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STUDY ON GROUND SEGMENT AUTOMATION CONCEPTS FOR PAST AND PRESENT VLEO SATELLITE MISSIONS

Abstract

The collaborative research center (CRC) "Advancing Technologies of Very Low Altitude Satellites (ATLAS)" at the University of Stuttgart, funded by the German Research Foundation (DFG), focuses on extending satellite lifetime in very low Earth orbit (VLEO) by an order of magnitude. The project encompasses 17 interdisciplinary research projects, which are investigating topics related to the fundamental understanding of gas-surface interactions, novel subsystem solutions, and challenges on a mission level. The proposed study, conducted at the University of Stuttgart's Institute of Space Systems (IRS) as part of the ATLAS CRC, investigates the challenges of operating VLEO satellites below 450 km altitude.

The increase in active satellites in low Earth orbit (LEO), largely driven by constellations like Starlink and OneWeb, raises concerns about cascading effects of space debris from potential collisions. While collisions in LEO pose long-term risks, the VLEO regime benefits from a self-cleaning effect due to the comparatively high atmospheric drag, which accelerates satellite decay. However, this drag also presents significant operational challenges that require automation solutions in the ground segment.

This paper investigates the automation solutions deployed during previous and currently planned VLEO satellite missions within their respective ground segments. Past missions in the VLEO regime have demonstrated a clear need for higher levels of automation compared to LEO missions, due to the unique challenges in this environment. Nevertheless, among the different VLEO projects differing levels of automation have been utilized. To better understand the particular differences, this paper aims to identify the major drivers behind these automation approaches. The paper examines the major boundary conditions as well as the mission profiles, as both significantly influence the selection of automation solutions. Given the low number of VLEO satellite missions and the associated scarcity of information, currently planned missions are additionally discussed without, however, assessing their demonstrated effectiveness during active operations. Through this comprehensive analysis, the paper seeks to provide insight on past and current VLEO automation concepts to enhance the understanding of their necessity and applicability across different mission scenarios.