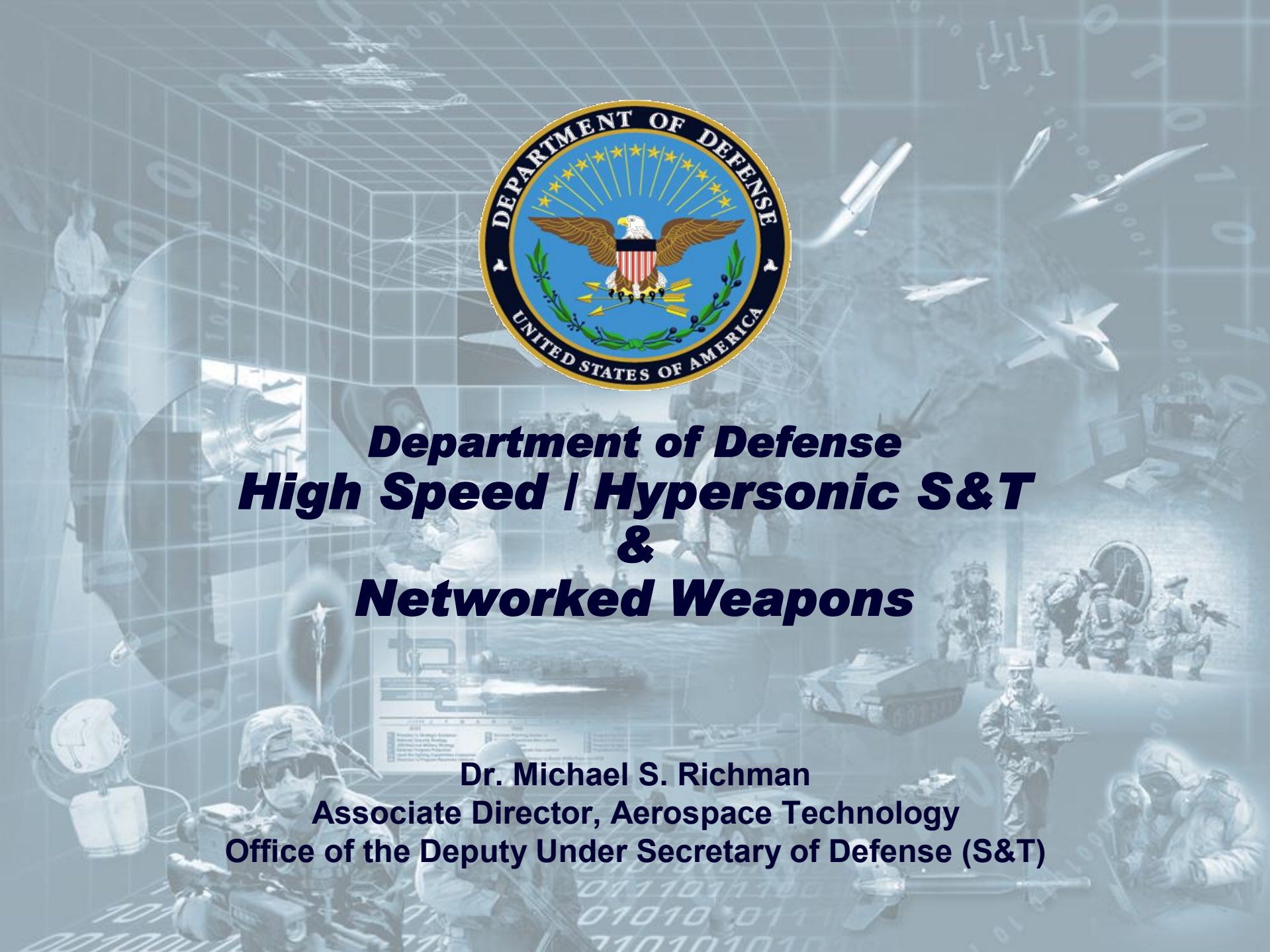


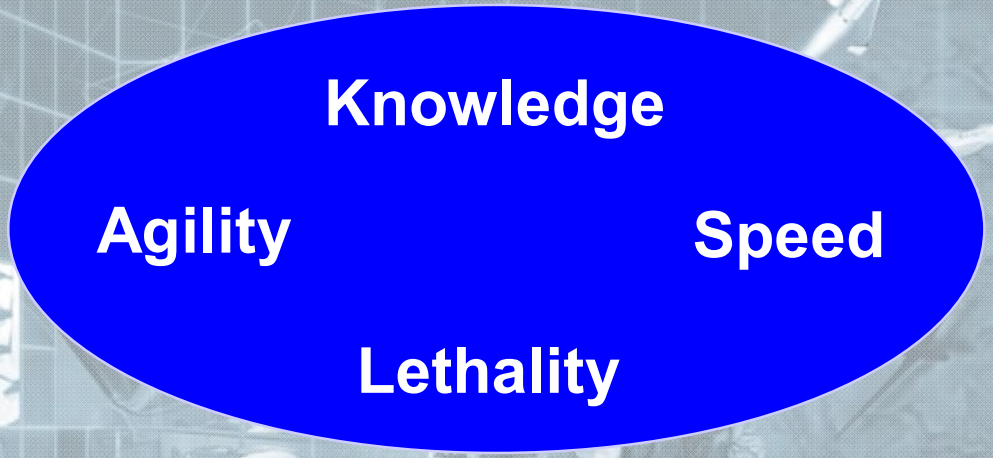
Department of Defense
High Speed / Hypersonic S&T
&
Networked Weapons

Dr. Michael S. Richman
Associate Director, Aerospace Technology
Office of the Deputy Under Secretary of Defense (S&T)

Outline

- DDR&E Transformation Initiatives
- NAI – High Speed / Hypersonic S&T plan
- Networked Weapons

Technology and Transformation
Transformational Attributes



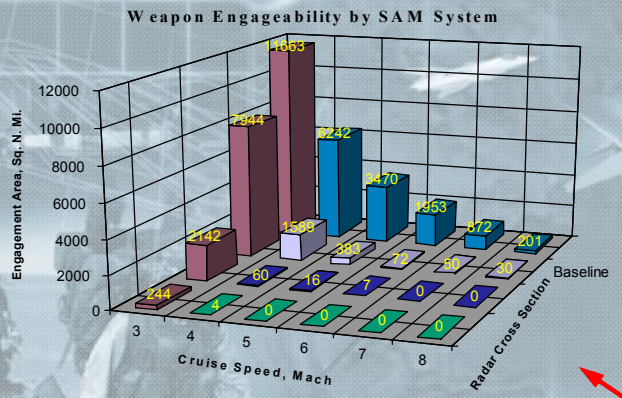
- **DDR&E Transformation Technology Initiatives**
  - **National Aerospace Initiative**
  - **Energy and Power Technologies**
  - **Surveillance and Knowledge Systems**

Value of Speed… global strike

Benefits

- Reduced Adversary Detection and Reaction Time
- Reduced Strike Package Assets
- Increased Engagement Area by a Single Platform
- Increased Shooter Survivability
- Increased Kills per Launch
- Address the Deep Penetration Problem

1.8m (speed) ~ Survivability/Vulnerability ~ 1/10 (Signature)



Space Access

Reconnaissance

Theater of Operation

Anti-access

Boost/Ascent

NPR

Long Range Strike

Time Critical Target

Cruise

Cruise

Missile Defense

SEAD

Notional System Attributes

- Speed (Average Velocity) = Mission Range / Mission Time
  - Application – Time Critical Strike
  - Application – Hard and Deeply Buried Targets
  - Application – Prompt Global Strike
- Survivability = 1/Vulnerable Time, which is the amount of time that the vehicle is susceptible to detection and intercept
  - Application – Speed option to access capability
- Payload Capacity = Payload Mass Fraction x Takeoff Gross Weight
  - Application – Space Access
  - Application – Long-range Strike

Notional System Attributes

BASELINE

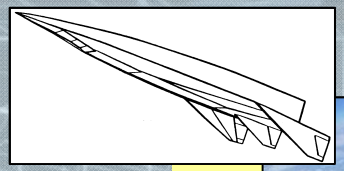
B-2, B-777,SR-71, D-21, SLAM-ER, JASSM, ASALM, STS

Phase I – 2010

Expendable Systems
- Mach 4-6+ Cruise
- Range up to 1000 nmi
- 15% Payload Mass Fraction

Reusable Systems
- Mach 5-7 Flight

Near Term



Phase II – 2015

Expendable Systems
- Mach 6-8 Cruise
- Range up to 2000 nmi
- 30% Payload Mass Fraction

Reusable Aircraft Systems
- 5000 miles in < 2 hrs
- 3x Improved Survivability

Reusable HTHL TSTO
- 3% Payload Fraction
- One failure in 500 flights
- $5,000 per pound to LEO

Mid Term

Phase III – 2020

Expendable Systems
- Mach 12+ Interceptor

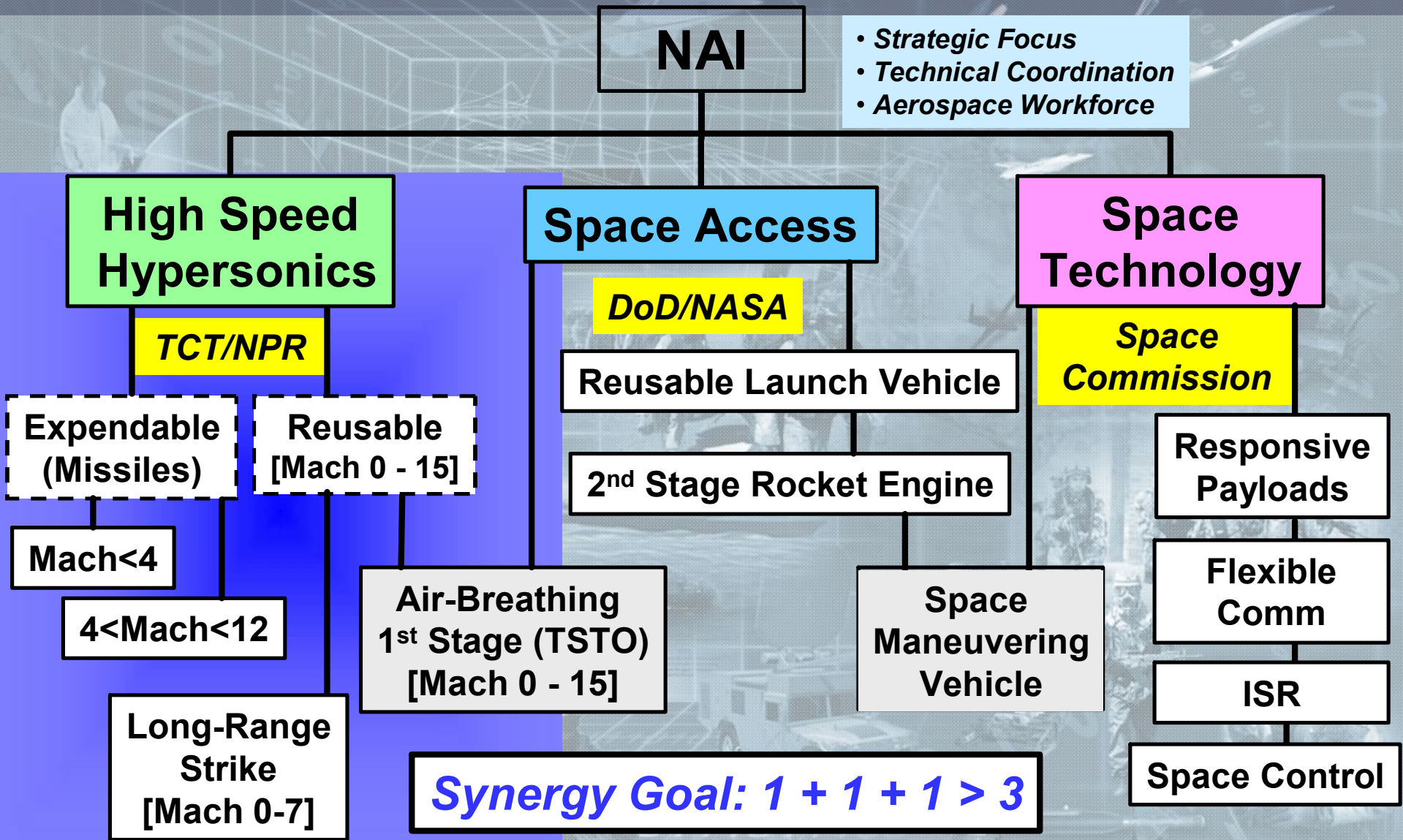
Reusable Aircraft Systems
- Anywhere in < 2 hrs
- 6x Improved Survivability

Reusable HTHL TSTO
- 5% Payload Fraction
- One failure in 5,000 flights
- $1,000 per pound to LEO

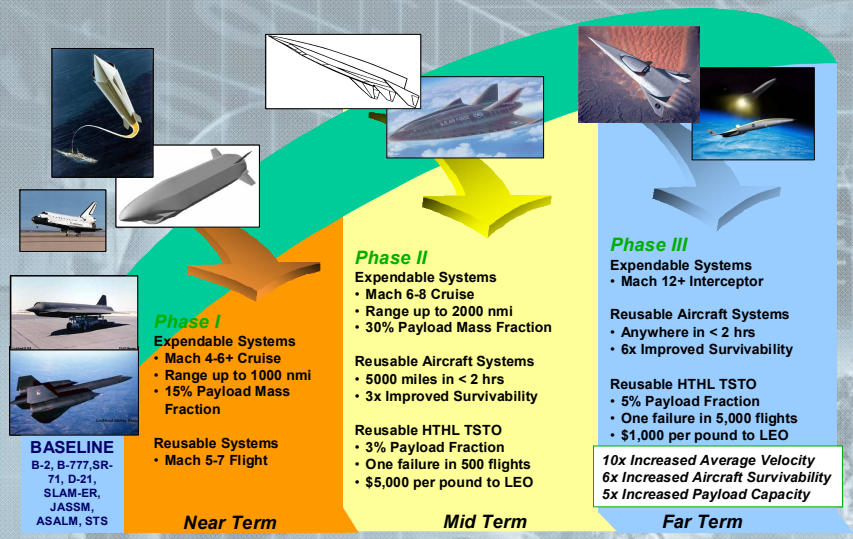
10x Increased Average Velocity
6x Increased Aircraft Survivability
5x Increased Payload Capacity

Far Term

NAI Technology Framework



High Speed/Hypersonics Taxonomy



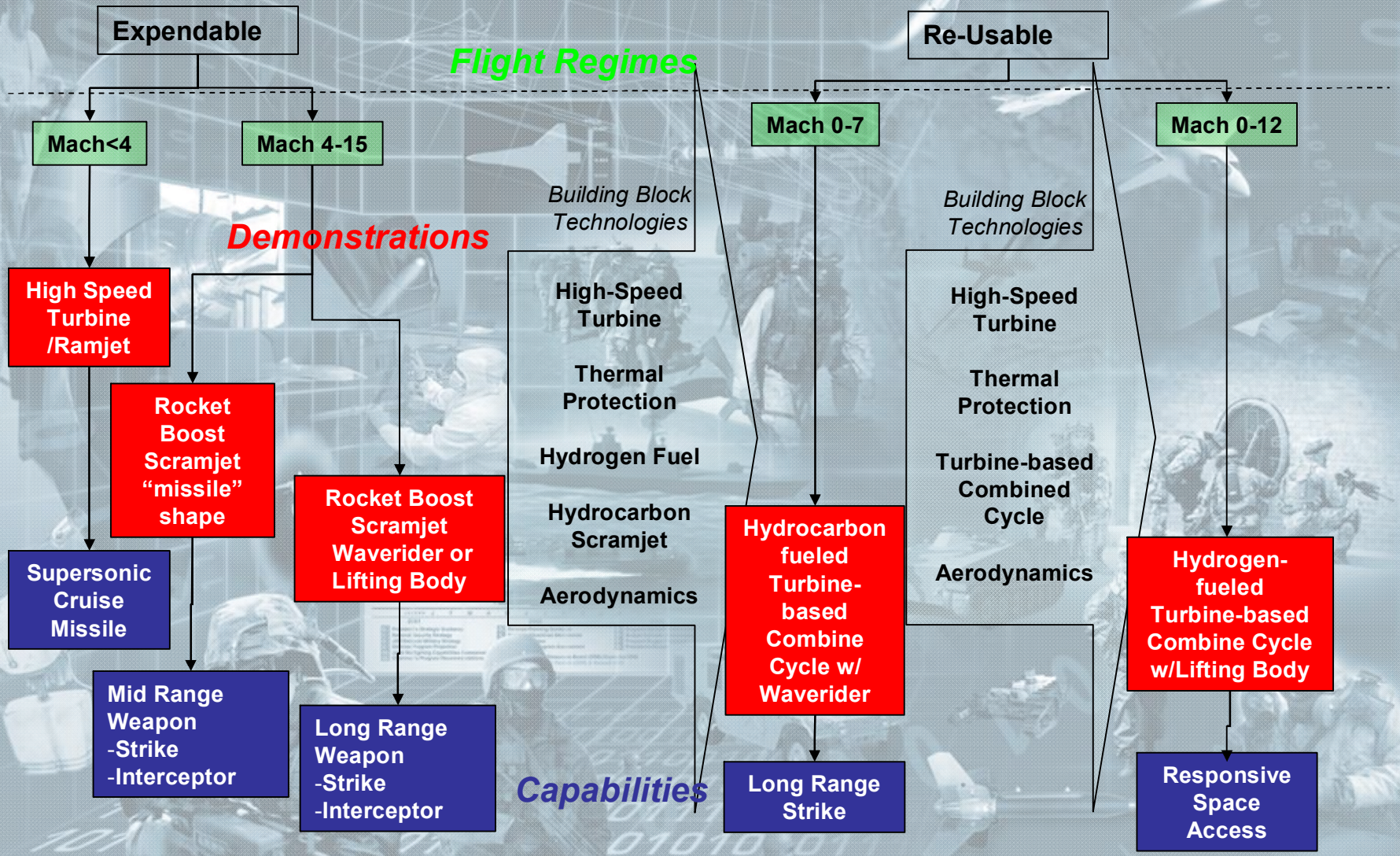
Capabilities Supported

- On-demand Spacelift
- Assured Access Spacelift
- Long Range Strike
- Global Precision Engagement
- Air & Missile Defense

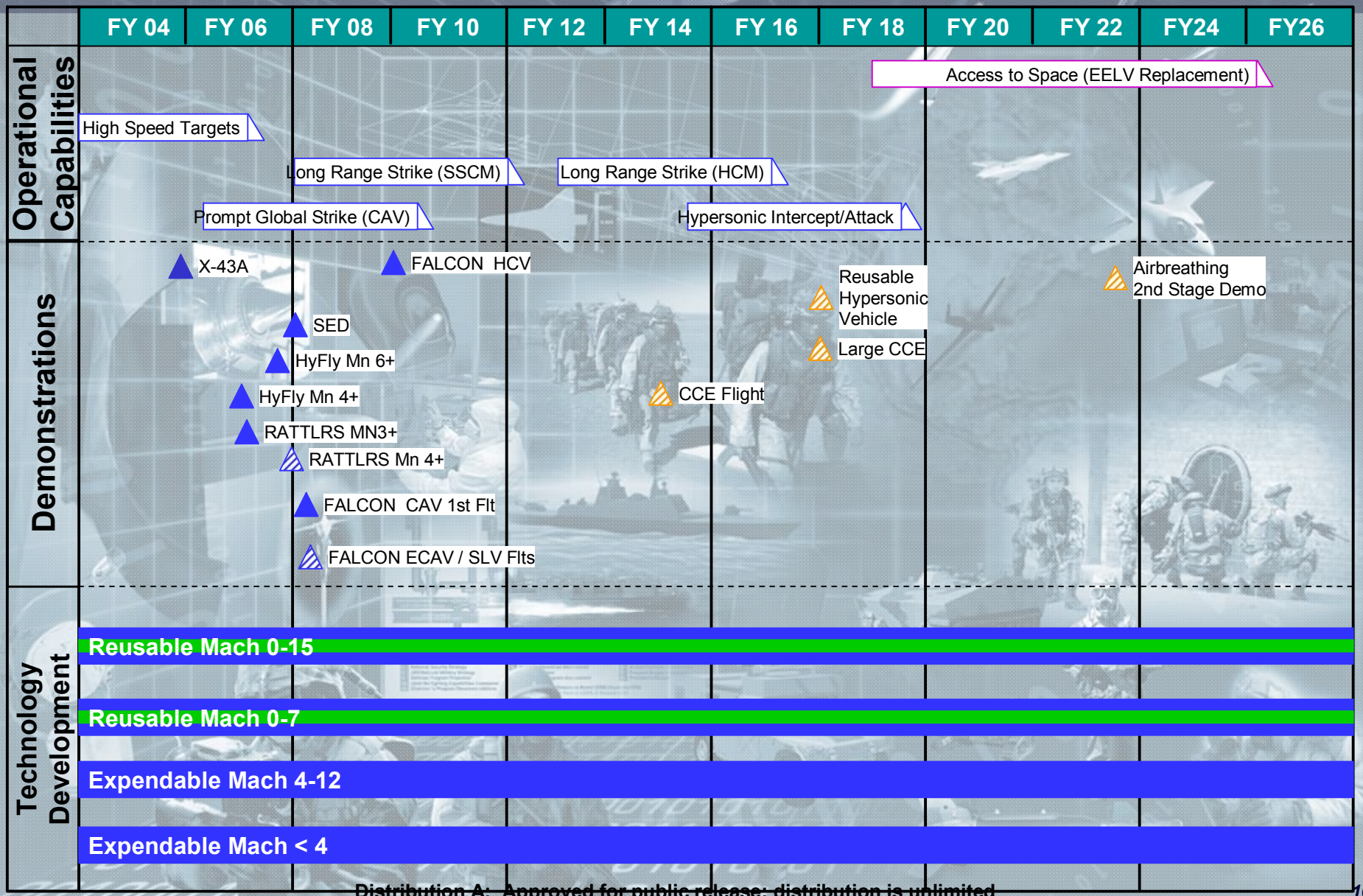
System	Subsystem	Research Area
Airframe	Configuration	Propulsion/Airframe Integration Design Tools Shock Interaction Airframe Thermal Loads
	Subsystems	SOA
	Stability & Control	Propulsion/Airframe Integration Design Tools Guidance, Navigation & Control
	Thermal Management & Structures	Design Tools Shock Interaction Airframe Thermal Loads
	Propellant Systems	Fuel Control System Airframe Thermal Loads
Propulsion	Air Induction	Engine Performance Propulsion/Airframe Integration Design Tools Shock Interaction
	Compression	Engine Materials Thermal Balance Design Tools
	Combustion	Endothermic Fuel Coking Design Tools Fuel Control System
	Turbines	Endothermic Fuel Coking
	Exhaust	Propulsion/Airframe Integration Engine Performance Design Tools
	Propellants	Endothermic Fuel Coking Fuel Control System
	Structures & Materials	Engine Thermal Loads Engine Materials Thermal Balance
	Cycle Integration	Thermal Balance Engine Performance Design Tools
	Control Systems	Fuel Control System
	Mechanical Systems	Engine Materials Thermal Balance
	Boosters	SOA

Note: Reusable airframe technologies addressed via Space Access pillar

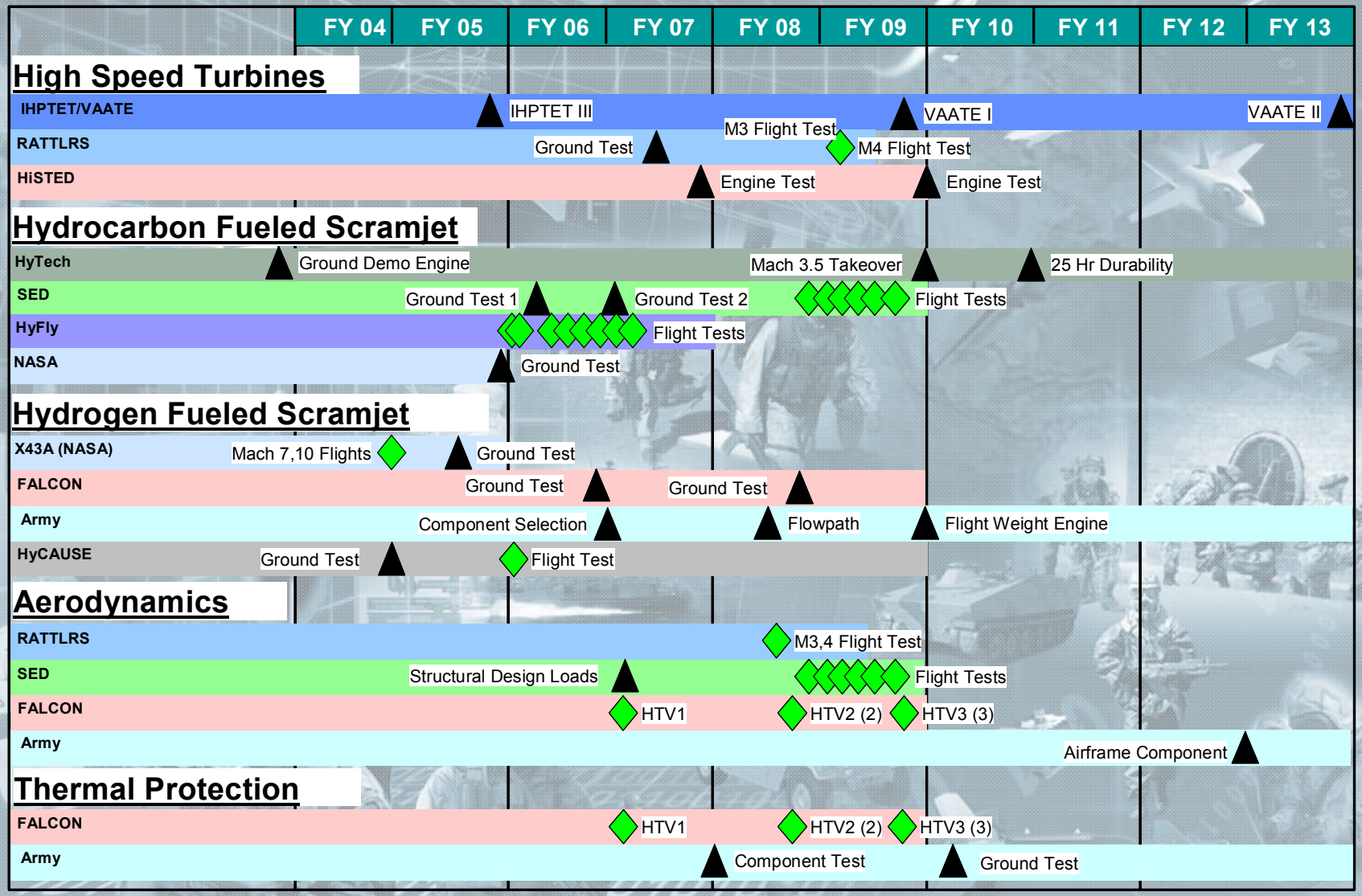
Technology Critical Path



High Speed/Hypersonics Level I Roadmap

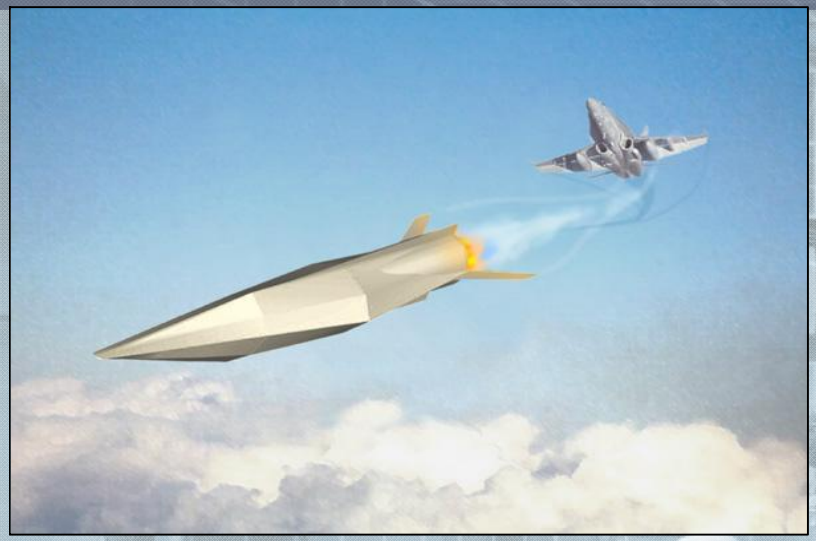


High Speed / Hypersonic S&T



RATTLRS Flight Demonstration

(**R**evolutionary **A**pproach **T**o **T**ime-Critical **L**ong-**R**ange **S**trike)



OBJECTIVES:

- Flight Demonstrate a Supersonic Expendable Turbine-Powered Flight Vehicle Demonstrating Integrated Inlet/Nozzle/Airframe/Engine System Technologies Which is Traceable To A Tactical Weapon System
- **Minimum Objectives :**
  - Two Mach 3 Flight Demonstrations 2008
  - Traceability to a Weapon System
  - Mach 3.0+ Cruise
  - Acceleration: 0.25 g or greater
  - Cruise Time: 5-minutes or greater
- **Growth Objectives :**
  - One Mach 3 Flight Demonstration 2008
  - Two Mach 4 Flight Demonstrations 2010
  - Mach 4 Cruise
  - Acceleration > 0.5 g
  - Cruise Time > 15-minutes
  - Traceability to a Weapon System
  - Optimized Vehicle Configuration
  - Flexible Flyout in Multiple Speed Regimes

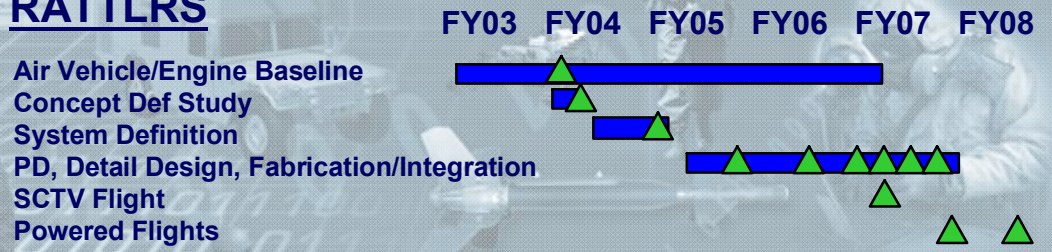
PAYOFFS:

- **Ability to Engage Time-Critical Targets**
- **High Efficiency Engine Enables Extended Ranges**
- **Potential High-Speed and Loiter Capabilities**
- **Flexible, Multi-Mission Weapons**
- **Multiple Launch Platform Compatible**
- **Steppingstone to Space Access, NAI**

READINESS (TRL 4-6):

- **Mach 3+ Expendable Turbine (TRL 4 to 6)**
- **High L/D Configurations (TRL 5 to 6)**
- **Aeropropulsion Integration Methodology (TRL 5)**
- **High Temperature Airframe Mat'l (TRL5 to 6)**

RATTLRS

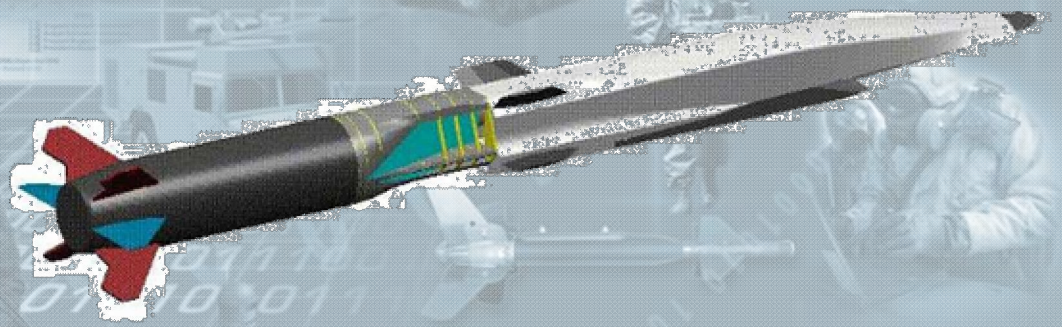


Air Force/DARPA Scramjet Engine Demo (SED) Program

Objective : Demonstrate viability of the endothermic hydrocarbon-fueled scramjet engine developed under the USAF Hypersonic Technology (HyTech) program.

SED Will:

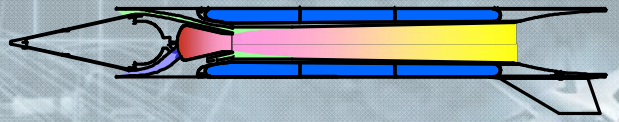
- Collect ground & in-flight test data of an operating hydrocarbon fueled scramjet engine
  - Actively fuel-cooled engine controlled using a closed loop, digital, fuel distribution system.
  - Uses airframe and subsystem technologies developed under the DARPA Affordable Rapid Response Missile Demonstrator (ARRMD) program.
- Validate design methodologies and tools (including computational and ground test techniques)
- Complete a flight test series
  - Operate scramjet from 4.5 M to 6.0-7.0+ M
  - 4-8 flights, starting in FY09



DARPA/ONR Hypersonic Flight Demonstration (HyFly) Program

Approach

Rocket Boosted Axisymmetric Vehicle
- Dual Combuster Hybrid Ramjet
- Liquid Hydrocarbon Fueled

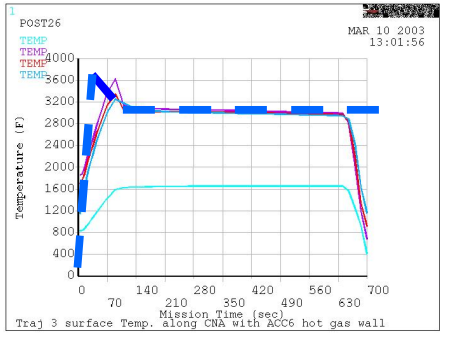


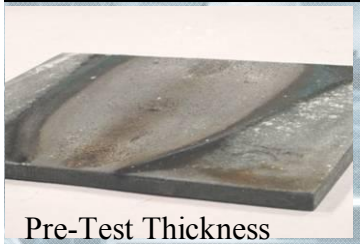
Program Objectives

Tactical Sized Powered hypersonic Missile flight
- **6 Powered Flights**
- **Mach 6 sustained cruise, Fly 400 nmi**
- **Submunition dispense demonstration**

Uncooled Structures
- Ceramic Matrix Based Engine, Nose & Leading Edges
- Cast Titanium Airframe

Recent Progress

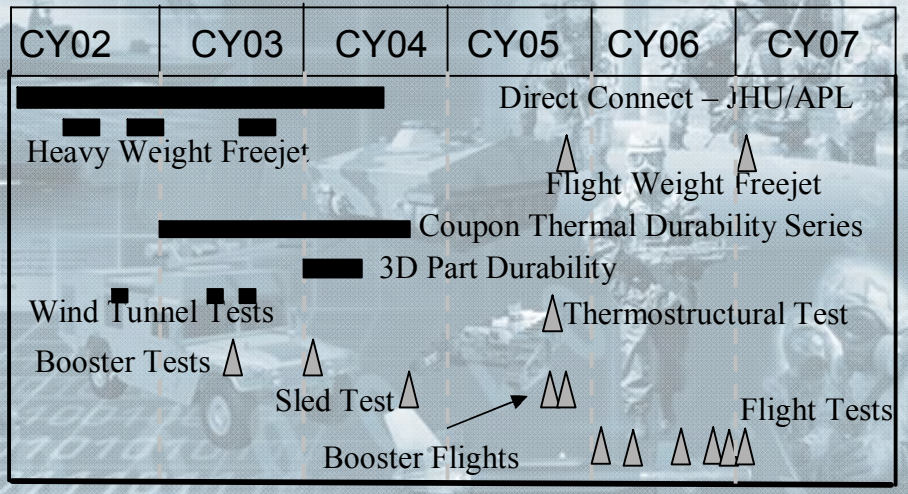




Pre-Test Thickness
Range 0.183 - 0.188”
Post-Test Thickness
Range 0.179 - 0.181”

Material coupons tested to 4200°F near zero erosion
CMC Engine Component pathfinder prototypes complete
Mach 6.5 Engine Operability Demonstrated
Booster-Sustain Vehicle Separation Demonstrated

Milestones



National Aerospace Initiative
High Speed / Hypersonics S&T

High Speed / Hypersonics On-Track

Expendable

- Navy/DARPA HyFly Program [Mach 6 Dual Combustion Ramjet]
- AFRL/DARPA Single Engine Demonstrator [Mach 8 Scramjet]
- Navy RATTLRS Cruise Missile Demo [Mach 3+ Turbine]

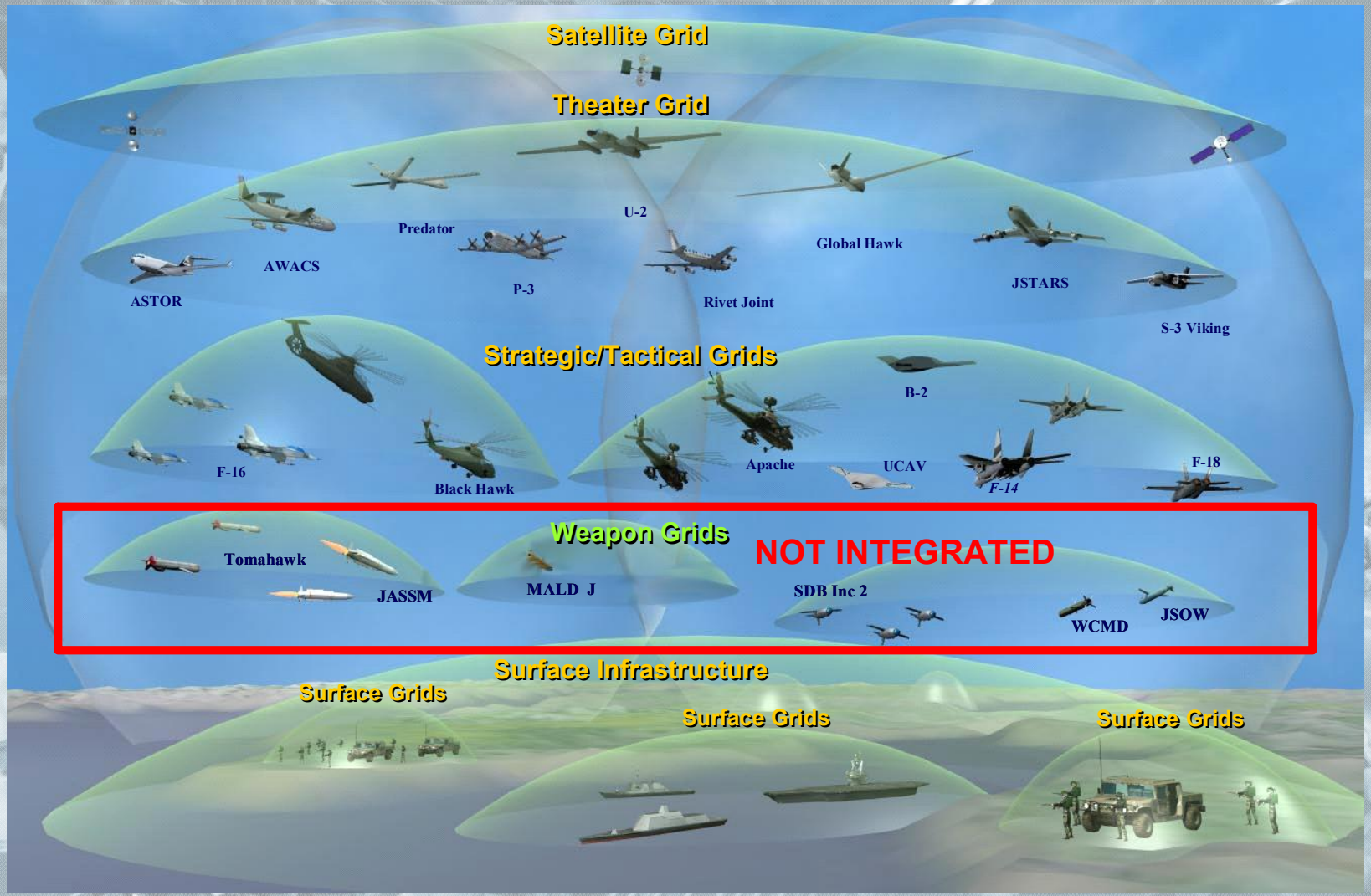
Re-usable

- DARPA FALCON Program
  - Phase I & II Common Aero-Vehicle (CAV)
  - Phase III Hypersonic Cruise Vehicle
- DARPA Re-usable Space Plane

Pervasive

- Air Force/Navy/Army/NASA/DARPA Versatile Advanced Affordable Turbine Engines (VAATE) Program begins 2005
- Army Hydrogen Scramjet Research
- DARPA/University of Queensland Collaboration
- Air Force/DARPA High Speed Turbine Engine Demonstrator (HiSTED) Program

Networked Weapons



Force Application ACTDs…
Big Enabler on the Battlefield!

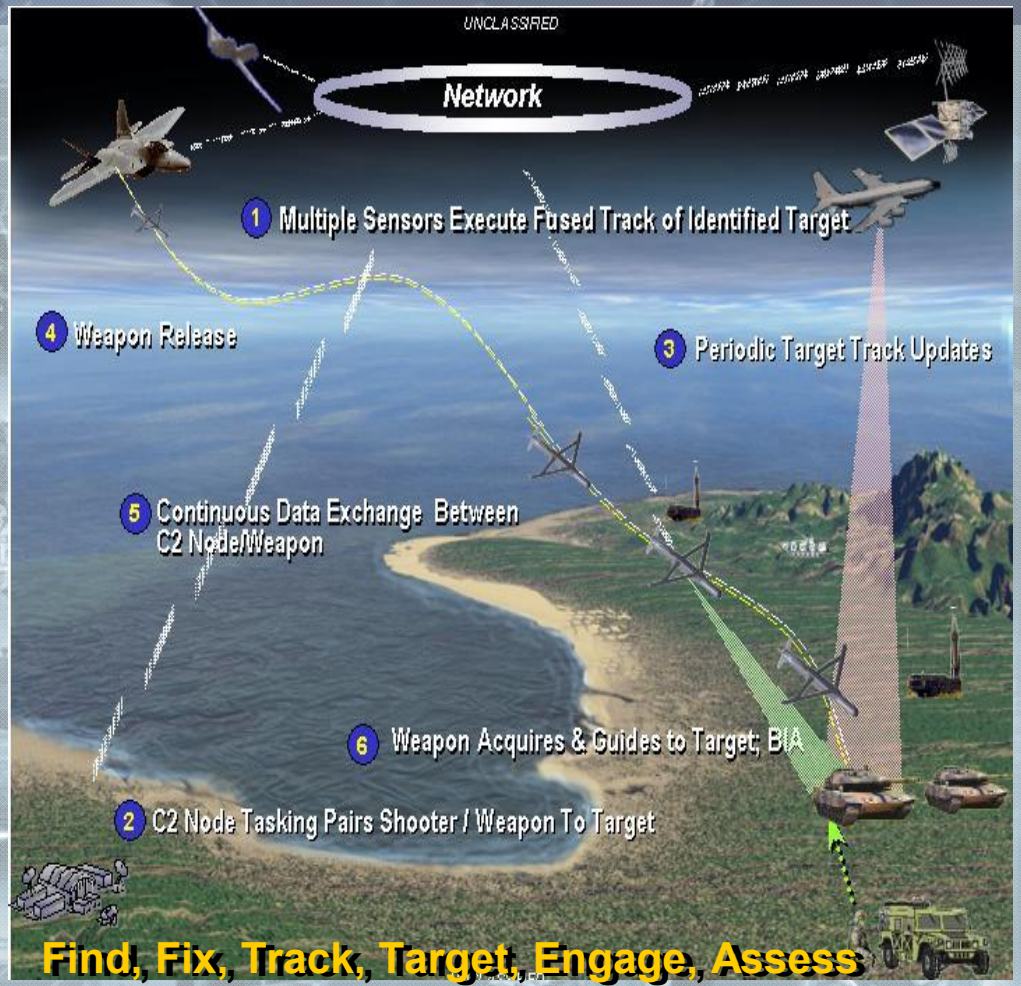
- Net Centric Collaborative Targeting (NCCT)
  - Multi-INT Targeting Short On-Time Threat Emitters
- Thermobaric Weapon (Eglin/DTRA Team)
  - *ACTD Team of the Year – 2005 !!*
- Weapon Data Link Network (WDLN)
  - Realizing the great potential of an 'integrated' weapons grid
- Tunnel Target Defeat (TTD)
  - Strategic HDBT Defeat Planning/Targeting Tools
- Active Denial System (ADS)
  - Non-Lethal Force Application capabilities
- Advanced Tactical Laser (ATL) - SOCOM
  - Directed Energy Weapons on Airborne Platforms
- AC-130 SOF Precision Engagement
  - Precision Guided Weapons to SOF teams
- GRIDLOCK
  - Rapid Geo-registration of Motion Imagery

Force Application Needs for the Future

- QDR is mandating new capabilities
- Combating WMD… in all phases
  - Effective Agent Defeat
- STRATCOM's Global Strike / ISR / IO Mission
  - Prompt Global Strike (conventional capability) – Speed!!
- Robust HDBT Defeat Capability
  - Target sets going deeper
  - FCT: Programmable Intelligent Multi-Purpose Fuse (PIMPF)
- Geospatial Intelligence (Better Accuracy! / TLEs too large!)
  - Immediate targeting of battlefield sensors (UAVs Included) for rapid employment of GPS Weaponry
- Moving Targets – Advanced SAMs / Counter Maritime

WDLN ACTD Program Description

- **FY05 ACTD Program to Integrate Data Link Capability into Weapons, Sets Stage for Weapon Integration into Network Centric Warfare**
  - **Risk Reduction for Weapon SPOs Data Link Programs**
  - **Develops Architectural Framework Supporting Current/Future Weapons Needs (2010, ~2020)**
  - **Establishes CONEMP and Common Network Interface**
  - **Identifies C2 and Aircraft Infrastructure Mods**



Pathfinder for Network-Enabled Weapons Capability

Weapon Datalink Network

Problem

-- Weapon connectivity to ISR, C2 and Strike A/C needed for improved weapon precision, moving target engagement, responsiveness to TSTs, weapon tracking, weapon BIA and abort on command

Objectives

-- Define requirements for network weapon integration

-- Demonstrate network that provides weapon status, re-targeting, target updates, BIA

Technologies

-- AFRL ATD Weapon Data Link Transceiver

-- Miniaturized network transceiver suitable for captive flight testing

-- Network weapons message set

-- Standardized messages (uses, meanings, time slots) for C2, shooters, ISR, TACPs

-- Link 16 and/or UHF networks

Participants

-- ACC, AFMC (AFRL/MN & IF, Air Armament Center & Electronic Systems Center)

-- Navy (SPAWAR & NAVAIR)

-- DARPA

Schedule:

-- FY05/06 ACTD - FY07 Transition

Residuals

-- Requirements for C2 networks, initial CONOPS, Interface Control Document (ICD) defining network weapon messages

-- Weapon JTRS compliance definition

-- Pod for weapon/network integration testing

Comments

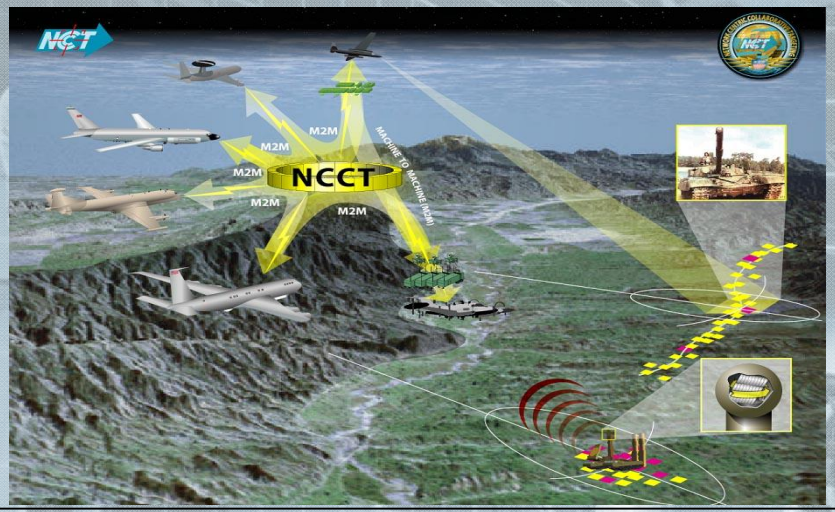
-- ICD invaluable for weapon datalink network-centric interoperability

-- Shortens F2T2EA kill chain for TSTs

-- Enhances weapon precision

Network-Centric Collaborative Targeting (NCCT)

FY 2001



Problem This Solves: Lack of PGM quality targeting information on mobile / relocatable time critical targets to support rapid engagement.

Solution: Horizontally integrate ISR platforms in a network centric environment to allow machine-to-machine collaboration on target identification and geolocation. Airborne SIGINT with MTI.

Participants: USCENTCOM, USAF, USA, USN, NRO

Schedule:

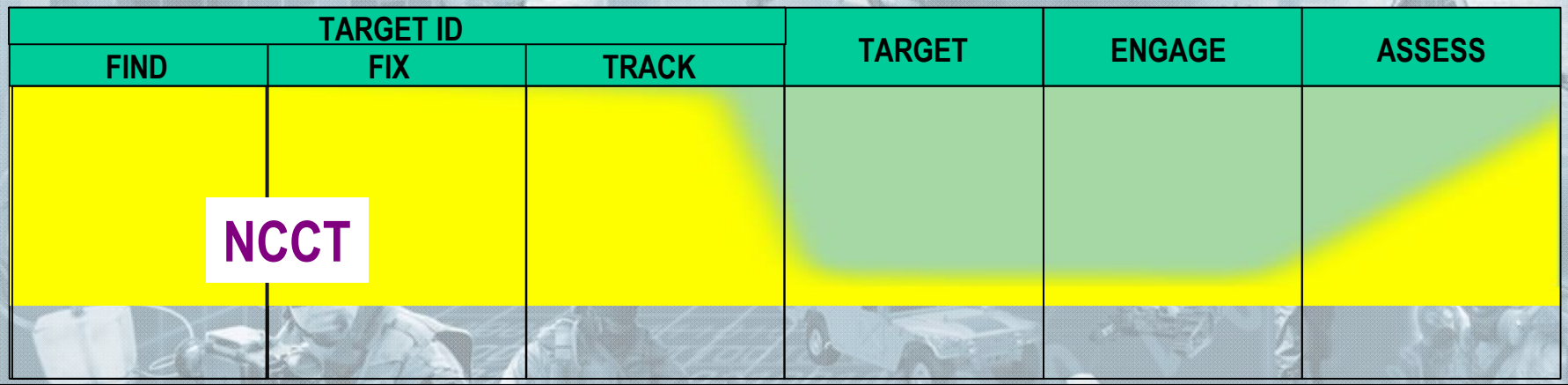
FY01-2Q04: Incremental phased development & assessment simulation & live-fly all platforms integrated on network

3Q04-05: Residuals and 'one year earlier than planned' transition

Status: All participants up on classified network integrating Systems Integration Labs (SILs). Running actual software on systems. Interim MUA completed at JEFX04 Summer 2004.
Army working GUARDRAIL participation for future inclusion into the net.

NCCT Focus

- Orchestrate currently stand-alone SIGINT, GMTI, Imagery sensors to make them operate as a collaborative team via machine-to-machine interactions
  - Automated ***cross cueing***, re-tasking of sensors, ***correlation*** of data
- Creates actionable information on fixed, stationary and moving surface targets with improved speed and accuracy
  - Single ***collaborative NCCT track*** within 1-2 minutes with 10x greater accuracy than single platform operations
- Focus on find, fix, track, and assess phases of kill chain
- Results provided rapidly to C2 decision makers



NCCT Rapidly Delivers Actionable Information on TSTs

Advanced Tactical Targeting Technology (AT3)

FY03 ACTD

Problem

- Timely air defense system destruction requires better detection ranges; emitter tracking; geo-location; targeting
- Objectives: Demonstrate an imbedded multi-platform ELINT capability

Technology

- **Digital receivers, distributed digital processing & netted sensors. Precise/stable TDOA/FDOA**
- **Residuals: Digital equipped, AT3 capable (ALR-69U RWR systems) F-16's in FY06**

Participants

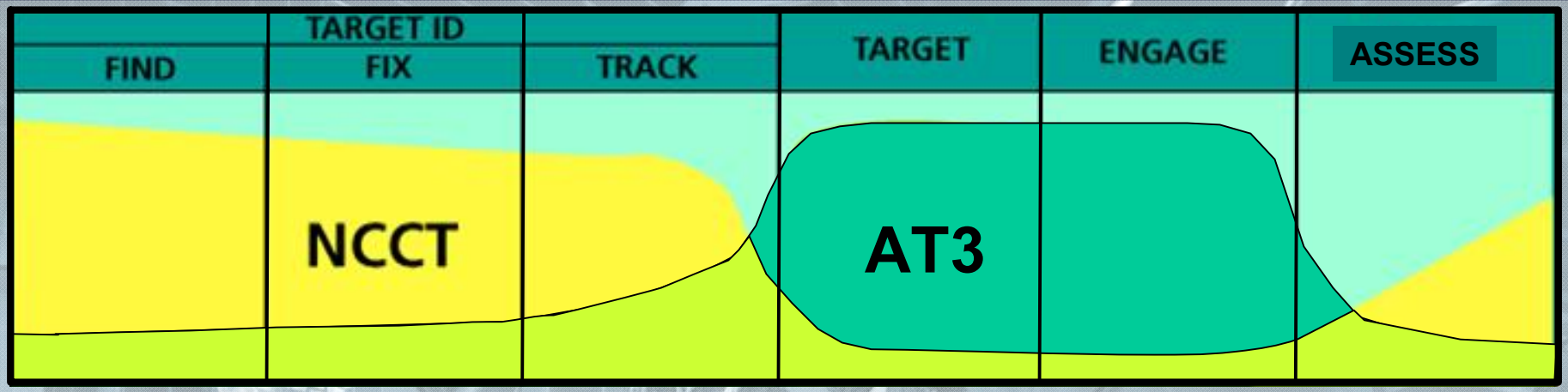
- **Lead Service: Air Force**
- **Sponsor: CENTCOM**

Schedule

- **Demo FY04-05**
- **Residual: FY06**

- **Enables GSTF/GRTF effects: neutralize, disrupt, degrade and access to denied areas**
- **Real-time precision targeting vs. time critical mobile/fixed targets without current LD/HD**

NCCT / AT3 Collaborative Effort



NCCT

- Orchestrate Stand alone SIGINT, GMTI and imagery Sensors To make them operate as a collaborative team via machine-to-machine interactions
- Creates actionable information on fixed, stationary and moving surface targets with improved speed and accuracy
- Focused on find, fix, track and asses phases of kill chain
- Result provided rapidly to decision makers

AT3

- Receive threat info from NCCT during ingress
- Generate rapid (real time) situational awareness
  - Single-ship and Multi-ship
  - Dispersed digital receivers within threat area
- Generate precision ID and Geolocation (target)
- Augment ROE requirements via NCCT
- Employ suppressive and destructive weapons (engage)
- Provide threat info to all players via NCCT

Bridging Activities (Phase 2)

Demonstrate:

- Wide area tactical network connection
- Joint/Coalition Operations in restrictive ROE
- Robust Destruction of Enemy Air Defenses

Challenges for the Future…

- **Theater TST** ***(can't get around the laws of physics!)***
  - To hit anything in a 600nm Theater in 10-15 mins… need a Mach 3.5 – 4 Weapon !
  - Need In-Flight Re-targeting / Re-Directing
- **Persistent ISR & Rapid Geo-Registration to support 'High- Speed' Weapons**
- **Alternatives for Speed Investment**
  - Seeker Investment (TLEs) / Stealth Investment (Loiter/Survive)
  - But… Doesn't get you to the Target quicker!!