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MISSION PLANNING FOR THE TIM NANOSATELLITE REMOTE SENSING CONSTELLATION

Abstract

This paper introduces the mission planning approach for the Telematics International Mission (TIM) nanosatellite remote sensing constellation. TIM's planning scheduling system is responsible for the overall constellation operations, including: (a) observations from a single satellite; (b) observations coordinated between two or more satellites; (c) ground-station passes for data downlink; (d) orbit control maneuvers.

At the same time planning tries to: (a) maximize observation time; (b) prioritize observations and data downlink within limited storage and downlink opportunities; (c) optimize fuel consumption. Planning needs to respect key operational constraints, including: (a) satellites can only perform one task at a time, due to power and/or geometric constraints. Planning must decide between, e.g. making observations or downlinking data; (b) attitude determination system can only perform control maneuvers when in sunlight; (c) the n satellites in the constellation share k ground-stations, with k<<n.

The planning system extends the APSI timeline-based framework, and the planning algorithms developed for the NetSat formation-flying mission, with a suite of optimization algorithms solving the multi-satellite multi-ground-station scheduling problems.

TIM is an international effort to build a constellation of cooperating nanosatellites. The main goal is to combine nanosatellites with different remote sensing capabilities and explore their synergies for different Earth observation applications. Germany contributes to TIM with the Telematics Earth Observation Mission (TOM). To better explore TIM's synergies and optimize the use of resources, a centralized collaborative planning scheduling approach is introduced. A centralized planner receives observation requests, and generates a coherent schedule for observations and ground-station contacts for the entire constellation. This schedule considers individual satellite constraints, tries to maximize overall data collection and prioritizes acquisition and downlink of data from user-defined Points-Of-Interest.

This paper starts with an overview of the TIM/TOM project. A formulation for the overall planning scenario and domain, constraints and different optimization problems is derived. Next, the planning and optimization technologies behind our system are reviewed. Namely, the APSI framework, its timeline-based planning formalisms, its flaw-based PLASMA solver and the plan synthesis in form of time-flexible domain timelines. Three optimization strategies for ground-station scheduling are introduced, based on hill climbing algorithm, greedy search paradigm and genetic algorithm. Next the integration of APSI's PLASMA solver with a decoupling algorithm, and with the optimization strategies used for ground-station scheduling to produce time-flexible schedules for the satellites constellation is outlined. Finally, the implementation is evaluated against a set of mission scenarios derived from the TIM/TOM project.