SPACE SYSTEMS SYMPOSIUM (D1)
Space Systems Engineering - Methods, Processes and Tools (2) (4B)

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NAVIGATING THE DEPLOYMENT AND DOWNLINK TRADESPACE FOR EARTH IMAGING CONSTELLATIONS

Abstract

Distributed Spacecraft Missions (DSMs) are gaining momentum in their application to Earth Observation (EO) missions owing to their unique ability to increase observation sampling in spatial, spectral, angular and temporal dimensions simultaneously. DSM design includes a much larger number of variables than its monolithic counterpart, therefore, Model-Based Systems Engineering (MBSE) has been often used for preliminary mission concept designs, to understand the trade-offs and interdependencies among the variables. MBSE models are complex because the various objectives a DSM is expected to achieve are almost always conflicting, non-linear and rarely analytical. NASA Goddard Space Flight Center is developing a pre-Phase A tool called Tradespace Analysis Tool for Constellations (TAT-C) to initiate constellation mission design [Le Moigne et al, IGARSS'2017]. The tool will allow users to explore the tradespace between various performance, cost and risk metrics (as a function of their science mission) and select Pareto optimal architectures that meet their requirements.

A previous publication [Nag et al, AIAA Space 2016] discussed some rules for streamlining the design space, the tradespace search function and well-designed orbit and coverage computations within TAT-C, that have yielded significant speed-ups, as validated against AGI's Systems Tool Kit. This paper will describe the different types of constellations that TAT-C's Tradespace Search Iterator (TSI) is capable of enumerating (homogeneous Walker, heterogeneous Walker, precessing type, ad-hoc) and their impact on key performance metrics such as revisit statistics, time to global access and coverage. We will also discuss the ability to simulate phased deployment of the given constellations, as a function of launch availabilities and/or vehicle capability, and show the impact on performance. All performance metrics are calculated by the Data Reduction and Metric Computation (RM) module within TAT-C, which issues specific requests and processes results from the Orbit and Coverage (OC) module. Our TSI is also capable of generating tradespaces for downlinking imaging data from the constellation, based on permutations of available ground station networks - known (default) or customized (by the user). We will show the impact of changing ground station options for any given constellation, on data latency and required communication bandwidth, which in turn determines the responsiveness of the space system.