

# Hypersonics Overview

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# Hypersonics 101

# Hypersonics 101

- Hypersonic is defined as five times the speed of sound.
- The speed of sound is about 750 mph\* or about 1000 feet per second\*.
- The speed of sound is the basis for a unit called Mach Number.
- A mile is 5280 feet, so the threshold for hypersonic flight is about a mile per second, or Mach 5.
- Advanced fighters fly at about Mach 3; the SR-71 flew about Mach 4. The fastest human-piloted aircraft (X-15) achieved Mach 6.7.
- For reference, earth orbital velocity is about 25,000 feet per second and provides an upper limit to the hypersonic flight regime.

\* At flight altitude

## Engineering Challenges

Vehicle shape changes in hypersonic flight, creating challenges for flight control

Difficult to simulate velocity, temperature, and Mach number on the ground

Difficult to design sensors & actuators that can operate in a hypersonic flight environment

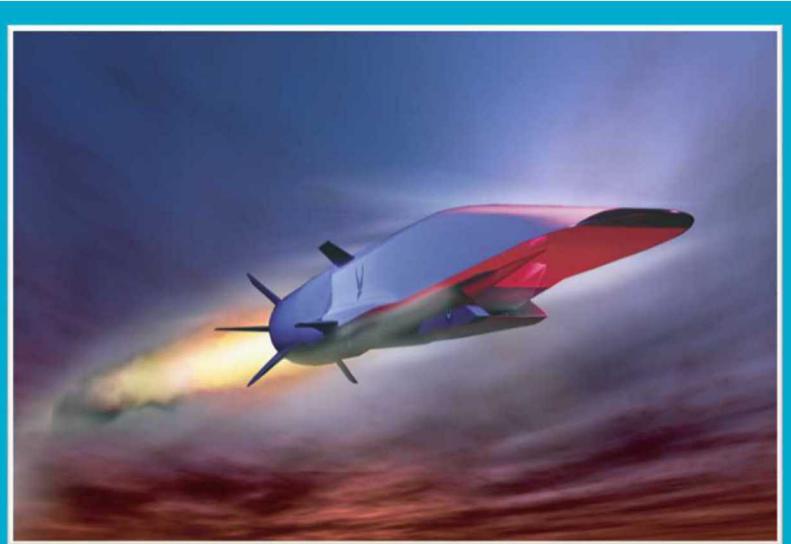
Calculations are extremely time consuming

# Different Hypersonic Systems



## Boost-Glide Systems

- Rocket boosted to velocity outside the atmosphere
- Reenters and establishes glide across upper atmosphere (near space)
- Cruise is typically between M 5 - 25
- Dives to target

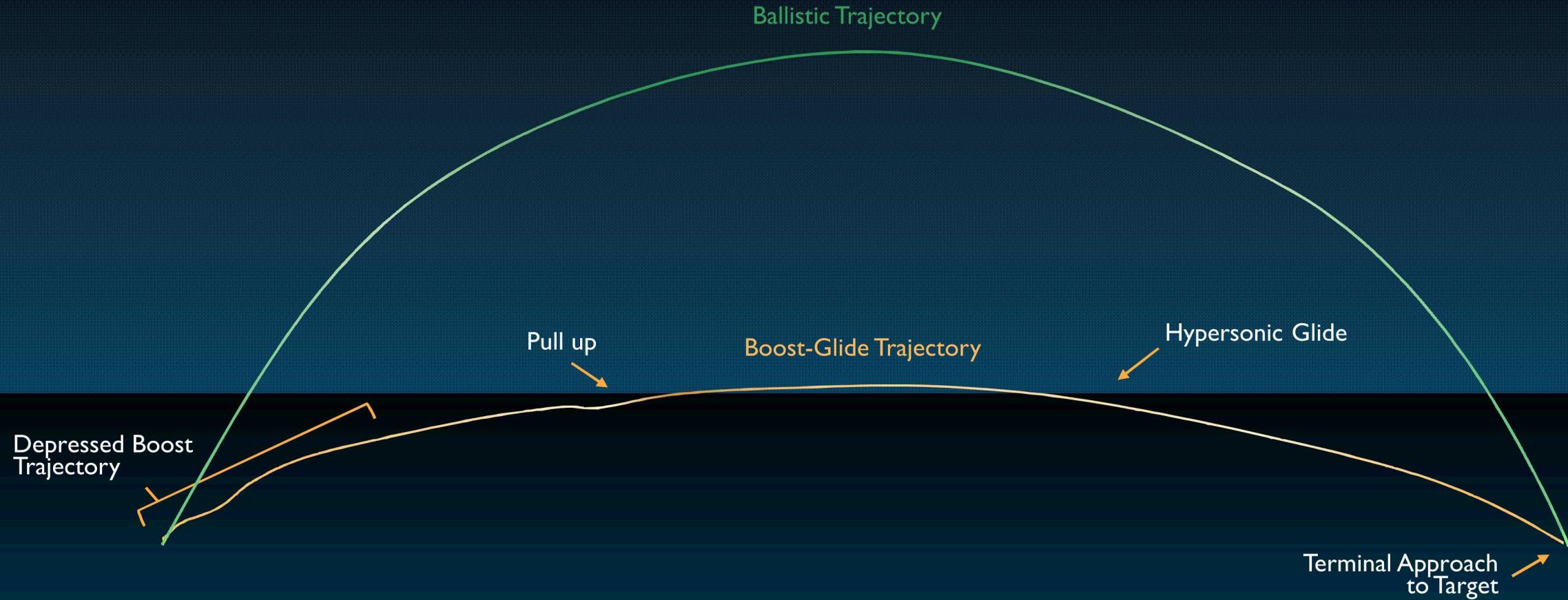


## Air-Breathing Systems

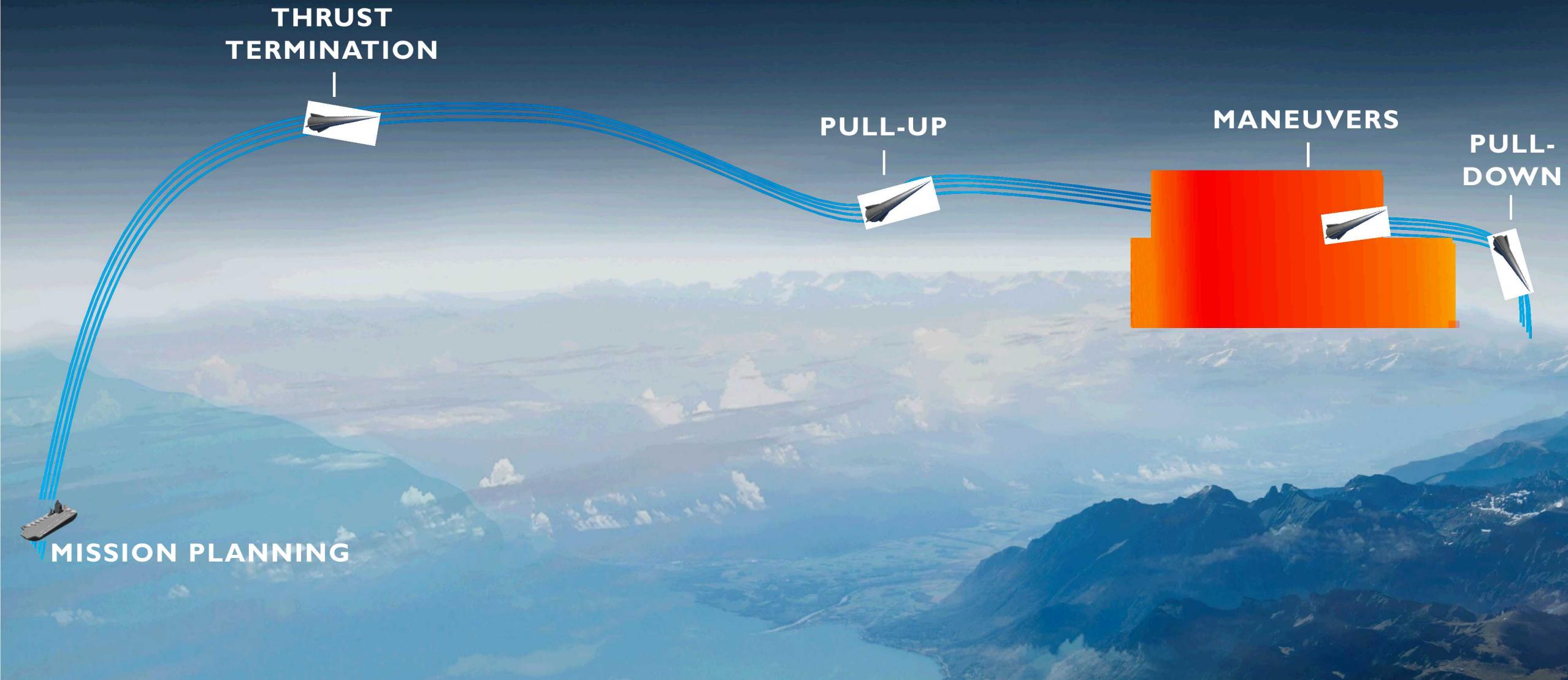
- Rocket boosted into altitude and velocity
- SCRAMJET propulsion cruise across upper atmosphere
- Cruise is typically between M 5 - 6
- Glides to target

# Why Hypersonic Glide?

*Hypersonic systems fly distinctly different trajectories from Ballistic systems*



# Operational View





# Sandia's History of Boost-Glide System Development and Flight Testing

# History of Hypersonics at Sandia National Labs

## *Sandia Winged Energetic Re-entry Vehicle Experiment (SWERVE)*

- SWERVE started in the 1970s and culminated with a successful flight test in 1985.
- The vehicle was launched from Sandia's Kauai Test Facility, in Hawaii, on a Strypi IX booster.
- The test demonstrated a sophisticated maneuvering reentry vehicle technology.
- The flight was the first step in the development of a long-range smart weapon system.

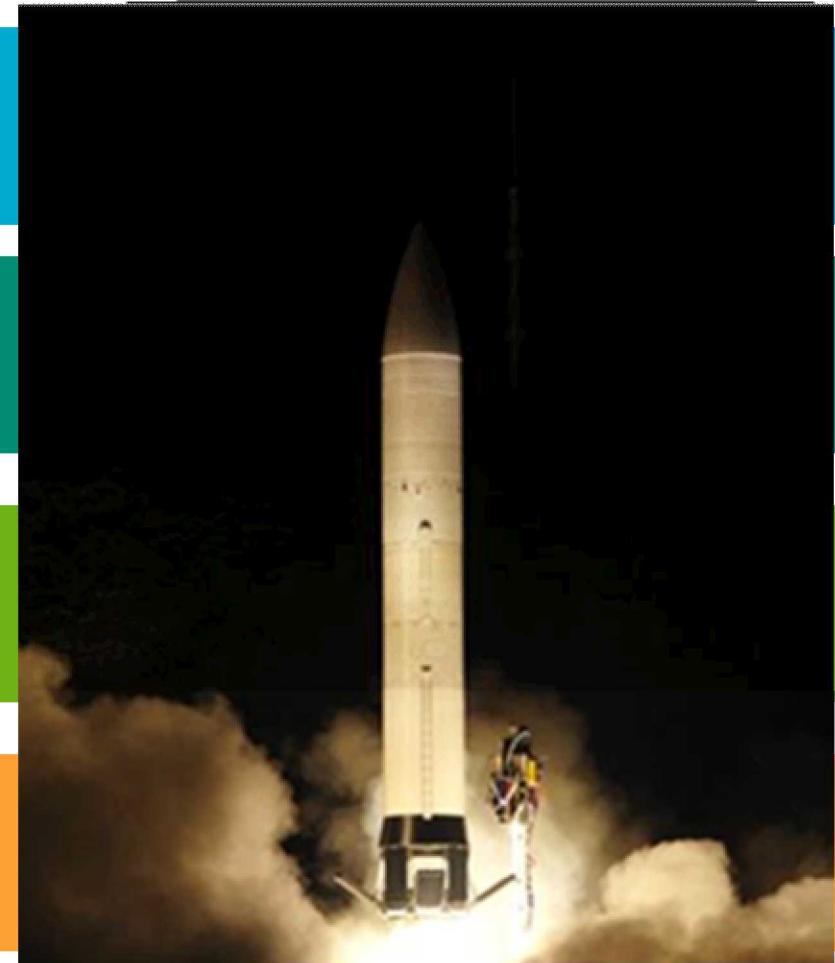


Sandia's Kauai Test Facility

# History of Hypersonics at Sandia National Labs

## *Advanced Hypersonic Weapon 1 – Flight Test 1 (AHW FT1A)*

- AHW FT-1A had a successful flight test in November 2011.
- The three-stage booster system and glide vehicle were developed by Sandia under the direction of the USASMDC/ARSTRAT.
- The test flight represented about four years of work for up to 200 Sandia employees across the Labs.
- AHW FT-1A built upon a foundation of work from as long as 35 years ago, including SWERVE, the Strategic Target System (STARS), and the Tactical Missile System-Penetrator (TACMS-P).



AHW-FT1A

# History of Hypersonics at Sandia National Labs

*Conventional Prompt Strike – Flight Experiment / Test (CPS – FEI)*

- On behalf of the Department of Defense and Navy Strategic Systems Programs, Sandia conducted the FE-1 test from its Kauai Test Facility in October 2017.
- The Sandia team served as the lead technical integrator.
- The flight test collected data on hypersonic boost-glide technologies which will anchor ground testing, modeling, and simulation of future CPS concepts.





# The Future of Hypersonics

# Autonomy for Hypersonics



Hypersonics provide a lot of military utility

- Hypersonics offer survivability and utility at long/strategic ranges, since they travel at exceptional speeds and are less susceptible to anti ballistic missile countermeasures and other defensive systems

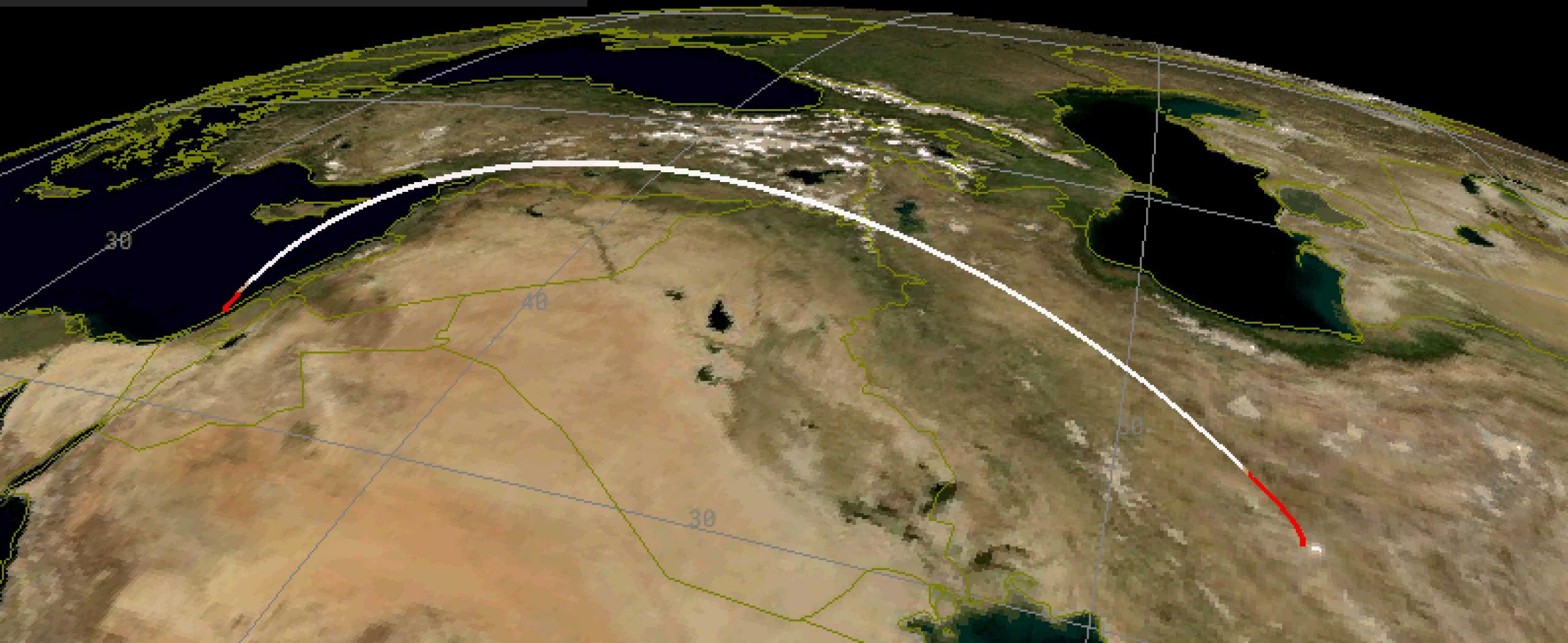
These systems will offer the most utility if they are able to:

- Utilize rapidly constructed flight plans (enable speed of action)
- Navigate without GPS
- Perceive their environment and adapt to it to its counter moving targets
- Employ tactics and engagement strategies that are highly effective in complex, rapidly evolving environments and heavily defended areas
- Cooperate with other hypersonic systems



# Mod/Sim Environment

To build the necessary AI, we need tools that aim to improve our ability to model key components of the complex environment.



# Evolution of Hypersonic Strike Capability





Sandia National Laboratories



# Hypersonics Technical Writing and Communications Overview

# Who We Are - 5400 Technical Writing Team

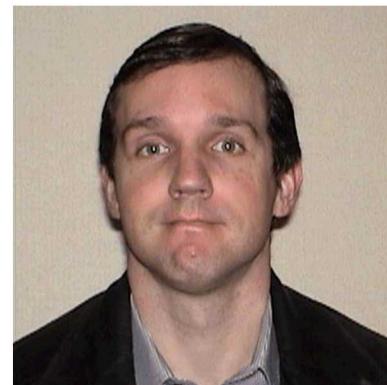
Todd Heinrichs



Becky Cox



Billy Pinson



Lindsey Kibler

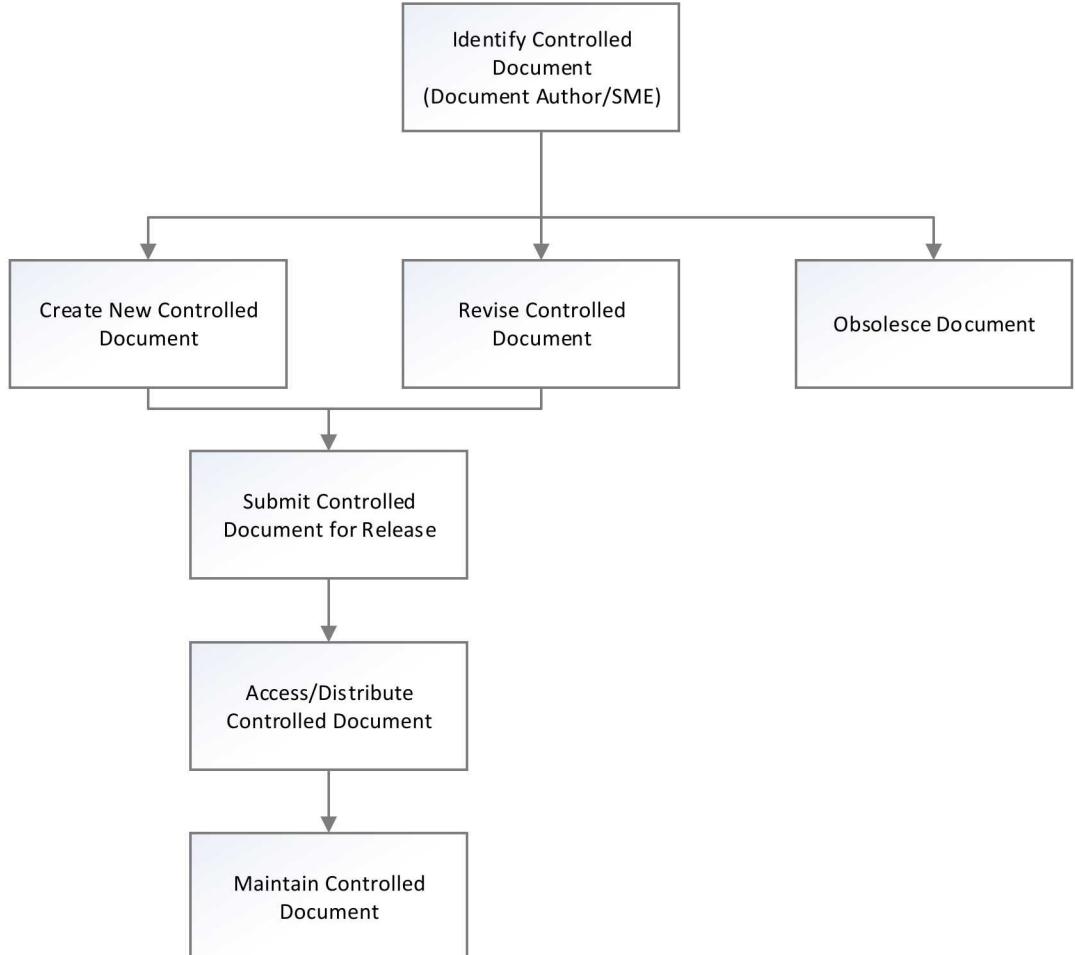


# What We Do

The 5400 technical writing team supports all phases of Hypersonics program development.

## Deliverables :

- Technical Work Documents (TWDs)
- Procedures (~300 procedures developed and used for FE-1)
- Program-Level Documents (System Engineering Plans, Environmental Specifications, Interface Control Documents [ICDs])
- Test Plans
- Test Reports
- Templates



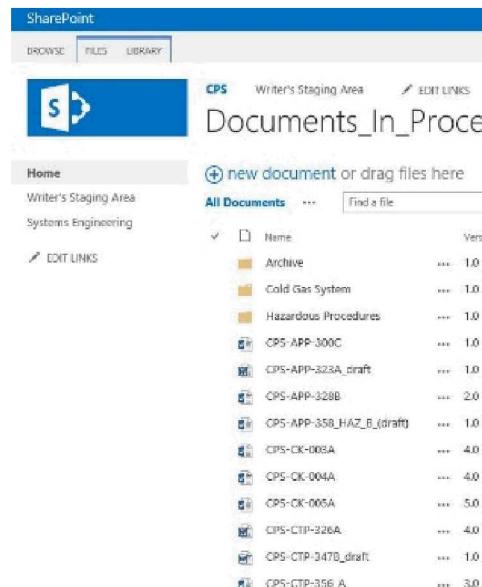
# CPS FE-1 Technical Writing Support

The Conventional Prompt Strike (CPS) Flight Experiment-1 (FE-1) program was the first Hypersonics program at Sandia with full technical writing support for the duration of the program.

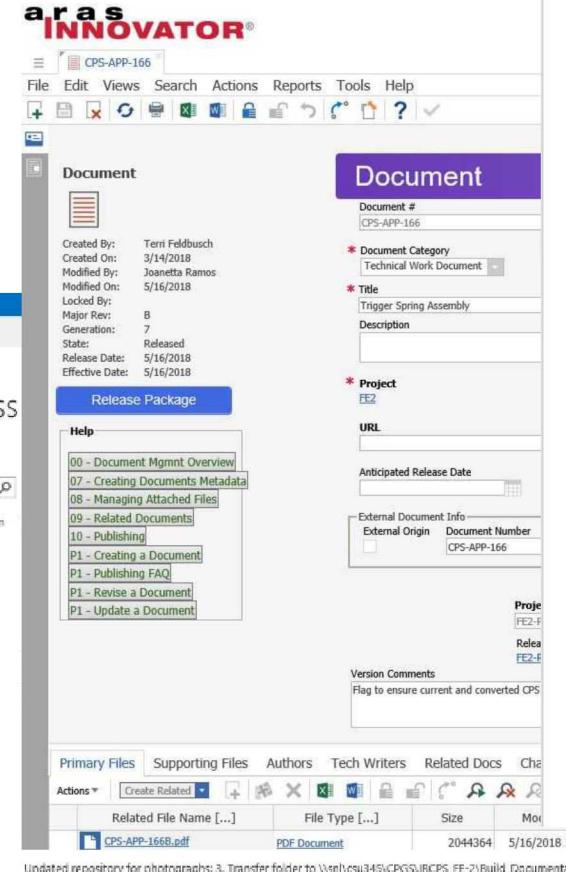
The technical writing team edited, routed for approval, published, and stored over 400 program documents and procedures.

## Challenges:

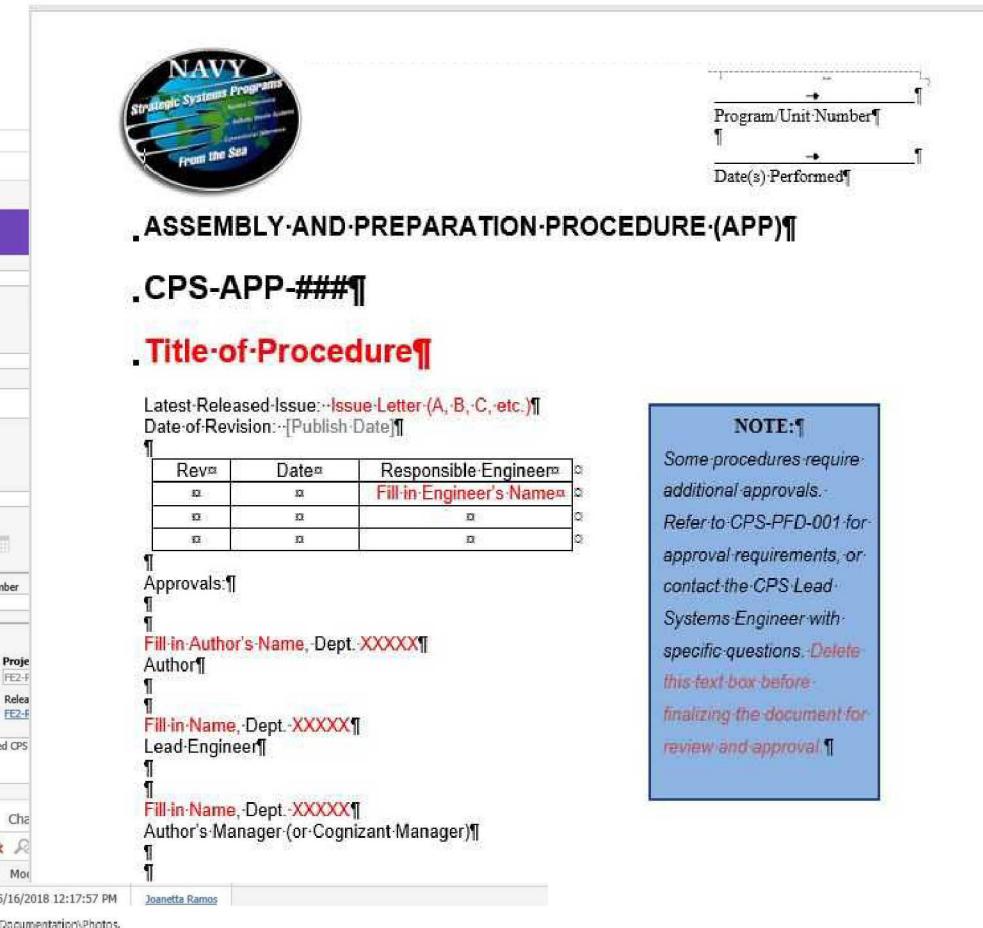
- Fielding support
- Hazardous procedures



SharePoint  
BROWSE FILES LIBRARY  
CPS Writer's Staging Area EDIT LINKS  
Documents\_In\_Process  
Home Writer's Staging Area Systems Engineering  
EDIT LINKS  
new document or drag files here  
All Documents Find a file  
Name Version  
Archive 1.0  
Cold Gas Systems 1.0  
Hazardous Procedures 1.0  
CPS-APP-300C 1.0  
CPS-APP-323A\_draft 1.0  
CPS-APP-326B 2.0  
CPS-APP-358\_HAZ\_B\_(draft) 1.0  
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CPS-CR-005A 5.0  
CPS-CTP-226A 4.0  
CPS-CTP-3470\_draft 1.0  
CPS-CTP-356\_A 3.0



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CPS-APP-166  
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Created On: 3/14/2018  
Modified By: Joaquina Ramos  
Modified On: 5/16/2018  
Locked By:  
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Effective Date: 5/16/2018  
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P1 - Publishing FAQ  
P1 - Revise a Document  
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Version Comments  
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NAVY Strategic Systems Programs  
From the Sea  
ASSEMBLY-AND-PREPARED-PROCEDURE-(APP)¶  
CPS-APP-###¶  
Title of Procedure¶  
Latest Released Issue: Issue Letter (A, B, C, etc.)¶  
Date of Revision: [Publish Date]¶  
Project FE2  
Release FE2-F  
URL  
Anticipated Release Date  
External Document Info  
External Origin Document Number  
CPS-APP-166  
Approvals:  
Fill-in Engineer's Name  
Author:  
Fill-in Author's Name, Dept. XXXXX¶  
Author:  
Fill-in Name, Dept. XXXXX¶  
Lead Engineer¶  
Fill-in Name, Dept. XXXXX¶  
Author's Manager (or Cognizant Manager)¶  
NOTE:  
Some procedures require additional approvals. Refer to CPS-PFD-001 for approval requirements, or contact the CPS Lead Systems Engineer with specific questions. Delete this text box before finalizing the document for review and approval.

# Support of Integrated Military Systems Programs

Technical writing support of the hypersonics program impacts its mission success. This same support is given to other programs in the Integrated Military Systems Center.

- Targets and Countermeasures Associated Objects
- Kauai Test Facility
- High Operational Tempo
- Environment, Safety, and Health
- Mission Assurance





# Questions