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Sandia National Laboratories

Progress at Sandia for the DoD Common Hypersonic Boost Glide Vehicle and Autonomy for Hypersonics

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U.S. DEPARTMENT OF ENERGY

NNSA

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Sandia National Laboratories Provides Innovative, Science-based Systems Engineering Solutions

- **Established in 1949** to be the nation's nuclear ordnance laboratory after being part of Los Alamos during WWII
- **Our Purpose:** Develop advanced technologies to ensure global peace
- **Federally Funded Research and Development Center (FFRDC) sponsored by** Department of Energy/National Nuclear Security Administration (DOE/NNSA)
  - FFRDCs are long-term strategic partners to the federal government, operating in the public interest with objectivity and independence and maintaining core competencies in missions of national significance

    FAR 35.017 – Federally Funded Research and Development Centers

    - We accomplish tasks that are integral to the mission and operation of the agency
    - We exercise technical capabilities for the NNSA through application to other national security missions
- Operated for the DOE/NNSA by **National Technical and Engineering Solutions of Sandia, LLC (NTESS)**, with partnership and oversight by the NNSA Sandia Field Office (SFO)
  - FY20: $3.8B, 13,000 employees

…In my opinion you have here an opportunity to render an exceptional service in the national interest.

– President Harry S. Truman

History and Current Hypersonics

SWERVE
1981-1985

PGR Grand Challenge
2003-2005

AHW- FT1A
2011

CPS- FE1
2017

A4H
2017-2025

CPS- FE2
2020

FT-3
FY2021

JFC-1A and JFC-1B
FY2022

Sandia's Hypersonics History

Sandia has a long history in hypersonic systems development

- Leveraging Atomic Energy Commission work in reentry technology
- Development of multiple systems in the 70s/80s leading to SWERVE
- SWERVE culminated with a successful flight test in 1985 and was the first demonstration of a controlled boost-glide system
- AHW- FT1A (partnership with OSD/Army SMDC)- flight test in 2011
- CPS FE-1 (partnership with OSD/Navy/Army) flight test in 2017
- CPS FE-2 (partnership with OSD/Navy/Army) flight test in 2020

DOE has a long history in hypersonics

- Pre-SWERVE, SWERVE, and PGR were all DOE R&D investments
- DOE continues to invest and lead in the future of hypersonics technology development through the A4H Mission Campaign

In partnership with the DoD, Sandia has successfully performed multiple flight tests of a hypersonic boost-glide vehicle

- Sandia's long history and expertise are leveraged to support continued hypersonic technology development in the national interest

Through a multi-service/OSD MOA, Sandia's glide body design has been designated the DoD Common Hypersonic Glide Body (C-HGB)

2017: CPS FE-1 launch

ACRONYMS KEY
- ***SWERVE:*** *Sandia Winged Energetic Reentry Vehicle*
- ***SMDC:*** *Space & Missile Development Center*
- ***PGR Grand Challenge:*** *Prompt Global Response Grand Challenge*
- ***AHW-FT1A:*** *Advanced Hypersonic Weapon Flight Test 1A*
- ***CPS FE-1:*** *Conventional Prompt Strike Flight Experiment 1*
- ***A4H:*** *Autonomy for Hypersonics*
- ***CPS FE-2:*** *Conventional Prompt Strike Flight Experiment 2*

OSD

Research & Engineering

NAVY

Strategic Systems Programs (SSP)

ARMY

Rapid Capabilities and Critical Technology Office (RCCTO)

MDA

Advanced Targets

Sandia's Current Programs - Meeting the National Need

OSD/Army/Navy

- **Support upcoming flight tests for Common Hypersonic Glide Body (HGB) program**
  - FT-3 in FY21
  - JFC-1A and JFC-1B in FY22
- **Transfer design information and integration expertise to identified industry partners**
  - Working with industry to capture Sandia designed vehicles into industry produced hardware
- **Science and Technology investments (OSD/CPS and now JHTO)**
  - Developing new technologies including boundary layer transition predictions, Autonomous Flight Safety System (AFSS), mission design, Advanced Navigation, Guidance, & Control, and more!

Missile Defense Agency (MDA)

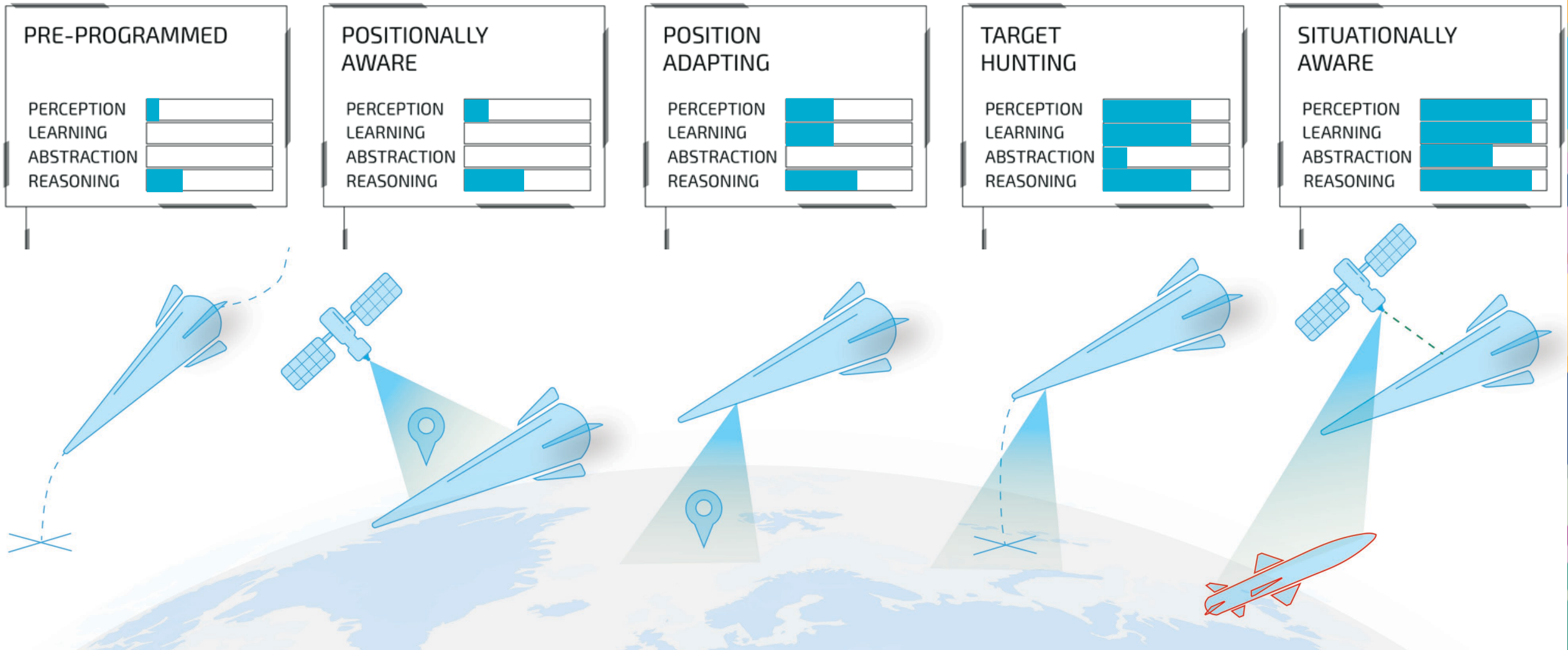
- **Advanced Targets**
  - Launch support for targets for the purpose of tracking and interception
  - Designing/developing an MDA target system that demonstrates an expanded performance envelope

Navy/Conventional Prompt Strike Investment in Advanced Capabilities

- **Advanced Capability Effort for Block Upgrades**
  - Upgrade common hypersonic glide body for navigation, sensing, and improved lethality
  - Mature technologies via High Operational Tempo hypersonic sounding rocket flights

Sandia's vision of our contribution to Hypersonics

Sandia's Hypersonics of the Future Roadmap



Sandia research aims to enable adaptive hypersonics systems and solutions beyond the current SWERVE derivatives

Sandia's Research is Enabling Autonomy for Hypersonics

Sandia's discretionary research investment is enabling Autonomy to transform the warfighting capability of hypersonic systems by enabling:

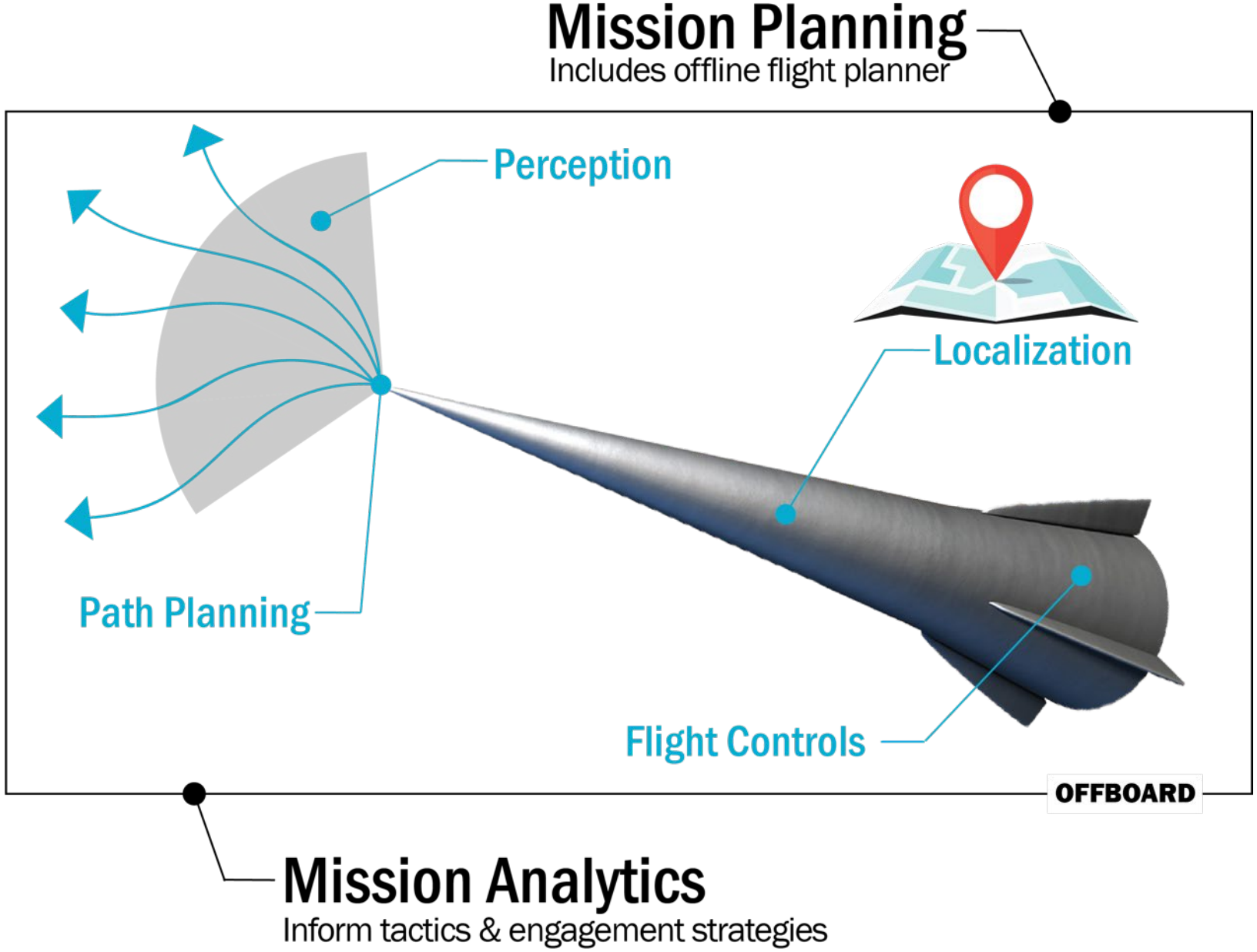
- Rapid construction of flight plans (enabling speed of action)
- Real-Time Trajectory Modifications (through immediate flight path changes)
- Robust Navigation and Control (providing robustness in uncertain conditions for control and localization)
- Perception of the environment and ability to adapt (increasing survivability and ability to counter moving targets)
- Adaptive tactics and engagement strategies (enabling effective target prosecution in complex, rapidly evolving environments and heavily defended areas)
- Cooperation with other systems (enabling distribution of tasking to a diverse team of autonomous agents)

Laboratory Directed Research & Development (LDRD)
- 6.5 years: FY18-FY24
- Investment: $38M investment + AutonomyNM investment

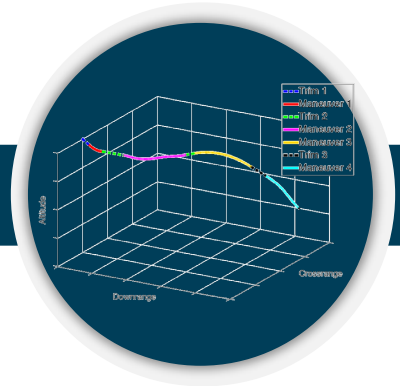
Autonomy for Hypersonics

Transitions to Program of Record

- **Vehicle Control**
  - Optimal Control Allocation
  - Robust Gain Scheduling
- **Mission Generation**
  - Re-entry Analysis Program to Optimize Roll (RAPTOR)
  - Rapid Trajectory Generation
  - HyperSim for fast guidance-in-the-loop simulation



Preparing Autonomous Technologies for System Insertion



Develop New Ideas in Simulation

Demonstrate in Virtual Environment

Fly in Slow Airborne Demonstrator

Demonstrate in Hypersonic Virtual Flight Environment

Fly in Hypersonic Sounding Rocket Experiment

AutonomyNM

Ready for System Integration

We don’t do it alone | Thank you

- We have partnered with others to fly system demonstrators for the military
- We are currently transitioning technology and supporting industry to produce a warfighting capability
- We are enabling the next generation hypersonic to be autonomous, adaptive, and prosecute more targets

Johns Hopkins Applied Physics Laboratory
Dynetics
MOOG
Collins Aerospace
Honeywell
Lockheed Martin
General Atomics Aeronautical
Draper
EBAD Ensign-Bickford Aerospace & Defense
Northrop Grumman
Raytheon
DEVCOM Aviation & Missile Center
NAVSEA Warfare Centers Crane