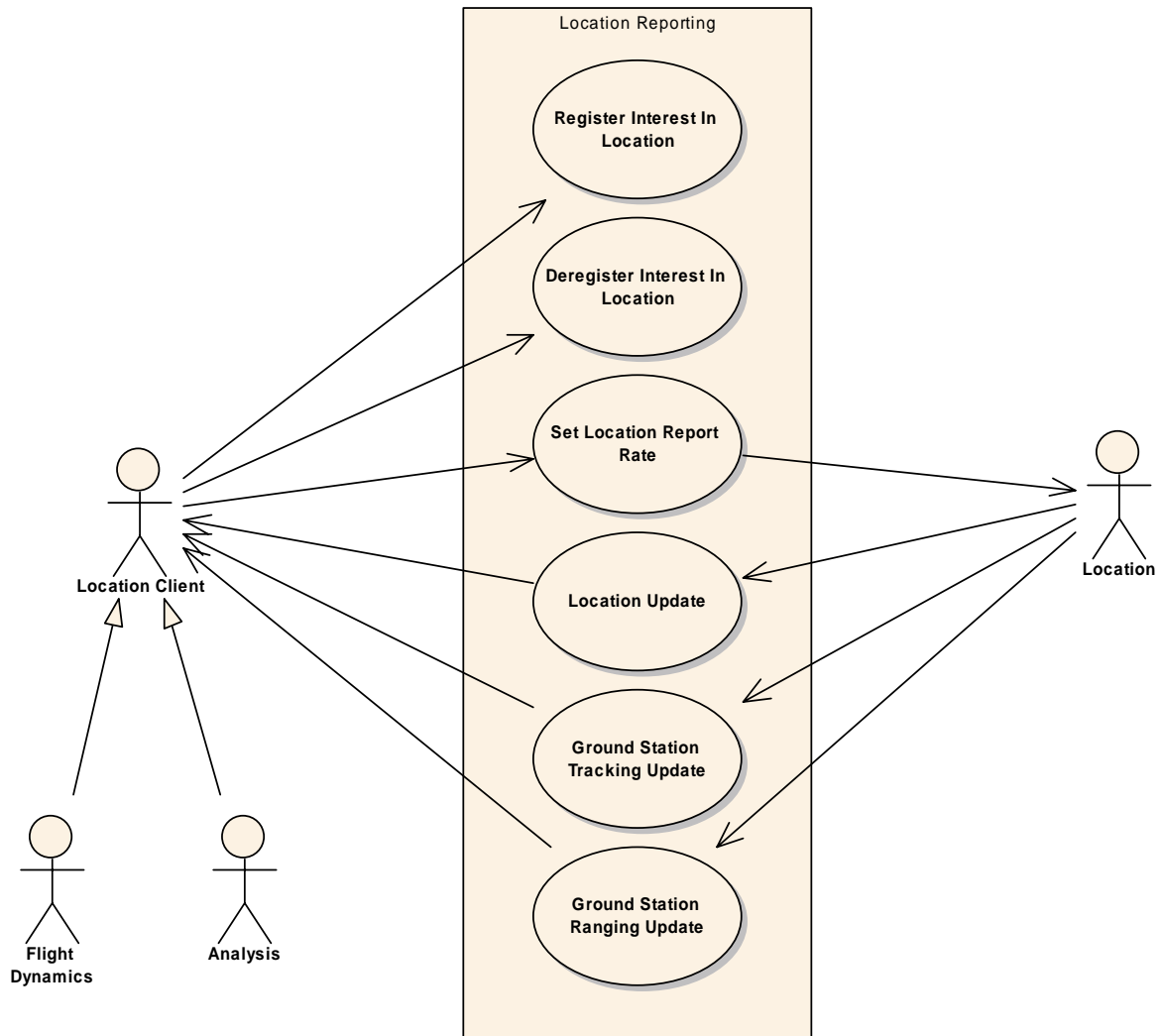


Figure A-19: Location Reporting Use Case Diagram

Use Case	Register Interest In Location
Brief Description	Allows a client to register interest in location reports.
Primary Actor	Location Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> Client is registered for location reports.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Deregister Interest In Location
Brief Description	Allows a previously registered client to stop receiving location reports.
Primary Actor	Location Client
Preconditions	Client was previously registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Client no long receives location reports.

Use Case	Set Location Report Rate
Brief Description	Set the location reporting rate. Most probably only supported by spacecraft supporting onboard location service.
Primary Actor	Location Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Location reporting rate is modified.

Use Case	Location Update
Brief Description	Location update is sent.
Primary Actor	Location
Preconditions	Client has registered for updates.
Main Success Scenarios	<ul style="list-style-type: none"> • All registered client receive a location update.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Ground Station Tracking Update
Brief Description	Tracking update is sent.
Primary Actor	Location
Preconditions	Client has registered for updates.
Main Success Scenarios	<ul style="list-style-type: none"> • All registered client receive a tracking update.

Use Case	Ground Station Ranging Update
Brief Description	Ranging update is sent.
Primary Actor	Location
Preconditions	Client has registered for updates.
Main Success Scenarios	<ul style="list-style-type: none"> • All registered client receive a ranging update.

A5.6.3 Location Control use cases

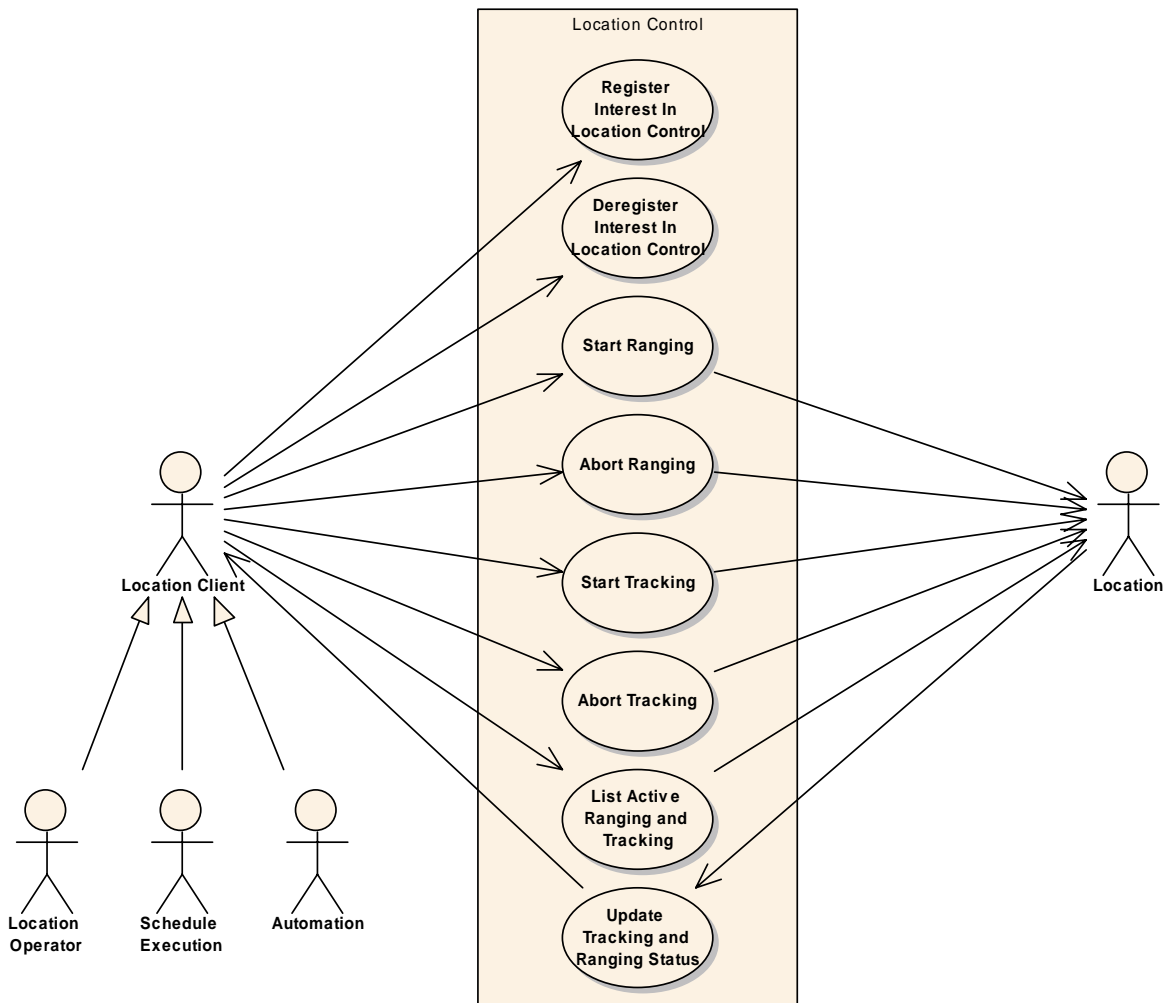


Figure A-20: Location Control Use Case Diagram

Use Case	Register Interest In Location Control
Brief Description	Allows a client to register interest in location control updates.
Primary Actor	Location Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> Client is registered for location control updates.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Deregister Interest In Location Control
Brief Description	Allows a previously registered client to stop receiving location control updates.
Primary Actor	Location Client
Preconditions	Client was previously registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Client no long receives location control updates.

Use Case	Start Ranging
Brief Description	Client requests the start of the ranging operation.
Primary Actor	Location Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Ranging starts.

Use Case	Abort Ranging
Brief Description	Aborts a previously active ranging task.
Primary Actor	Location Client
Preconditions	Ranging is active.
Main Success Scenarios	<ul style="list-style-type: none"> • Ranging task is aborted.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Start Tracking
Brief Description	Client requests the start of the tracking operation.
Primary Actor	Location Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Tracking starts.

Use Case	Abort Tracking
Brief Description	Aborts a previously active tracking task.
Primary Actor	Location Client
Preconditions	Tracking is active.
Main Success Scenarios	<ul style="list-style-type: none"> • Tracking task is aborted.

Use Case	List Active Ranging and Tracking
Brief Description	Provide the client with a list of active operations and their status.
Primary Actor	Location Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Provide the Client with a list of all operations that are currently active.

Use Case	Update Ranging and Tracking Status
Brief Description	Ranging or Tracking update is sent.
Primary Actor	Location Client
Preconditions	Client has registered for updates.
Main Success Scenarios	<ul style="list-style-type: none"> All registered clients receive the update.

A5.6.4 Flight Dynamics Control use cases

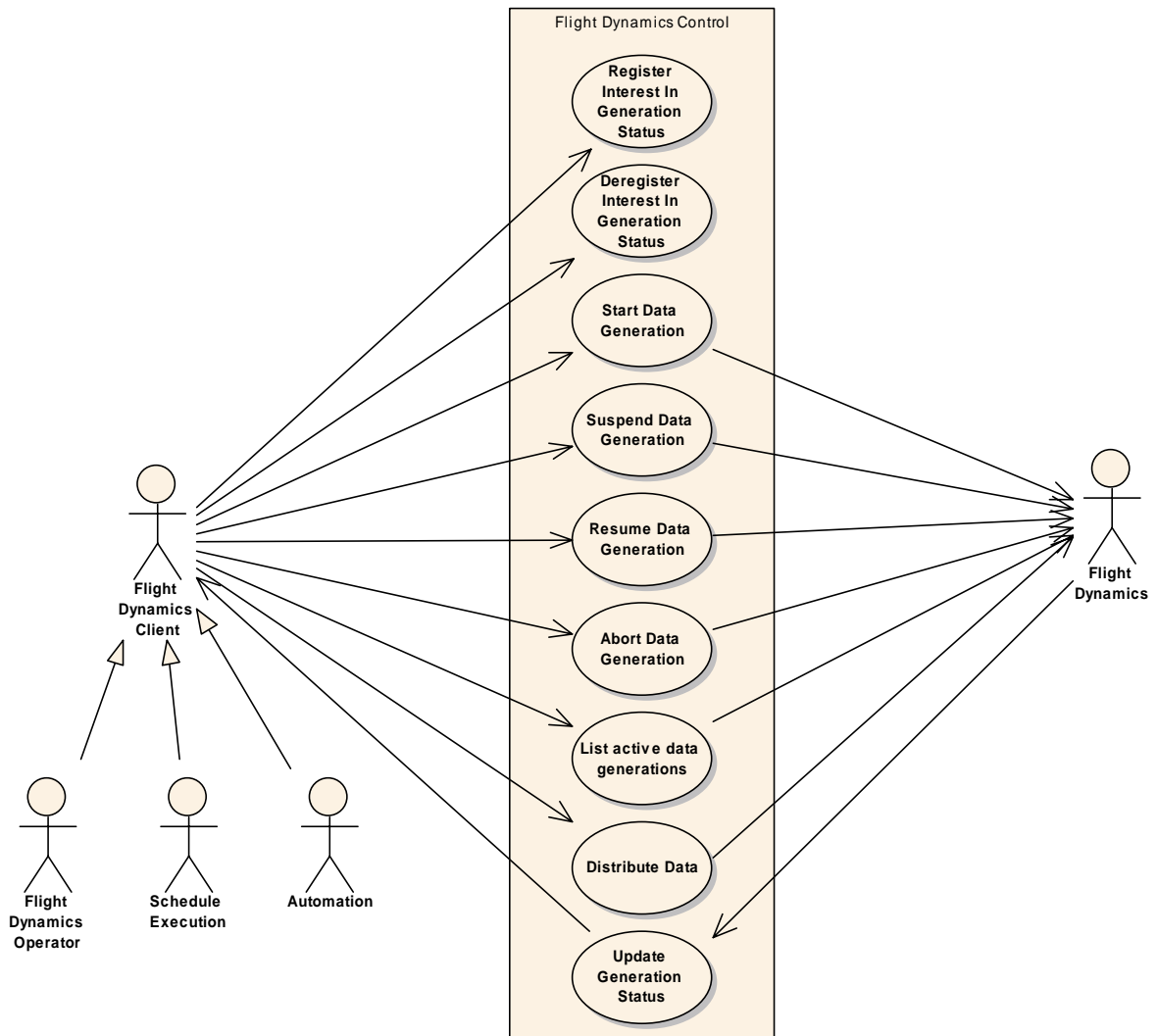


Figure A-21: Flight Dynamics Control Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Register Interest In Generation Status
Brief Description	Allows a client to register interest in flight dynamics generation status.
Primary Actor	Flight Dynamics Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Client is registered for generation status notification. • Report the current status to the client.

Use Case	Deregister Interest In Generation Status
Brief Description	Allows a previously registered client to stop receiving flight dynamics generation status.
Primary Actor	Flight Dynamics Client
Preconditions	Client was previously registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Client no long receives generation status notification.

Use Case	Start Data Generation
Brief Description	Client requests the start of the generation of some flight dynamics data. Data items include: <ul style="list-style-type: none"> • Orbit vectors • Ground station visibilities • Predicted events • Antenna steering data • Attitude data • Physical state data • Manoeuvre control data • Fuel budget assessment • End of Life prediction
Primary Actor	Flight Dynamics Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Data generation starts.

Use Case	Suspend Data Generation
Brief Description	Client requests that the data generation is suspended.
Primary Actor	Flight Dynamics Client
Preconditions	Data generation is active.
Main Success Scenarios	<ul style="list-style-type: none"> • The active generation is suspended.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Resume Data Generation
Brief Description	Resumes a previously suspended generation.
Primary Actor	Flight Dynamics Client
Preconditions	Data generation is suspended.
Main Success Scenarios	<ul style="list-style-type: none"> The suspended generation is resumed.

Use Case	Abort Data Generation
Brief Description	Aborts a previously active or suspended generation task.
Primary Actor	Flight Dynamics Client
Preconditions	Data generation is active or suspended.
Main Success Scenarios	<ul style="list-style-type: none"> Generation task is aborted.

Use Case	List Active Data Generations
Brief Description	Provide the client with a list of active data generations and their status.
Primary Actor	Flight Dynamics Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> Provide the Client with a list of all generations that are currently executing.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Distribute Data
Brief Description	Triggers the distribution to data clients of the result of a generation operation.
Primary Actor	Flight Dynamics Client
Preconditions	The generation operation must have completed successfully.
Main Success Scenarios	<ul style="list-style-type: none"> • The data product is distributed.

Use Case	Update Generation Status
Brief Description	Informs clients registered for updates of a change in the state of a generation task.
Primary Actor	Flight Dynamics
Preconditions	Client is registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Report the generation to all Clients which have registered to receive updates.

A5.6.5 Flight Dynamics Monitoring use cases

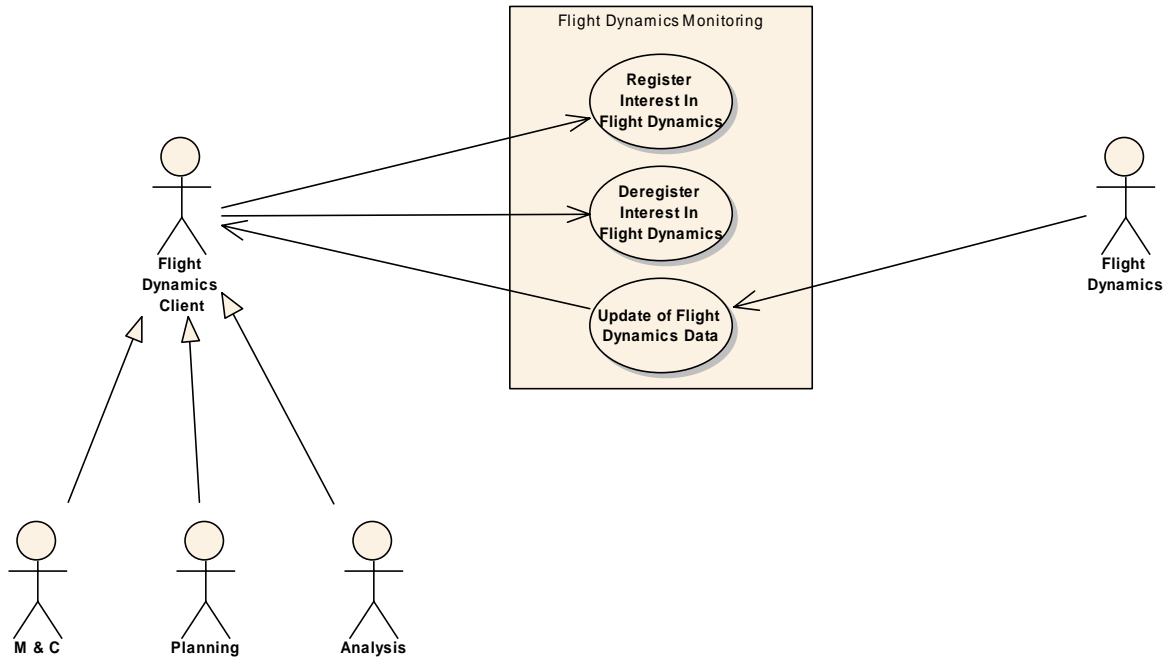


Figure A-22: Flight Dynamics Monitoring Use Case Diagram

Use Case	Register Interest In Flight Dynamics
Brief Description	<p>Allows a client to register interest in flight dynamics data. The registration allows the client to select the type of data it wants to receive. Data items include:</p> <ul style="list-style-type: none"> • Orbit vectors • Ground station visibilities • Predicted events • Antenna steering data • Attitude data • Physical state data • Manoeuvre control data • Fuel budget assessment • End of Life prediction
Primary Actor	Flight Dynamics Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Client is registered for data notification. • Report the current status to the client.

Use Case	Deregister Interest In Flight Dynamics
Brief Description	Allows a previously registered client to stop receiving flight dynamics data.
Primary Actor	Flight Dynamics Client
Preconditions	Client was previously registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Client no long receives data.

Use Case	Update Of Flight Dynamics Data
Brief Description	A new version of a data files has been distributed.
Primary Actor	Flight Dynamics
Preconditions	Client is registered.
Main Success Scenarios	<ul style="list-style-type: none"> Send the data to all Clients which have registered to receive it.

A5.7 REMOTE SOFTWARE MANAGEMENT USE CASES

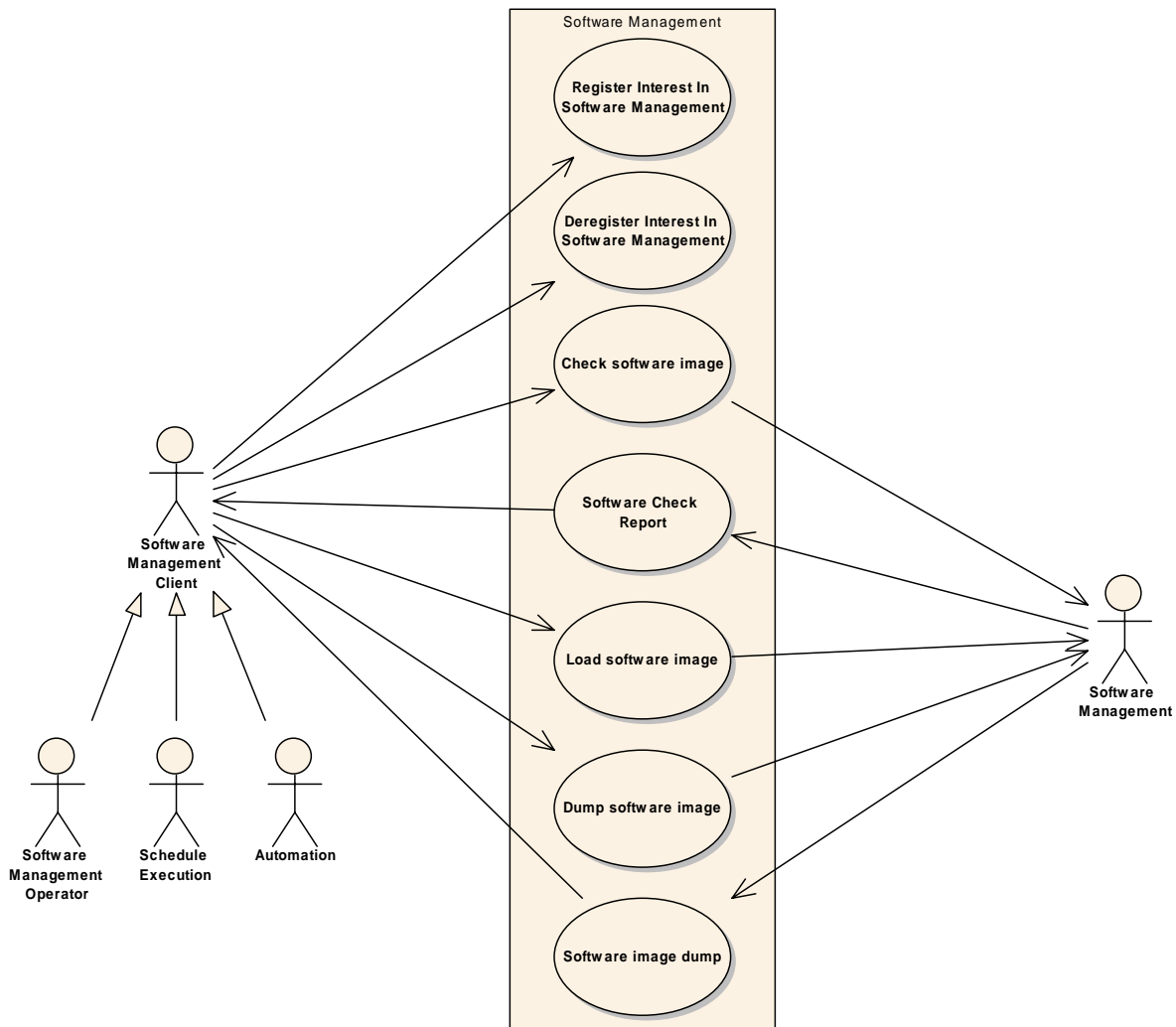


Figure A-23: Software Management Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Register Interest In Software Management
Brief Description	Allows a client to register interest in Software Management data.
Primary Actor	Software Management Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Client is registered for data notification.

Use Case	Deregister Interest In Software Management
Brief Description	Allows a previously registered client to stop receiving Software Management data.
Primary Actor	Software Management Client
Preconditions	Client was previously registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Client no long receives data.

Use Case	Check Software Image
Brief Description	Triggers the check summing of the software image.
Primary Actor	Software Management Client
Preconditions	Software Image exists.
Main Success Scenarios	<ul style="list-style-type: none"> • The check sums are returned to the client.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Software Check Report
Brief Description	Reports the result of a software check.
Primary Actor	Software Management
Preconditions	Client is registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Send the data to all Clients which have registered to receive it.

Use Case	Load Software Image
Brief Description	Triggers the load of a software image.
Primary Actor	Software Management Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Software image is loaded.

Use Case	Dump Software Image
Brief Description	Triggers the dumping of the software image.
Primary Actor	Software Management Client
Preconditions	Software Image exists.
Main Success Scenarios	<ul style="list-style-type: none"> • The software image is dumped.

Use Case	Software Image Dump
Brief Description	Sends the dump of the software image to the client.
Primary Actor	Software Management
Preconditions	Client is registered. Software Image exists.
Main Success Scenarios	<ul style="list-style-type: none"> Send the data to all Clients which have registered to receive it.

A5.8 PAYLOAD DATA PRODUCT MANAGEMENT USE CASES

A5.8.1 Data Product Management use cases

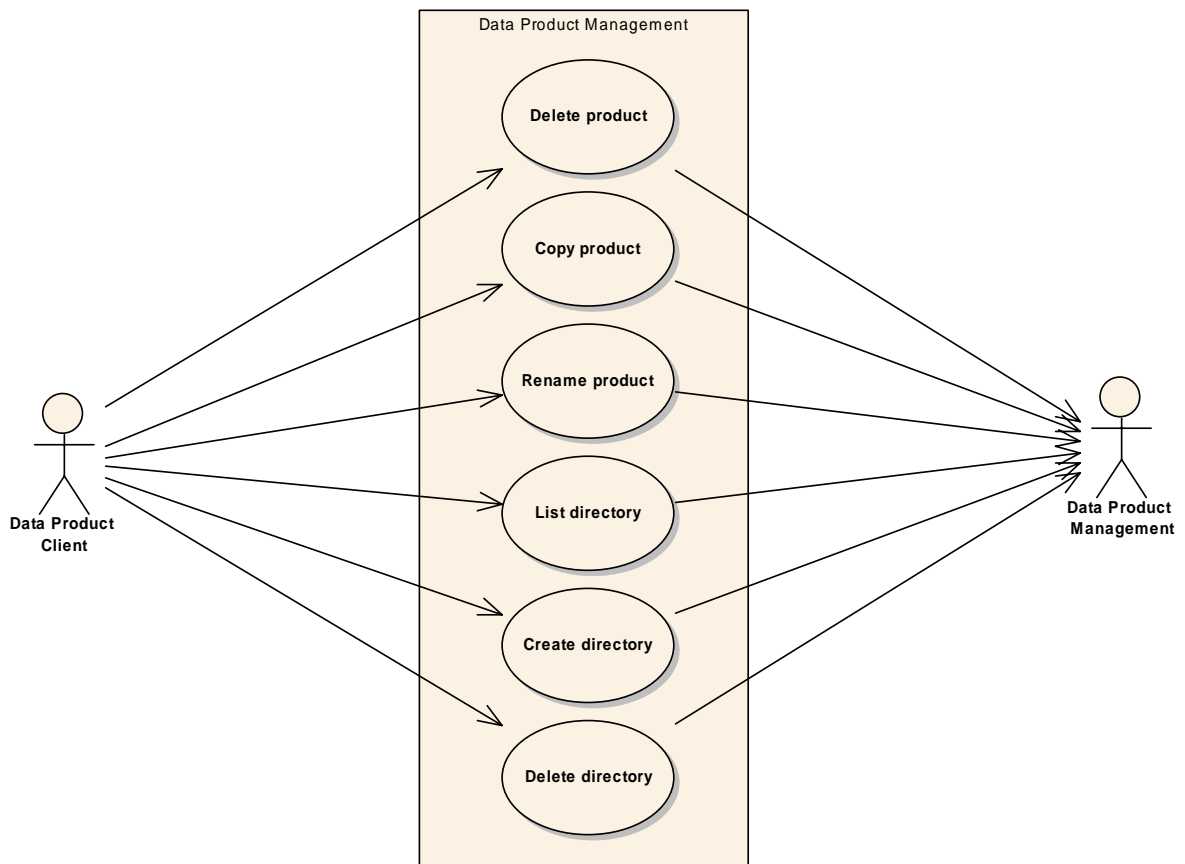


Figure A-24: Data Product Management Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Delete Product
Brief Description	Deletes a product from the remote data store.
Primary Actor	Data Product Client
Preconditions	Product exists in the store.
Main Success Scenarios	<ul style="list-style-type: none"> • Product is deleted.

Use Case	Copy Product
Brief Description	Copies a product in the remote data store.
Primary Actor	Data Product Client
Preconditions	Product exists in the store.
Main Success Scenarios	<ul style="list-style-type: none"> • Product is copied.

Use Case	Rename Product
Brief Description	Renames a product in the remote data store.
Primary Actor	Data Product Client
Preconditions	Product exists in the store.
Main Success Scenarios	<ul style="list-style-type: none"> • Product is renamed.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	List Directory
Brief Description	Returns a list of files in the specified directory.
Primary Actor	Data Product Client
Preconditions	Directory exists in the store.
Main Success Scenarios	<ul style="list-style-type: none"> • Directory list is returned.

Use Case	Create Directory
Brief Description	Creates a directory from the remote data store.
Primary Actor	Data Product Client
Preconditions	Parent directory exists in the store. No existing directory or file with the same name.
Main Success Scenarios	<ul style="list-style-type: none"> • Directory is created.

Use Case	Delete Directory
Brief Description	Deletes a directory from the remote data store.
Primary Actor	Data Product Client
Preconditions	Directory exists in the store and is empty.
Main Success Scenarios	<ul style="list-style-type: none"> • Directory is deleted.

A5.8.2 Data Product Transfer use cases

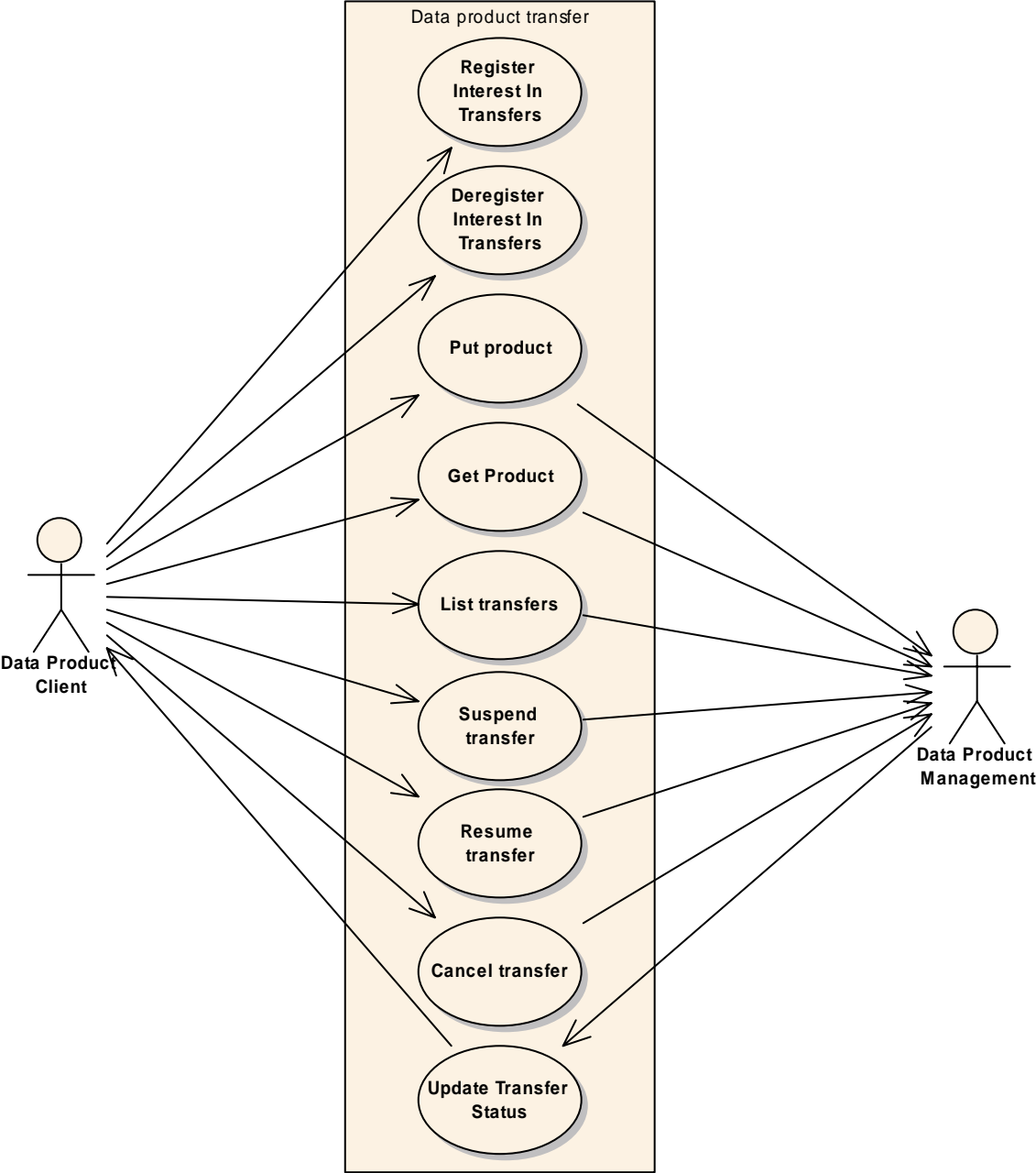


Figure A-25: Data Product Transfer Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Register Interest In Transfers
Brief Description	Allows a client to register interest in data transfer status updates.
Primary Actor	Data Product Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Client is registered for data notification. • Report the current status to the client.

Use Case	Deregister Interest In Transfers
Brief Description	Allows a previously registered client to stop receiving status updates.
Primary Actor	Data Product Client
Preconditions	Client was previously registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Client no longer receives status updates.

Use Case	Put Product
Brief Description	Initiate a transfer of a data product from the local to the remote data store.
Primary Actor	Data Product Client
Preconditions	Product does not already exist in the remote store.
Main Success Scenarios	<ul style="list-style-type: none"> • Starts a transfer from the local to the remote.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Get Product
Brief Description	Initiate a transfer of a data product from the remote to the local data store.
Primary Actor	Data Product Client
Preconditions	Product exists in the remote store.
Main Success Scenarios	<ul style="list-style-type: none"> Starts a transfer from the remote to the local.

Use Case	List Transfers
Brief Description	Provide the client with a list of active data transfers and the status of them.
Primary Actor	Data Product Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> Provide the Client with a list of all transfers that are currently executing.

Use Case	Suspend Transfers
Brief Description	Client requests that the data transfer is suspended.
Primary Actor	Data Product Client
Preconditions	Data transfer is active.
Main Success Scenarios	<ul style="list-style-type: none"> The active transfer is suspended.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Resume Transfer
Brief Description	Resumes a previously suspended transfer.
Primary Actor	Data Product Client
Preconditions	Data transfer is suspended.
Main Success Scenarios	<ul style="list-style-type: none"> • The suspended transfer is resumed.

Use Case	Cancel Transfer
Brief Description	Cancels a previously active or suspended transfer task.
Primary Actor	Data Product Client
Preconditions	Data transfer is active or suspended.
Main Success Scenarios	<ul style="list-style-type: none"> • Data transfer is cancelled.

Use Case	Update Transfer Status
Brief Description	Informs clients registered for updates of a change in the state of a transfer.
Primary Actor	Data Product Management
Preconditions	Client is registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Report the transfer state change to all Clients which have registered to receive data product updates.

A5.8.3 Data Product Monitoring use cases

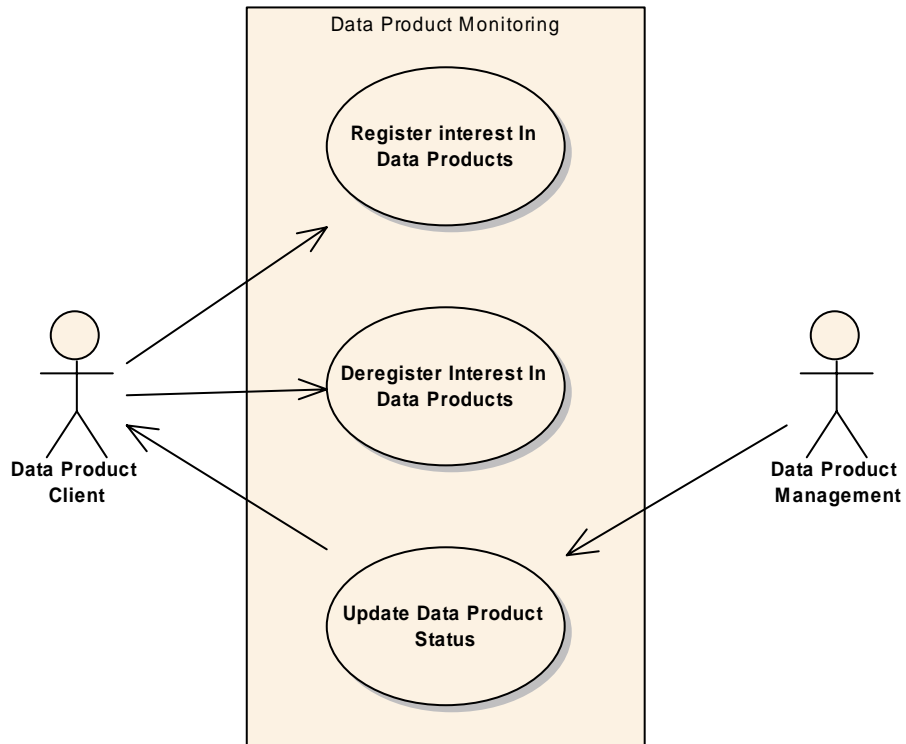


Figure A-26: Data Product Monitoring Use Case Diagram

Use Case	Register Interest In Data Products
Brief Description	Allows a client to register interest in data product status updates.
Primary Actor	Data Product Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> Client is registered for data product notification.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Deregister Interest In Data Products
Brief Description	Allows a previously registered client to stop receiving product updates.
Primary Actor	Data Product Client
Preconditions	Client was previously registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Client no long receives product status updates.

Use Case	Update Data Product Status
Brief Description	Informs clients registered for updates of a change in the state of a data product.
Primary Actor	Data Product Management
Preconditions	Client is registered.
Main Success Scenarios	<ul style="list-style-type: none"> • Report the data product state change to all Clients which have registered to receive updates.

A5.9 OPERATOR INTERACTION USE CASES

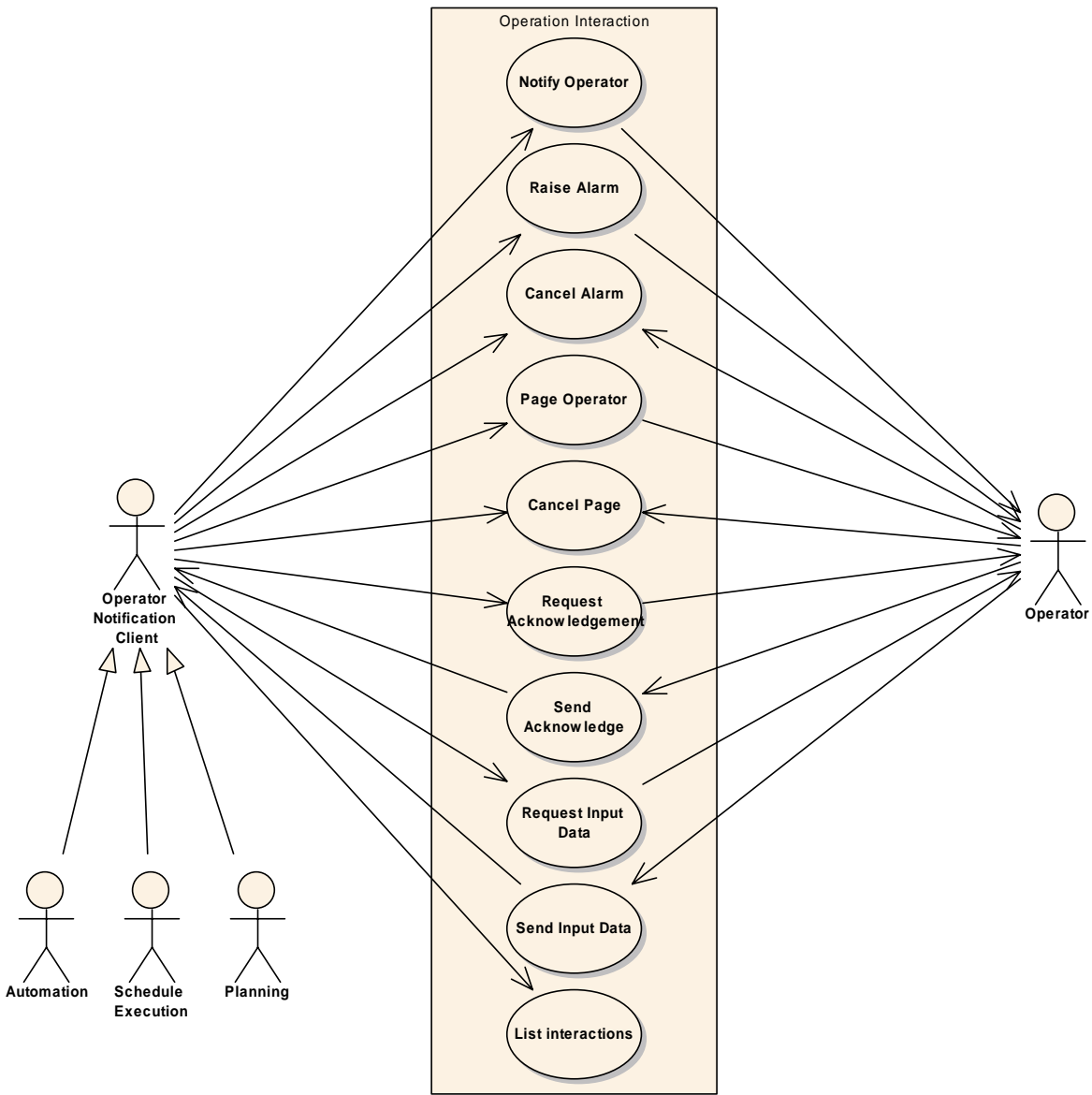


Figure A-27: Operator Interaction Use Case Diagram

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Notify Operator
Brief Description	Used to send a message to an operator that does not require acknowledgement.
Primary Actor	Operator Notification Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Operator is notified.

Use Case	Raise Alarm
Brief Description	An alarm is raised to the operator, possibly audible.
Primary Actor	Operator Notification Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Alarm is raised.

Use Case	Cancel Alarm
Brief Description	An existing alarm is cancelled.
Primary Actor	Operator
Preconditions	Alarm is active.
Main Success Scenarios	<ul style="list-style-type: none"> • Alarm is no longer active.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Page Operator
Brief Description	Request the presence of an operator. The distinction from this and an alarm is that in this situation it is assumed that the relevant operator is not present in the system (logged in).
Primary Actor	Operator Notification Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Operator is paged.

Use Case	Cancel Page
Brief Description	Cancel an existing page.
Primary Actor	Operator
Preconditions	Page is active.
Main Success Scenarios	<ul style="list-style-type: none"> • Page is cancelled.

Use Case	Request Acknowledgement
Brief Description	Request an acknowledgement from an operator.
Primary Actor	Operator Notification Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Operator is requested for acknowledge.

REPORT CONCERNING MISSION OPERATIONS SERVICES CONCEPT

Use Case	Send Acknowledge
Brief Description	Send an acknowledgement to a request.
Primary Actor	Operator
Preconditions	Request is active.
Main Success Scenarios	<ul style="list-style-type: none"> Request is acknowledged.

Use Case	Request Input Data
Brief Description	<p>Request input data from an operator. This is separate from normal operator interaction with client application, it is expected that normally autonomous systems shall use it when operator interaction is required.</p> <p>Several input methods are likely to be supported:</p> <ul style="list-style-type: none"> String Number Select option
Primary Actor	Operator Notification Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> Input is requested from operator

Use Case	Send Input Data
Brief Description	Sends the input data that was requested previously.
Primary Actor	Operator
Preconditions	Input data was requested.
Main Success Scenarios	<ul style="list-style-type: none"> Input data is sent.

Use Case	List Interactions
Brief Description	Provide the client with a list of active interactions and the status of them.
Primary Actor	Operator Notification Client
Preconditions	None.
Main Success Scenarios	<ul style="list-style-type: none"> • Provide the Client with a list of all interactions that are currently outstanding.

A6 HARMONISATION OF SERVICES

This section maps to the analysis stage given in 5.2.5.

From A5 the use cases have been grouped into sets of similar operations and responses. In most cases the use has been reduced to just the operation rather than the full explicit operation. For example *Start* rather than *Start Data Generation*, *Start Plan Generation*, *Start Activity*, etc.

Table A-1: General Service Operations

Function Area	Operation	Common Type
Control	Abort	Directive
	Activate	Directive
	Cancel	Directive
	Resume	Directive
	Start	Directive
	Stop	Directive
	Suspend	Directive
Maintenance	Add	Directive
	Append	Directive
	Clear	Directive
	Copy	Directive
	Create	Directive
	Delete	Directive
	Merge	Directive
	Modify	Directive
	Replace	Directive
Reporting	Register Interest	Directive
	Deregister Interest	Directive
	List	Directive
	Update Status	Event
	Send Report	Report

The following operations could not be generalised and are listed for completeness:

Table A-2: Specific Service Operations

Service	Operation	Type
Automation	Load Activity	Directive
Core SM&C	Set Parameter	Directive
Data Product Management	Get Product	Directive
	Put Product	Directive
	Rename Product	Directive
Flight Dynamics	Distribute Data	Directive
Interaction	Notify Operator	Directive
	Page Operator	Directive
	Raise Alarm	Directive
	Raise Alert	Directive
	Request Acknowledgement	Directive
	Request Input Data	Directive
Location	Set Location Report Rate	Directive
Schedule	Time Shift Schedule	Directive
Software Management	Check Software Image	Directive
	Dump Software Image	Directive
	Load Software Image	Directive
Time	Correlate Time	Directive
	Set Time Report Rate	Directive

The following responses could not be generalised and are listed for completeness:

Table A-3: Specific Service Responses

Service	Operation	Type
Interaction	Send Acknowledge	Event
	Send Input Data	Report
Software Management	Software Image Dump	Report