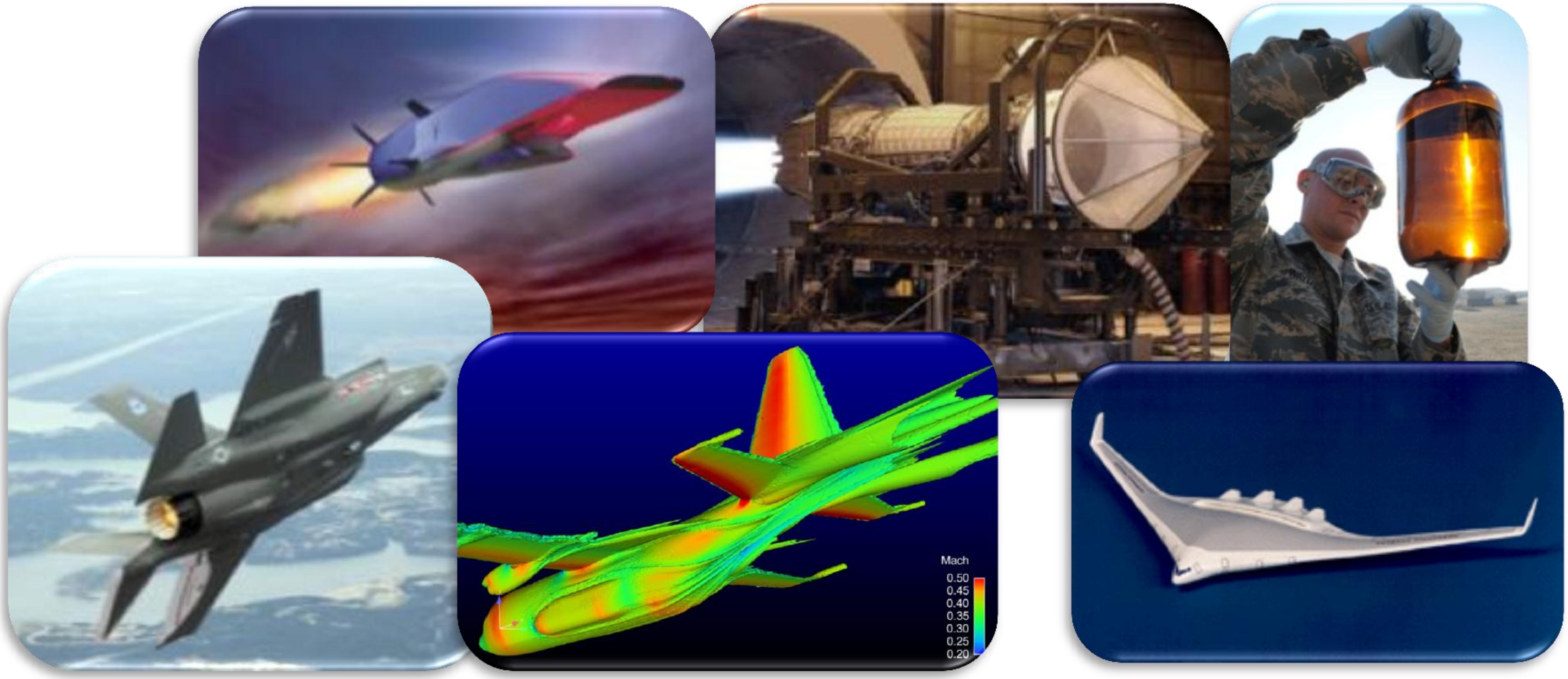
Next Generation Aerospace Systems

Integrity ★ Service ★ Excellence

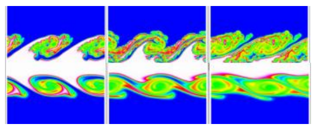
Next Generation Aerospace Systems

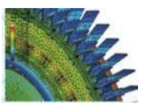
<u>MISSION/VISION</u>: Leading discovery and development of world class integrated Aerospace Systems S&T for national security



Next Gen Aerospace Systems Core Technical Competencies (CTCs)

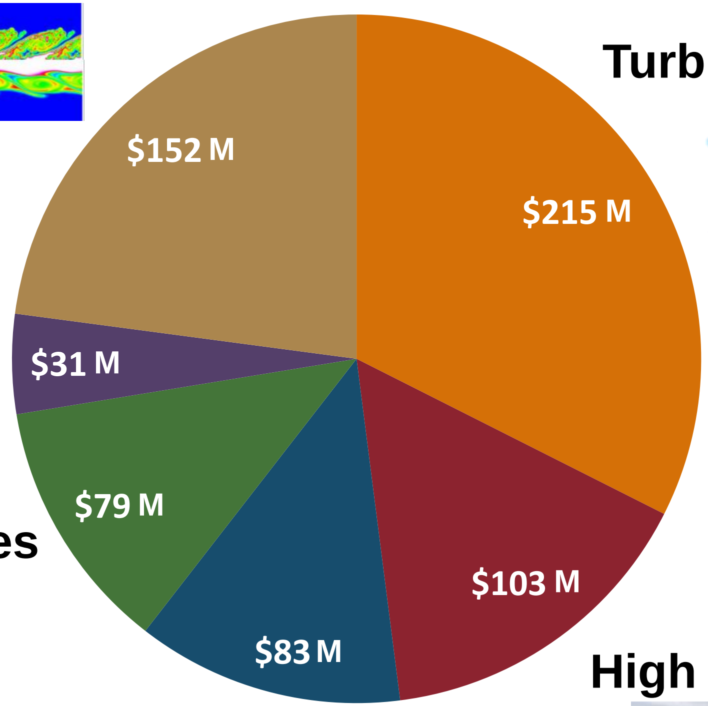
Basic Research



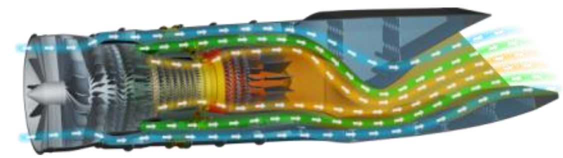


Structural Materials & Applications

Aerospace Vehicles

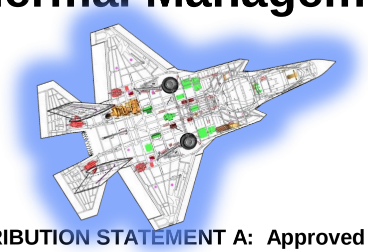


Turbine Engines



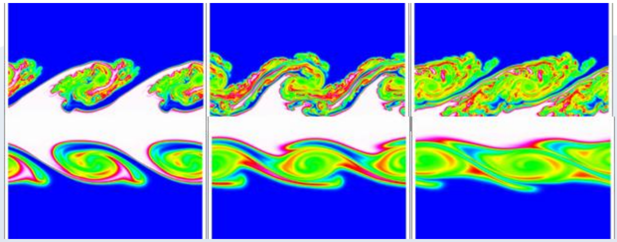
High Speed Systems

Control, Power, & Thermal Management



Basic Research for Next Gen Aerospace Systems

$152M / year



Dr. Graham Candler at Univ. of Minnesota and others use computational fluid dynamics to study high-temperature reacting flows and hypersonic flows.

Motivation

- Understand foundation of energy transfer in multi-physics flow phenomena
- Understand complex physical phenomena crucial to the design and control of future AF systems
- Advance fundamental understanding of complex, time-dependent flow interactions
- Develop new and revolutionary flight structures

Mission/Vision Statement

Mission: We discover, shape, and champion basic science that profoundly impacts the future Air Force.

Vision: The U.S. Air Force dominates air, space, and cyber through revolutionary basic research.

Technical Approach/Ideas

Fundamental science to support AF needs in multiple applications:

- Explore canonical problems that capture the behavior of representative mechanisms and build a cohesive understanding of the energy transfer processes
- Analyze and predict physical phenomena of aerospace systems via computational mathematics
- Integrate theoretical, analytical, numerical, and experimental approaches to understand fundamental flow physics
- Generate understanding required to design and manufacture new aerospace materials and structures

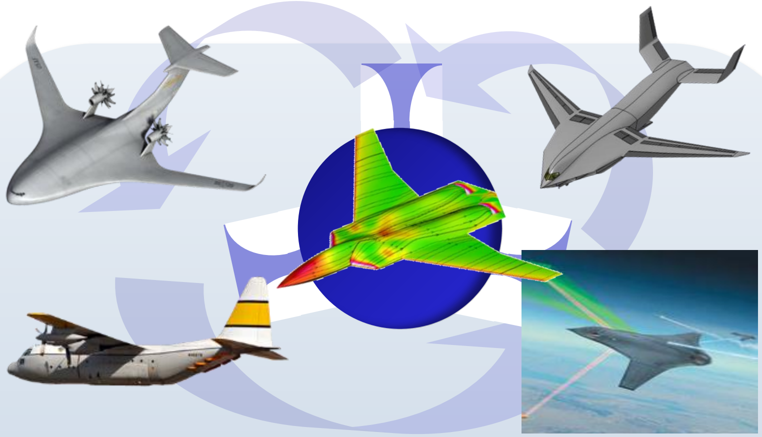
Goals/Objectives

Goals: Develop the fundamental scientific knowledge required for revolutionary advancements in a broad variety of future AF capabilities for energetically-efficient air and space systems.

Objectives: Enable rapid global and regional response, create new materials and structures, and develop a framework for control of uncertain, information-rich, dynamic environments.

Aerospace Vehicles CTC

$79M / year



Motivation

- A2AD– Operate from minimal basing locations and at extended ranges by enabling efficient, lightweight, and sustainable vehicle technologies for FAD and mobility A/C
- Air Force Energy Plan– Reduce fuel demand by increasing the energy efficiency of legacy fleet and future aircraft
- Airframe Lifecycle Management- Optimized lifecycle management for capability, availability, and cost
- Nat'l Aerospace R&D Plan – Certify composites, demonstrate multifunctional structures, and reduce A/C drag

Mission Statement

- Discover, develop, demonstrate, and deliver aerospace vehicle-focused technologies to assure warfighter air dominance.

Goals/Objectives

- 4-10% efficiency improvements on legacy fleet A/C
- Deliver mature sustainment technologies to the fleet
- Deliver tools and technologies for affordable sustainment and A/C life extension
- 2X improvement in range for next generation mobility aircraft over C-17 baseline
- Enable extended range and capability for FAD.

Technical Approach/Ideas

- Global Mobility . . . right effects, right place, right time
  - ➢ Efficient propulsion integration
  - ➢ Drag reduction (high span wings, laminar flow)
  - ➢ Lightweight composite structures
- Future Air Dominance . . . trade space and tech mat
  - ➢ Conceptual designs and technology trades to support AFLCMC and ACC in AoA activities
  - ➢ Develop multi-disciplinary design methods
- Sustainment . . . near to far
  - ➢ Re-engineering structure
  - ➢ Structural Health Monitoring
  - ➢ Fleet Health Management
  - ➢ Affordable A/C Life Extensions

Aerospace Vehicles CTC

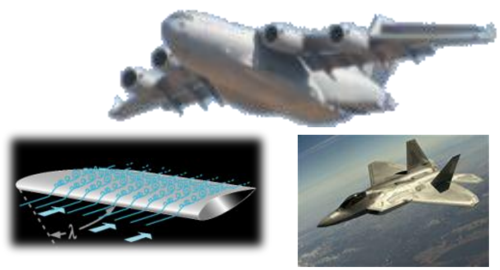
Near-Term	Mid-Term	Far-Term
FY14-19	FY20-25	FY26-30

Legacy Energy Efficiency Upgrades, Adv. Design Methods, and Sustainment Retrofits

- C-130 Drag Reduction
- C-17 Formation Flight
- B-2 Windshields
- Re-engineering obsolete structures (C-5,C-130,F-15)
- FAD Design Methods

- >10M Gal/yr Fuel Savings
- >$Ms Logistic Savings

Major Legacy Upgrades



- C-17Re-engine/Re-wing Feasibility
- Laminar Flow Designs
- High Bypass Efficient Propulsion Integration
- Composite Structure Life Assmt
- Structural Health Monitoring
- Per A/C Sustainment Tracking
- Physics-based Design methods
- Structurally Integrated Antenna Demonstration

- >100M Gal/yr Fuel Savings
- Service Life Extension Program
- >$10M Logistic Savings

Revolutionary Configurations

- New Mobility Aircraft Designs - 60% fuel burn reduction
- Optimized Future Air Dominance
- Certified Primary Composite Structures
- Per A/C Sustainment and Life Extensions

- Rapid Global Mobility
- Future Air Dominance

High Speed Systems CTC

$103M / year

Motivation

- Current capabilities are missile-scale, hydrocarbon-fueled scramjets, expendable structures, and load-superposition-based structural life prediction tools
- Current limitations are physical scale; expendable structures; and operability range (delta Mach)
- New capabilities will enable reusable, high Mach air-platforms at appropriate scale for strike and ISR

Mission/Vision Statement

- CTC MISSION: Develop technology options for high speed strike and penetrating regional ISR platforms
- VISION: Hypersonic platform technologies to produce revolutionary warfighting capabilities

Goals/Objectives

- Develop hydrocarbon-fueled scramjet, Mach 4-7 flight
- Develop reusable hydrocarbon-fueled scramjet and combined cycle engines
- Develop aerodynamic, aero-heating, and propulsion/weapon integration technologies for sustained high speed cruise
- Develop and exploit new structural concepts and physics-based methods to enable optimized high speed aircraft

Technical Approach/Ideas

- Develop endothermic fuel cooled hardware that maintains positive thermal balance throughout mission
- Develop advanced materials/structures that operate at high temperatures and support reusable high Mach aircraft
- Develop life prediction tools for aircraft/engine structures operating in harsh environment based on accurately modeling load interactions
- Develop ground test and analysis-based methods to evaluate and mature large hypersonic engines and aircraft structures

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High Speed Systems CTC

Near-Term
FY14-19

Small-Scale Scramjet Engines and Hypersonic Flight Research

- 1st Gen Hypersonic Cruise Missile Propulsion using conventional jet fuels
- X-51A flights in 2010-2013
- Flight Tested Hypersonic Research Vehicles Atop Sounding Rockets (HIFiRE)

Global Precision Attack

Mid-Term
FY20-25

Medium-Scale Hypersonic Propulsion and High Speed Strike Weapon (HSSW)

- Extended life, performance, operability of scramjets
- High Speed Strike Weapon (HSSW) integrated weapon demo in 2017

Global Precision Attack
Global Integrated ISR

Far-Term
FY26-30

Large-Scale Combined Cycle Propulsion Systems

- Highly reusable, very wide operating range scramjets
- Integration of scramjets with turbines and/or rockets
- High temperature structures for reusable Mach 5-7 ISR/Strike aircraft

Global Precision Attack
Global Integrated ISR

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Turbine Engines CTC

$215M / year

To develop, demonstrate, and transition **ADVANCED** multi-use, Turbine Engine technologies that provide a revolutionary improvement in **AFFORDABLE CAPABILITY** to a broad range of legacy, emerging, and future military propulsion and power needs, with explicit **VERSATILITY** for dual-use application.

Motivation

- A2AD and Pivot to Pacific – ADVENT, AETD, HEETE, STELR programs to provide highly-efficient turbine engines for long-range requirements
- Air Force Energy Horizons – Highly efficient engines & alternative fuels improve US energy position
- Nat'l Aerospace R&D Plan – Develop knowledge base to link emissions (and mitigation) to fuel composition
- Primary TFA: NGenAS; Leveraged: Afd&Sus, ISR, Wpns

Mission/Vision Statement

- Focused on 10x improvement in affordable capability
- Improving fuel efficiency and thrust/weight ratio
- Reducing development, production, and maintenance costs

Goals/Objectives

Propulsion System Class	(CCI) GOAL * VAATE I 2009	VAATE II 2013	VAATE III 2017
Turbofan/Turbojet - Large	4X	6X	10X
- Small**	3X	5X	8X
Turboshaft/prop	3X	4X	5X
Expendable	4X	6X	10X

* CCI = Capability Cost Index
Baseline FY2000 State-of-the-art

Technical Approach/Ideas

- Adaptive Versatile Engine Tech (ADVENT) & Adaptive Engine Tech Development (AETD)
  Objective: : Fully mature fuel efficient (+25%) adaptive component technologies for low-risk accelerated engine development for future combat aircraft
- Highly Energy Efficient Turbine Engine
  Objective: Improve fuel efficiency (+35%) through demo of ultra high bypass ratio; integrated inlets, exhaust, & thermal management; and high temperature, high strength materials
- Advanced Energy & Sustainment Technologies for Propulsion (AESTP); Emerging & Fielded Systems
  Objective: Safely reduce Propulsion O&S cost through S&T
- Aerospace Fuels
  Objective: Understand effects of fuels composition & spec tolerance to advanced engines performance & emissions.

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Turbine Engines CTC

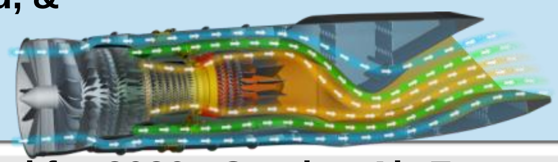
Near-Term (FY14-19)	Mid-Term (FY20-25)	Far-Term (FY26-30)

Adaptive Versatile Turbine Engine (ADVENT)

- Engine demos in 2013
- 25% SFC improvement
- Increased range, speed, & persistence

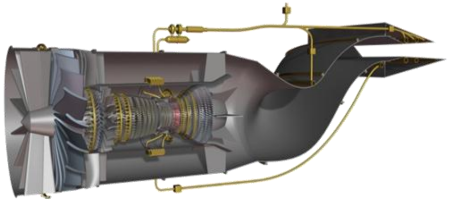
Adaptive Engine Tech Development (AETD)

- Could Save 1.4B Gallons of Fuel by 2040



Targeted for 2020+ Combat Air Force Future Air Superiority & Strike Aircraft

Highly Energy Efficient Turbine Engine (HEETE)



- 35% SFC improvement for existing and future mobility, tanker and ISR platforms
- High overall pressure ratio

Supports Rapid Global Mobility

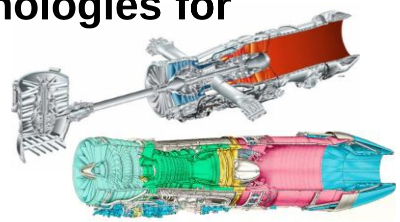
Supersonic Turbine Engine for Long Range (STELR)

- Mach 3+ operations
- 1 Hour at max Mach

Supports LRSO/ALCM, RPAs, & Adv Cruise Missiles

Advanced Energy & Sustainment Technologies for Propulsion (AESTP)

- Emerging and Fielded Systems



Addresses Rising O&S Costs

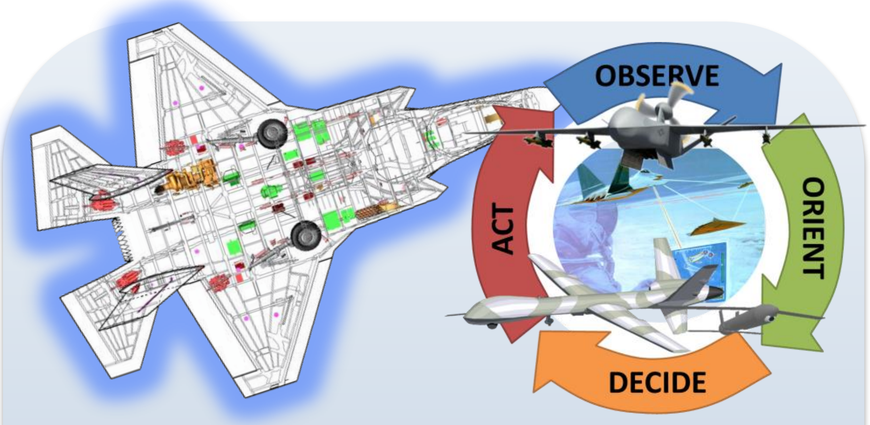
Aerospace Fuels (AF)

- Understand effects of fuels composition & spec tolerance to advanced engines performance & emissions.

Supports AF Energy Horizons

Control, Power, and Thermal Management CTC

$83M / year



Motivation

Current capabilities limited by:

- Ability to seamlessly integrate unmanned aircraft into training and operational environments
- Automation brittleness in uncertain, complex and contested environments
- Ability to model, design and assess integrated power and thermal system performance

Mission/Vision Statement

Lead the nation's S&T in integrated aircraft systems (controls, power, thermal management) for autonomous flight control and energy optimized aircraft

Technical Approach/Ideas

- Seamless integration of unmanned aircraft into airbase and airspace operations
- Cooperation and teaming of unmanned and manned aircraft
- Enhanced awareness of and real-time response to state of system, mission and environment
- Model-based design of integrated propulsion, power and thermal systems
- Verification and validation technologies to allow cost effective certification of new capabilities

Goals/Objectives

Realize new mission and operational capabilities by:

- Enabling robust, safe, high-functioning automation for manned systems and autonomous UAS
- Removing power and thermal limitations for existing and new special mission systems

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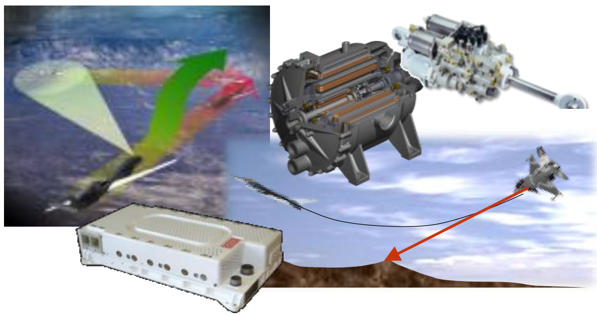
Control, Power, and Thermal Management CTC

Near-Term (FY14-19)	Mid-Term (FY20-25)	Far-Term (FY26-30)

Near-Term (FY14-19)

Safety, Robustness for Current Operations



- Ground Collision Avoidance for Manned Fighters
- Sense & Avoid (SAA) for UAS Airspace Integration
- Electrical, Power and Thermal component technologies - Generators, Accumulators, Solid State Elect Distribution

SAA – Global Hawk, GIISR
Auto-GCAS transitions
INVENT – F-35, Air Sup.

Mid-Term (FY20-25)

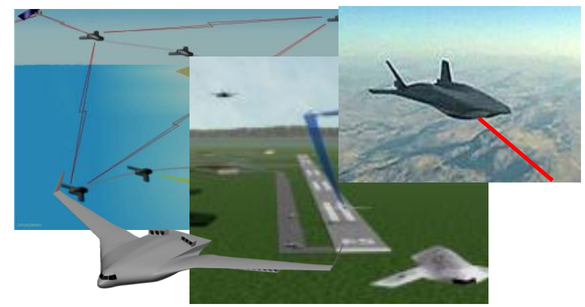
Operations in Complex, Contested Environments

- UAS Airspace Integration – Autonomous Terminal Area Op's
- Tactical Off-Board Sensing - teaming behaviors (TOBS)
- INVENT – Integrated power and thermal management
- Verification & Validation of Adaptive & Autonomous Systems

UAS Airspace Integration - GIISR
TOBS – AFSOC
INVENT – NGAD, AS

Far-Term (FY26-30)

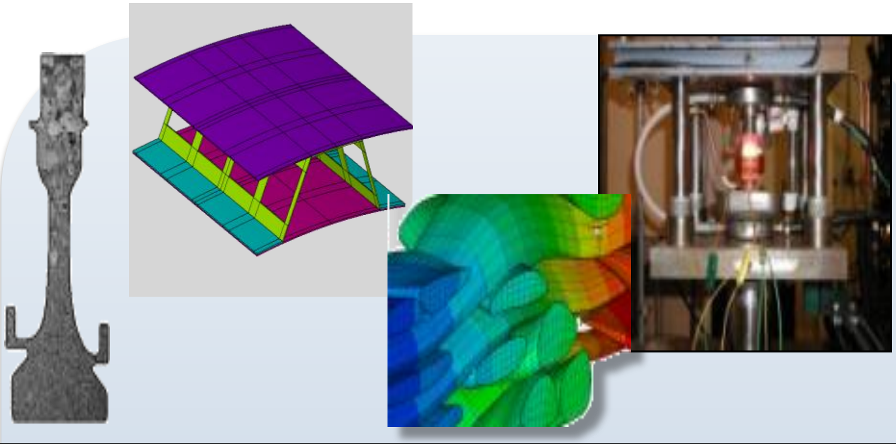
New Operational Capabilities



- Integrated UAS Operations – Manned-Unmanned teaming
- Robust autonomous system response to mission, environment, power, thermal needs
- Integration and certification through design

Structural Materials & Applications CTC

$31M / year



Mission/Vision Statement

- Delivering paradigm changing materials, processes, and NDE prototypes to enable new structural design concepts and their life-cycle management

Goals/Objectives

- Develop materials that can operate at much higher temperatures with comparable or better durability, weight, and affordability
  - Includes subsonic, supersonic, and hypersonic structures and propulsion systems
- Develop sensing capabilities for NDE and real time condition based maintenance

Motivation

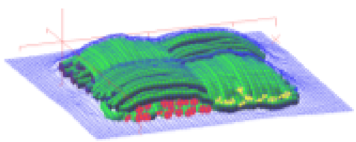
- Next Generation Aerospace Systems are fundamentally limited by the capabilities and affordability of current materials and materials processing, design, validation, & certification

Technical Approach/Ideas

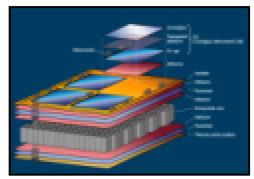
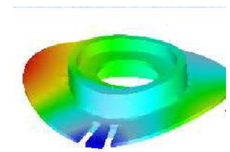
- Shift from standardized to designed materials tailored for the applications
- Lighter weight materials that do much more than carry load
- Higher temp materials enabling faster, cheaper, more durable systems
  - Enhanced performance and increased fuel efficiency
- Material and damage state assessment & prediction of component life
- Materials & processing as integrated variables in component design
- More capable, reliable, efficient inspections to reduce maintenance burden

Structural Materials & Applications CTC

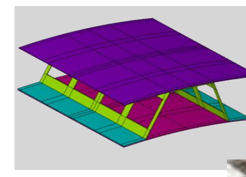
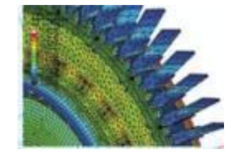
Near-Term	Mid-Term	Far-Term
FY14-19	FY20-25	FY26-30


- Hybrid Superalloy turbine engine compressor disk
- Ceramic Matrix Composite (CMC) components for engines and hot structures
- Modeling codes for integrating high temperature resin & fibers for organic matrix composites

- Integrated Ceramic Matrix Composite (CMC) components for engines and hot structures
- Multifunctional structural concepts for EM and HPM protection
- Integration of computational methodologies into standard industry design practices


- Affordable & robust thermal protection systems
- Validated computational models for microstructure component performance
- On-site inspection of airframe & engine components

SUMMARY
Next Generation Aerospace Systems

- **CTCs poised to provide technologies for future weapon systems**
  - **Basic Research**
  - **Turbine Engines**
  - **Aerospace Vehicles**
  - **High Speed Systems**
  - **Control, Power, and Thermal Management**
  - **Structural Materials & Applications**

- **For more information contact:**

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