

IAF SPACE OPERATIONS SYMPOSIUM (B6)
Large Constellations & Fleet Operations (5)

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THE CONSTELLATION FORMATION OPERATIONS PLANNING SOFTWARE: ENABLING
SCALABLE FORMATION MANAGEMENT FOR SPACECRAFT FLEETS**Abstract**

This paper presents the features, design, and architecture of the Constellation Formation Operations Planning Software, a tool enabling scalable operations for formation flying satellites. With the increasing popularity of satellite constellations, particularly in the commercial sector, there is a practical challenge with the operational complexity of larger constellations. The knowledge required to control spacecraft formations is highly specialized and time intensive, with expertise typically in short supply. This, combined with the repetitive nature of the complex analysis involved in the verification and manual planning of operations does not scale well with constellation size. With no readily available commercial-off-the-shelf product capable of managing large constellations of formation flying clusters, a software application that performs this task while being accessible to those with little or no domain-specific expertise is motivated. Thus, a novel formation management software was developed for satellite constellation operations by the Space Flight Laboratory (SFL). This tool is packaged as a desktop application with a Graphical User Interface (GUI) that abstracts the complex formation flying algorithms from the user. The tool enables operators to focus on planning rather than understanding the underlying relative astrodynamics to control satellite formations. The software services satellite formation-flying clusters throughout the duration of their missions, focusing primarily on maintaining the satellite cluster's spatial diversity against orbital perturbations resulting in deviations from the desired configuration. This is known as station keeping, wherein the user specifies the desired constellation's spatial distribution as formation pairs using relative orbital element states, and the software determines the necessary thrust plans required to achieve it. Once set, the software determines the thrust plan on a user-defined periodic basis to ensure the target formation is established and maintained. Additionally, further verification and visualization capabilities are provided to the user, such as user-defined thrust command generation for impromptu orbit adjustments, 3D constellation visualizations, post-maneuver Two Line Element generation, and relative motion plots for each spacecraft in the cluster. The features of the Constellation Formation Operations Planning Software will be outlined within this work, in addition to the software's general design and architecture. The paper concludes with the tool's impact on constellation operations efficiency through a capability demonstration that was conducted, in which the software maintains the formations through an arbitrary time window for a satellite constellation currently on-orbit.