Affordability & Sustainment

Integrity ★ Service ★ Excellence

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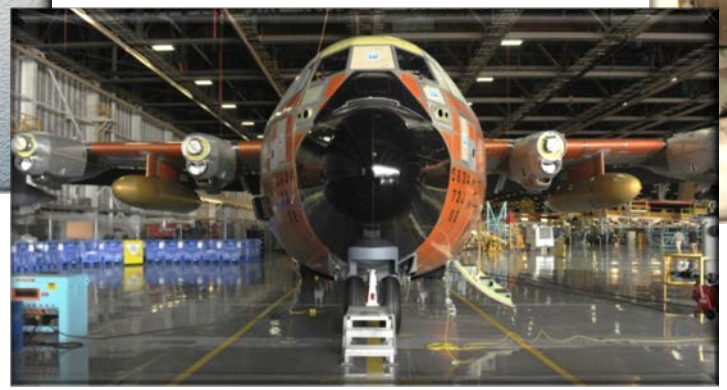
Affordability & Sustainment

- **Research and technology transition efforts to reduce the time and cost of fielding and maintaining the fleet**
  - **Manufacturing technologies**
  - **Diagnostic and maintenance tools for Operational, Intermediate and Depot level maintenance**
  - **Technical support to resolve current system issues**



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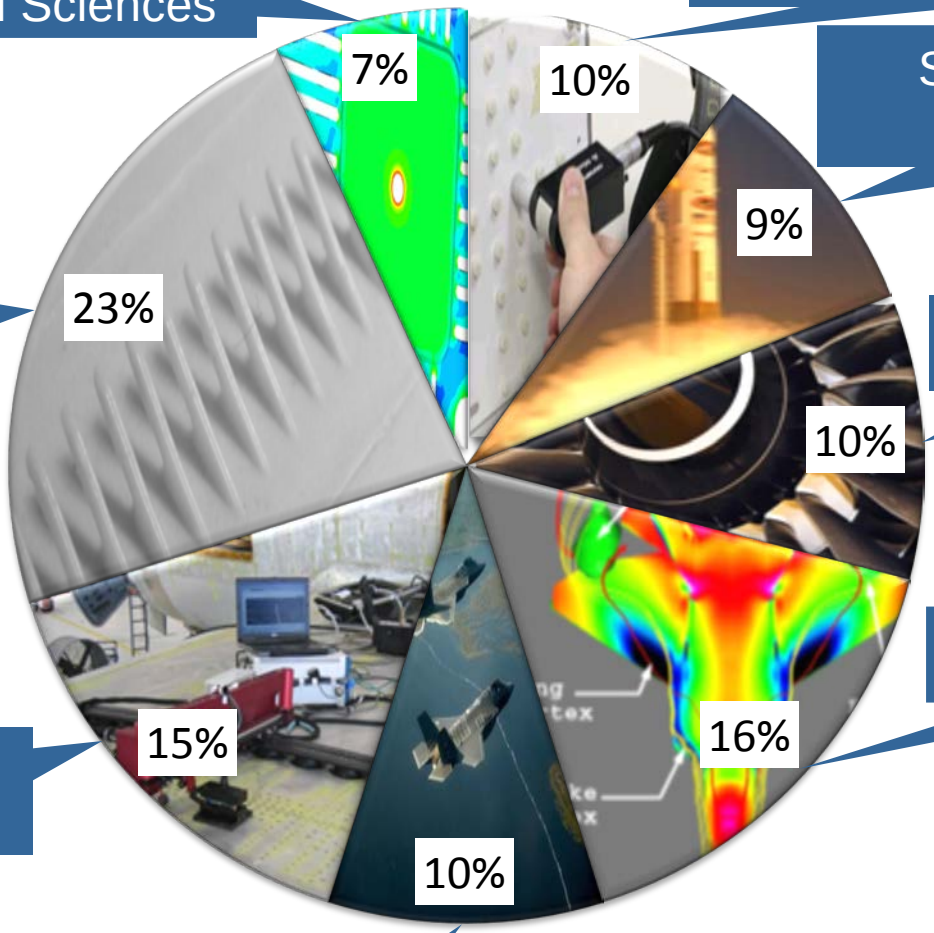
Affordability and Sustainment Core Technical Competencies (CTCs)



Basic Research -- Aerospace, Chemical & Material Sciences

Support for Operations

Space and Missile Propulsion

Turbine Engines

Aerospace Vehicles

Functional Materials & Applications

Structural Materials & Applications

Manufacturing Technology

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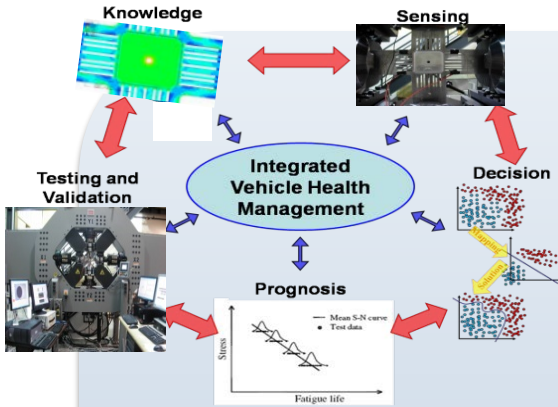
Affordability and Sustainment Basic Research

$10M / year



Researchers at UC San Diego are developing a framework for "optimal" model selection, performance assessment, updating, and uncertainty assessment in aerospace structural modeling.

Motivation

- Increased understanding/Reduced uncertainty of processing and damage progression
- Prediction of flight structures "hot spots" prone to early in-service failure and/or degradation
- To develop material-level modeling and predictive simulation of damage progression
- To advance structural-level modeling and predictive simulation of long-term load-bearing capability

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.

Goals/Objectives

Goals: Advancement Capability to predict by unique identifiers when a device or component, or system is reaching a state where it must be repaired, upgraded, or graciously replaced.

Objectives: To enable a robust predictive-analysis tool that will offer on–demand continuous assessment capability of upcoming structural state under evolving operational requirements and threat environment

Technical Approach/Ideas

Fundamental science to support AF needs in multiple applications:

- Integration of structural health monitoring, Immersive Environments, and Physics-based Modeling
- Ability to sense, predict, forecast & respond to failures before they occur
- Develop non-linear reduced order response prediction methods under operational loads and extreme environmental conditions
- Virtual modeling capability to make required maintenance actions & repair decisions before fleet arrives

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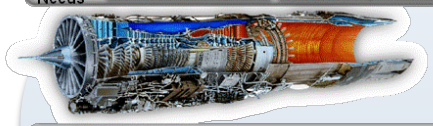
Structural Materials & Applications CTC

$30M / year

Legacy System Needs	50% Extension of Life	Low-Cost, Longer Life Spares	100% Expected Readiness	Reduce Mishap Rate 1/2
System Req's	Quantified System Risk	Rapid Certification of Alternative Materials	System/Component State Awareness	Alternate Low-Cost Manufacturing Processes
Structural Materials Activities	Probabilistic Behavior Representation	High Fidelity Damage Evolution and Growth Prediction	Advanced Validation Science	High Fidelity Defect and Precurser Detection	Long Range M&P Development



Mission/Vision Statement

- We want to make paradigm changing structural materials, associated processes, and Non-Destructive Inspection/Evaluation (NDE/NDI) technologies a reality.

Goals/Objectives

- Materials that can operate at much higher temperatures with comparable or better durability, weight, and affordability.
- Robust sensing capabilities for NDE/NDI and real time condition based monitoring and maintenance technologies
- Capability to transition new and existing materials to new applications much faster.
- Increased fidelity of system design and life-cycle performance predictions

Motivation

- The cost of aging legacy systems will continue to increase
- Current inspection techniques are costly and time consuming impacting aircraft availability
- Current design tools and methodologies do not take advantage of available materials and manufacturing and sustainment enterprise

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
- Material and damage state assessment & prediction of component life
- More capable, reliable, efficient inspections to reduce maintenance burden

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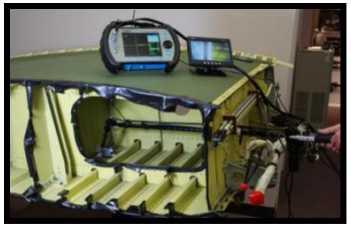
Structural Materials & Applications CTC

Near-Term
FY14-19

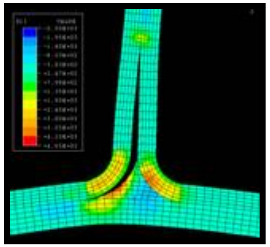


- Reduced sustainment burden
- Improved NDI tools
- Affordable materials

Mid-Term
FY20-25

- CBM+ Structural Integrity
- Improved engine durability
- Materials state NDI
- Probabilistic life prediction tools
- Sustainability models enabling sound design trades
- Standardized sustainment tools

Far-Term
FY26-30



- Seamless digital interfaces throughout design-manufacturing enterprise
- Advanced state awareness
- Advanced, more sustainable structures and propulsion
- Risk-based engine life management

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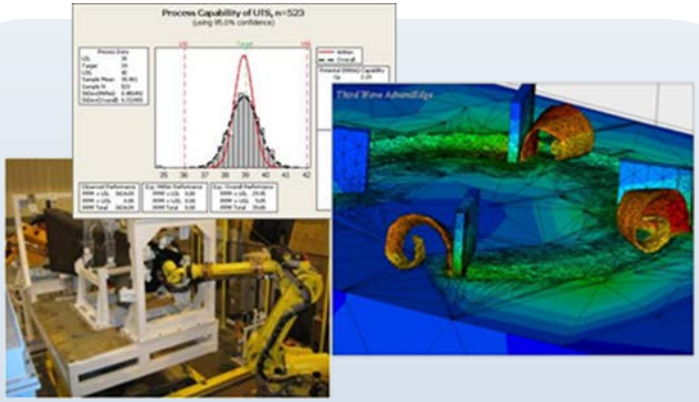
Manufacturing Technology CTC

$31M/year



Mission/Vision Statement

- Affordable Warfighting Capability via Next Generation Agile Manufacturing

Goals/Objectives

- Reduced costs for acquisition & sustainment
- Reduced time for technology transition, manufacturing, and maintenance
- Reduced risk when introducing new or improved system capabilities
- Increased availability of technologies, materials, or components through shaping of the industrial base

Motivation

- Acquisition and LCC affordability and risk is limited by our ability to consider manufacturability as early as technology maturation in S&T through detailed design
- A recent March 2012 GAO study of 96 Major acquisition programs found costs increased 54% ($113B total RDT&E cost growth) and schedule slipped an average of 32%
- Additionally, the Air Force is dependent on a small and ever decreasing industrial base which operates on dramatically longer cycle time, producing low volume, more advanced and higher risk technology as compared to commercial industry

Technical Approach/Ideas

- Moving Manufacturing Left - Earlier & higher fidelity consideration of manufacturing & LCC issues in design
- Cradle To Cradle Digital Thread - Digital environments and tools that increase efficiencies across the life-cycle
- Responsive, Integrated Supply Base - Network connectivity, insight, and tools for optimum supply chain performance and risk management
- Factory of the Future - Flexible, rate-independent assembly and fabrication technologies

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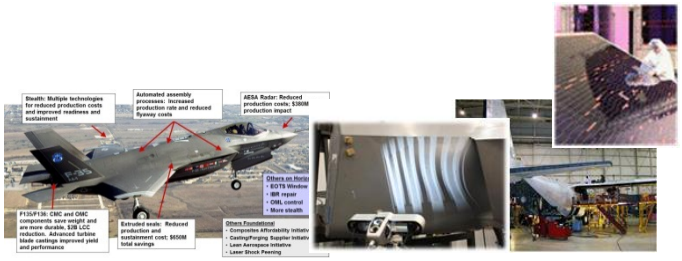
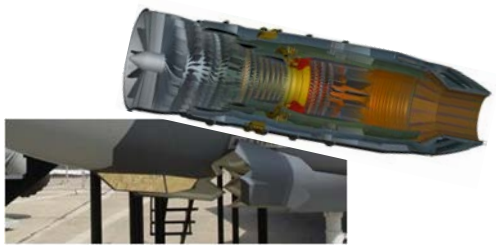
Manufacturing Technology CTC

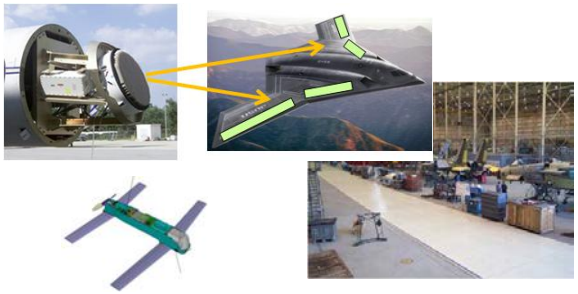
Near-Term	Mid-Term	Far-Term
FY14-19	FY20-25	FY26-30



- Multi-application manufacturing technology driving down costs/risks of high priority systems
- Drive down costs for JSF & depot support of legacy systems
- Establish producibility of large mid-wave IR sensor windows
- Reduce cost of ≥ 33% efficient solar cells



- Transition adv materials for next-gen turbine engines
- Reduce overall cost of V & W band datalink by 4x
- Establish producibility of conformal mid-wave IR sensor windows
- Reduce cost of ≥ 35% efficient flexible solar cells



- Affordable next gen conformal AESA sensors
- Resolve power, comm, guidance mfg challenges for mini-munitions
- Continue efforts to drive down legacy system sustainment costs

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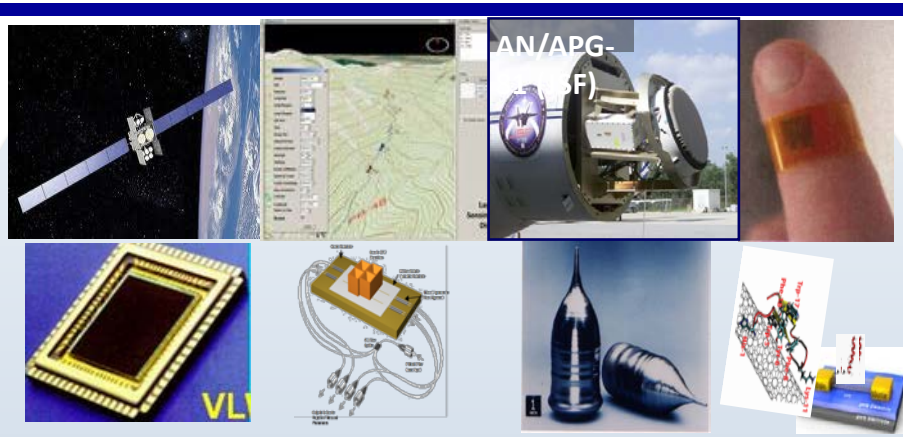
Functional Materials & Applications CTC

$27M/year



Mission/Vision Statement

- Develop and rapidly transition nano, bio, electronic, and optical materials and associated processes to critical Air Force Applications

Goals/Objectives

- Enable Freedom of Operations in Contested Environments
- Enable Continuous/Novel ISR presence
- Facilitate Improved Human System Performance

Motivation

- Future air dominance and situational awareness is threatened by the emergence of advanced foreign laser, high power RF & electronic technologies
- Substantial performance improvements in advanced protection, sensor, electronic, human performance monitoring and power systems are driven by high value material technologies that are increasingly being developed globally

Technical Approach/Ideas

- Solutions to ensure access to denied environments
- Improved material systems for continuous, robust, and non-conventional ISR applications
  - EO/IR, RF, and human system
- Facilitate improved human system and warfighter/ machine interface
- Energy dense, compact / lightweight, autonomous power/energy AF-unique system applications
- Materials and components for near-zero collateral damage tactical strike and airborne self-defense
- Functional materials & processing motifs as integrated variables in component design

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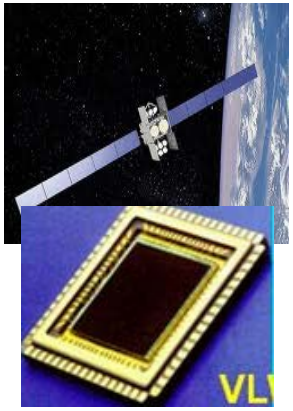
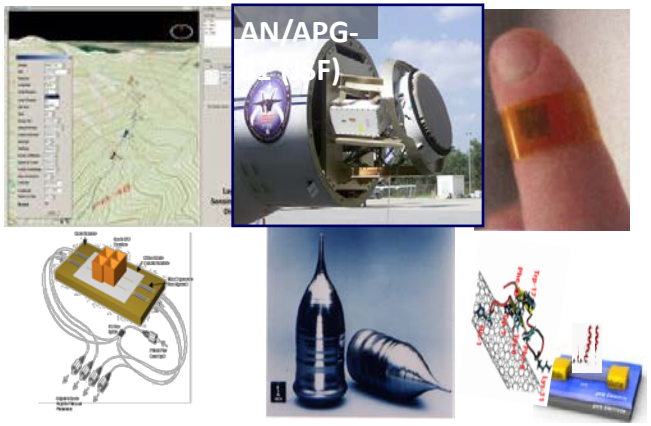
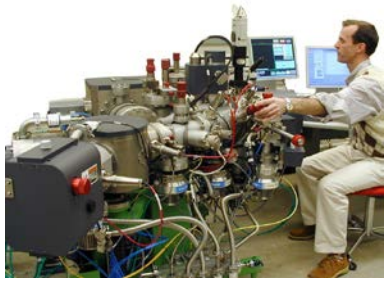
Functional Materials & Applications CTC

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







- High-Threat Eye & Sensor Protection
- Full Polarization Sensitivity for ISR
- Reduced mass MWIR/VLWIR Satellite Arrays
- Low-Impact IR Tagging
- Biomolecular-Nano Design and Fabrication for Functionality

- Tunable, Full Spectrum Protection
- Conformal, High Power, Wideband RF
- Ubiquitous Performance Monitor
- Non-invasive, Wireless, Human Performance Monitor

- Processing-Performance Design
- Responsive Material Design & Integration

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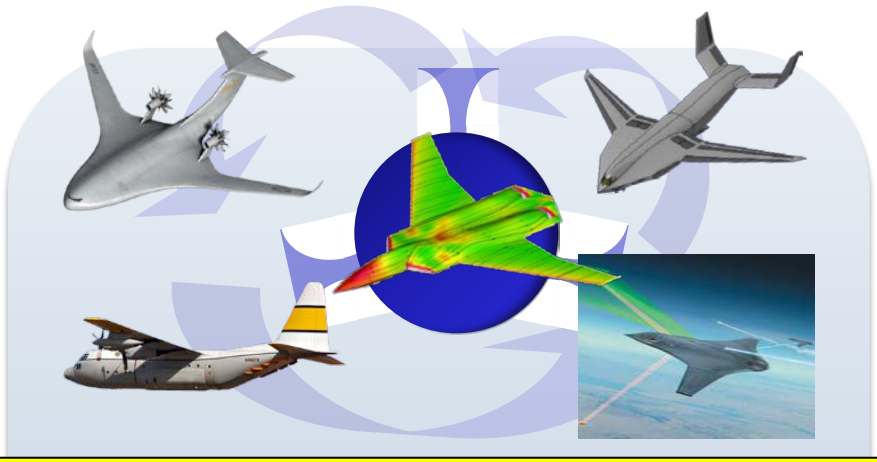
Aerospace Vehicles CTC

$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

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Aerospace Vehicles CTC

Near-Term
FY14-19

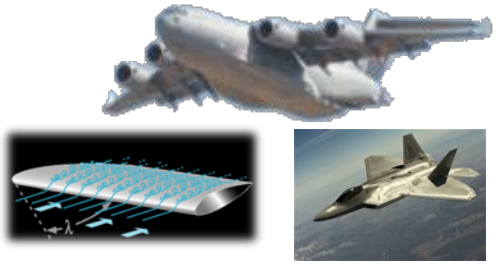
Legacy Energy Efficiency Upgrades, Adv. Design Methods, and Sustainment Retrofits

- 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

Mid-Term
FY20-25

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

Far-Term
FY26-30

Revolutionary Configurations

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

- Rapid Global Mobility
- Future Air Dominance

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Turbine Engines CTC

$215M / year

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)

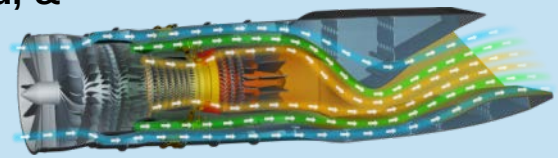
Adaptive Versatile Turbine Engine (ADVENT)

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

Mid-Term (FY20-25)

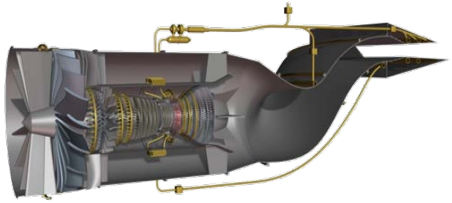
Adaptive Engine Tech Development (AETD)

- Could Save 1.4B Gallons of Fuel by 2040



Far-Term (FY26-30)

Highly Energy Efficient Turbine Engine (HEETE)



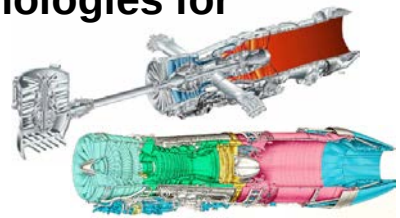
- 35% SFC improvement for existing and future mobility, tanker and ISR platforms
- High overall pressure ratio

Supersonic Turbine Engine for Long Range (STELR)

- Mach 3+ operations
- 1 Hour at max Mach

Advanced Energy & Sustainment Technologies for Propulsion (AESTP)

- Emerging and Fielded Systems



Aerospace Fuels (AF)

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

Addressing Rising O&S Costs

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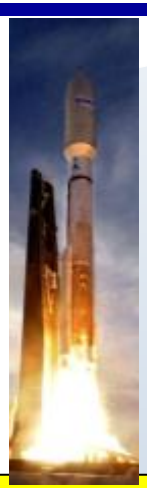
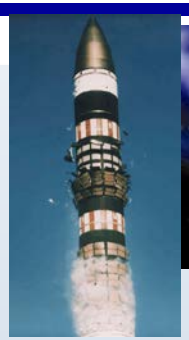
Space & Missile Propulsion CTC

$66M / year





Motivation

- Current capability:
  - Life limited strategic systems, empirical/statistical life assessment
  - 1960s space access propulsion
  - Fixed mission spacecraft propulsion
- ICBM global reach, >20% LCC savings
- High perf, lower cost space access
- Highly flexible spacecraft propulsion

Mission/Vision Statement

- Develop and demonstrate advanced rocket propulsion technologies addressing DoD mission requirements for space access, strategic and spacecraft systems

Goals/Objectives

- Be the technology provider for the rocket propulsion community and users
- Increase performance while reducing cost of all forms of rocket propulsion systems
- Expand the tech base in Industry, sustaining the US capability to develop rocket propulsion systems

Technical Approach/Ideas

- Ox-rich Staged Combustion for space access
- Innovative cycles for future space access
- “Real-time” health monitoring for solid rocket motors – cradle to grave
- Sustainable strategic systems capable of global range
- Multi-mode spacecraft propulsion
- Non-toxic mono & bi-propellants

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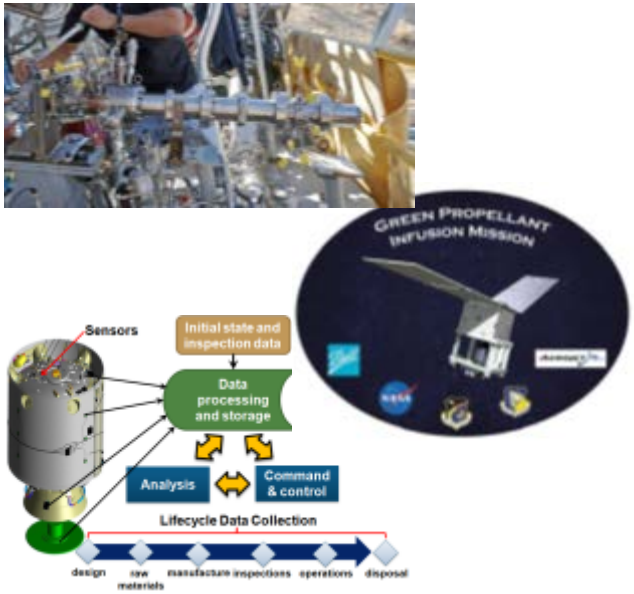
Space & Missile Propulsion CTC

Near FY13-FY18

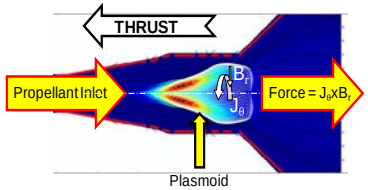


- AF-M315E non-toxic mono propellant
- Aging & Surveillance for ICBMs

Mid FY19-FY24

- Adv. Mono/bi-propellants for spacecraft & missiles
- Adv. missile propulsion
- ORSC tech for liquid rocket engines

Far FY25-FY35



- Low cost space access
- Multi-mode propulsion
- Adv. missile propulsion

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Support for Operations CTC

$11M/year

Mission/Vision Statement

- We merge systems engineering application expertise with materials and processes (M&P) technology expertise to provide timely, effective solutions to user

Goals/Objectives

- Sustain Excellent S&T in-house laboratory and M&P technical expertise for identifying AF mishap root causes of materials failures and addressing critical AF problems
- Deliver Expertise in Aerospace M&P for providing the AF unbiased findings, trusted advice to acquisition programs and AF depots, and conducting AF O&M mission
- Apply lessons learned to prevent future mishaps and transition risk appropriate M&P technologies/methods to industry and AF depots & field maintainers

Motivation

The AFRL Materials & Processes Center of Expertise & Facility - Located in One Place & Dedicated to Solve Today's Air Force & DoD Problems

- AF Source for Real-time Unbiased Advice /Support to the Operations, Maintenance, Acquisition, and Development Communities - Rapid Response Materials and Manufacturing Expertise Throughout AF Weapon System's Lifecycles
- Leverage all RX & AFRL Capabilities to Provide M&P Applications Expertise and Deliver Optimized Technology Solutions Meeting Users Needs from More than 70 Organizations per year from all commands and DOD services - collaborations include AFMC, AF safety Center, ACC, GSC, AMC, Industry OEMs and M&P supply chain vendors

Technical Approach/Ideas

AF Leadership roles in:

- Materials/Processes & Manufacturing for Sustainment M&P advisors for AFLCMC Integrity Programs
- Structural and Electronic Failure/Root Cause Analysis
- Adhesives, Composites and Elastomers
- Nondestructive Evaluation/Inspection
- Electrostatic Discharge & Deicing Technology
- Rain/Particle Erosion Evaluation and Control
- Pollution Prevention and Materials Substitution
- AF Corrosion Prevention & Control

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SUMMARY
Affordability and Sustainment

- **CTCs poised to provide technologies for current and future future weapon systems**
  - Basic Research
  - Turbine Engines
  - Aerospace Vehicles
  - Structural Materials and Applications
  - Functional Materials and Applications
  - Manufacturing Technology
  - Space and Missile Propulsion
  - Support for Operations

- **For more information contact:**

Joe Baker
AFRL/RXT
email: joseph.baker@wpafb.af.mil

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