Autonomous Satellite Technology for Resilient Applications - ASTRA

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This paper describes a project which leverages a NASA developed platform (NPAS – NASA Platform for Autonomous Systems) for implementation of on-board "thinking" autonomy on-orbit, including avionics, software, and autonomous operations. The autonomy capability is currently being validated as a payload rider on-board LizzieSat-1 (LS-1), a commercial satellite launched and operated by Sidus Space.

ASTRA is demonstrating a new paradigm that enables on-board "thinking." ASTRA is a system autonomy capability (including digital twins, anomaly detection, diagnostics/prognostics, and mission management) enabled by an innovative technology, NPAS, developed by NASA Stennis Space Center (SSC) Autonomous Systems Laboratory (ASL) with support from NASA Exploration Systems Development Mission Directorate (ESDMD) Advanced Exploration Systems (AES) and Mars Campaign Office (MCO). ASTRA was enabled by an AES/MCO funded initiative, Polaris Program, instituted to help NASA solve the difficult problems associated with sending humans to the Moon and Mars. ASTRA includes advances in hardware required for implementing autonomy. NPAS is running on the latest commercial hardware that provides the computational and memory resources needed for on-board autonomous behavior and operations. ASTRA is a containerized implementation that is demonstrating hierarchical distributed autonomy encompassing 2 autonomous system managers working together to achieve coordinated objectives. In addition to autonomous operations, ASTRA establishes a dual testbed for NASA SSC Autonomous Systems Laboratory (SSC ASL): (1) on orbit - in space on-board the satellite and (2) on the ground using a complete set of flight telemetry, processed through a flight equivalent engineering unit, throughout the mission.

The avionics implementation for the LS-1 satellite includes 3 on-board processors, an SP0 processor running the satellite operations implemented in Core Flight Software (cFS) and 2 NVIDIA General-Purpose Computing Graphics Processing Unit (GPGPU) processors running Linux; one of the GPGPUs is owned by Sidus Space and hosts multiple payloads, and the second GPGPU is dedicated to ASTRA. ASTRA is a uniquely configured payload that can

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operate LS-1 when enabled. ASTRA is designed to evolve via software uploads. The first version of ASTRA Flight Software (FS) encompasses core capabilities to validate communications, command, and control. The second version of ASTRA FS is designed to monitor and eventually manage the LS-1 onboard electrical power system (EPS), including load-shedding in low power generation conditions. NASA SSC ASTRA coordinates operations with LS-1 using NPAS' Software Bus Network (SBN) bridge (the SBN bridge enables integration of NPAS applications with LS-1 cFS applications). Telemetry from LS-1 systems (e.g. power) is made available to ASTRA using SBN publish/subscribe capabilities. ASTRA data flow from LS-1 involves ASTRA Ground Operations performed at the ASTRA Payload Operation Command Center (POCC) at NASA SSC ASL. Prescribed telemetry stream(s) are transmitted from LS-1 to the Sidus Mission Command Center (MCC) and then bent piped to the ASTRA POCC. LS-1 data is transmitted to Sidus (MCC) via ground stations Sidus leases daily from KSAT and ATLAS ground station providers. All data collected at the Sidus MCC is pushed (encrypted) to the SSC ASL POCC via UDP connection. Telemetry data is streamed immediately to ASTRA POCC during each successful LS-1 communication pass.

This technology demonstration will enable development, test, and validation of autonomous satellites, and of autonomy capabilities needed to support future Artemis and Moon-to-Mars (M2M) missions.

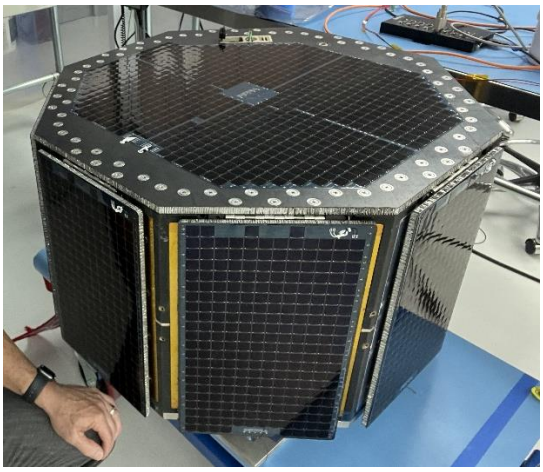

Fig. 1 LizzieSat-1 ready for ship to Vandenberg Space Force Base.

A. References

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