Polaris Project: Autonomous Satellite Technology for Resilient Application (ASTRA)

Active Technology Project (2021 - 2025)

Project Description

Project Description & Objectives

National Aeronautics and Space Administration (NASA) selected 10 proposals led by early-career employees across the agency for two-year projects that will support the development of new capabilities for deep space human exploration. These proposals were selected under a new initiative, to support the NASA workforce in efforts to meet the challenges of sending humans to the Moon and Mars called Project Polaris, as small flight experiments or risk reduction projects to fulfill high-priority capabilities gaps, awarded through now Mars Campaign Office (MCO). The proposal submitted by the NASA Stennis Space Center (SSC) Autonomous Systems Laboratory (ASL) called Autonomous Satellite Technology for Resilient Applications (ASTRA) was one of these selected projects. NASA SSC is partnered with industry, Sidus Space for this project. Sidus Space has relevant prior experience and expertise to support this integration and infusion activity, and these skills were a critical component associated with selection of ASTRA project proposal. ASTRA will be a payload rider onboard the LizzieSat (LS)-1 small satellite, Sidus Space's premier satellite platform designed to provide turnkey access to space. As part of the partnership with Sidus, the NASA SSC team will work with Sidus to integrate the ASTRA hardware and software on LS-1. Sidus Space assumes responsibility for rocket launch to deploy satellite and all mission operations. The NASA SSC and Sidus teams are preparing for a 6 to 36 month on-orbit mission.

ASTRA will demonstrate autonomous operations in a spaceflight environment, while providing flight heritage for an MCO-derived autonomous systems software platform. ASTRA will operate as a payload rider using ARM/GPGPU based hardware – which meets advanced/sufficient computational power and storage requirements necessary for implementing autonomous operations. This will be first use of this hardware for autonomous operations on orbit. The software and hardware will be closing or mitigating multiple HEOMD Tier 1 autonomy capability gaps, advancing TRL, integrating ASTRA Flight Software (FS) with Core Flight System (cFS) applications, implementing distributed autonomous operations (based on Gateway autonomy design) and conducting mission management from ground. NASA Platform for Autonomous Systems (NPAS), the software platform that ASTRA FS is built upon, is being cultivated as a paradigm shift in the way NASA develops autonomous operation software that will enable cost effective, comprehensive, "thinking", and evolutionary autonomy for future space and ground systems.

The autonomous systems capabilities demonstrated by ASTRA will be immediately applicable to multiple Artemis elements. Artemis crew missions may only last days; however, Artemis systems (e.g., Gateway, LTV, HLS, Habitation Modules) will remain uncrewed in lunar orbit and on the lunar surface for many months, and will rely entirely on autonomous systems to maintain function. Keeping these systems viable is vital to the success of

Project Polaris was a new initiative to help small teams of mostly early career employees meet the difficult challenges of sending humans to the Moon and Mars.

Table of Contents

Polaris Project: Autonomous Satellite Technology for Resilient Application (ASTRA)

Active Technology Project (2021 - 2025)

Artemis**.** Trust must be established in autonomous systems to perform mission tasks, run spacecraft and surface systems, and plan and conduct mission operations. ASTRA is paving the path for reducing the time to deploy high-priority capabilities to Artemis missions and reduces risk, program cost, safety issues, and schedule challenges through the successful demonstration of autonomous operations.

The ASTRA project payload mission objectives for this technology demonstration on orbit include: implementation of an autonomous vehicle system manager for select satellite subsystems (Electrical Power System and Guidance Navigation and Control System), Integrated System Health Management (ISHM), and resource management. ASTRA will also conduct experiments to evaluate the on-orbit performance to real and simulated faults. Additionally, ASTRA will utilize a Gensym G2 Software-Software Bus Network (G2-SBN) bridge to cFS software, developed by prior public-private partnerships with industry, to communicate with the LS-1 payload processor. ASTRA is an integrated software and hardware system – technology demonstration activity.

ASTRA Payload Classification and Operating Modes:

- ASTRA hardware is a class D payload
- ASTRA FS is a class C software
- ASTRA will conduct health management in flight, and in parallel conduct Automated Flight Following (AFF) mode on the ASTRA hardware with ground validation
- Upon completion of all payload riders and LS-1 mission objectives, and at LS-1 end-of-mission, and concurrence from Sidus Space, ASTRA will operate in Vehicle Commanding (VC) mode sending commands to LS-1 flight computer to autonomously control LS-1 and accomplish targeted mission opportunities

FY 2021 – FY 2022

At the end of FY21, NASA announced selection of final project Polaris awardees https://spaceref.com/press-release/nasa-empowers-workforce-to-advance-deep-space-technologies/.

Activities accomplished during Year 1:

- ASTRA-Sidus Space Kick-off Meeting
- ASTRA and Sidus Space teams conducted trade studies in coordination with Sidus Space to select space flight processor
- ASTRA System Requirements Review (SRR)
- ASTRA Engineering Unit delivered to Sidus Space
- ASTRA Preliminary Design Review (PDR)
- ASTRA Flight Hardware received

Organizational Responsibility

Responsible Mission Directorate:

Exploration Systems Development Mission Directorate (ESDMD)

Lead Center / Facility:

Stennis Space Center (SSC)

Responsible Program:

Mars Campaign Office

Project Management

Program Directors:

Lindsay T Aitchison
Dayna S Ise

Project Manager:

Lauren W Underwood

Principal Investigator:

Fernando Figueroa

Co-Investigators:

Zachary H Lewton
Travis D Martin
Jonathan A Morris
Mark G Walker

FY 2023

Activities accomplished during Year 2:

- Version A of ASTRA Concepts of Operations (CONOPS), Mission Operating Plan (MOP), and Software Design Document (SDD) (which includes the Interface Control Document) were baselined in support of Sidus CDR
- Drafted ASTRA Contingency Plans
- Drafted ASTRA Flight Rules
- ASTRA Critical Design Review (CDR)
- ASTRA Pre-ship Readiness Review
- ASTRA FS v1.0.0 Code Review
- ASTRA Flight Readiness Review (FRR)

Other Activities

MCO has adopted ASTRA just in FY24 in support of activation and implementation and operation of payload operations command center and remote update of onboard ASTRA FS that will enable autonomous operations.

Tier 1 Gaps Addressed

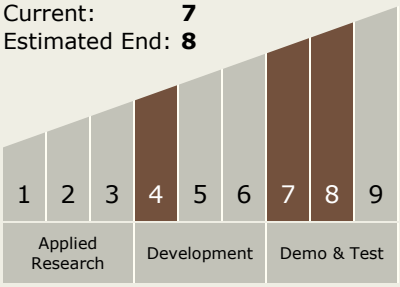
03-09a (Autonomous Systems); 03-09b, 03-09c (Power & Energy Storage); 10-04, 10-05 (Autonomous Systems); 13-06 (Ground, Test, and Uncrewed Surface Systems)

Anticipated Benefits

As a payload rider on LS-1, ASTRA is providing a hybrid test bed for demonstrating autonomous operation on-orbit with ground simulation and validation. Demonstration of autonomous operations on-orbit, on an advanced processor, has cross-cutting relevance for autonomy contributions to advanced technologies needed to close HEOMD autonomy gaps, to support Moon to Mars (M2M) program office needs (i.e. Orion, Gateway, HLS and Habitation), and to provide benefit to commercial space industry partners. ASTRA will demonstrate an autonomous operations technology in a spaceflight environment, advance TRL, and gain flight heritage for a GPGPU/ARM processor and autonomous systems development platform (NPAS).

Technology Maturity (TRL)

Start: **4**
Current: **7**
Estimated End: **8**



Technology Areas

Primary:

- TX10 Autonomous Systems

Target Destinations

Foundational Knowledge, Low Earth Orbit

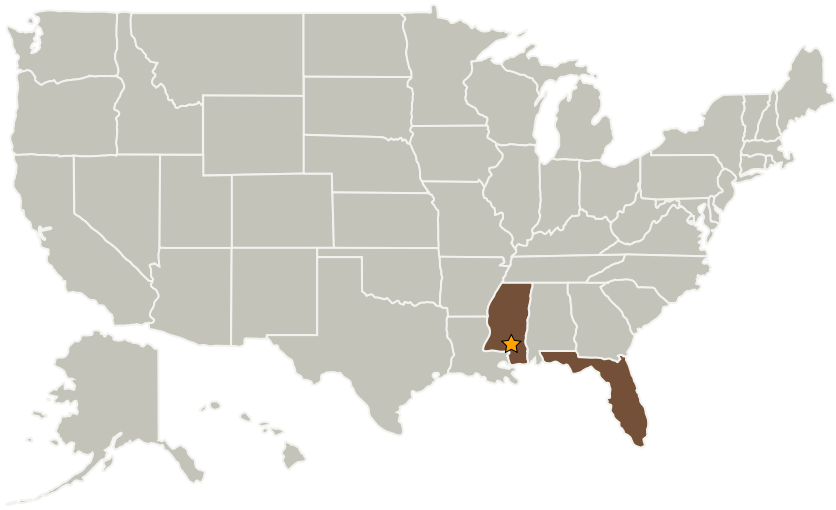
Views on TechPort

46 views

Polaris Project: Autonomous Satellite Technology for Resilient Application (ASTRA)

Active Technology Project (2021 - 2025)

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Stennis Space Center(SSC)	Lead Organization	NASA Center	Stennis Space Center, Mississippi
Sidus Space(SIDU)	Supporting Organization	Industry	Cape Canaveral, Florida

Co-Funding Partners	Type	Location
Exploration Systems Development Mission Directorate(ESDMD)	NASA Mission Directorate	

Primary U.S. Work Locations	
Florida	Mississippi

Images

ASTRA Flight Hardware
https://techport.nasa.gov/image/314570

ASTRA Flight Unit - ASTRA Flight Unit - Aitech S-A1760 Venus™ NVIDIA, Jetson™ Tx2i space-rated, rugged, radiation-characterized for Low Earth Orbit, GPGPU (General-Purpose Graphics Processing Unit)

ASTRA Payload Operation Command Center (POCC)
https://techport.nasa.gov/image/314560

ASTRA Payload Operation Command Center (POCC) - ASTRA Payload Operation Command Center utilizes dual User Datagram Protocol connections between Stennis Space Center and the Sidus Space Mission Operations Center to receive near real-time telemetered data from the Sidus Space LizzeSat -1 satellite

Project Polaris
https://techport.nasa.gov/image/314606

Project Polaris was a new initiative to help small teams of mostly early career employees meet the difficult challenges of sending humans to the Moon and Mars.