Comment to: “Optimal Nadir Observation Scheduling”

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This paper introduces an optimisation algorithm for the problem of observation scheduling applied to a fixed-orbit spacecraft. The technical name of the problem is SSSP, Swath Segment Selection Problem.

The subject is introduced by the authors with the identification and clarification of required definitions and concepts. The use of a simple example helps the non-specialised reader (like the commentator), to understand the subject, if not to appreciate in detail the novelty of the solution. Also very useful is a review of relevant literature, and in particular of papers describing work by other authors related to algorithms to solve similar scheduling problems.

Seen from the point of view of the user - the perspective which is closest to my personal experience and background - the problem of scheduling satellite observations consists mainly of collecting user requests, filter them through satellite and ground segment constraints and resource limitations, and come up with an operations schedule. Optimisation of the solution, which is the subject of this paper, is only one of the aspects of this problem. In fact it tends to come last, as very often mission control is about finding a solution, and the fact that it is optimal or not becomes secondary.

The advantage is that the entire optimisation problem can be treated in isolation from the rest of the planning and scheduling problems: the paper in fact follows this approach. The optimisation problem to be solved is defined as*”[to] choose a subset that respects the memory capacity and downlink capacity that maximises the area of the targets downlinked*”. Inputs to the problem are a set of observation targets, a set of possible observation segments a set of downlinks, a set of constraints (e.g. memory capacity).

Once the above is defined mathematical terms the optimisation algorithm is presented and the results discussed both in terms of the total area obtained (quality) and the time required to come up with the optimised solution. The latter is a very important factor in planning applications as the planning period is finite and normally relatively short. Various algorithms are compared in terms of the above defined parameters.

Without discussing the mathematical approach and solution, for which my experience and knowledge are certainly insufficient, as a user I have nevertheless identified several questions that perhaps go beyond the mere subject of the paper, but a stimulated by it. These issues are mainly related to the possibility of utilising such optimisation algorithms in the problems we are faced with in scheduling planetary exploration operations.

What is not obvious to me is how to come to the mathematical formulation of mission constraints and resources, such that they can be taken into account and fed into the algorithm. For example how can the overall time required to complete the observation be taken into account, or the environmental parameters that may vary depending on the optimised sequence of observations (e.g. illumination, angle of observation).

A planetary spacecraft like Mars or Venus Express requires attitude slews to satisfy the observation requests, but also to recover on-board resources (e.g. battery power) or to achieve ground contact via the fixed high gain antenna. Note that the latter point introduces a link between the observation schedule and the available downlink periods, with an additional complication (or at least an additional iteration) in the problem solution. Also how would additional selection criteria (impacting on the “reward” parameter) be taken into account, such as : priority of targets, seasonal preferences, etc.

Finally it would be interesting to discuss the opportunity of applying such optimisation algorithms to more complex observation problems, where the orbit is not fixed, but can in fact be driven by the observation schedule itself. This is the case of scientific spacecraft orbiting small bodies, such as NEAR or Rosetta.