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IN-SITU TESTBED ARCHITECTURES OF FLYING FORMATIONS DISPERSED IN L1 – L5 HALO ORBITS IN THE SUN – EARTH – MOON – PLANET SYSTEM

Abstract

This paper conceptualized incorporation of small – to – medium satellite formations in Deep Space Exploration. Prototyping Space Exploration Roadmap concept (PSER) pursued a system engineering approach to rapidly deploy a cohesive system of durable, expandable, reconfigurable autonomous architectures – prototypes (in-situ testbeds), missions, and ad-hoc and contingency scenarios encompassing probes to Earth Quasi – Satellites (EQSP); In-Situ Space Science Laboratory at Earth – Moon L5 (Space Lab); Interplanetary Transport System; ad-hoc scout missions dispatched from LEO to counteract hazardous events and celestial bodies; command and control architecture for operational control from LEO of deployed architectures and missions (LEO – C2). LEO – C2 architecture simulates real-time decision-making and communication of actionable data with Earth Ground Stations, testbed architectures in Halo orbits of Sun – Earth L2, Earth - Moon L1/L5 and dispatches probe missions (SAR, pathfinders, scouts, transfers). PSER will continue development of advanced active RFID technology for real-time unique identification of physical and electronic events. EQSPs are autonomously controlled by LEO – C2. ESQPs study the rates and factors influencing orbits and bi-directional reflectance spectra and geometries of celestial bodies rotating around the Sun in orbits that keep these asteroids as constant companions of Earth. In addition to forming dynamic science bank, these probes will gather real-time ephemerides and engineering health telemetry necessary for development of prepositioned SAR and ad-hoc scout missions. PSER will prototype reproducible, reusable, reconfigurable and re-positional in-situ space science platforms for in-situ multi-point and multi-target science observations of atmospheric, geophysics, cosmochemistry, ephemeris, astronomy, and navigation control (celestial mechanics, observational, radio, and radar astronomy). Space Lab at the Earth – Moon L5 will study Kordylewski dust clouds (KDCs) around the Earth-Moon L4 and L5. Software for integration of guidance navigation and control of a given mission-optimized formation with attitude and orbit control systems of individual craft (I- GNC/AOCS) to control a flying formation and its trajectory in the state of equilibrium remains unresolved. In proposed I – GNC/AOCS framework each individual spacecraft moves along its own trajectory and retains membership within the moving formation. Dynamic stochastic optimization with Kalman filtering differential equations combined with dynamic graphs form a framework for the integrated I-GNC – AOCS analytical solution. PSER operational testbeds simulate mission scenarios and define failure injection and propagation models. Engineering science and telemetry feed pre-development of full-scale missions. Resources for PSER were estimated at $5.2 billion$.