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DESIGN FOR CROSS-PLATFORM COMPATIBILITY AND RELIABILITY IN DISTRIBUTED DEEP SPACE ARCHITECTURES CONTROLLED BY THE LEO MULTI-PURPOSE COMMAND AND CONTROL MISSION

Abstract

Autonomous and human missions in the Sun – Earth – Moon System and beyond will call for (a) innovative architectures dispersed throughout the Deep Space in Halo Orbits, (b) design of parking orbits around Libration L2 and L1 points, (c) telescopes in a variety of L2 Halo Orbits (including a radio telescope on the Moon's far side), (d) continuous LEO – Earth-Moon L2 communication, (e) the interplanetary transfer trajectories from LEO to various destinations, (f) reusable interplanetary transport system between Earth and Mars, (g) transfer vehicle at Sun-Earth L2, and (e) C2 relay of small satellites in LEO. A reusable crew transfer vehicle (ITV) can be stationed at Sun-Earth L2 and/or in LEO. The prototyped architecture includes the following components: 1. crew-rest subarchitectures located at the Sun-Earth L2 and in LEO; 2. ITV parking subarchitectures located at the Sun-Earth L2 and in LEO; 3. C2 relay of five small satellites executing the mission control from LEO; 4. the Near-Earth Asteroid 1999 AO10 mission consisting of the 5-month round-trip flight and 30-day stay at the asteroid. One simulation scenario includes the mission trajectory that launches on September 24, 2025, arrives to the Near-Earth Asteroid 1999 AO10 Halo Orbit on December 20, 2025 and departs on January 19, 2026 returning to LEO on February 22, 2026. The LEO C2 relay simulation scenario continuously integrates the engineering health telemetry of all hardware components and monitors performance of the mission Attitude Orbit Control (AOC) and Guidance Navigation and Control (GNC). The ad-hoc simulation scenario assumed that the LEO C2 relay may dispatch a Deep Space satellite formation scout. Thereafter, FDIR requirements for a solar powered, ion-engined, medium satellite operating at aphelion distance of or above 2.18 AU, i.e., beyond Mars' orbit, include high autonomy, hardware redundancy and autonomous configurability, and real-time software surveillance of system-specific critical parameters. The FDIR requirements also assume the standard 10 days operability and two months survivability in safe configuration without ground contact. The prototype integrates the individual components, simulates end-to-end mission performance and defines failure injection and propagation models at the levels of mission control, spacecraft systems, data repositories, systems configuration and interfaces, limited scientific payload hardware and software. The proof-of-concept functional, expandable FDIR framework and FDIR neural networks simulation scenarios were sized at 2.5 M SLOC and estimated to complete in 45.6 months at about $1.12Binconstantdollars(parametricRayleighformproductioncurve)$.