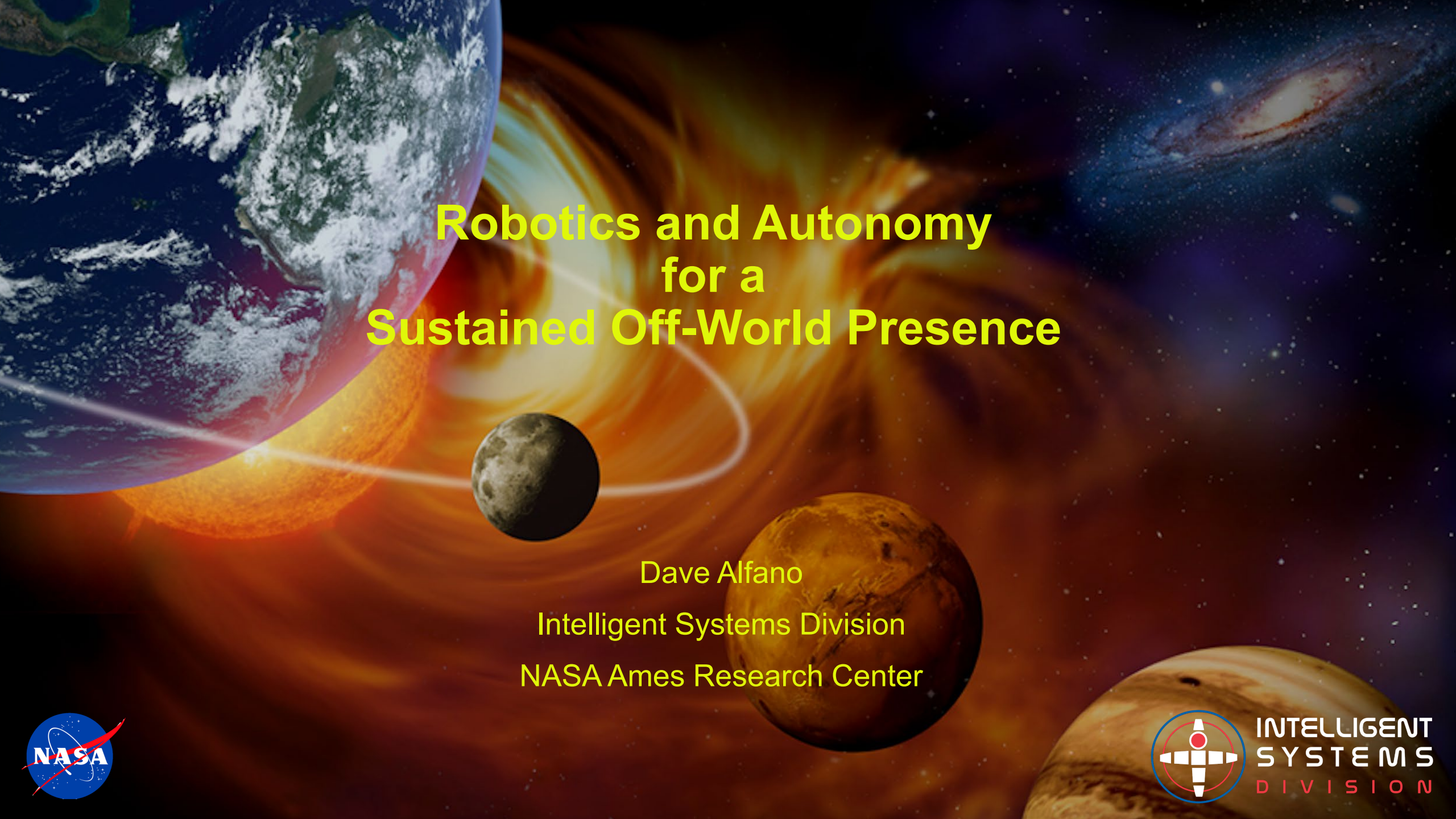


Robotics and Autonomy for a Sustained Off-World Presence

Dave Alfano

Intelligent Systems Division

NASA Ames Research Center

NASA

INTELLIGENT SYSTEMS DIVISION

What Does NASA Do?

Aeronautics Research







Transform Aviation through R&D

Space Operations





Launch and Space Operations

Deep Space Exploration Sys.









Moon to Mars Exploration

Science

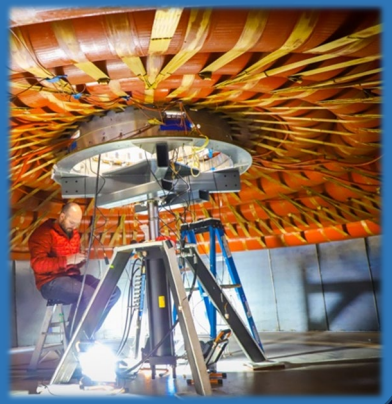




Understand the Sun, Earth, and Universe

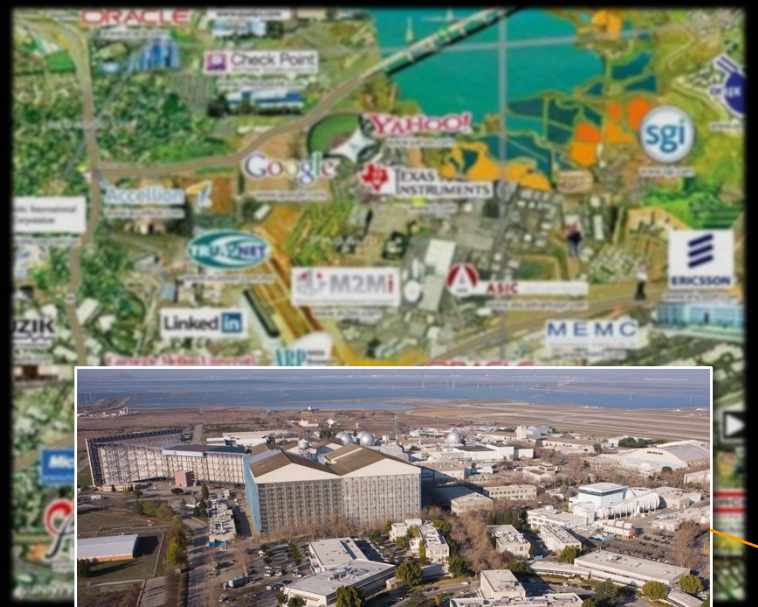
Space Technology



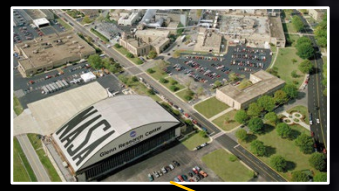


Develop and transfer revolutionary technologies

NASA Centers



Ames Research Center



Glenn Research Center



HQ



Goddard Space Flight Center



Langley Research Center





Marshall Space Flight Center



Armstrong Flight Research Center



Jet Propulsion Laboratory

Johnson Space Center



Stennis Space Center



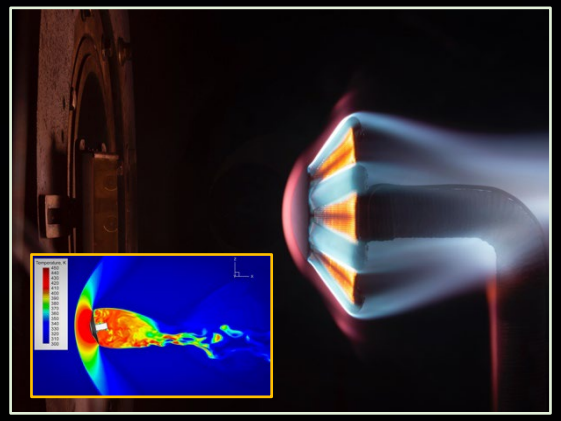
Kennedy Space Center

Core Competencies

Air Traffic Management



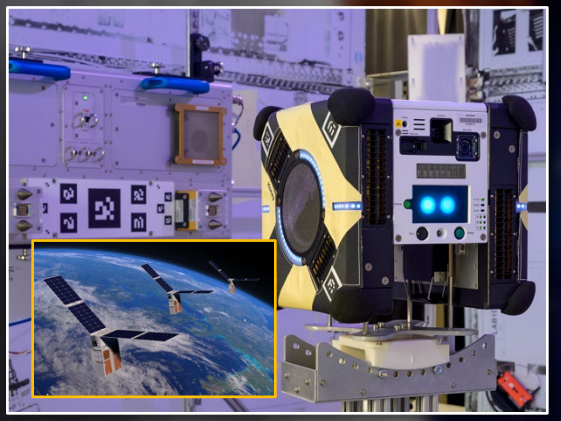
Entry Systems



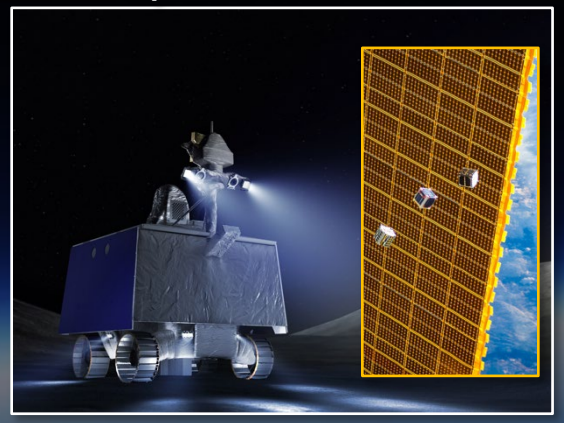
Advanced Computing & IT



Intelligent / Adaptive Systems



Cost-Effective Space Missions



Aerosciences



Astrobiology & Life Science



Space & Earth Sciences



Intelligent Systems Division Portfolio

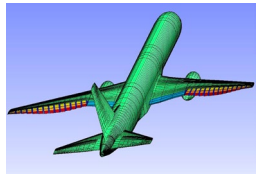
INTELLIGENT SYSTEMS DIVISION

Autonomous Systems and Robotics (ASR)

Enabling complex systems and operations through the development of technologies that can respond or adapt to changing conditions, knowledge, and constraints







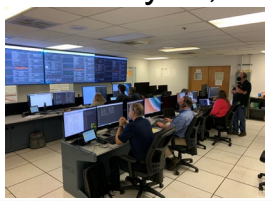
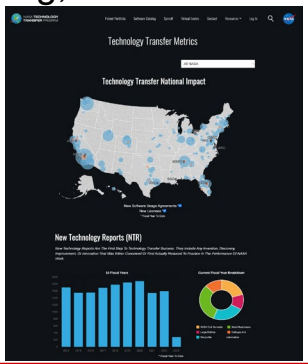




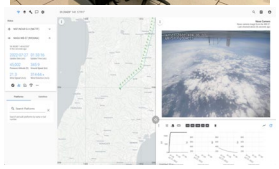
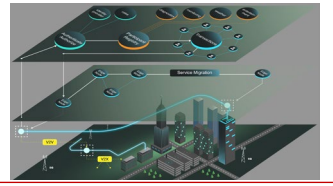


Collaborative and Assistant Systems (CAS)

Building advanced information systems to address data acquisition; data conditioning and integration; data storage, organization, and access; data visualization; and data analysis, mining, and extraction

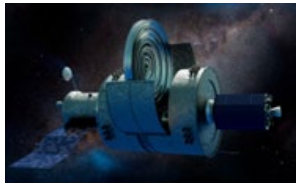


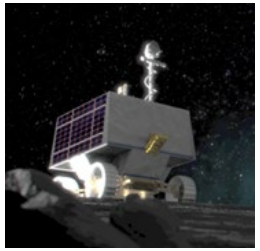



Discovery and Systems Health (DaSH)

Developing tools and methods for system health management, machine learning, physics modeling, computational materials modeling, and quantum computing






Robust Software Engineering (RSE)

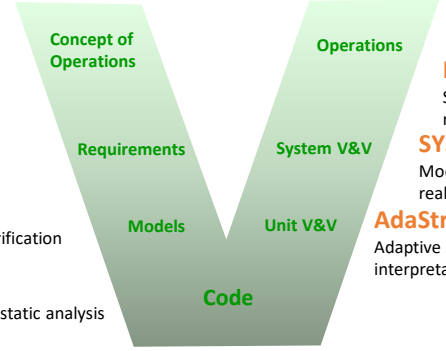
Increasing the reliability, robustness, and productivity of NASA's mission software through research, development, and application of automated software engineering technologies




FRET
Requirement analysis and formalization

CoCoSim
Simulink model verification

IKOS
C/C++ code static analysis



RACE/MESA
Run-time analysis of live data streams from airspace

R2U2
System health management & runtime monitor

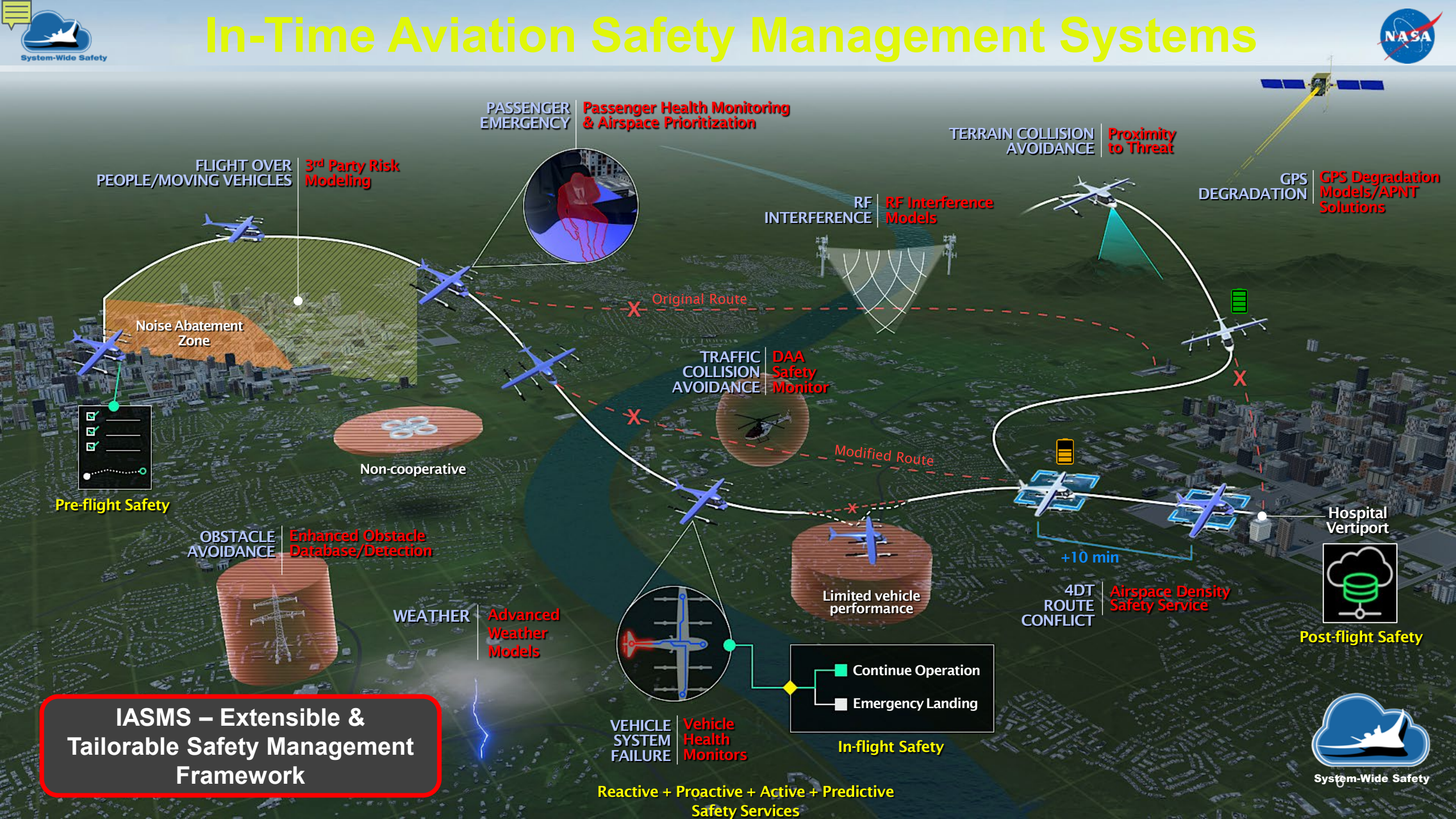
SYSAI
Model-based analysis of realizable goals in systems

AdaStress
Adaptive stress testing and interpretable categorization

Prophecy/SafeDNN
Property inference, probabilistic analysis and formal explanations for neural networks

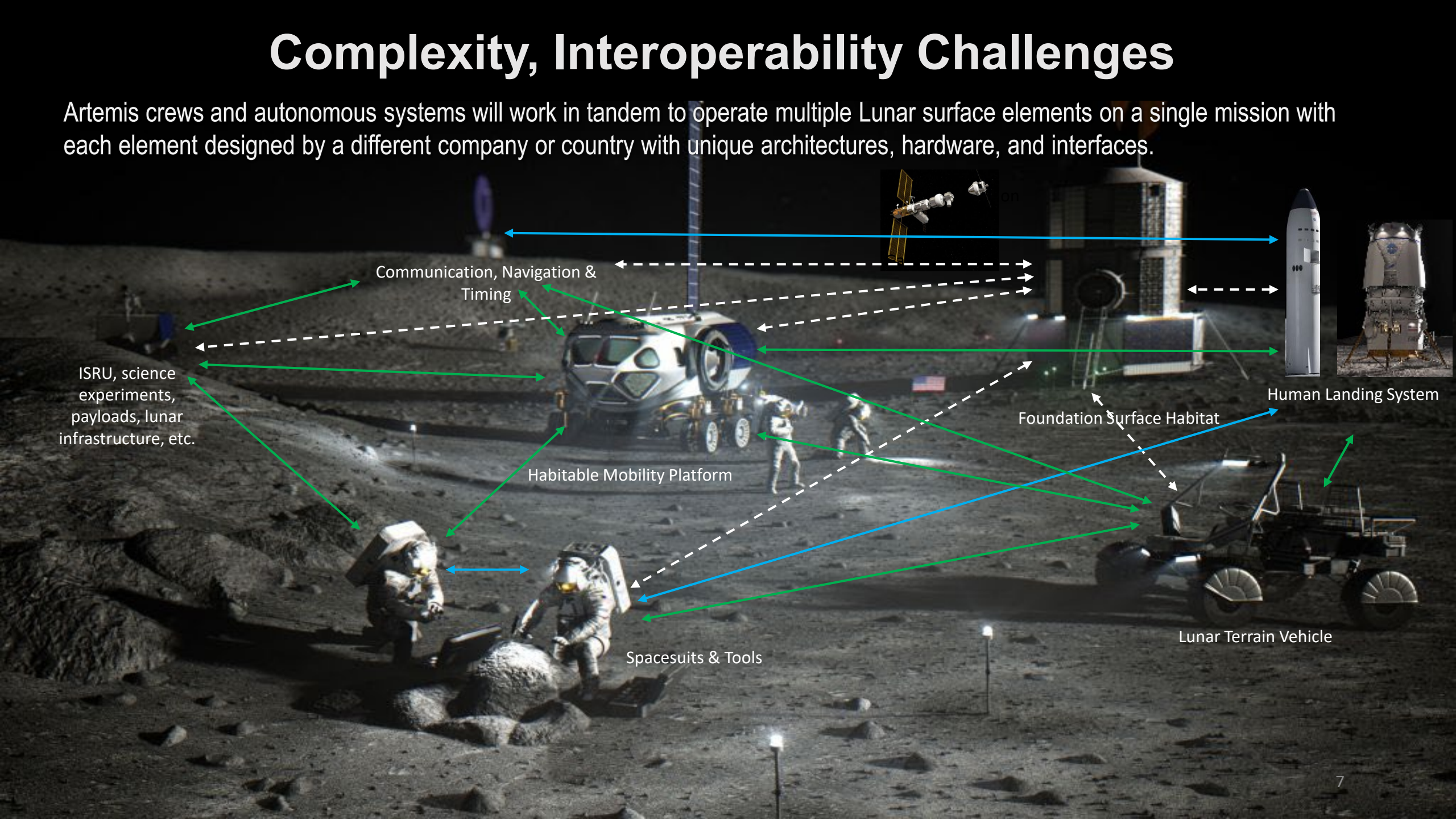
AdvoCATE
Assurance case automation

In-Time Aviation Safety Management Systems



Complexity, Interoperability Challenges

Artemis crews and autonomous systems will work in tandem to operate multiple Lunar surface elements on a single mission with each element designed by a different company or country with unique architectures, hardware, and interfaces.



Let's go to the Moon!

INTELLIGENT SYSTEMS DIVISION

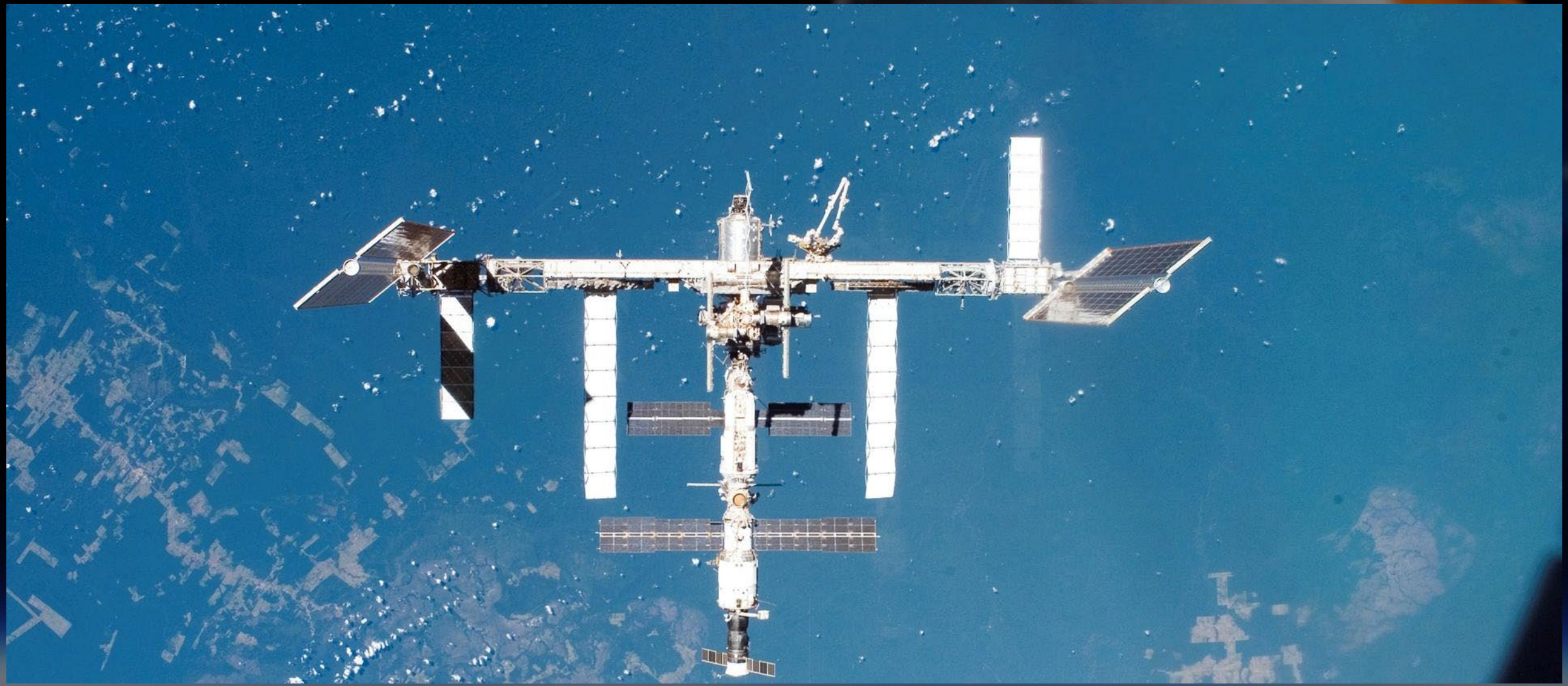
What does a "sustainable off-world presence" look like?



International Space Station

Our working example of sustainable off-world presence

INTELLIGENT SYSTEMS DIVISION



ISS Construction

ISS Facts:

Continuously occupied since 2000

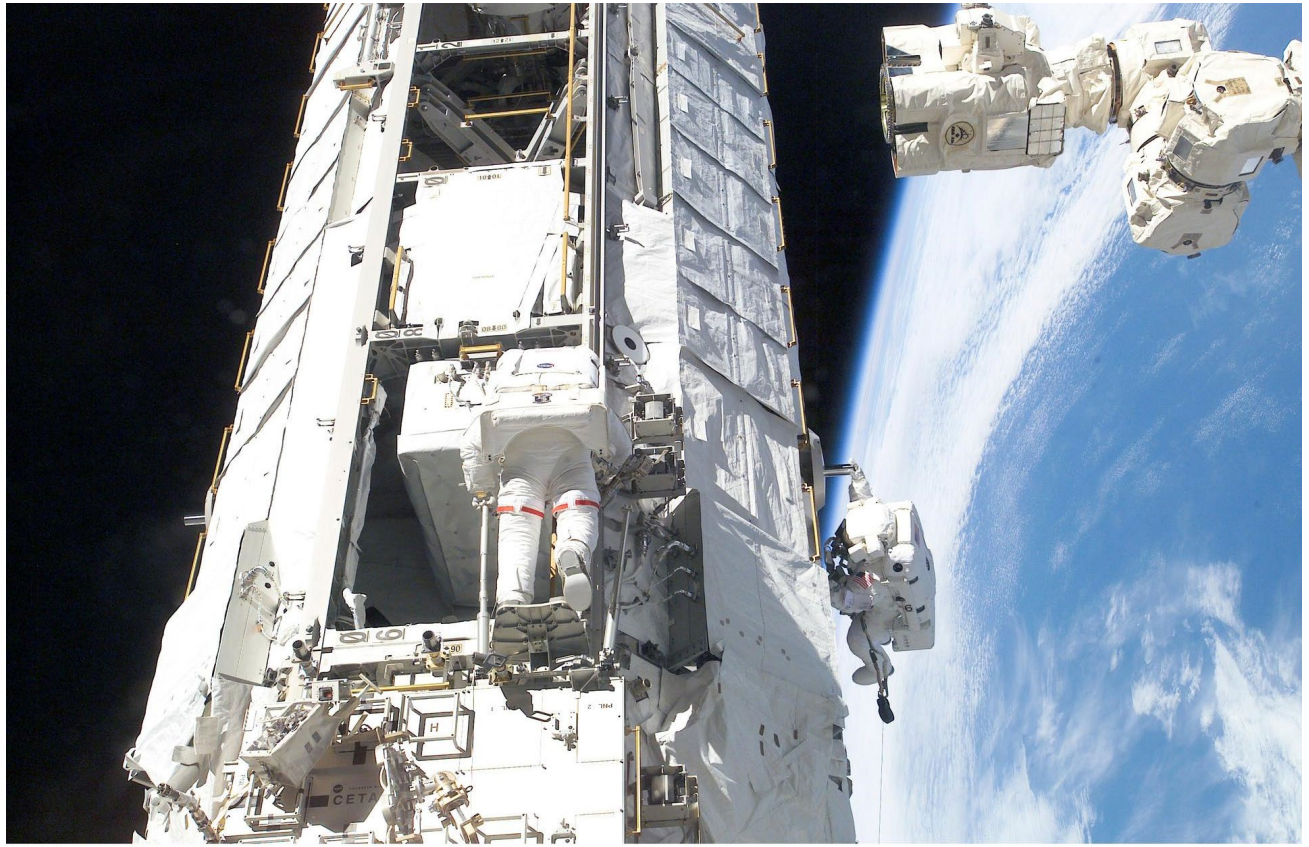
First segment launched November 1998

Construction considered complete 2011

Original plan: 106 EVAs for construction

161 EVAs completed by end of 2011

271 EVAs to date



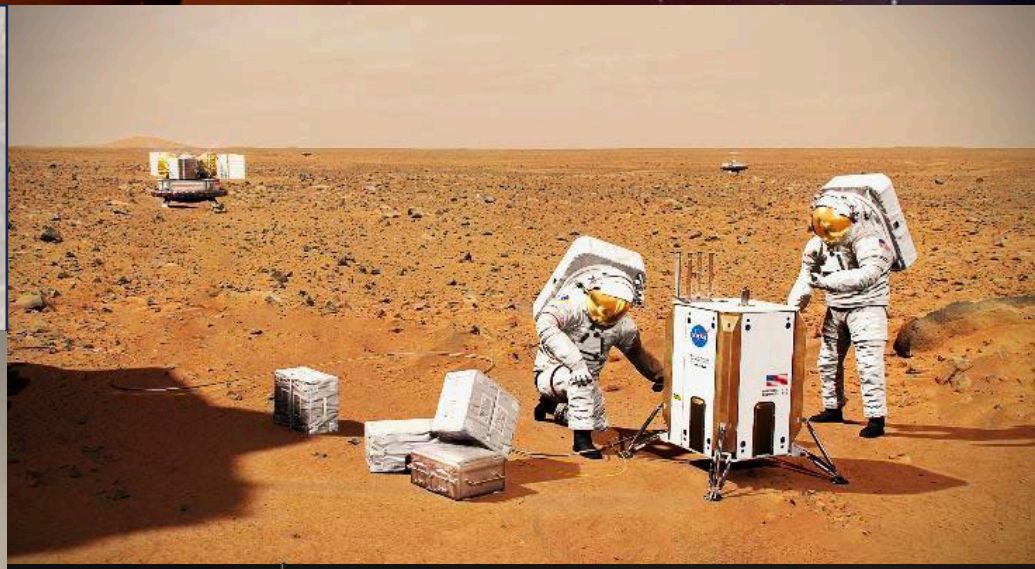
ISS005E21775

“Exploration Art”

INTELLIGENT SYSTEMS DIVISION

What is wrong with these images?...







Hazardous Operations



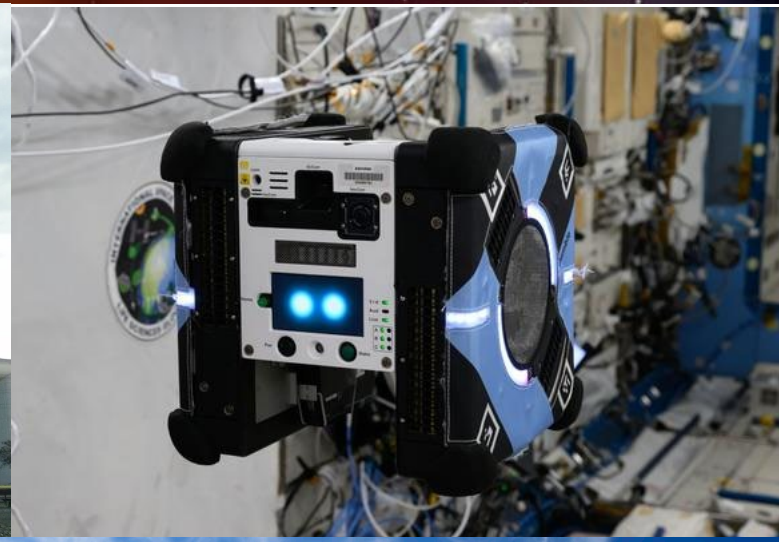
S111E5034

Robots come in many variations

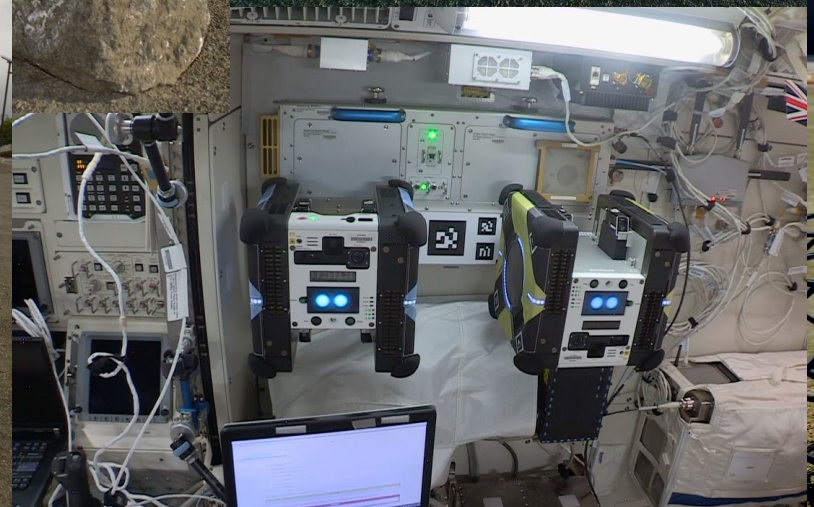
INTELLIGENT SYSTEMS DIVISION













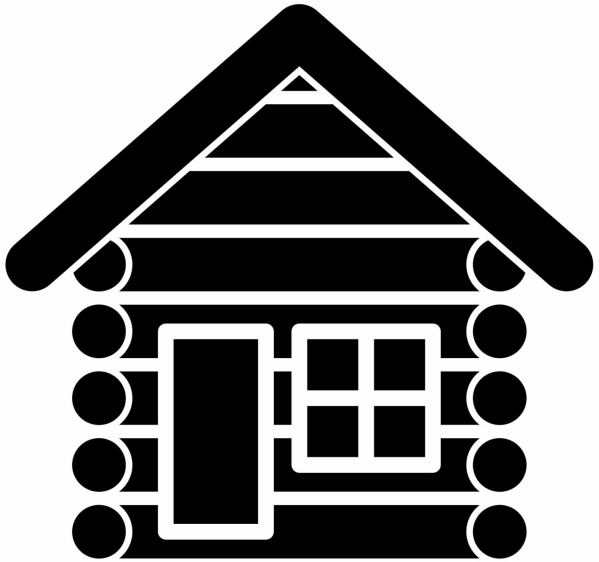
Planning for your trip off-world
(Log Cabin Challenge Session)

INTELLIGENT SYSTEMS DIVISION

What do you take with you?

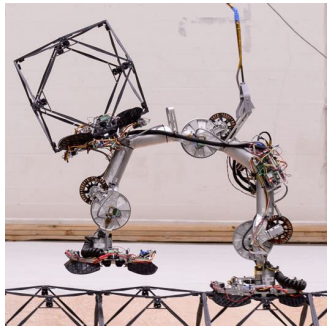
- Critical technology
- Not available locally
- Costly to transport





What do you use from the environment?

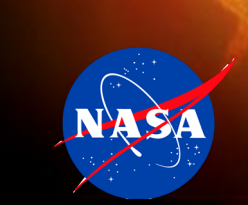
- *Detect*
- *Evaluate*
- *Excavate*
- *Build*
- *Connect*
- *Inspect*



<YOUR robot or tech here>

cabin image: vecteezy.com

Advantages of Robotic Autonomy Development





INTELLIGENT SYSTEMS DIVISION

In Space:

- Reduces reliance on crew time
- Different safety constraints
- Different time scales

On Earth:

- Reduces human exposure to safety hazards
- Supports extreme environmental conditions
- Expands terrestrial possibilities (workforce multiplier)
- Creates a body of experiential data

Proposal: Robotic Analog Collaboration

- Terrestrial robotic analogs
- Gradually reducing infrastructure support
- Identifying unanticipated gaps
- Exercising multiple alternative interoperability schemes
- Organic development of “best practices”
- Builds terrestrial training capability

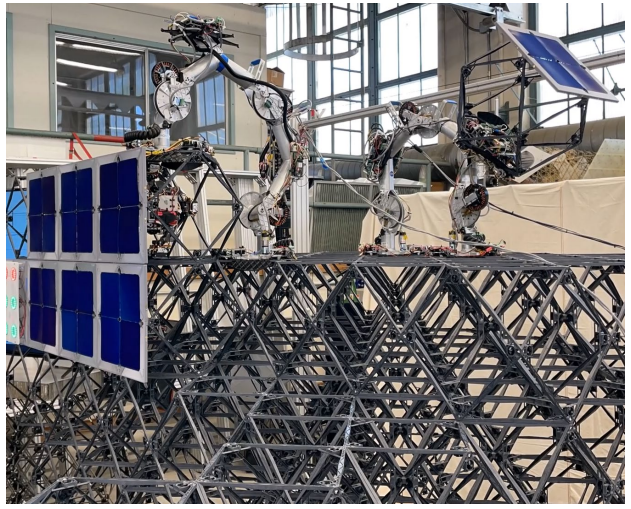
- Start small, but THINK BIG!

Prototyping Activities

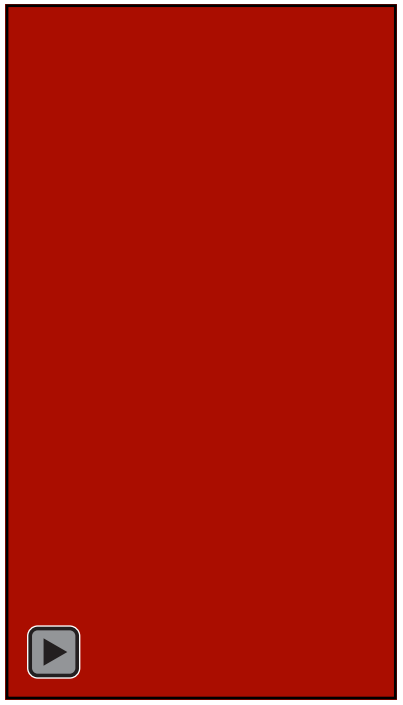




Testing for lighting extremes in polar conditions







Autonomous solar panel installation

ISRU mining/construction concept


NASA
*Concept image