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Common Aero Vehicle
High velocity payload delivery
system

Ken Qassim
AFRL/VS



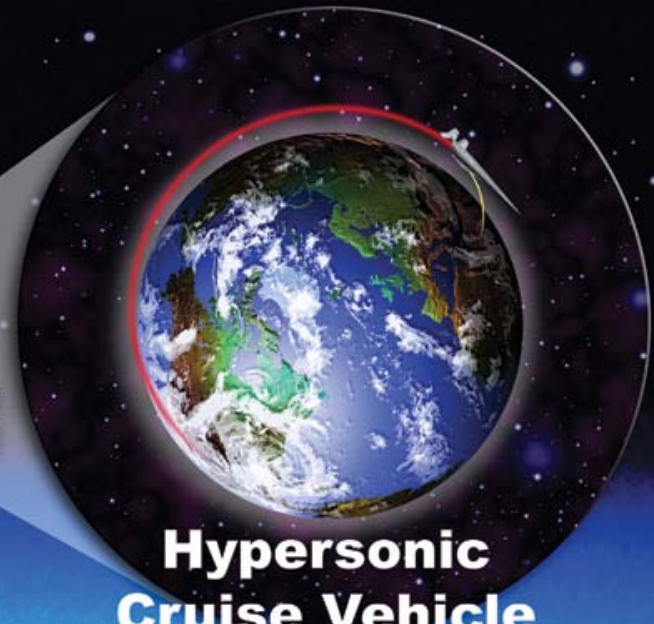
Dr. Russ Partch
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**Small Launch
Vehicle**

Operationally responsive and
affordable spacelift

**Joint DARPA/Air Force
Force Application and
Launch from CONUS
Technology
Demonstration**



**Hypersonic
Cruise Vehicle**

Prompt global reach

Report Documentation Page

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PROGRAM GOAL



**Develop and Validate, In-flight,
Technologies that will Enable Both Near-
term and Far-term Capabilities to Execute
Prompt Global Strike Missions while at the
Same Time, Demonstrating Affordable and
Responsive Space Lift**

***HYPERSONIC FORCE APPLICATION AND LAUNCH
TECHNOLOGY DEMONSTRATION***

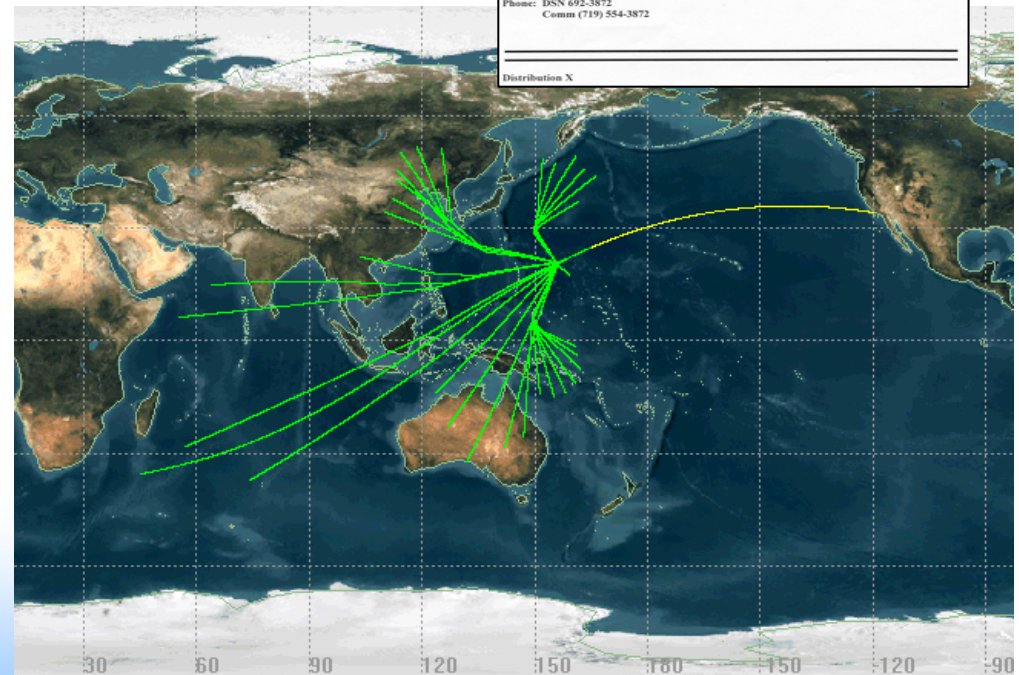
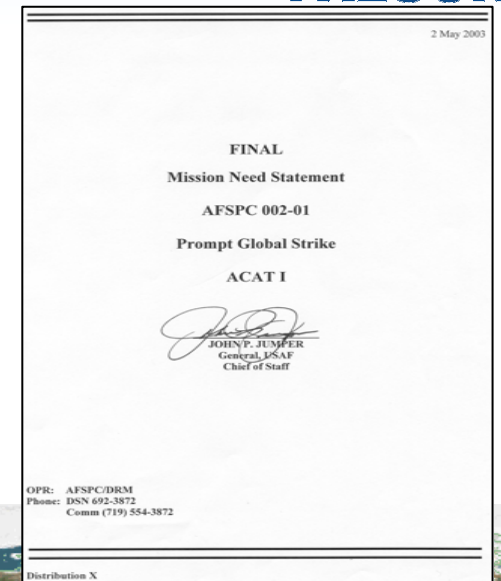


FALCON Program Advances Technology Necessary for Prompt Global Strike Capability



Prompt Global Strike (PGS) Requirements

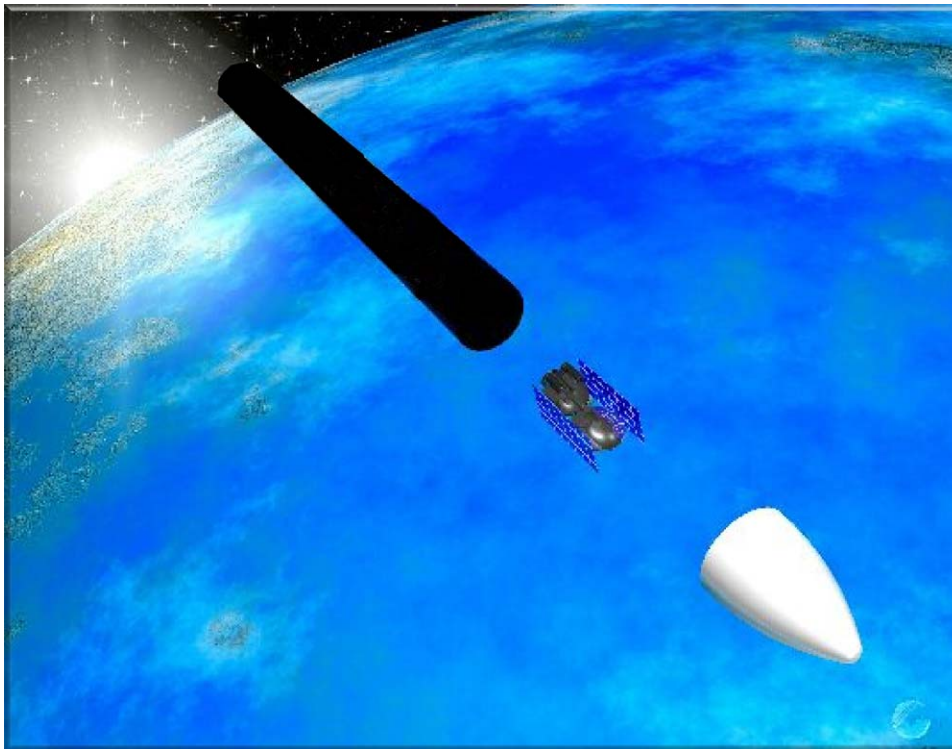
- Strike globally and rapidly with joint forces against high-payoff targets
- In a timeframe reduced from weeks/days to hours/minutes
- Even when no permanent military presence or only limited infrastructure is in a region
- Regardless of anti-access threats
- In a single or multi-theater environment



Distribution: Gov & Gov Contractors, ITAR Restricted



SMALL SATELLITE LAUNCH



Operationally Responsive Spacelift Capability

- » Small ISR payloads to Sun Synchronous Orbits
- » Low Recurring Launch Cost
- » New Launch Operations Paradigm



FALCON Hypersonic Technology Program will Achieve Near and Far Term PGS Objectives



Near Term Operational System

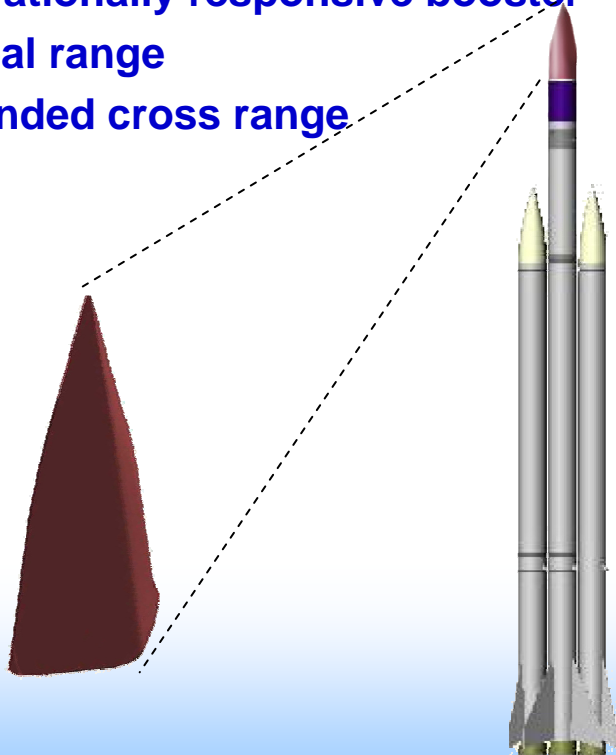
Common Aero Vehicle (CAV) and Small Launch Vehicle (SLV) System Capability:

- High Endurance CAV
 - Multiple payloads
 - Multiple munitions
- Operationally responsive booster
- Global range
- Extended cross range

FAR Term Operational System

Hypersonic Cruise Vehicle (HCV) System Capability:

- High Lift/Drag Configuration
- Multiple use payload bays
- Global down and cross range
- Aircraft operations
 - Reusable
 - Recallable
 - Launch on demand





Common Aero Vehicle (CAV)



Objective: CAV Technology Demonstration Flight Test

Description of CAV:

- Lifting aeroshell surviving >Mach 22 reentry velocity
- Maneuverable: >3000 nm range and >1000 nm crossrange
- Controllable with 3m accuracy objective

Hypersonic Technology Vehicle Flight Experiment:

- Prototype vehicle with available (SOTA) technology
- Vehicle Test flight with instrumentation (no weapons)
 - **TPS effectiveness & endurance (3500 F outside, 160 F inside)**
 - **Integrated aerodynamic performance**
 - **Guidance, navigation, and control**
 - **Communications and plasma effects**



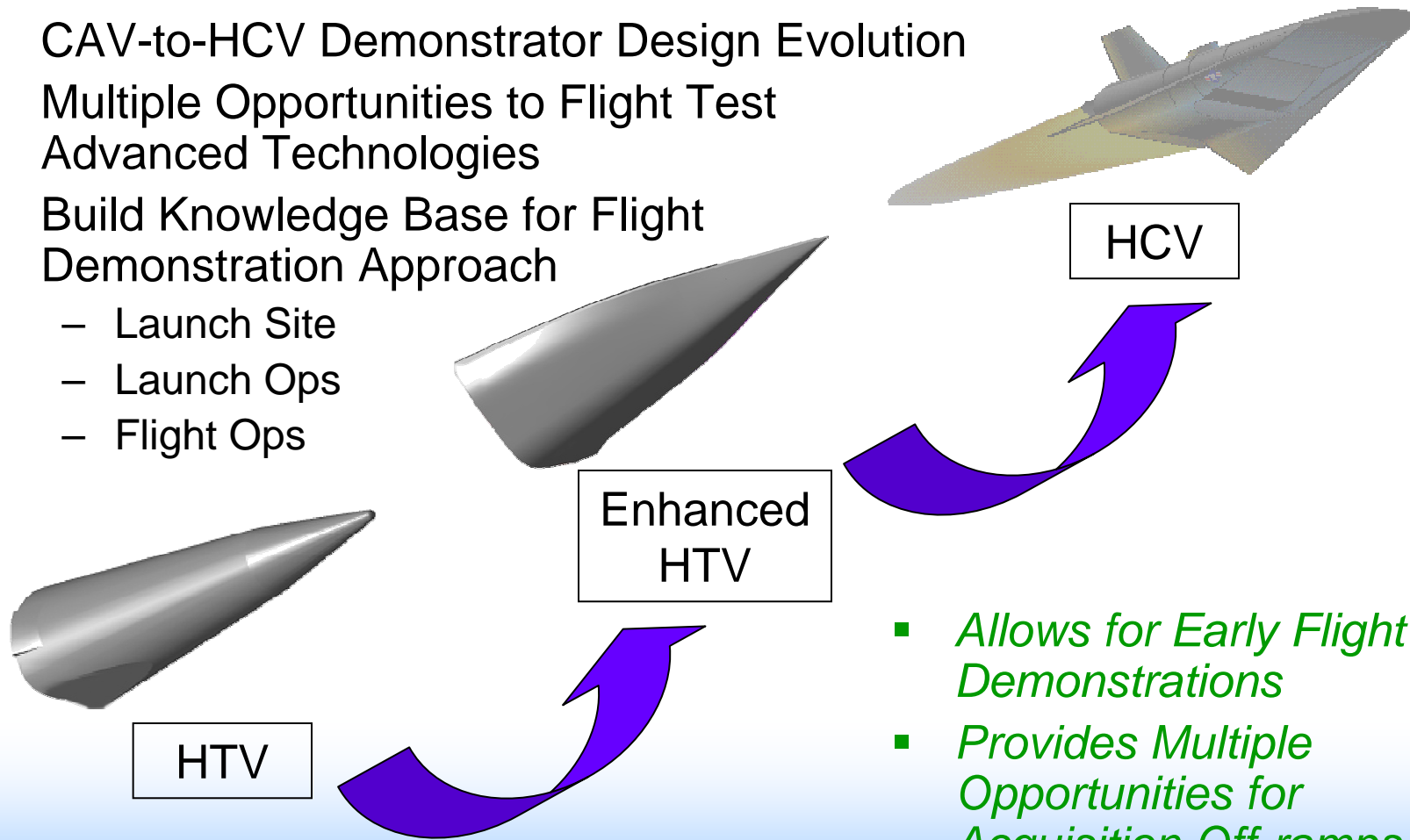


HYPERSONIC TECHNOLOGY EVOLUTION



Building Block Tech Development and Flight Demo Approach (Consistent with National Aerospace Initiative Philosophy)

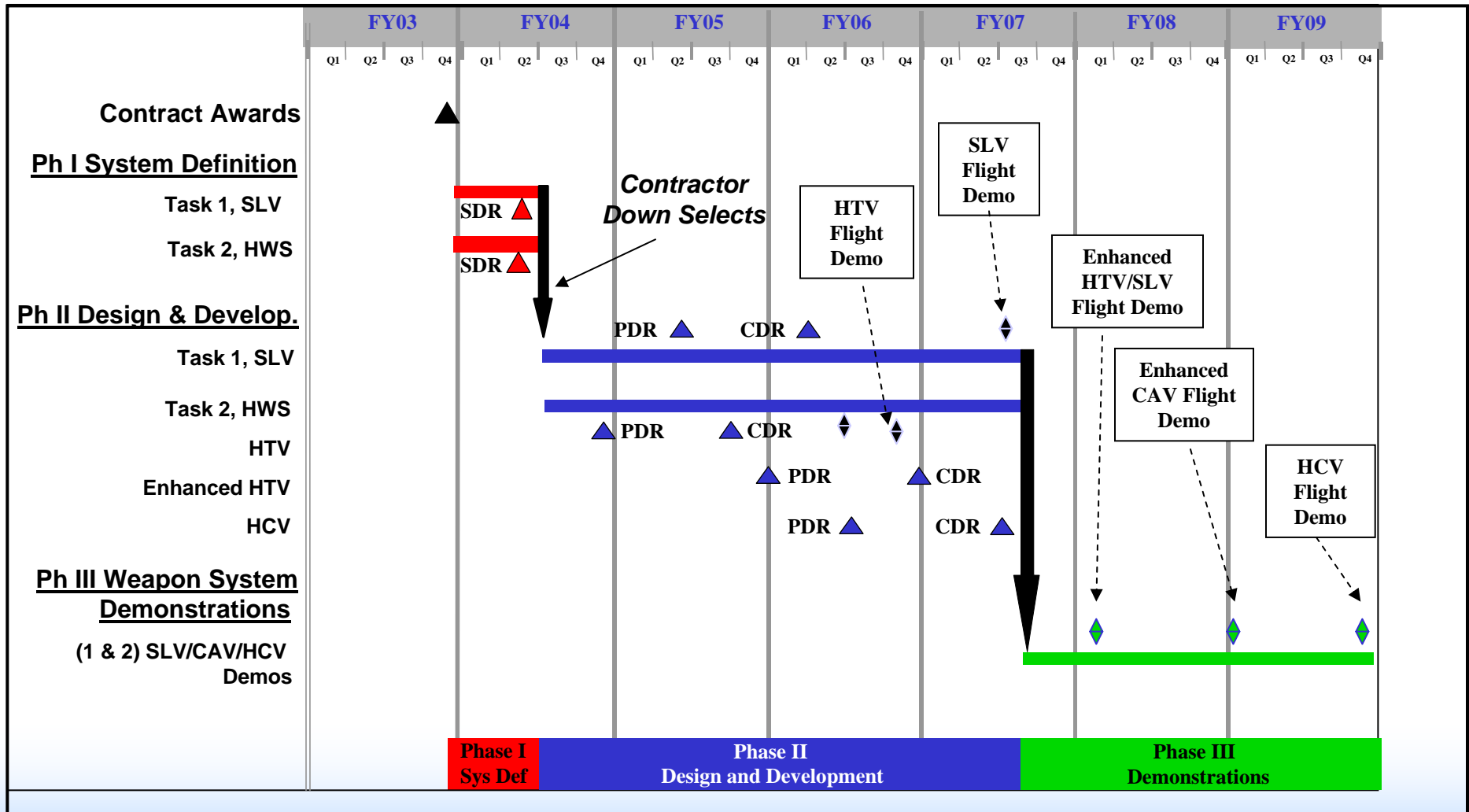
- CAV-to-HCV Demonstrator Design Evolution
- Multiple Opportunities to Flight Test Advanced Technologies
- Build Knowledge Base for Flight Demonstration Approach
 - Launch Site
 - Launch Ops
 - Flight Ops



- *Allows for Early Flight Demonstrations*
- *Provides Multiple Opportunities for Acquisition Off-ramps*



PROGRAM SCHEDULE



LOCKHEED MARTIN



Lockheed Martin selected for hypersonic technology development and flight demonstrations in phase II of the Falcon program.

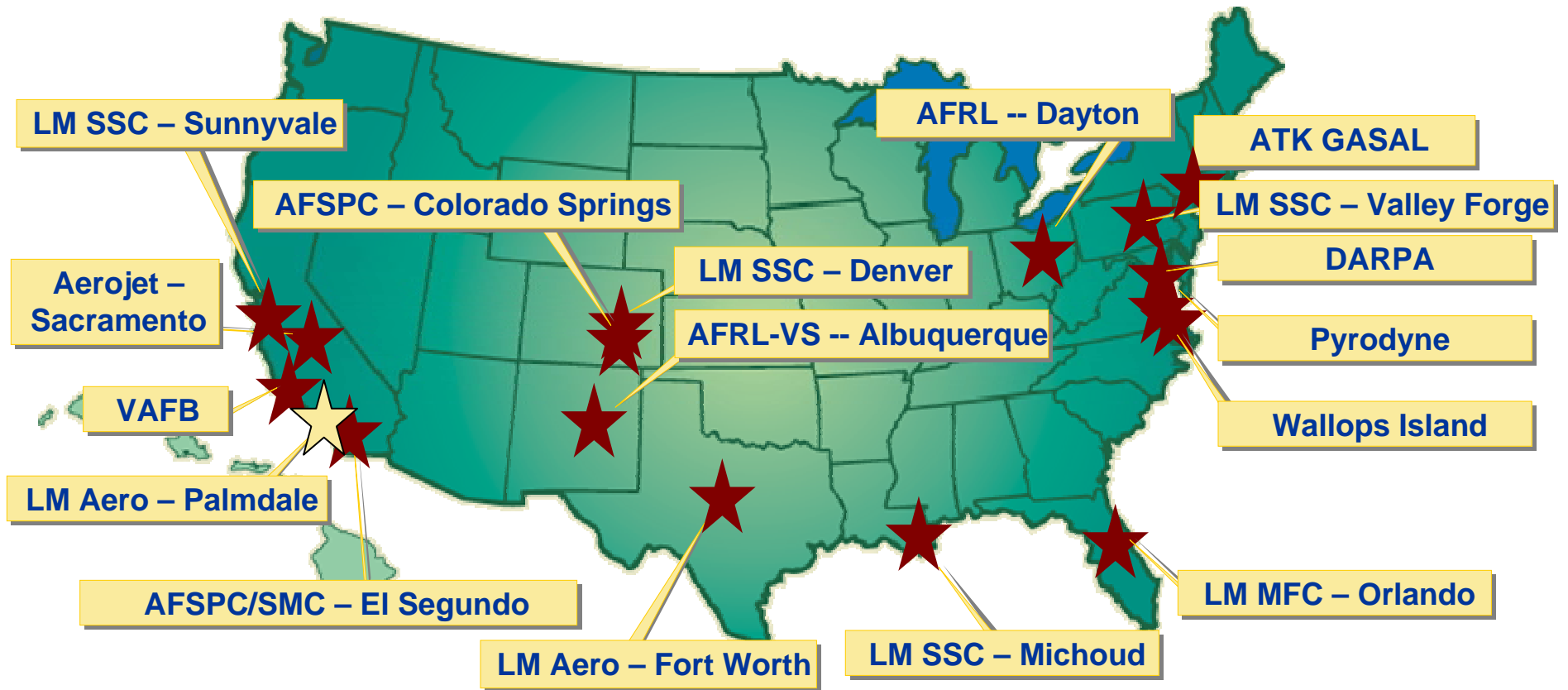
FALCON

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FALCON Program Team Built on National Capability





Phase 1 Output Summary



Phase I

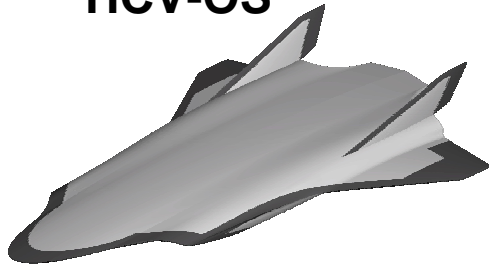
Phases II and III **FALCON**

Breakthrough HWS Operational System

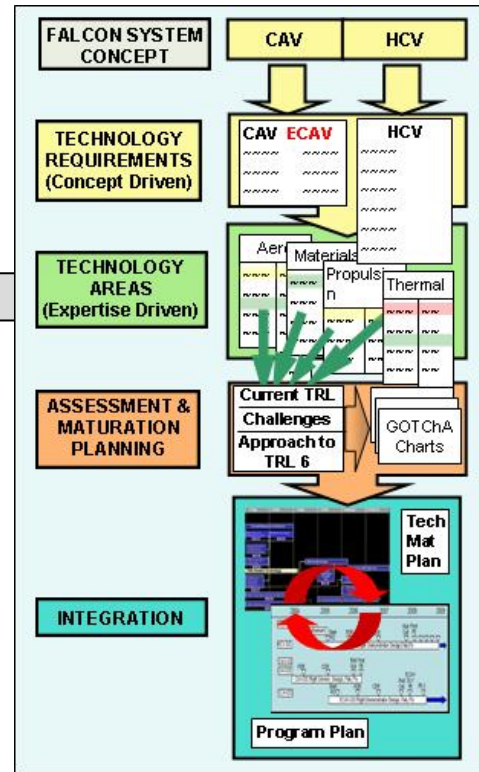
ECAV-OS



HCV-OS



Integrated Technology Maturation Plan



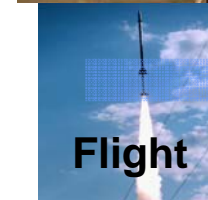
Linked Series of Flight Demonstrations

CAV

ECAV

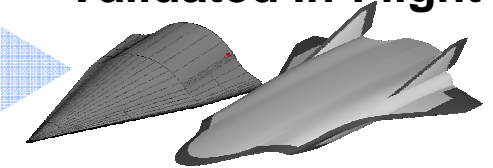
HCV

Risk Reduction



Flight

PGS Capabilities Validated In-Flight



Our in-flight demonstration program enables adoption of hypersonic prompt global strike solutions by the warfighter



FALCON CAV Operational System Meets Near Term Prompt Global Strike Objectives



Small Launch Vehicle System

+

Advanced
CAV
Aero-shell
and Insulation

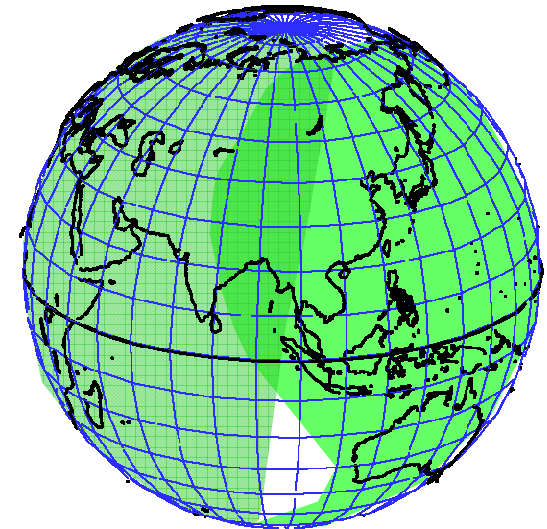


+

High Lift/Drag
Advanced GN&C and
Communications



Enables CAV Global
Reach from CONUS



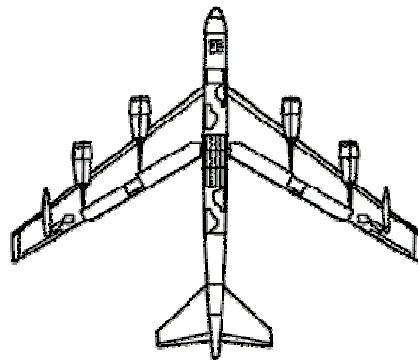
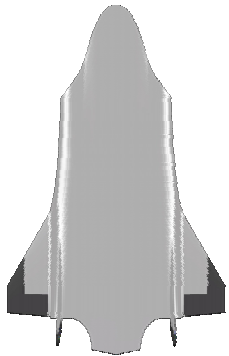
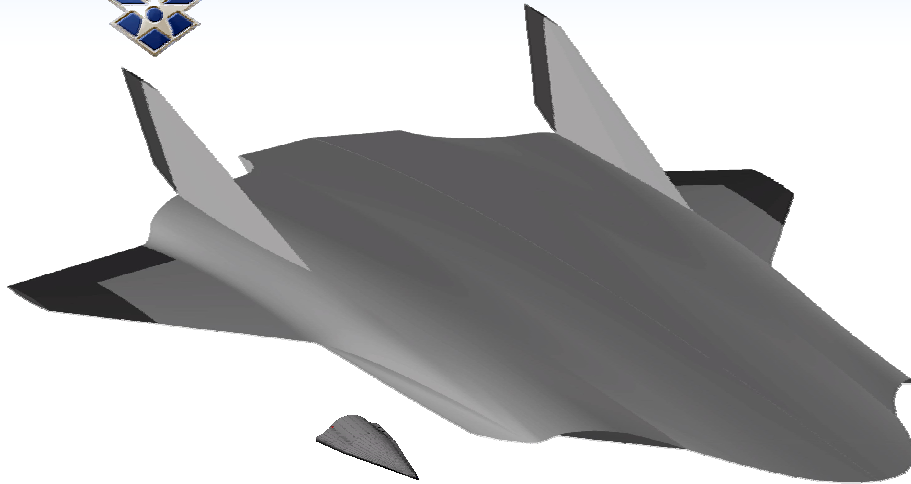
Multiple Payload Carriage

**Terminate and Re-target
Capability**

**Operation CAV/SLV System provides the warfighter with transformational
prompt, precision worldwide strike capability from CONUS**



FALCON HCV Operational System Meets Far Term Prompt Global Strike Objectives



B-52 Size and Weight Class

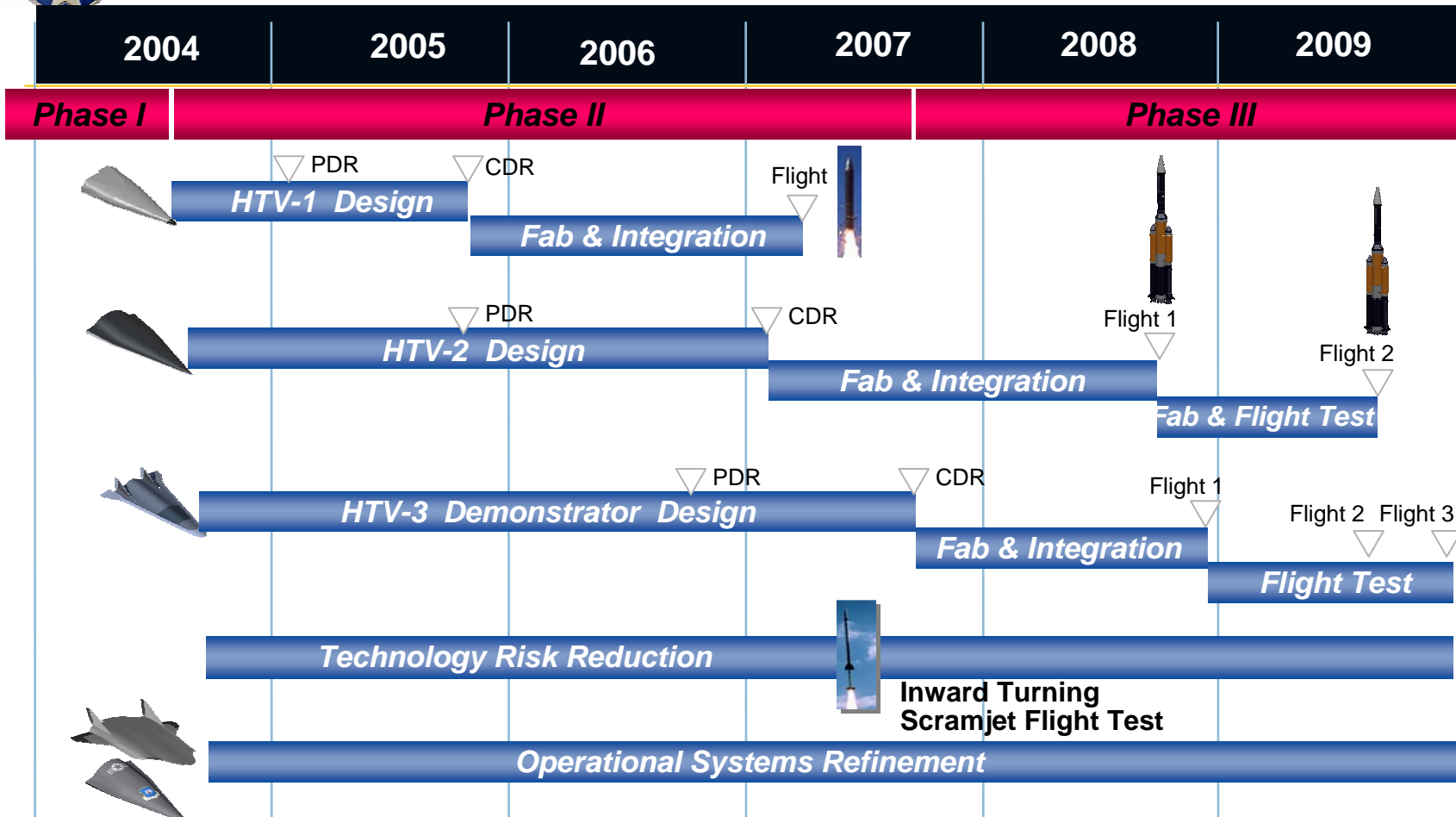
Technology Advances Required for:

- **Aerodynamic Vehicle Design**
- **Inward Turning Propulsion System Integration**
- **Passive Small Radius Leading Edges**
- **Metallic Encapsulated Thermal Protection System**
- **Hot and Warm Structure Technologies**
- **Internal Cryogenic Insulation**
- **Conformal Tanks**
- **Mixed Phase Hydrogen Pumps**

***FALCON HCV can strike the depth of any adversaries territory
at a size and cost acceptable to the warfighter***



FALCON Program Will Demonstrate Operational System Enabling Technologies



Three Distinct Hypersonic Technology Vehicles (HTV) Focus Technology Maturation in a Building Block Approach



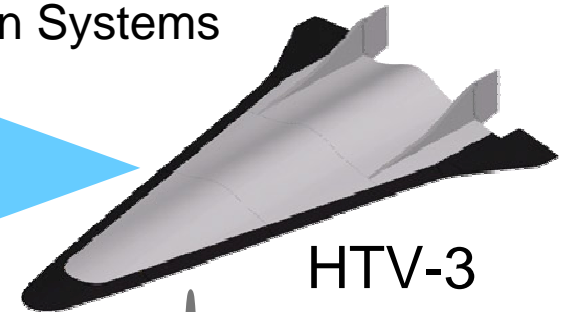
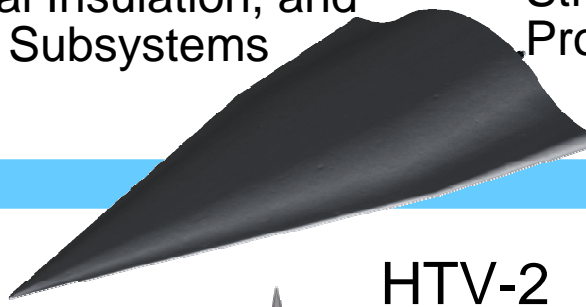
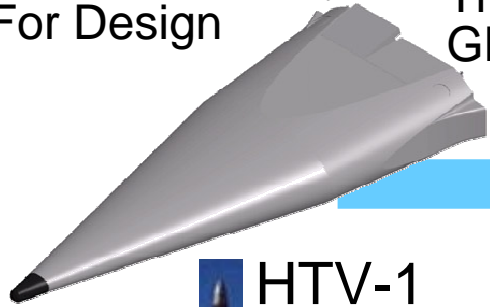
FALCON Phase II & III Demonstrates PGS Technology in Building Block Flight Demo's



Low Risk, Ready For Design

Revise Aero Shell, Thermal Insulation, and GN&C Subsystems

Revise Aero Shell, Internal Structure, Reusable Thermal Protection Systems



HTV-1

HTV-2

HTV-3

GFE Booster Launched

SLV Launched

SLV Core Launched

Validates

Validates

Validates

CAV System and Subsystem Technologies In Flight



All Enabling ECAV-OS Technologies In Flight

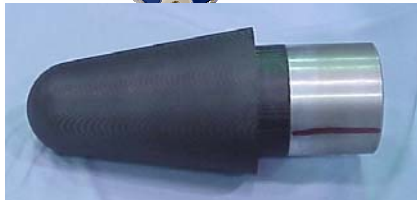
Enabling HCV-OS Aerodynamic & Structures Technologies In Flight

Inward Turning Engine Flight Demonstration Validates Enabling HCV-OS Propulsion Technologies in Flight

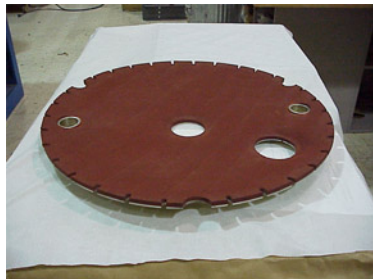
FALCON's evolutionary, spiral development flight demonstrator approach reduces technology validation cost and risk



HTV-1 Demonstration System Summary



Nosetip



Aft Cover

HTV-1 uses state-of-the-art materials and components to reduce overall program risk and demonstrate today's Common Aero Vehicle hypersonic technology capability



IR&D Aeroshell



Antenna Window



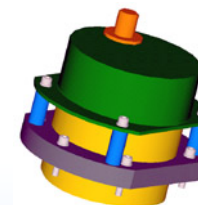
Carbon-carbon samples



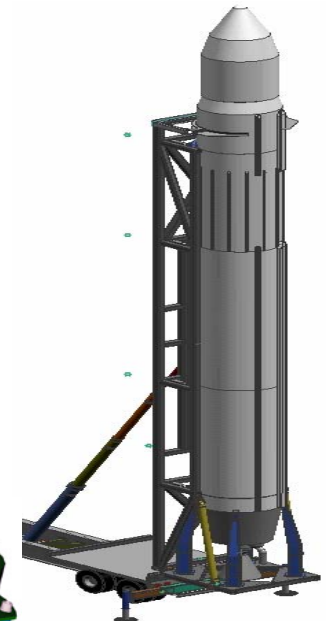
ESIGI



Encoder



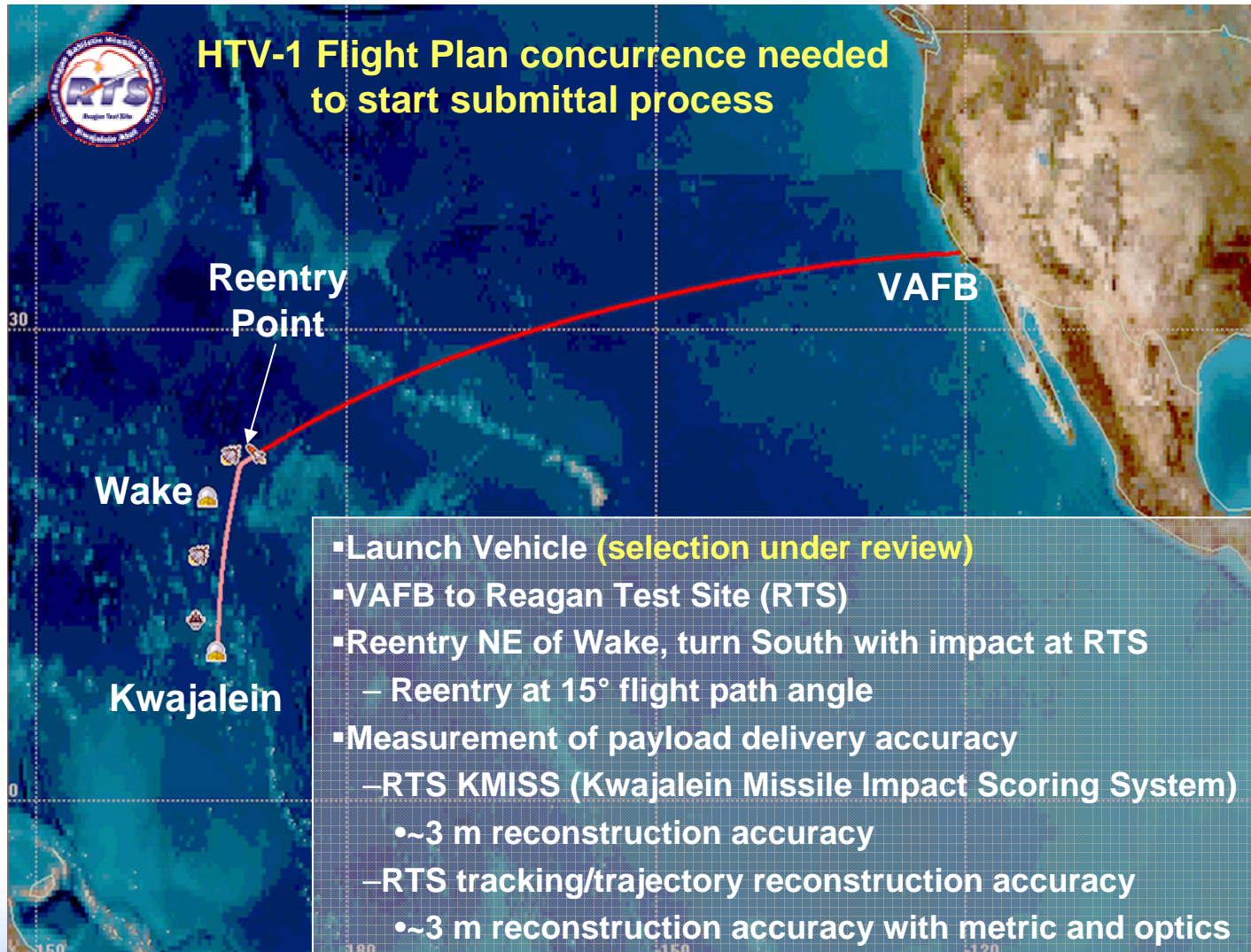
Antenna



Government Furnished Booster Launched



HTV-1 Flight Plan Vandenberg AFB to Kwajalein via Wake Is.





HTV-2 Objectives



Reference Trajectory

East launch, 28.5° latitude, VE = 23,500 ft/sec, hE = 350 kft

Key Objectives

- **Payload ~ 1000 lbs (TBD)**
- **Gross weight = 2000 lbs**
- **Downrange = 9000 nm**
- **Crossrange = 3000 nm**
- **Accuracy = 3 m CEP**
- **Global coverage**
- **Recallable and re-targeting capability**

Additional Objectives

- **Impact velocity ~4 kfps (TBD)**
- **All-azimuth terminal maneuver capability**
- **Carriage & high-speed dispensing of payloads (TBD)**
- **Minimize collateral damage**

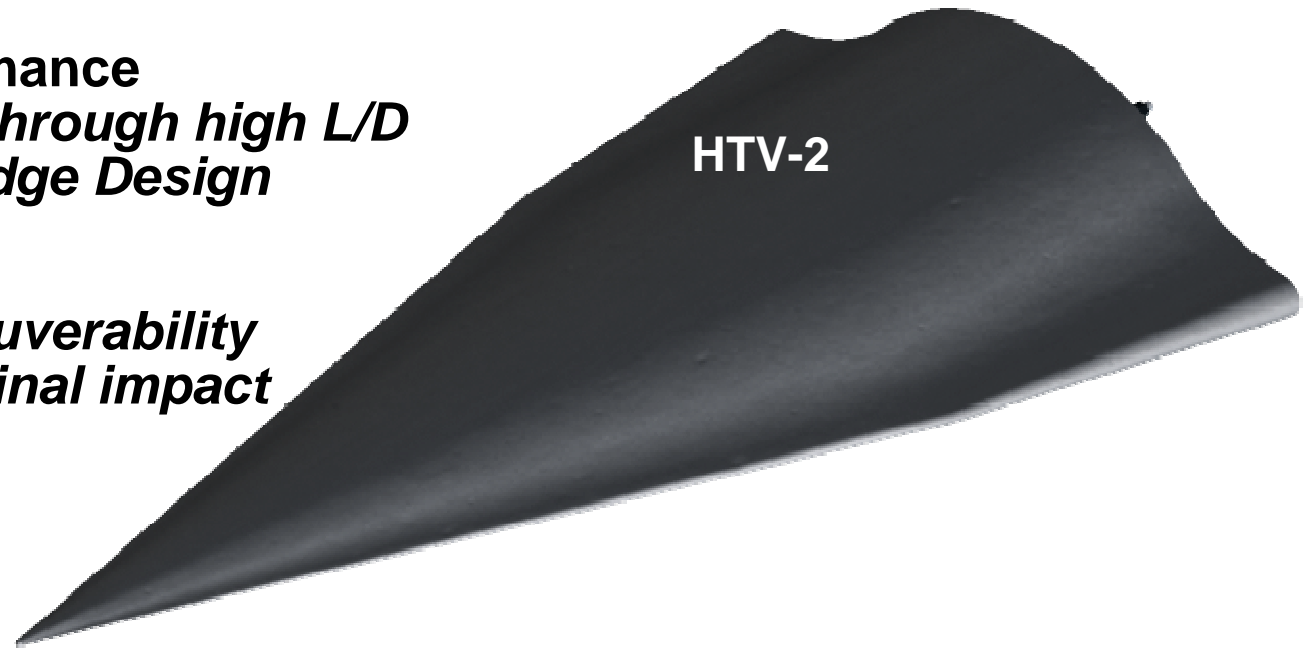
HTV-2 meets all objectives to provide flexible global capabilities



HTV-2 Demonstration System Summary



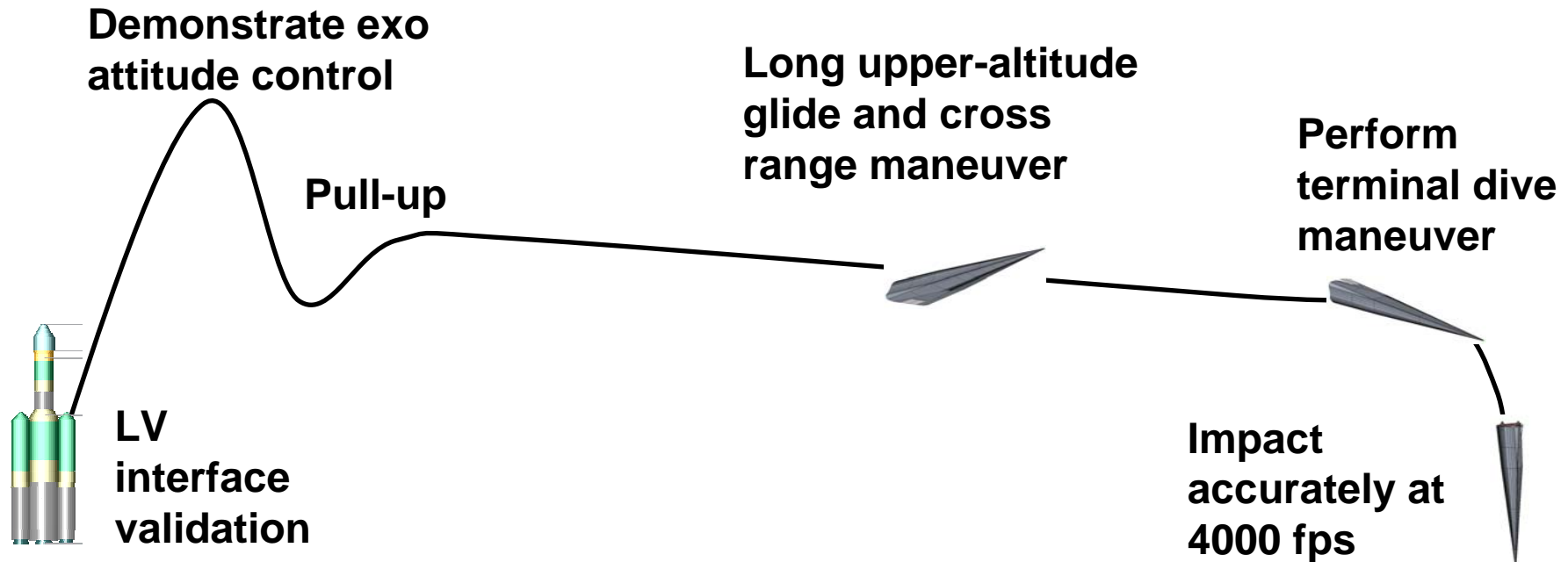
- **Thermal protection**
 - *Low recession carbon-carbon aeroshell*
 - *Advanced Multi-Layer Insulation for long duration reentry flight*
- **Aerodynamic performance**
 - *Extended range through high L/D*
 - *Sharp Leading Edge Design*
- **NG&C performance**
 - *Significant maneuverability required for terminal impact*
- **Communications**
 - *Maintain up/downlink throughout long-range flight*



***HTV-2 Demonstrates Enabling Hypersonic Technologies
for future Common Aero Vehicle Operational System***



HTV-2 Flight-Test Profile



Other objectives

- Maintain flight safety throughout
- GPS acquisition during boost phase
- Command/telemetry link throughout mission
- Objectives for 1st flight shown
- 2nd flight options
 - repeat 1st with equipment updates
 - perform payload dispensing demonstration

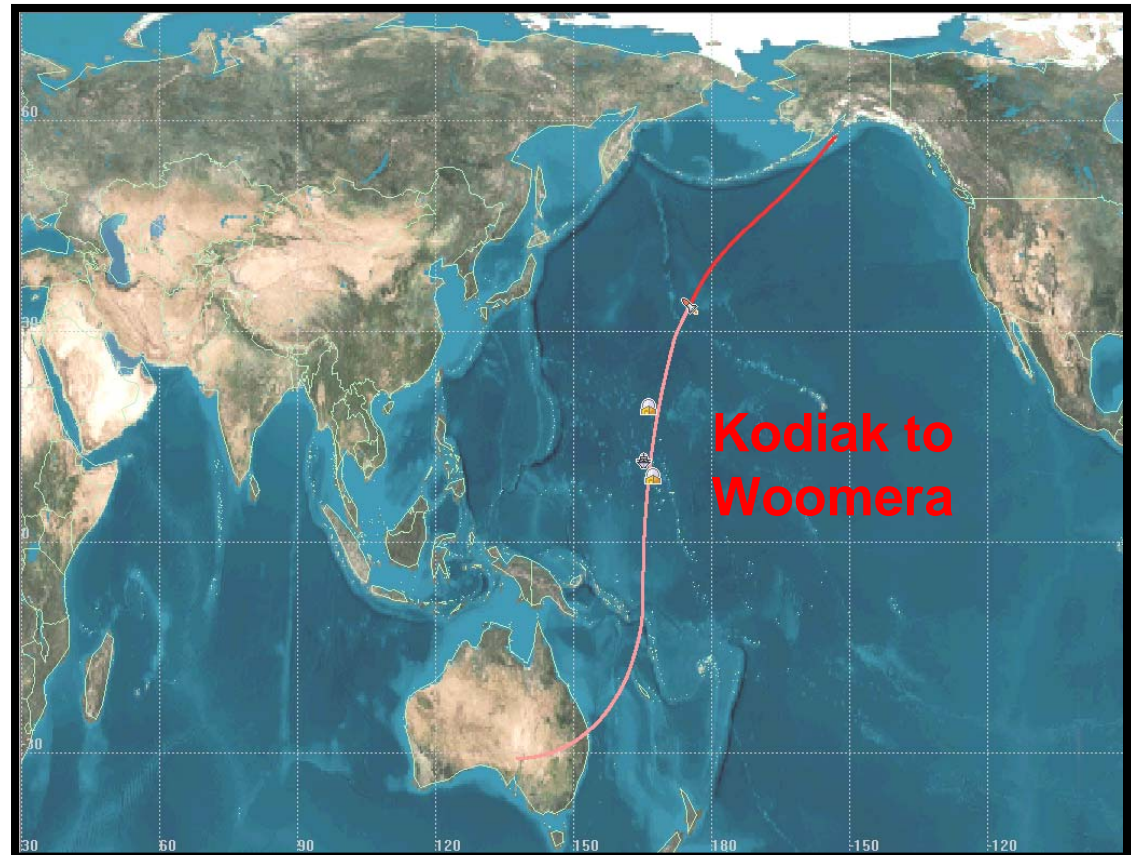
Our flight profile demonstrates all important performance attributes



Proposed HTV-2 Flight Plan



- SLV launch to reentry at 23,000 fps and 5° path angle
- Kodiak to Woomera (6200 nm) via Wake and Kwajalein
- Continuous tracking and telemetry use extended mobile range, AFSCN and MILSATCOM assets
- **Overflight of populated Australian east coast**
 - Flight crosses coast >100 kft altitude
 - Controlled Flight Termination available
- Terminal phase tracking available from Woomera



HTV-2 flight plan provides long-duration test environments



ECAV-OS Weight Traceability



	Weight (lbm)			Reduction Plan
			OS	
Payload			960	Customer Provided
Heatshield			400	Analysis refinement
Insulation			90	Analysis refinement
Structure			240	Analysis – g load reduction
Electronics			85	Actuator/battery refinement
Ballast			225	Structure/HS reduction, CG movement/aero refinement
Total			2000	

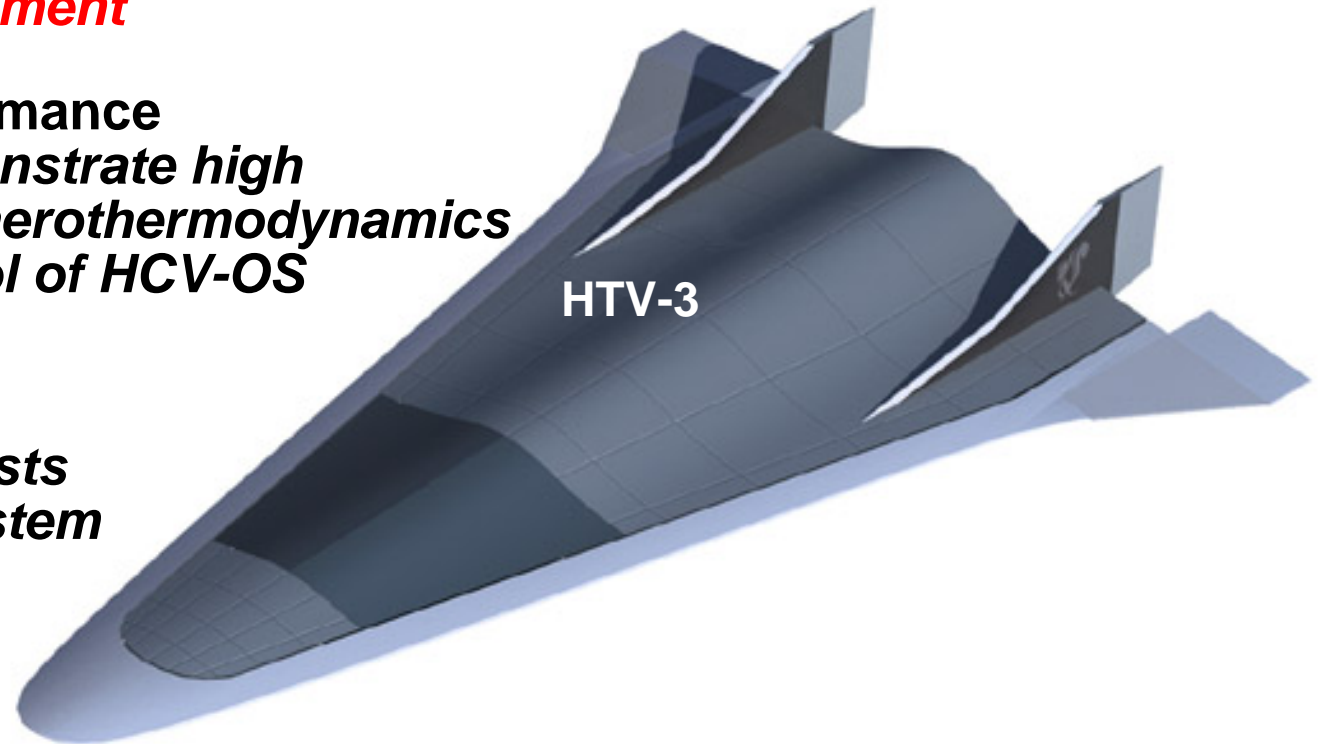
Roadmap defined to achieve 2000 lb ECAV-OS mass



HTV-3 Demonstration System Summary



- **Thermal Protection System (TPS)**
 - *TPS/Structure demonstrate capability for HCV-OS environment*
- **Aerodynamic performance**
 - *Shaped to demonstrate high aerodynamics, aerothermodynamics and flight control of HCV-OS*
- **Maximize Reuse**
 - *Multiple flight tests demonstrate system reusability/TPS refurbishment*
- **Builds upon HTV-1 and HTV-2 technologies**
 - *Technology risks minimized while payoff is maximized*



HTV-3 Demonstrates Enabling Hypersonic Technologies for future Hypersonic Cruise Vehicle Operational System

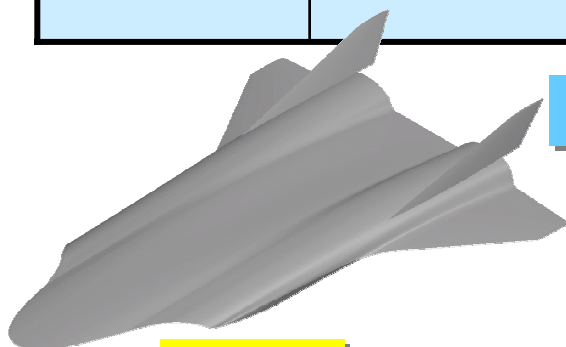


HTV-3 Design & Capabilities



HCV-OS primary objectives trace to HTV-DS design capabilities

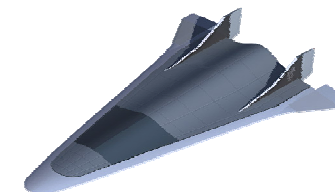
Mission Requirement	OS Design Objective	DS Verification Compliance
Global Reach 9000nm in 2 hours	<ul style="list-style-type: none"> ➤ Mission performance via high L/D osculating flowfield waverider configuration ➤ High tolerance to thermal environment 	<ul style="list-style-type: none"> ➤ Shaped to demonstrate high L/D wave-rider osculating flowfield aerodynamics, aerothermodynamics, flight control ➤ Demonstrate enabling TPS / structural technologies in OS flight environment
Aircraft-like operations	<ul style="list-style-type: none"> ➤ Reusability with rapid 12 hr turnaround and minimum maintenance 	<ul style="list-style-type: none"> ➤ Perform multiple flight tests, demonstrating system reusability / TPS refurbishment



HCV-OS

Demonstrate Key Enabling Technologies

- Osculating Flowfield Waverider shape
- 4000°F class passive TPS
- 3000°F class passive TPS
- Lightweight acreage passive TPS
- 'Warm' structure-tankage-TPS integration



Low Risk Demo

HTV-3 is directly traceable to HCV-OS to mitigate risk of key enabling technologies



FALCON Materials IPT



- **Materials IPT (MIPT) focusing on materials issues (TPS and hot structures) for HTV-2 and HTV-3**
 - HTV-1 is assumed to utilize state-of-the-art materials
 - In the initial phases of the MIPT, **only Airframe technology is considered**. Propulsion hot structures will be considered at a later date as required/requested.

- **MIPT objectives**
 - Evaluate relevancy of ongoing government funded materials/design efforts to HTV-1, HTV-2, HTV-3, ECAV-OS, and HCV-OS needs.
 - Work with the FALCON prime to develop a materials plan that integrates MIPT efforts with contractor efforts
 - Recommend supplemental and new start efforts to fill technology gaps



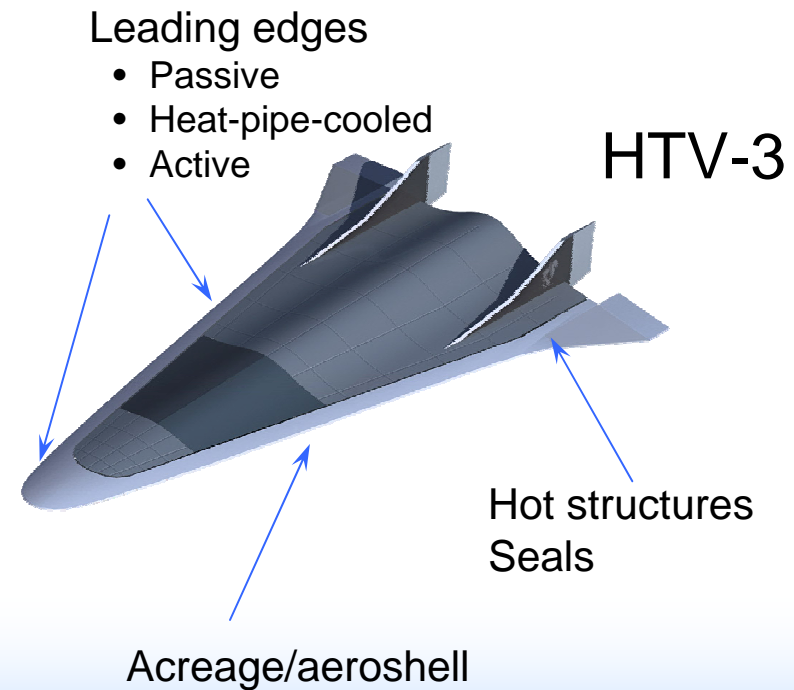
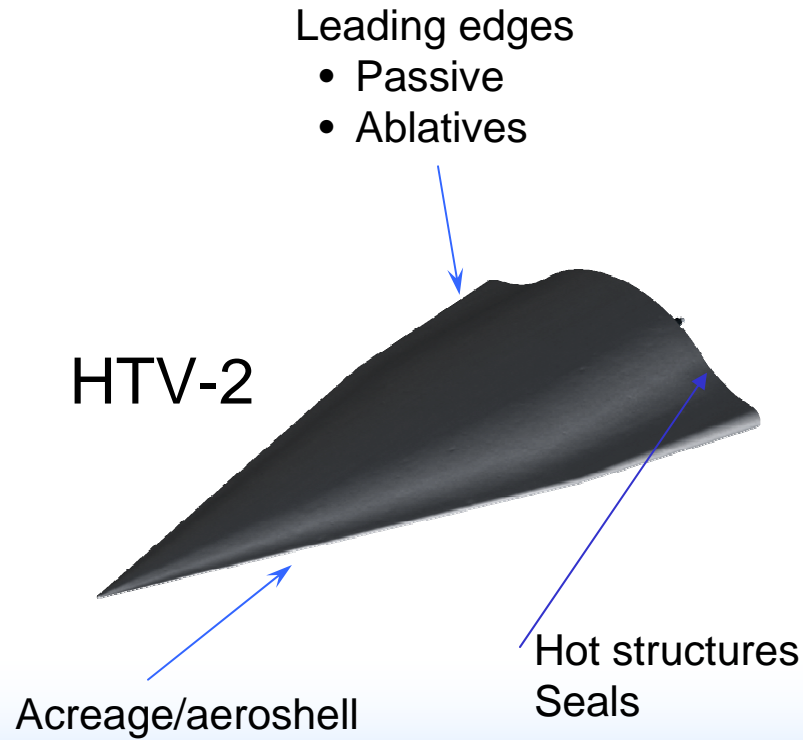
Critical Airframe Components

TPS/Hot Structures



Enhanced CAV (OS)

Hypersonic Cruise Vehicle (OS)





MIPT FY04 Activities Contracted Through UDRI



➤ 3000°F Carbon/Carbon Oxidation Protection

- C-CAT
- Pratt & Whitney

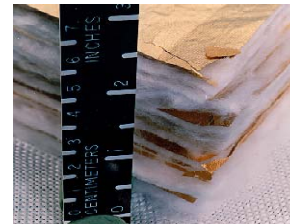


X-37 C/C control surface

➤ 3600°F Refractory Composites

- Physical Sciences, Inc. (PSI)
- Composite Innovations, Inc. (CIC)
- ATK

Sharp leading edge, $T > 3600^{\circ}\text{F}$

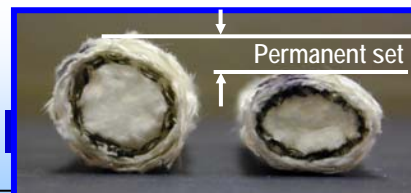
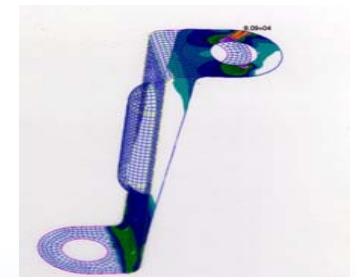


German multi-layer insulation

➤ High Temperature Multi-Layer Insulation

- Refractory Composites, (RCI)

FEA of TPS attachment



Seals after use at 1900°F



FALCON...
Enabling future hypersonic technologies



- Unprecedented hypersonic technology validation in flight
- Building block approach maximizes payoff while minimizing technology risks
- TPS is the key technology

Newly Established STRATCOM October, 2002

Unified Command - Given Global Strike Mission:

“Establish and provide full-spectrum global strike... to meet both deterrent and decisive national security objectives”

“The capability to plan for and deliver rapid, limited-duration, extended-range precision kinetic and non-kinetic effects”

FALCON will demonstrate technologies required for tomorrow's global reach missions!