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ON-BOARD IN LOOP SIMULATOR DESIGN AND MISSION TESTING FOR GUIDANCE, NAVIGATION AND CONTROL (GNC) SYSTEM FOR LANDING MISSIONS

Abstract

The design of interplanetary landing missions pose far more challenges than earth observation satellites as they are to operate in relatively unknown areas - gravity variations, terrain undulations, atmospheric conditions etc. must be factored. Limited ground visibility, time criticality of descent control operations and single opportunity for landing usually necessitate complete autonomy. Rapid failure detection and auto-reconfiguration features are also built in. This paper discusses a simulator design which not only tests the Guidance, Navigation and Control (GNC) functionalities of Lander Mission but also enables the recreation of exhaustive test scenarios involving physical parameter variations and various failure conditions to demonstrate the performance robustness and stability. The simulator test bed focuses on testing the Guidance, Navigation and Control system which forms the core of such missions. The GNC system acquires sensor data, fuses them to determine the navigation state, controls the actuators to steer towards the target, analyses faults and re-configures the system without compromising the mission profile. The simulations are demanding in terms of resources so as to match the actual scenario – high fidelity mathematical models need to be executed for all subsystems working in unison within a stipulated deadline in a closed-loop simulation environment. This paper mainly addresses the Closed Loop Simulations in the real time environment. The real-time features like kernel pre-emption patch for Real Time Operating System (RTOS), multi-threading based sensor modelling, distributed architecture, real time communication interface and time synchronization are discussed. The simulator has been designed to simulate various failure scenarios across different mission phases with corresponding assessment of mission performance. Stress environments are simulated to check for the GNC system software integrity. Additionally, the simulator

must cater for appropriate parameter scaling such as atmospheric factors for equivalent tests done here on earth. As the test cases shall be exhaustive to simulate all possible scenarios, manual testing and verification may be prone to human errors and time consuming , hence the automations developed to carry out closed loop mission testing and results analysis is also discussed. The simulator has been newly developed and is being in use for rigorous validation of ISRO's landing missions.

Keywords: GNC, Simulator, RTOS, Landing Mission, Automations