Smart-1 Scheduler - A Cost Effective Mission Scheduler compatible with SCOS2000

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Abstract. SMART-1 is the first of the Small Missions for Advanced Research and Technology (SMART): an element of ESA's Horizons 2000 plan for scientific projects, which aims to test key technologies for future cornerstone missions. It is intended as a flight demonstration of Electric Primary propulsion (EP). The Flight Control Team (FCT) controls the mission from the SMART-1 Mission Operations Centre located at ESOC.
SMART-1 being a low-cost mission required all facilities to be based on extensions of existing ground segment infrastructure, tailored to meet the requirements of the SMART-1 mission. This constraint together with the concern on end-to-end consistency – from Flight Control Procedure (FCP) design towards Telecommand execution onboard – form the driving factors for the Smart-1 Scheduler (S1S) development. Finally, as the Smart-1 mission control team is only a very small team, the main operational purpose of the S1S is to improve efficiency by automating routine tasks during operations whilst minimising the additional effort in the preparation phase..

1 End-to-End Integration and Closed Loop

1.1 Ensuring Consistency between Procedure Design and Mission Planning

Ensuring Consistency between Procedure Design and Mission Planning – All types of Operations Requests are referencing procedures that have been established by the Flight Control Team with the MOIS5 Toolset – A procedure preparation environment interfacing to the SCOS2000 Spacecraft Database and capable of generating Telecommand sequences in return.
The MOIS5 Procedure preparation toolset has been fully integrated into the S1S, to allow each engineer specifying Mission Planning information on each procedure in terms of Pre/Post-conditions and duration. The scheduler then has access to this information at its source and translates it into resource usage. Currently, the scheduler defines resource models for instrument modes, ground station passes, eclipses, power and downlink/dump capacity.

1.2 Guaranteeing Command Syntax Consistency

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In the same way as MOIS5 accesses the SCOS-2000 database for procedure design, the scheduler uses the same database to produce Detailed Schedule Files instantiating the Telecommands for the MCS from the Operations Requests. These are transferred automatically to SCOS-2000 which are then uplinked by the FCT. This guarantees syntax consistency for the spacecraft commanding.

1.3 Guaranteeing Overall Plan consistency in relation to other ESOC facilities

The S1S integrates the transfer of products from and towards the various sources within the MOC such as Flight Dynamics and the Station Scheduling Office. Together with these inputs the FCT adds platform operations to the plan to complete the set of activities including Payload Operations Request and Flight Dynamics Requests dedicated for the Smart-1 Spacecraft.
This closes the loop from the initial design of the procedure until scheduled execution on board thereby minimising the probability of error.

2 Fast Deployment by Reuse of Existing Facilities

2.1 Integration into the OPS Preparation toolset MOIS5

This does not only guarantee consistency as mentioned above, but provides a multi-user and configuration controlled environment for designing Flight Control Procedures that are to be used by the scheduler. MOIS5 could be reused without modification for other missions.

2.2 Reuse of the MOIS5 Writer for Scheduler Operations Request Editor

The S1S provides an editing facility whereby requests can be inserted manually. The same MOIS5 Editor that is used to define Flight Control Procedures is used to define Operations Requests referring to these FCPs. It has been extend with minimum effort to allow a more flexible

timing. Being part of MOIS5, the OR editor could be reused without modification for other missions.

2.3 Use of a Simple Generic Planning Engine

In the S1S design phase, we have taken the choice to keep the generic model as simple as possible. Complexity and specific implementations have been done in a specific SMART1 layer. This has the advantage that the Generic Planner can be reused “as is” for other missions. On the other hand, because of the modular design, other planning engines with more elaborated conflict detection and resolution can replace this planning engine.

2.4 Configuration of Application COTS

COTS such as Microsoft-FTP, Excel-Graph for the resource usage representation and Gantt Controls to represent the schedules activities and constraints have been used.
This reuse and tailoring of COTS kept the development effort low (approximate 1.5 man-year). New missions comparable to SMART1 in terms of complexity are likely to require only customisation effort and the design is open for implementation of new planning algorithms or integration of other planning engines.

3 Replacing Manual Operations with Automation

3.1 Minimising efforts of the FCT at procedure design time

A driving factor for the design of the S1S is to allow maximum flexibility for additions to the mission-planning model without requiring updates to the Procedures. There is therefore a clean separation between expressing the conditions for the execution of a procedure and the translation into MPS resource usage. Conditions are specified by each procedure engineer at design time; their translation into resource usage is done by the MPS engineer in configuration tables.

3.2 Towards Automation – Operations Request Editor & Template Definition

The Mission Planner Engineer is responsible for filling-in the plan with the Spacecraft Operations Requests (SORs) dedicated for platform activities. Experience reveals that these activities are quite repetitive and generally linked to events rather then fixed time. As mentioned before, the OR Editor timing information allows coping with repetition.
A ‘**save to request file**’ is provided by the Operations Request Editor. This allows creation of ‘SOR templates’, which can be reused in any other plan for any other period in time. The Flight Control Team thereby automates routine activities by attaching requests to events from various sources.

In practical terms the Scheduler saves a significant amount of manual analysis and command preparation that would otherwise need to be performed by the Flight Control Team.