National Aeronautics and Space Administration

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 TRANSFER PROGRAM

BRINGING NASA TECHNOLOGY DOWN TO EARTH

DIGITAL TRANSFORMATION

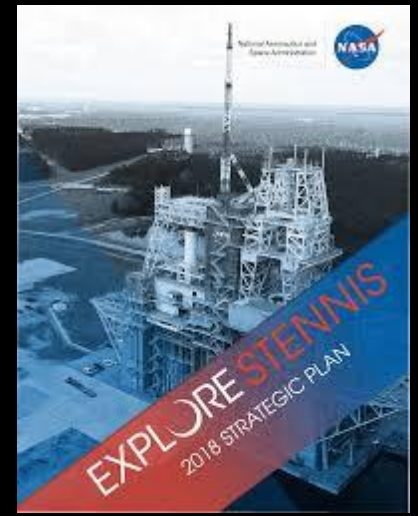
Technology Development - ASL

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

NASA STEM Engagement

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



Marshall Space Flight Center

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/

ASL NASA Platform for Autonomous Systems – NPAS

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

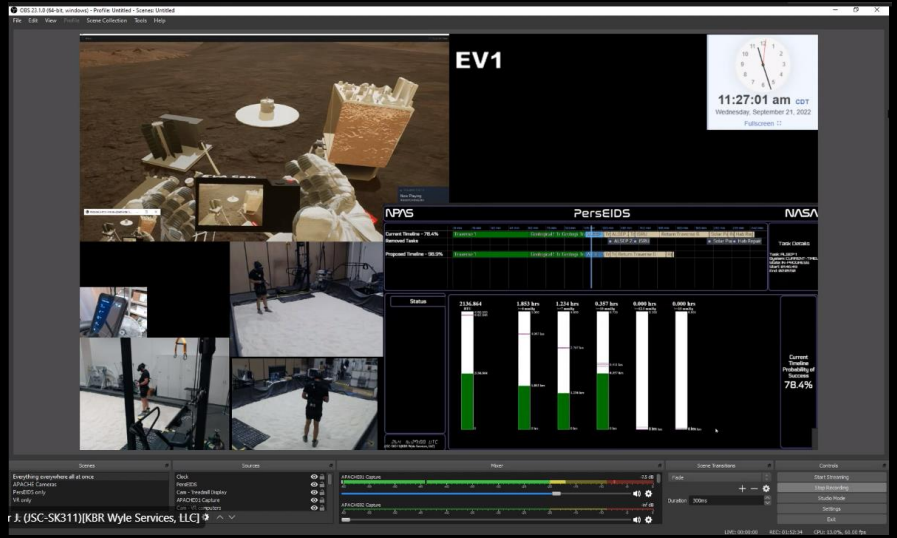
- ✓ CMMI rating increases confidence for developing NASA Safety Critical Software, and decreases risk in software product development
- ✓ Reduces risk for both safety and schedule on future projects with both NASA and commercial industry

NPAS Project received a Benchmark CMMI Appraisal Level 2

NPAS Autonomous System Reasoner

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

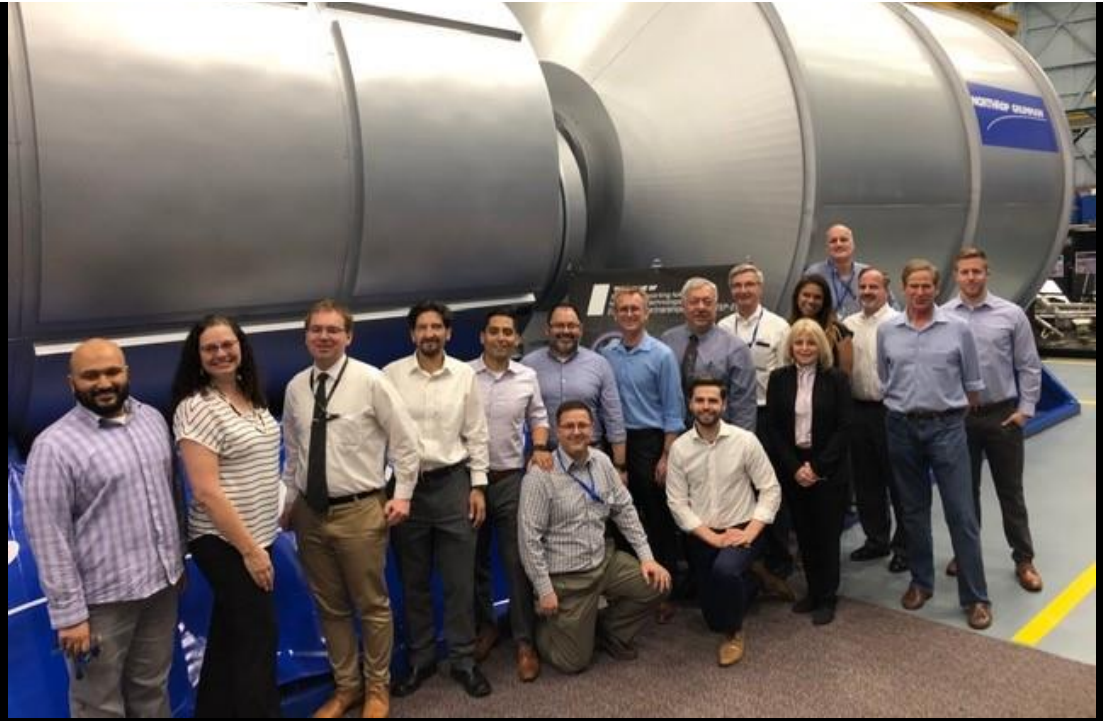
- ✓ Demonstrate an autonomous operations technology in a spaceflight environment, provide flight heritage and testing for an autonomous system manager on LizzieSat™ (a Sidus Space proprietary multipurpose satellite bus that integrates custom payloads).
- ✓ Evaluate, validate and stress test on-orbit,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

Industry Partner: Sidus Space

https://sidusspace.com/09-2021-sidus-space-awarded-nasa-heomd-aes-project-polaris-awards-for-autonomous-satellite-technology-for-real-time-applications-astra/

NextSTEP-2, Habitation Partnership - Outcome

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

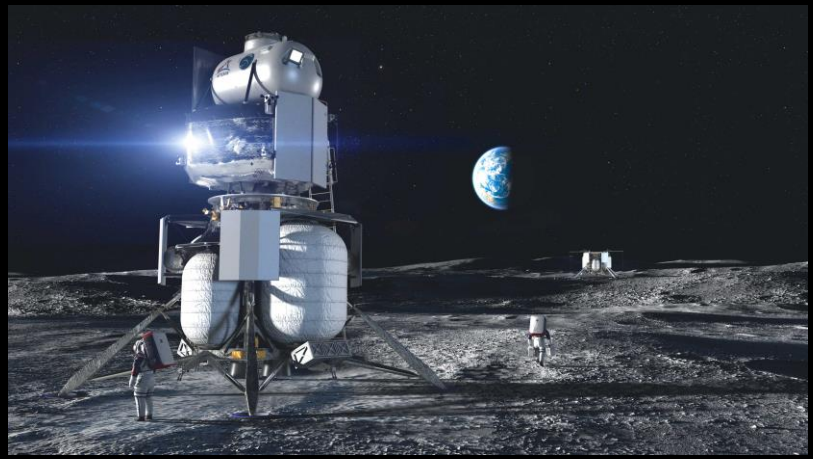
Lockheed Martin Collaboration Effort

Project Description

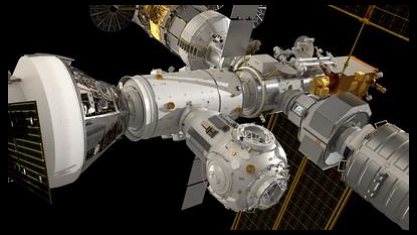
Artemis Ops & Integration Development Test: Demonstrate integrated autonomous mission operations spanning multiple Artemis elements. Demonstrate Vehicle System Manager (VSM)-Module System Manager (MSM), and System Manager (SM) integration of multi-element systems.

"…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

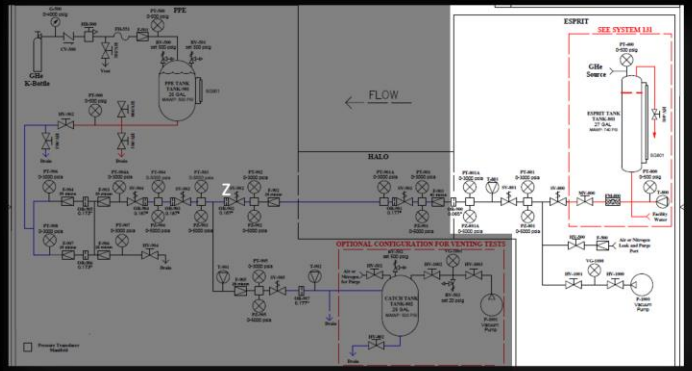


NPAS Gateway Refueling Project

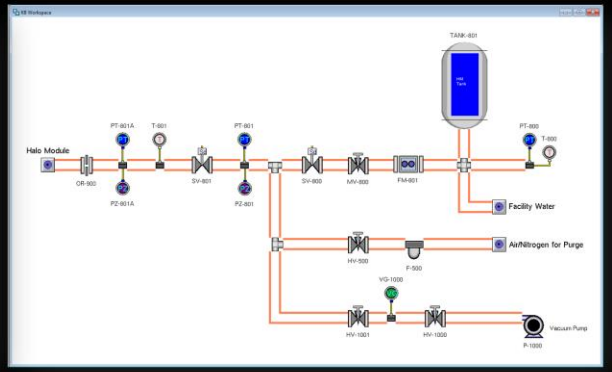


Objectives: As part of approved risk mitigation for identified risk - *'Insufficient verification for chemical propulsion refueling*', a simplified fluid system 'breadboard' emulator is being fabricated to test autonomous refueling

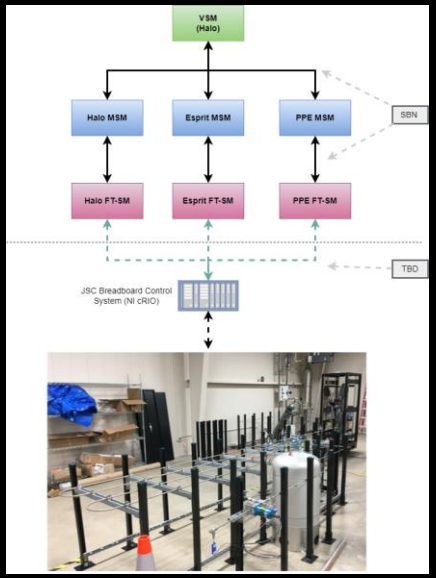
Using NPAS to create digital twins



Breadboard schematic – ESPRIT Highlighted



NPAS Domain Model - ESPRIT Fuel Transfer System



"Refueling Breadboard" hardware in the loop

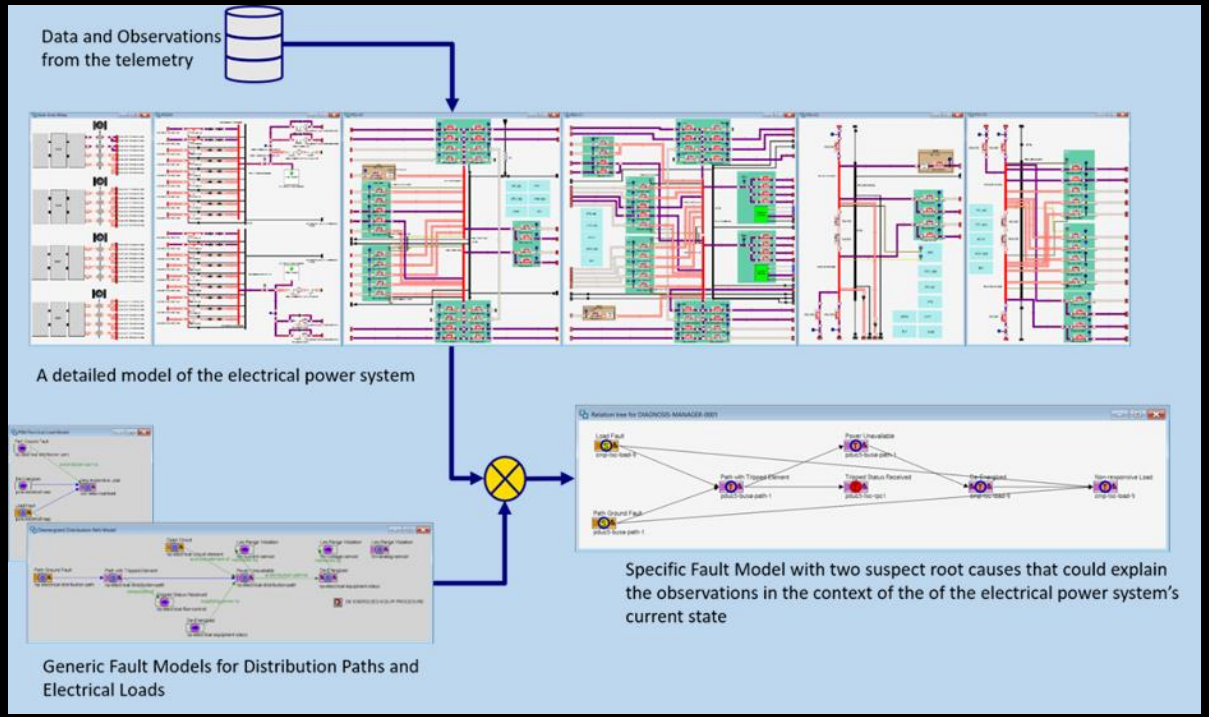
ASL Collaboration Opportunities

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

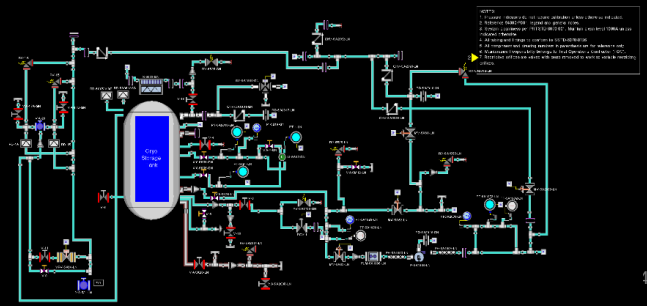


NASA SSC: NPAS Autonomous Power System Domain Model

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

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

- ✓ NASA STEM Engagement

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**

- ✓ 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

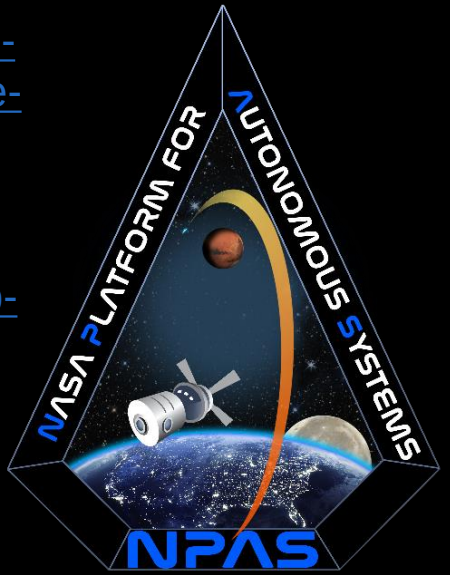
TechPort Fact Sheet: https://techport.nasa.gov/view/94884

Sidus Space Press Release: https://sidusspace.com/09-2021-sidus-space-awarded-nasa-heomd-aes-project-polaris-awards-for-autonomous-satellite-technology-for-real-time-applications-astra/

NASA Internal – Project Polaris Press Release: https://www.nasa.gov/feature/nasa-empowers-workforce-to-advance-deep-space-technologies

D2K Press Release: https://www.d2ktech.com/post/nasa-aes-awards-contract-for-autonomous-systems-in-space

NASA SSC Press Release: https://www.nasa.gov/centers/stennis/news/releases/2021/SSC-Gaining-Recognition-for-Cutting-Edge-Autonomous-Systems-Work



NPAS - NASA Platform for Autonomous Systems
Roadmap


UPSS @ KSC


Orion EFT-1


RAD750 (SP-0)


SVMF @ JSC – HITL with NextSTEP-2 partner

2005 Intelligent ISHM Initial funding for integrated systems health management, testbeds and prototypes

2006

2007 Public-Private Partnership with General Atomics for an ISHM integration & modeling software platform

2008

2009 Chemical Steam Generator pilot implementation

2010

2011 KSC Cryogenic Testbed

2012 CSG Skid Pilot Project


CTL @ KSC

2013

2014 Autonomous Propellant Loading Demo at KSC

2015 Universal Propellant Servicing System at KSC

2016 Orion EFT-1 Demo

2017 HPGF ISHM Monitoring System

Autonomous Systems Domain Specific Language

Port G2 to RAD750

Demo at JSC of Distributed Autonomous Operations – Vehicle Manager, Power & Avionics Systems

2018 INSIGHT Nitrogen Verification, Validation & Deployment

Autonomous Systems Design Guidelines for Flight Hardware

2019 Autonomous Systems Intelligent Strategies

SSC-MSFC partnership NPAS certification for Class A systems

NPAS optimization for flight systems via public-private partnership. SBN Bridge for seamless NPAS-cFS interface

2020 Gateway demo with NextSTEP-2 partner

Autonomous Avionics Risk Reduction Activity with Commercial Partner

2021 NPAS demo for Gateway

2022 LSII: Build, and Excavation Autonomous System Transport (BEAST). Lead by GRC

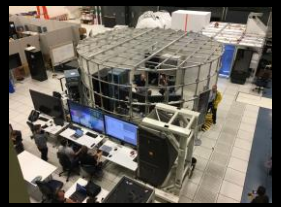
2023


X-Lab @ JSC - autonomy architecture down to the system manager level; create schedule and execute task and timelines across multiple modules developed by separate teams

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


HPGF @ SSC


iPAS lab @ JSC


iPAS lab @ NPAS demonstrated as an integrated hierarchical distributed capability