# Mission Planning and Scheduling Services Outline

## Service Identification

Four principal services have been identified in the Green Book:

1. Planning Request [**PRS**]
2. Plan Distribution and Retrieval [**PLS**]
3. Planning Process Management [**PMS**]
4. Plan Execution Management [**PE3**]

| Service *Provider* | Capabilities | Data | Description |
| --- | --- | --- | --- |
| Planning Request [PRS]  *Planning* | Submit Request  Update/Cancel Request  Edit Plan Content  Update Planning Events and Resources  Provide Request Status Feedback  Manage Request Definitions | Planning Request  Plan  Planning Activity  Planning Event  Planning Resource  Planning Constraint | Asynchronous submission of planning requests, associated responses and their subsequent management and status feedback.  Update (editing) of the executing Plan at activity level.  Update of Planning Events and Resources  A Planning Request may reference a Plan (output from an earlier planning process), in which case the provided feedback includes the statios of the Plan in terms of its contained activities and other items. |
| Plan Distribution & Retrieval [PLS]  *Planning* | Retrieve Plan or Plan Status  Subscribe to Plan or Plan Status | Plan  Planning Activity  Planning Event  Planning Resource  Planning Constraint | Provides distribution and access to plans generated by the planning function. |
| Planning Process Management [PMS]  *Planning* | Initiate, Monitor and Control Planning Processes  Update Plan Status  Manage Planning Definitions | Plan  Planning Activity  Planning Event  Planning Resource  Planning Constraint | Management of the planning process itself - initiation, status feedback and control.  Also supports provision of Plan status updates by a third party. |
| Plan Execution Management [PES]  *Plan Execution* | Initiate, Monitor and Control execution of a Plan  Manage Planning Definitions | Plan  Planning Activity  Planning Event  Planning Resource  Planning Constraint | Control and Management of the execution of a plan, including actions to Start/Stop and Pause/Resume execution of the Plan. |

## Mission Planning & Scheduling Service Descriptions

The following paragraphs provide greater detail on the scope of each of the proposed services.

### Planning Request Service [PRS]

#### Service Summary

The Planning Request service supports the submission of discrete planning requests by a consumer function. This includes the associated responses and provision of asynchronous status feedback by the provider function at the level of those planning requests; and the ability to manage requests post submission.

#### Provider Function

The **Planning** function is provider of the Planning Request service.

#### Consumer Functions

Consumers of the Planning Request service are functions that raise planning requests and include:

* Planning GUI, gateway or portal used directly by human users of the system.
* **User Support**: for the submission of end-user planning requests (e.g. for observations or other payload operations).
* **Navigation**: for the submission of planning requests for spacecraft manoeuvres, pointing and other AOCS operations.
* **Operations Preparation**: for the submission of planning requests to perform on-board configuration management operations (e.g. updates to on-board software or procedure definitions).
* **Planning**: It is noted that the Planning function may itself be hierarchical and/or distributed. In this context, Planning may also act as a consumer of the service (submitting planning requests to another Planning function), although it is more likely that the Plan Distribution and Retrieval Service would be used to submit a high-level or partial Plan.

#### Data Objects

**Planning Request**: this corresponds to a reference to a defined template for one [or more TBD] root-node planning activities and any associated trigger condition. It includes the provision of the values of planning request attributes and arguments (as literals, or formulae), and may include specific planning constraints.

Planning Requests are derived from COM Activity objects. Separate objects represent the Identity, Definition and Occurrences of the Planning Request.

Planning requests may also reference other Data Objects, including:

* Organisation and/or User: as the source of the Planning Request
* **Planning Activity**: the planning request is to plan one or more root-node Planning Activities.
* **Planning Event**: the planning request may have a trigger associated with a Planning Event.
* **Planning Resource**: the planning request may have arguments or constraints expressed as constraint types or formulae that reference Planning Resources.
* **Planning Constraint**: the planning request may reference or specify a self-standing constraint to be applied in the context of a Plan.

#### Operations

The following is a potential set of Operations associated with the service, subject subject to detailed specification:

| Operation | MAL Pattern | Description |
| --- | --- | --- |
| SubmitRequest | REQUEST | Send Planning Request to Provider, returns Occurrence ID of Planning Request created. |
| UpdateRequest | SUBMIT | Send updated Planning Request to Provider (same occurrence). |
| CancelRequest | SUBMIT | Send cancellation of Planning Request to Provider. |
| InsertActivity UpdateActivity DeleteActivity  InsertEvent UpdateEvent DeleteEvent  UpdateResource | SUBMIT | Edit the currently executing Plan (or Schedule). Operations are provided to Insert, Update and Delete occurrences of Planning Activities and Events. Note that inserting a hierarchical Activity will result in the creation of an entire tree of Activities. When deleting an Activity, deletion of any sub-tree of Activities is optional. Resources do not have occurrences, and so may only be Updated. |
| ListRequests | REQUEST | Returns list of current Planning Request occurrences (subject to filter: All, by Domain, by Source.) |
| GetRequestState | REQUEST | Returns current state of specified Planning Request occurrence. Note this is a one-shot operation. The COM Activity Tracking service can also be used to subscribe to Planning Request status updates. |
| ListRequestDefs  ListEventDefs  ListActivityDefs  ListResourceDefs | REQUEST | Returns list of current definitions for Planning Requests (also Planning Events, Planning Activities and Planning Resources). |
| AddRequestDef  UpdateRequestDef  RemoveRequestDef | REQUEST  REQUEST  SUBMIT | Manage current definitions for Planning Requests, with operations to Add, Update and Remove Planning Request definitions. |

Note that the provision of operations to edit the executing Plan (and also to update Planning Events and Resources) within this service is TBD. An alternative would be to integrate the edit operations within the Plan Execution Management service.

Note that the provision of operations to manage Planning Request definitions within this service is TBD. The same operations are also identified as part of the Planning Process Management Service, where they may be considered more appropriate. If provided, these operations may be supported through use of the MO Common Configuration Service.

#### Usage of MO Framework Services

Assuming Planning Requests objects are derived from the MO COM, standard MO Framework services can be used to support some aspects of the service:

* The COM Archive Service supports the storage, update and querying of Planning Request History.
* The COM Activity Tracking Service supports Publish/Subscribe access to evolving Planning Request status.
* The COM Event Service supports the notification of specified service events.

MO Common Directory and Login services may be used in conjunction with the Planning Request service.

The MO Common Configuration service may be used to support the management of current Planning Request definitions.

### 6.3.2 Plan Distribution and Retrieval Service [PLS]

#### Service Summary

The Plan Distribution and Retrieval Service provides distribution and access to Plans generated by a Mission Planning function and the associated feedback, or Plan Status.

#### Provider Function

The **Planning** function is provider of the Planning Distribution and Retrieval service.

#### Consumer Functions

Consumers of the Planning Distribution and Retrieval service are functions supporting one of the following main use cases:

1. A User function accessing Plans or Plan Statuses for reference purposes or display. This may include **User Support** and **Navigatio**n functions, or a Planning GUI, gateway or portal used directly by human users of the system
2. A **Planning** function accessing Plans or Plan Statuses from another distributed Planning function or a Plan Execution function.

#### Data Objects

Both **Plans** and **Plan Statuses** are composite data structures that contain a set of Planning Activities (and possibly Planning Events and Planning Resources) over a specified time period.  A Plan Status is a snapshot of the refined planning or execution status of a Plan at a given point in time.  Both data structures may be stored and transferred as files.

The Plan or Plan Status is effectively a container object with associated metadata, including:

* Scope of the Plan (plan type, applicable period, domain scope)
* Generation Date
* Predecessor Plan
* Status
* Reporting Date [for Plan Status]

The body of the Plan or Plan Status comprises sets of:

* Plan Elements:  **Planning Activity** occurrences + Triggers
* **Planning Event** occurrences
* **Planning Resource** states

Planning Activities and Planning Events are derived from COM Activity objects.  Separate objects represent their Identity, Definition and Occurrences.  The source reference of Planning Activities may be a parent Planning Activity, a Planning Event or a Planning Request.

Planning Resources are derived from the base COM object (they do not have limited duration), but also comprise Identity, Definition and State objects.  Within a Plan each Resource may have multiple timestamped states representing a predicted state vector over the duration of the Plan.

Each Planning item (Activity or Event) also has associated status.  In the case of a Plan, this could be used to indicate its change status with respect to the Predecessor Plan [New, Modified, Deleted, Unchanged].  In the case of a Plan Status, some attributes of the item may have been modified with respect to the original plan (for example, execution times) to reflect their current state, and the item status is used to indicate its current refined planning or execution status.

#### Operations

The following is a potential set of Operations associated with the service, subject subject to detailed specification:

| Operation | MAL Pattern | Description |
| --- | --- | --- |
| ListPlans | REQUEST | Returns a list of available Plans (subject to filter: All, by Domain, by Status, by Predecessor) |
| GetPlan | REQUEST | Returns the specified Plan. |
| GetPlanStatus | REQUEST | Returns the Plan Status for the specified Plan. |
| SubscribeToPlan | PUBLISH-SUBSCRIBE | Consumers register interest in a filtered set of Plans. When published by the Provider, these are then forwarded to all registered Consumers. Consumers deregister to stop receiving Plans. |
| SubscribeToPlanStatus | PUBLISH-SUBSCRIBE | Consumers register interest in a filtered set of PlanStatuses. When published by the Provider, these are then forwarded to all registered Consumers. Consumers deregister to stop receiving PlanStatuses. |

#### Usage of MO Framework Services

Standard MO Framework services can be used to support some aspects of the service:

* The live reporting of Plan Execution Status is derived from the COM Activity Tracking service. Similarly Plan (or Schedule) Execution History is supported through the use of the COM Archive service.
* The COM Event Service supports the notification of specified service events.

MO Common Directory and Login services may be used in conjunction with the Plan Distribution and Retrieval service.

### 6.3.3 Planning Process Management Service [PMS]

#### Service Summary

The Planning Process Management Service supports the monitoring, control and configuration of the planning process itself. This includes the initiation of implementation specific planning tasks, provision of status feedback on the execution of those planning tasks, and the ability to control ongoing planning tasks. The service also supports the management of Planning object definitions (Planning Requests, Activities, Events, Resources and potentially self-standing Constraints).

It is noted that this is essentially a Monitoring and Control service for the Planning function. It may therefore be appropriate to implement the Planning Control Service as an instance of the MO Monitoring & Control service.

#### Provider Function

The **Planning** function is provider of the Planning Control service.

#### Consumer Functions

Consumers of the Planning Control service are functions that can directly invoke the Planning process. This can be used to support end-to-end automation of Mission Operations processes in which Planning is but one stage. Potential consumers include:

* Plan Execution: e.g. to invoke re-planning following an anomaly in the execution of the current plan.
* Planning: e.g. to coordinate planning processes in a hierarchical/distributed planning context.
* Mission Control: e.g. to integrate planning processes into automated operations
* Navigation & Timing: e.g. to invoke re-planning following submission of a manoeuvre Planning Request or generation of predicted Planning Events

#### Data Objects

The following data objects defined by the MO Monitoring & Control service are reusable in the context of Planning Control:

* **Action**: a control directive supported by a Planning function.
* **Parameter**: a monitoring state supported by a Planning function.
* **Alert**: an asynchronous notification generated by a Planning function.

Planning Control actions will typically operate on **Plans**.

The Definitions of the following data objects are subject to management by the Planning Control service:

* **Planning Requests**
* **Planning Activities**
* **Planning Events**
* **Planning Resources**
* **Planning Constraints [TBD]**

#### Operations

The following is a potential set of Operations associated with the service, subject subject to detailed specification:

| Operation | MAL Pattern | Description |
| --- | --- | --- |
| SubmitAction | SUBMIT | Sends Planning Control directive to the Provider. |
| MonitorValue | PUB/SUB | Monitor value of Planning function parameters. |
| GetValue | REQUEST | Returns the value of a Planning function parameter. |
| SetValue | SUBMIT | Set the value of a Planning function parameter. |
| UpdatePlanStatus | REQUEST | Update of Plan status by a third party. |
| ListRequestDefs ListEventDefs ListActivityDefs ListResourceDefs ListConstraintDefs | REQUEST | Returns list of current definitions for Planning Requests (also Planning Events, Planning Activities, Planning Resources and potentially self-standing Planning Constraints). |
| AddRequestDef AddEventDef AddActivityDef AddResourceDef AddConstraintDef  UpdateRequestDef UpdateEventDef UpdateActivityDef UpdateResourceDef UpdateConstraintDef  RemoveRequestDef RemoveEventDef RemoveActivityDef RemoveResourceDef RemoveConstraintDef | REQUEST  REQUEST  SUBMIT | Manage current definitions for Planning Requests, Events, Activities and Resources (and potentially self-standing Constraints) with operations to Add, Update and Remove definitions. |

#### Usage of MO Framework Services

Operations associated with control Actions and monitoring Parameters are a subset of those already defined for the MO Monitoring & Control service, which can be re-used in this context.

The update of Plan status by a 3rd party may require a dedicated operation to be defined, however it should be considered whether this can be satisfied using the standard SetValue operation of the MO Monitoring & Control service.

The publishing and monitoring of Alert notifications can be supported using the COM Event service.

List, Add, Update and Remove Definition operations may be supported through use of the MO Common Configuration Service.

MO Common Directory and Login services may be used in conjunction with the Planning Control service.

### 6.3.4 Plan Execution Control Service [PEC]

#### Service Summary

The Plan Execution Control service supports the execution of plans by a Plan Execution function, including plan execution status feedback and update [editing] of the executing Plan. The service also supports the management of Planning object definitions used by the Plan Execution function (Planning Activities, Events and Resources).

#### Provider Function

The **Plan Execution** function is provider of the Plan Execution Control service.

#### Consumer Functions

The **Planning** function is the principal consumer of the Plan Execution Control service.

Those operations specifically concerned with the control of the Plan Execution function may also be used by Mission Control automation functions or a Plan (or Schedule) Execution GUI.

#### Data Objects

The data for the service is mostly common with that of the Plan Distribution and Retrieval service, including the following planning data structures and objects:

* **Plans**
* **Plan Status**
* **Planning Activities**
* **Planning Events**
* **Planning Resources**

In the case of Plan Execution Control, Planning Activities, Events and Resources are not handled purely as elements of Plan and Plan Status structures, but can be interacted with individually as live data objects.

As for the Planning Control Service, the following data objects defined by the MO Monitoring & Control service are reusable in the context of Plan Execution Control:

* **Action**: a control directive supported by a Plan Execution function.
* **Parameter**: a monitoring state supported by a Plan Execution function.
* **Alert**: an asynchronous notification generated by a Plan Execution function.

Plan Execution Control actions will typically operate at the level of the executing **Plan** (or Schedule) or sub-plans at the level of planning domains.

#### Operations

The following is a potential set of Operations associated with the service, subject subject to detailed specification:

| Operation | MAL Pattern | Description |
| --- | --- | --- |
| LoadOrMergePlan | REQUEST | Requests that the Plan Execution Provider loads or merges a specified Plan into the currently executing Plan (or Schedule).  The operation has two option flags: Load/Merge and Return Execution Status.  Load implies clearing and replacing the currently executing Plan (or Schedule) with the specified Plan.  Merge implies applying changes [relative to the predecessor Plan] to the currently executing Plan only [insertions, updates and deletions].  The provider acknowledges synchronously and, if the Return Execution Flag is set returns a final Plan Status once the Plan has been executed. |
| SubmitAction | SUBMIT | Sends Plan Execution Control directive to the Provider. The set of supported Actions is implementation specific, but is expected to include directives to Start/Stop and Pause/Resume execution of the Plan (or potentially a sub-plan by Planning Domain). |
| MonitorValue | PUB/SUB | Monitor value of Plan Execution function parameters. |
| GetValue | REQUEST | Returns the value of a Plan Execution function parameter. |
| SetValue | SUBMIT | Set the value of a Plan Execution function parameter. |
| ListEventDefs ListActivityDefs ListResourceDefs ListConstraintDefs | REQUEST | Returns list of current definitions for Planning Events, Activities and Resources (and potentially self-standing Constraints) supported by the Plan Execution function. |
| AddEventDef AddActivityDef AddResourceDef AddConstraintDef  UpdateEventDef UpdateActivityDef UpdateResourceDef UpdateConstraintDef  RemoveEventDef RemoveActivityDef RemoveResourceDef UpdateConstraintDef | REQUEST  REQUEST  SUBMIT | Manage current definitions for Planning Events, Activities and Resources (and potentially self-standing Constraints) with operations to Add, Update and Remove definitions. |

#### Usage of MO Framework Services

Operations associated with control Actions and monitoring Parameters are a subset of those already defined for the MO Monitoring & Control service, which can be re-used in this context.

The LoadOrMergePlan operation could be implemented as a dedicated operation, which references a Plan previously distributed to the Plan Execution function using the Planning Request Service. Alternatively it may itself be implemented as a standard SubmitAction operation of the MO Monitoring & Control service.

The publishing and monitoring of Alert notifications can be supported using the COM Event service.

List, Add, Update and Remove Definition operations may be supported through use of the MO Common Configuration Service.

MO Common Directory and Login services may be used in conjunction with the Planning Control service.