CONSAT: A Tool for Planning and Scheduling Ground Satellite Operations

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Abstract.
The purpose of the paper is to give an overview of a software tool already developed that allows to plan and schedule nominal operations to perform in the satellites along the year for the commercial Spanish satellites company, HISPASAT. The tool, CONSAT, is currently in the user validation phase.

1 The HISPASAT domain

HISPASAT is a Spanish multi-mission system in charge of satisfying national communication needs. It also supplies capacity for digital TV in Europe, America and North Africa, TV image, radio and other signals, and special communications for defence purposes. It is the first European satellites system to offer transatlantic capacity that allows simultaneous coverage between South and North America.

Every operation in orbit must have explicit engineering instructions. These instructions provide a guide for technicians to consider the work accomplished. Currently, the engineer group generates this documentation for every satellite and year *by hand* and *on paper*. Later, this documentation is revised, modified and verified.

Some operations in the HISPASAT domain are driven by external events. The external (i.e. eclipses and blindings) and seasonal (i.e. solstice and equinox) events are foreseen several weeks before the year starts. Examples of these operations are CONF-ADCS, performed during the sun blinding periods, or SASS DATA, performed in solstices and equinoxes.

Other operations are scheduled having in mind the date when a South Maneuver was performed. They are performed every two weeks at an hour corresponding to the secular drift direction. The engineers know the satellite affected by the secular drift, and the date and time in the year during which the Maneuver is going to be performed. Given that the maneuvers are forbidden during moon or sun blindings they have to be moved ahead twenty-four or forty eight-hours (in case two moon blindings appear in following days) from the secular drift time. The two maneuvers that follow the first one must be also moved ahead the same number of hours.

The rest of the operations start/finish some hours before/after the start/end of the South Maneuver. Some operations cannot be performed if in that week a Maneuver has been scheduled, while others must be performed during Maneuvers. Others just have to be performed *N* days/weeks/months since the last operation.

2 The Tool

The CONSAT[1] architecture can be seen in Figure 1, and it is composed of the following subsystems that will be described in the next subsections (R-Moreno *et al.* 2002):

- **The user subsystem:** is in charge of the control access to the tool and the interaction with the user in order to obtain and manipulate all the data needed for planning and scheduling.
- **The reasoner subsystem:** once the input data is introduced, a domain independent planner is in charge of generating the solution to the problem.
- **The generator susbsystem:** is responsible for maintaining coherence between the two possible representations that the tool offers: *annual* to provide a general overview of the operations and *weekly* for a more detailed view of the hours and resources (if any) involved in the operations. If the user modifies the *weekly* representation, the *annual* representation will be updated automatically. This subsystem also allows to convert the solution to a specific format document type, compare two different solutions, or generate an HTML version.

2.1 The User Subsystem

The User Subsystem is in charge of data introduction. It allows the user to specify data in their usual current way and the subsystem automatically translates it into the internal model.

This subsystem provides the following more specific functionality:

- In the case of external events and South Maneuver, the events are known in advance by means of specific supporting engineering tools that predict, according to some

[1] It stands for SATellite CONtrol in Spanish.

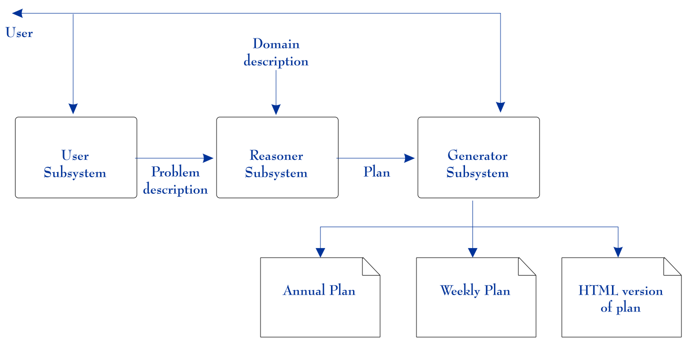

Figure 1: Architecture of the planning tool.

parameters, when the events will occur and the hour at which the South Maneuver can be performed every day of the year. These software tools generate the data in a set of ASCII files. The subsystem allows to import these files and detect the correct file format.

- Nowadays, the engineers represent this data in a specific document, and schedule the operations according to it. Every time a new modification is done, the engineer in charge of it must sign the document. Therefore this subsystem also controls the user access to register who is creating, revising, modifying or verifying the schedule.
- The engineers do not need to find in the last year's document when some operations were performed. If the tool has been previously used, this data is available to the user subsystem and automatically re-used.
- Finally, it assists the user in validating the introduced data. This allows to avoid the possible user inconsistencies.

2.2 The Reasoner Subsystem

The User Subsystem translates all this information into a suitable format for input to the Reasoner Subsystem. It is in charge of the plan generation, with temporal and resource reasoning. It generates a problem file with all the information introduced by the user. The planner output is saved into another ASCII file that will be manipulated to generate the input to the Generator Subsystem. For more details about the reasoner subsystem go to (R-Moreno *et al.* 2001).

2.3 The Generator Subsystem

Currently, once the engineers know every external event and have represented them in a document, the laborious task of scheduling every operation starts. They generate two types of documents:

- A document which provides an overview of all the operations performed each day of the year; and
- A document that represents in more detail each operation duration, type of manoeuvre, the resources, if any, affected in the operation as batteries or tanks, etc.

The weekly representation is generated every week having in mind the annual representation.The problem of maintaining two documents relates to the incongruencies between them.

The Generator Subsystem guarantees the consistency of the two representations allowing to easily modify the results obtained by the planner by just dragging and dropping the symbols in the table of the annual or weekly representations. It also allows to: compare two solutions, showing the differences between them; convert the results to the document format that the engineers use in its daily operation; and generate the solution in HTML for visualisation at the other centers.

3 Conclusions and Future Work

In this paper, we have presented a tool that gives solutions to the problem of scheduling satellite ground operations along the year for a commercial satellite company. Before the software development, the engineer group generated by hand and in paper the operations that have to be done along the week and year. There were many incongruencies between the two types of representation used (weekly and annual) and the document modification was a tedious task.

The tool saves a lot of time to the user due to its capability of importing files of any type, representing the results in a table that allows easily to modify them by just drag and drop, generate more than one solution, see the differences between any two solutions, and generate the result in its internal format or in HTML. The tool is currently under the step of user validation.

We want to explore in the future the possibility of adding more satellites allowing to define/delete new operations. This would allow us to study the scalability of the approach of dealing within the planner with planning, temporal and resource reasoning.

It would be also interesting to integrate a monitoring module to execute the scheduled operations obtained by the planner and to re-plan in case of a failure.

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