NASA Autonomous Systems Lab: Capabilities to Enhance the Blue Economy

Ground Operations

Gateway

HLS

Dynetics
A Leidos Company

SPACEX

HUMAN LANDING SYSTEM
NATIONAL TEAM

ISRU

Habitat & LTV

Spacesuit
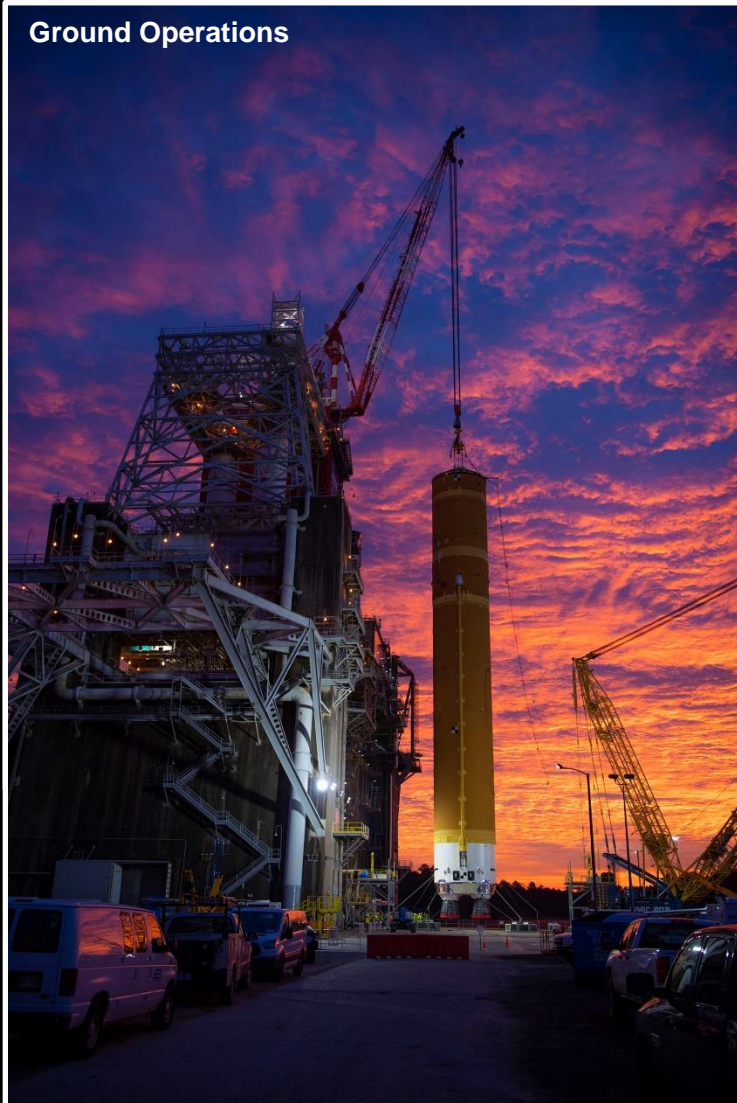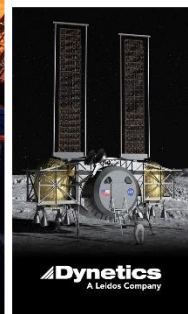
Autonomous Systems Lab Introduction

- Decades of experience in autonomous systems and supporting technologies

- Dedicated team of NASA civil servants and contractors

- Won multiple medals and awards for technical excellence

- Customers include multiple NASA centers/programs and a Who's-Who list of aerospace organizations

- Use the COTS G2 software as the foundation for development

- Created the NASA Platform for Autonomous Systems (NPAS) to simplify and streamline the process of creating robust, intelligent, operational autonomous systems

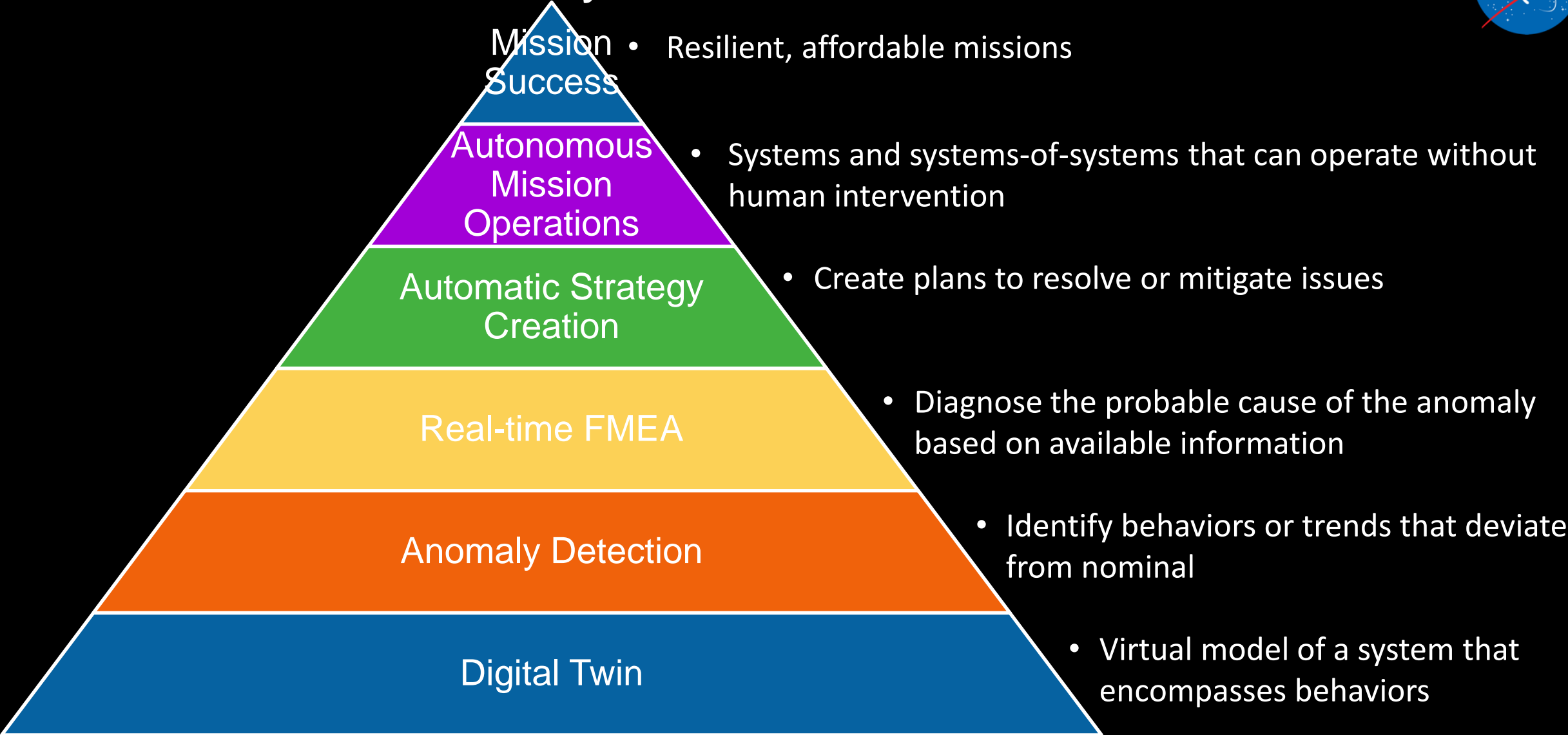- Successfully used NPAS on multiple projects for NASA and industry

What We Provide

- Rigorous software engineering to design, build and deploy operational (not research), safety-critical, autonomous systems

- Distributed, hierarchical architecture to enable robust operation of complex systems-of-systems

- Hardware and software solutions that scale from the edge to the cloud

- Provide
  - Model-based engineering
  - Autonomous systems
  - Integrated Systems Health Management (aka Fault Detection Isolation and Recovery)
  - Predictive- and condition-based maintenance

Pyramid of Solutions

Mission Success

Autonomous Mission Operations

Automatic Strategy Creation

Real-time FMEA

Anomaly Detection

Digital Twin

- Resilient, affordable missions

- Systems and systems-of-systems that can operate without human intervention

- Create plans to resolve or mitigate issues

- Diagnose the probable cause of the anomaly based on available information

- Identify behaviors or trends that deviate from nominal

- Virtual model of a system that encompasses behaviors

The Autonomous Blue Economy

- The blue economy includes all industries and sectors related to oceans, seas, and coasts.

- It includes vehicles operating subsurface, on the surface, in the air, and in space.

- It includes facilities such as ports and shipyards.

- Emerging technologies such as big data, model-based enterprises, internet of things, AI/ML, and autonomous systems are already having an impact.

- The SSC ASL can help the local blue economy conduct research, optimize operations, lower operating and maintenance costs, and compete in a global market.
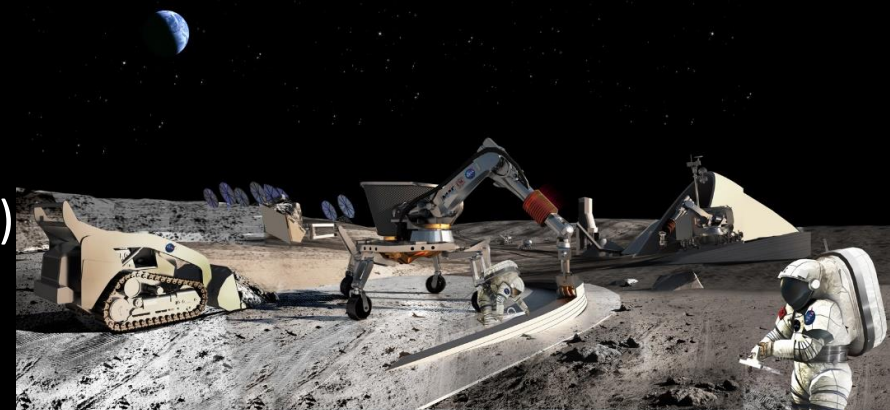
Example Current ASL Projects - 1

- **ASTRA – Autonomous Satellite Technology for Real-time Applications**
  - Demonstrate an autonomous system manager for small satellites
  - Integrated Systems Health Management
  - Hierarchical system management (resource → subsystem → vehicle)
  - Payload operations

- **BEAST – Build & Excavation Autonomous System with Transport**
  - Design, build, and demonstrate on Earth a reconfigurable robotic vehicle capable of autonomously excavating, transporting, and depositing regolith over without human intervention
  - Manage multiple rovers (system of systems)
  - Integrated Systems Health Management
  - Hierarchical system management (resource → subsystem → vehicle)

Example Current ASL Projects - 2

- **Edge Machine Learning Predictive Anomaly Detection for Autonomous Operations**
  - ASL team won a **2021 IEEE Aerospace Conference best paper award** for work in predictive- and condition-based maintenance
  - Extending that work to include machine learning deployed at the edge in small embedded systems

- Gateway Refueling
  - The Gateway is a new space station that will orbit the Moon and enable astronauts to reach new areas of the Moon
  - The Gateway consumes fuel to change orbits, so over time it must be refueled in space
  - The ASL team is creating a reference design for in-space fuel transfer operations
  - Integrated Systems Health Management
 - Hierarchical system management

- **Class A Human Rated, Safety-Critical Autonomous Operations**
  - CMMI Level 3 certification for the ASL team

- **Spacesuit Upgrades**
  - The ASL is assisting another NASA team working on the design of the spacesuits for Artemis missions
  - Integrated Systems Health Management
  - Hierarchical system management
  - Reduce/eliminate the need for monitoring by Mission Control or nearby astronauts

xEMU

Orion Crew Survival System

Recent ASL Customers

- **Northrop-Grumman -** helped secure a sole-source contract for the Gateway HALO module

- **Lockheed-Martin/Blue Origin -** completed the most comprehensive-to-date demonstration of autonomous capabilities to enable safe, sustainable operation of the interacting Gateway, Orion, and Human Landing System vehicles in cislunar space

- **NASA Centers**
  - Provided tools to GRC, JSC, KSC, and SSC

- **NASA Programs**
  - Advanced Exploration Systems
  - Gateway Program
  - Rocket Propulsion Testing Program

- Collaborating
  - NRO/Space Force
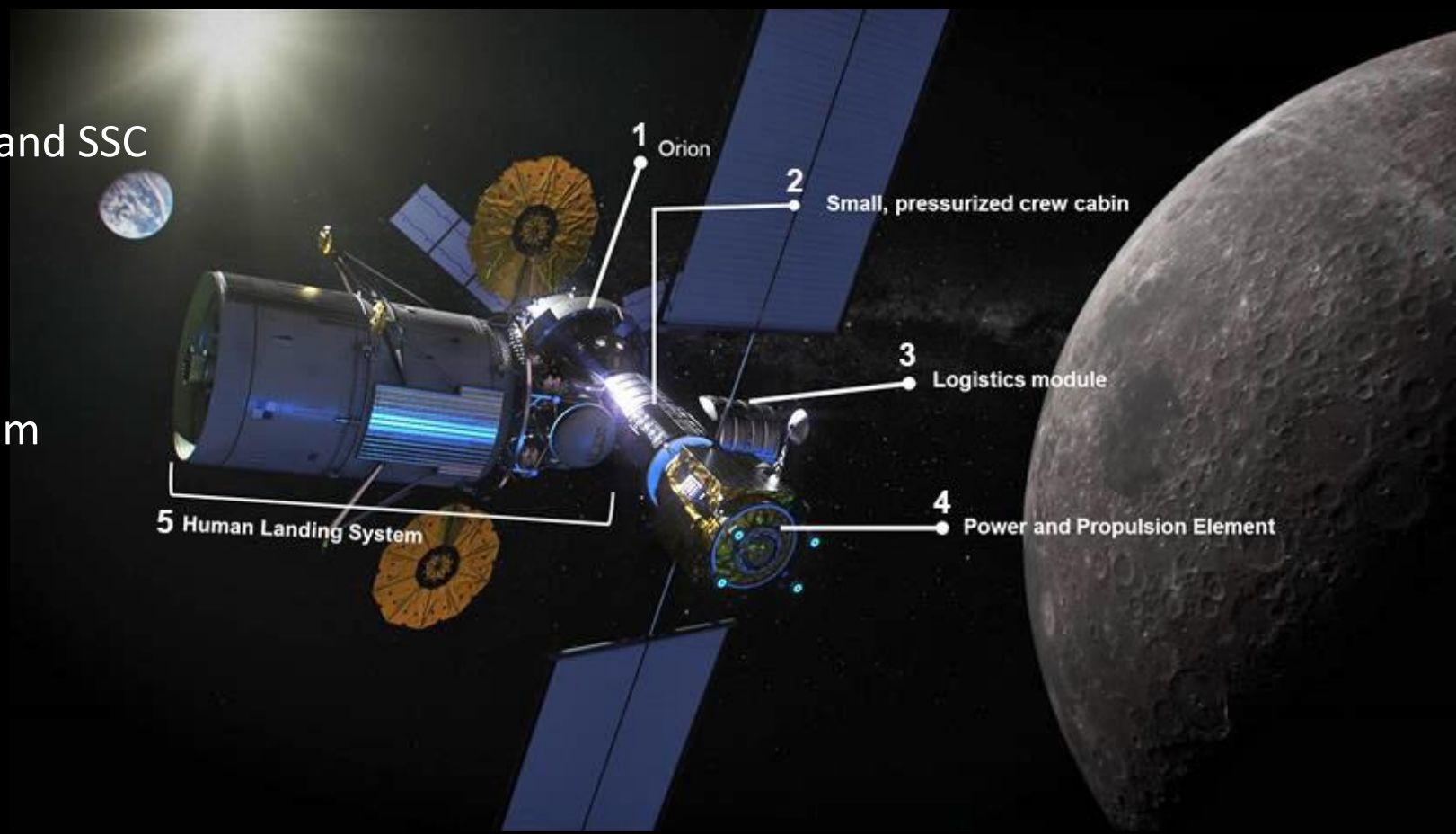
Summary

- The Stennis Space Center (SSC) Autonomous Systems Lab (ASL) provides state-of-the-art, mission-ready, solutions to customers across the aerospace industry

- ASL expertise and tools are directly applicable to challenges facing those in the blue economy

- To learn more or discuss partnership opportunities, contact

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