Chapter Title

Overview of NASA’s Propulsion 21 Effort

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State-wide coalition focused on research and development aimed at three aircraft engine-related goals:

• more energy efficient
• quieter
• more reliable
Management Structure

Executive Board NASA/GE/OSU

Co-operative Agreement

Data Control Plans

Ohio State University

Contract

Associate Contractor Agreements

University of Cincinnati

Timken

Webcore

Transmet

General Electric Aircraft Engines

NASA

University of Akron

Parker-Hannifin

Argo-Tech

GMI

Case Western Reserve University

University of Dayton

University of Akron

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Propulsion 21 Technologies

Turbine Engine Prognostics
- Disk Life Meter
- Sub-System Health Management

Active Controls for Emissions and Noise reduction
- Intelligent Combustor
- Active Noise Reduction

Active Structural Control
- Turbine Cooling Control
- Smart Containment System
- High Pressure Turbine Clearance Control

Modeling, Analysis and System Studies
- System Studies
**Disk Life Meter**

**Objective:**
Develop materials models and sensors to measure remaining life in turbine disk materials at sustained high operating temperatures.

Pit Formation and Growth Now Need to Be Understood
Sub System Health Management

**Objective:**
Develop bearing diagnostics and health monitoring system for inter-shaft bearings to provide early detection of impending bearing failure. Demonstrate a conceptual monitoring system for a differential roller bearing.

Assembled Bearing Test Rig
Intelligent Combustor

**Objective:**
Develop a combustor incorporating advanced diagnostics and active combustor control to reduce NOx emissions by 85% relative to 1996 ICAO standards, while retaining the performance of existing combustors.
Active Noise Control

**Objective:**
Use fluidic injection, shape memory alloys, and/or plasma actuators to enhance exhaust nozzle jet mixing to actively reduce jet engine noise. Incorporate active/smart concepts into acoustic liner design to increase liner acoustic performance.
**Objective:**
Develop and demonstrate innovative turbine system and component cooling technologies with active flow and temperature control, including prognostic / diagnostic sensors, for improved engine fuel burn and emissions.

**Advanced Cooling Concepts**
- Cooled Cooling Air, Active Flow Control, Next-Gen Airfoil Cooling

**Thermal Management & 3D System Simulation**

**Sensors for Active Control & Prognostics**
Objective:
Develop an innovative “smart” softwall containment system that capitalizes on the anisotropic nature of composites.
**Objective:**
Develop an HPT clearance control system that can adapt to changing environment/requirements.

![Diagram of HPT clearance control system](image-url)
System Studies

Objective:
Perform technology assessment and identify needed modeling improvements to handle adaptive technologies.

\( \Delta \) Noise Cumulative Margin, EPN\text{dB}

Steady Fluidic Injection
Synthetic Jet Actuators
Shape Memory Alloy
Active Liners

\( \Delta \) 5600 NM Fuel Burn from QAT/UEET Engine, %

Intelligent HPT rotor
Cooled cooling
HPT Clearance Control
High Temp SMA
HPT blade cooling flow modulation
Shape Changing Airfoil

\( \Delta \) NOx Reduction (%)

Baseline Engine is 2015 QAT/UEET

\( \Delta \) CO\textsubscript{2} Reduction (Fuel Burn)

Baseline Engine is 2015 QAT/UEET
Summary

• Propulsion 21 technologies contribute to reducing CO$_2$ and NO$_x$ emissions and noise

• Integrated Government/Industry/University research efforts have produced promising initial technical results

• Graduate students from 5 partnering universities will benefit from this collaborative research--> educating the future engineering workforce

• Phase 2 Efforts scheduled to be completed 3QFY06