SSC EA03 Office of Technology Development

- Technology Development
- Technology Transfer
Office of Technology Development Overview

✓ Technology Development

✓ Technology Transfer

Small, agile, lean and impactful team

Innovative partnerships
Technology Development - ASL

Autonomous Systems Lab (ASL)
- R&D and operational systems
- NASA Platform for Autonomous Systems (NPAS)
- Tools for NASA MSFC, JSC, KSC, SSC, STMD and as well as industry customers

- Lockheed Martin
- Northrop Grumman
- Boeing
- Ignite Technologies
- D2K Tech
- Mississippi Research Consortium

NASA STEM Engagement

STMD: Game Changing Development
SSC Autonomous Systems Lab (ASL)

Enable development and testing of autonomous operational capabilities

✓ High performance computing workstation
✓ ASL Virtual Connectivity Network

✓ Enables the types of development to support partnerships with NASA and industry
✓ Supports development of capabilities required for sustainability on the moon and mars
✓ Provides tools and expertise to solve complex problems
SSC FY23 CIF Projects

• Enhanced Autonomous Refueling Capability for Gateway and Surface Systems, PI: Dr. Fernando Figueroa

• Development of Spike Ejector Technology, PI: Daniel Jones

• Edge Machine Learning Predictive Anomaly Detection for Autonomous Operations, PI: Zach Lewton

✓ Purdue University

✓ Edge Impulse

https://www.edgeimpulse.com/
Why is this project important?

✓ As NASA extends Exploration Missions beyond the Moon to Mars, reliance on and confidence in autonomous systems becomes critical to crew health and mission success.

✓ The NPAS project is maturing autonomous systems technology and deployment to help close the highest priority technology capability gaps and support Artemis and Exploration Missions.
NPAS Process Improvement: Path to Class A Certification

✓ CMMI rating increases confidence for developing NASA Safety Critical Software, and decreases risk in software product development
✓ Reduces risk for both safety and schedule on future projects with both NASA and commercial industry

NPAS Project received a Benchmark CMMI Appraisal Level 2
NPAS is partnered with the JSC Human Physiology, Performance, Protection & Operations (H-3PO) Lab team at JSC which support Crew Health and Performance (CHP) EVA (Extravehicular Activity) testing

Project Title: NPAS Crew State & Risk Model (CSRM) implementation with Crew Health and Performance (CHP) Extravehicular Activity (EVA) model (Personalized EVA Informatics & Decision Support - PersEIDS) to help improve CHP EVA Decision Support System (DSS) capabilities

✓ New autonomous operation capabilities must be developed and matured to close this capability gap, to protect crew health and performance during EVA.
ASTRA – Autonomous Satellite Technology for Resilient Applications

ASTRA
✓ Demonstrate an autonomous operations technology in a spaceflight environment, provide flight heritage and testing for an autonomous system manager on LizzieSat™ (a Sidus Space proprietary multipurpose satellite bus that integrates custom payloads).
✓ Evaluate, validate and stress test on-orbit, autonomous operations of satellite management and subsystem functions.

Industry Partner: Sidus Space

Northrop Grumman was awarded a sole-source contract to provide the Gateway HALO module, the first crew module for Artemis.
Human Lander System Integrated Demonstration

Lockheed Martin Collaboration Effort

Project Description
Artemis Ops & Integration Development Test: Demonstrate integrated autonomous mission operations spanning multiple Artemis elements. Demonstrate Vehicle System Manager (VSM)-Module System Manager (MSM), and System Manager (SM) integration of multi-element systems.

"...perfectly representative of the entire base phase...we can do things fast... this was really impressive today" - Paul Anderson, Director, Lockheed Martin Space Systems

"Wow! I am blown away, We are so impressed with what all of you were able to incorporate into one demo."
- Vanessa Aponte Williams, Ascent Element Mission Operations Sr. Manager, Human Landing System, Lockheed Martin
NPAS Gateway Refueling Project

Objectives: As part of approved risk mitigation for identified risk - ‘Insufficient verification for chemical propulsion refueling’, a simplified fluid system ‘breadboard’ emulator is being fabricated to test autonomous refueling

Using NPAS to create digital twins

Breadboard schematic – ESPRIT Highlighted

NPAS Domain Model - ESPRIT Fuel Transfer System

“Refueling Breadboard” hardware in the loop
Orion Power System Digital Twin

Orion Program Management identified a gap in Orion from a data-centric standpoint; tasked Agency Model-Based Systems Engineering (MBSE) Team to develop a strategic plan to lead the effort for the development of an Orion Digital Twin.

Pilot project: Develop a digital twin application for the Orion electrical system power system
- Identified SSC as “Vanguard” contributor to this effort.

NASA SSC: NPAS Autonomous Power System Domain Model
ASL Successes

The Stennis ASL team developed expertise and processes, and created a strategy and unique software platform (NPAS) to enable SSC autonomous systems to enhance ground operations and enable distributed hierarchical autonomy for spaceflight and Lunar/Mars surface missions.

- Created the software infrastructure to implement autonomous operations for the nitrogen system.
- Class C Safety Critical certification – 1st NASA autonomous system with that distinction.
- Enabler of future autonomous operational capability for industry, SSC and NASA.
Innovative Partnerships

✓ M2M X-Hab partnerships with universities to design systems, concepts and technologies to potentially support the agency’s deep space exploration capabilities

✓ NASA STEM Engagement

✓ IDIQ contracts with regional universities to quickly create teams with skills matched to the task
  • Mississippi Research Consortium

✓ Dual Use – SSC creates public-private partnerships with industry to share the cost of developing technologies of mutual interest
  • Ignite Tech

Oklahoma State University
  Project Title: User Interfaces for Autonomous Operations

University of Michigan –
  Project Title: Gateway Voice Control

North Dakota State University
  Project Title: Power Rover Project

✓ Paper and presentation for IEEE Aerospace 2021, summarizing work performed, Title “A Case Study on the Challenges and Opportunities for the Deployment of PHM Capabilities in Existing Engineering Systems”
✓ Best paper award for session – Predictive Maintenance and ISHM

Project Title: Predictive and Condition Based Maintenance of Pumps
ASL Recent Advances

TechPort Fact Sheet: https://techport.nasa.gov/view/94884


NPAS - NASA Platform for Autonomous Systems

Roadmap

SSC ASL Project
Establish new capabilities to design, build and deploy intelligent autonomous systems
Enable rapid, economical development of robust, safety-critical autonomous systems
Support ground operations and Exploration missions
Can also benefit SMD and ARMD and HEOMD Tier 1 Capability Gaps
Utilize experienced space systems engineers and s/w developers