Rapid prototyping of Planning & Scheduling tools

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***Abstract*—In this paper we show the usefulness of a flexible timeline representation framework for rapid prototyping of Space Planning and Scheduling tools. In particular we applied this approach to a problem in the domain of the HERSCHEL mission.**

I. INTRODUCTION

The Advanced Planning and Scheduling Initiative, or APSI, is an ESA programme to implement Artificial Intelligence (AI) techniques in planning and scheduling that can be applied generically to different types and classes of space mission operations. The goal of the APSI is twofold: (1) creating a software framework to improve the cost-effectiveness and flexibility of mission planning support tool development; (2) bridging the gap between AI planning and scheduling technology and the world of space mission planning.

A key aspect of the success of this project is the presence of a flexible time-representation module. This paper aims at showing such a flexibility by using a real problem in the space realm – the HERSCHEL Science Long Term Planning process.

II. DESCRIPTION OF THE RESEARCH

The ESA's HERSCHEL Space Observatory will be the largest ever infrared space observatory when it is launched in early 2009 [1]. The on-board instruments will allow to observe at wavelengths that have never previously been explored.

The goal of the HERSCHEL Science Long Term Planning (LTP) process is to satisfy as much as possible the observation requests of the scientific community. Each observation may specify different constraints such as the scientific target, relations with other observations, instrument to use. The spacecraft has three scientific instruments: HIFI, PACS, and SPIRE. However as the last two of these can be used in two different modalities or in parallel, for scheduling matter, it is possible to consider HERSCHEL being equipped with six "scheduling" instruments. A set of constraints also limits the usage of these instruments (for instance some of them need to be regularly cooled). The LTP process consists then of two aspects: deciding which HERSCHEL instrument has to be "on" at any given time, and allocate the observation requests. Obviously these two aspects are connected and should be considered together to solving this problem.

In this paper we consider APSI for designing a solving engine for the HERSCHEL Science LTP problem. In particular we exploit the flexibility of the APSI timeline representation [2] to obtain two different modeling approaches for the problem:

a. The first, more direct, model is based on the use of a combination of state-machine, resources, and activities.
b. A second model instead is based on the use of a combination of binary resources and activities.

While both the approaches are able to capture the characteristics of the problem, the former requires both planning and scheduling techniques for finding a solution. Conversely for the latter it is sufficient to use resource scheduling techniques (the complexity is then moved from the solving to the modeling side). Therefore, thanks to the presence of these alternative modeling approaches, it is possible to evaluate different combinations of models and solving approaches.

III. DISCUSSION AND FUTURE DIRECTIONS

ESA missions have already benefited from the use of advanced planning systems – for instance, in the case of MARS-EXPRESS two planning tools have been developed for supporting operations [3] [4]. One limitation of the previous tools is that were both developed from scratch.

One of the APSI goals is instead to promote a common framework where different algorithms may be rapidly implemented and tested. Of course this approach cannot be considered as the panacea: it would be wrong to expect that the APSI framework will solve all the planning and scheduling problems of the space realm. What we do believe instead is that timeline-based flexible representation is the right choice to have an efficient approach to planning and scheduling problems and, in particular, to foster a quick deployment of prototypes for proving concepts and testing algorithms.

In particular, for the future we would like to further develop APSI in the direction of further facilitating the quick modeling of planning and scheduling problems. Works in the area of knowledge engineering and in the definition of planning/scheduling high-level languages are foreseen.

REFERENCES

[1] Herschel mission web-page. [Online]. Available: http://sci.esa.int/herschel
[2] A. Cesta and S. Fratini, "The Timeline Representation Framework as a Planning and Scheduling Software Development Environment," in *PlanSIG-08. Proceedings of the 27th Workshop of the UK Planning and Scheduling Special Interest Group*, 2008.
[3] A. Cesta, G. Cortellessa, M. Denis, A. Donati, S. Fratini, A. Oddi, N. Policella, E. Rabenau, and J. Schulster, "MEXAR2: AI Solves Mission Planner Problems," *IEEE Intelligent Systems*, vol. 22, no. 4, pp. 12–19, 2007.
[4] ——, "RAXEM – A Support Tool to Plan Uplink Activities for MARS EXPRESS – A Timeline Based Approch," in *i-SAIRAS-08. Proceedings of the* 9^{th} *Int. Symp. on Artificial Intelligence, Robotics and Automation in Space*, 2008.