

## OVERVIEW OF NASA'S PROPULSION 21 EFFORT

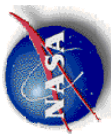
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# Overview of NASA's Propulsion 21 Effort

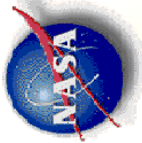
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# Propulsion 21

## Propulsion 21: Partners & Purpose



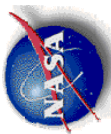
GE Aircraft Engines



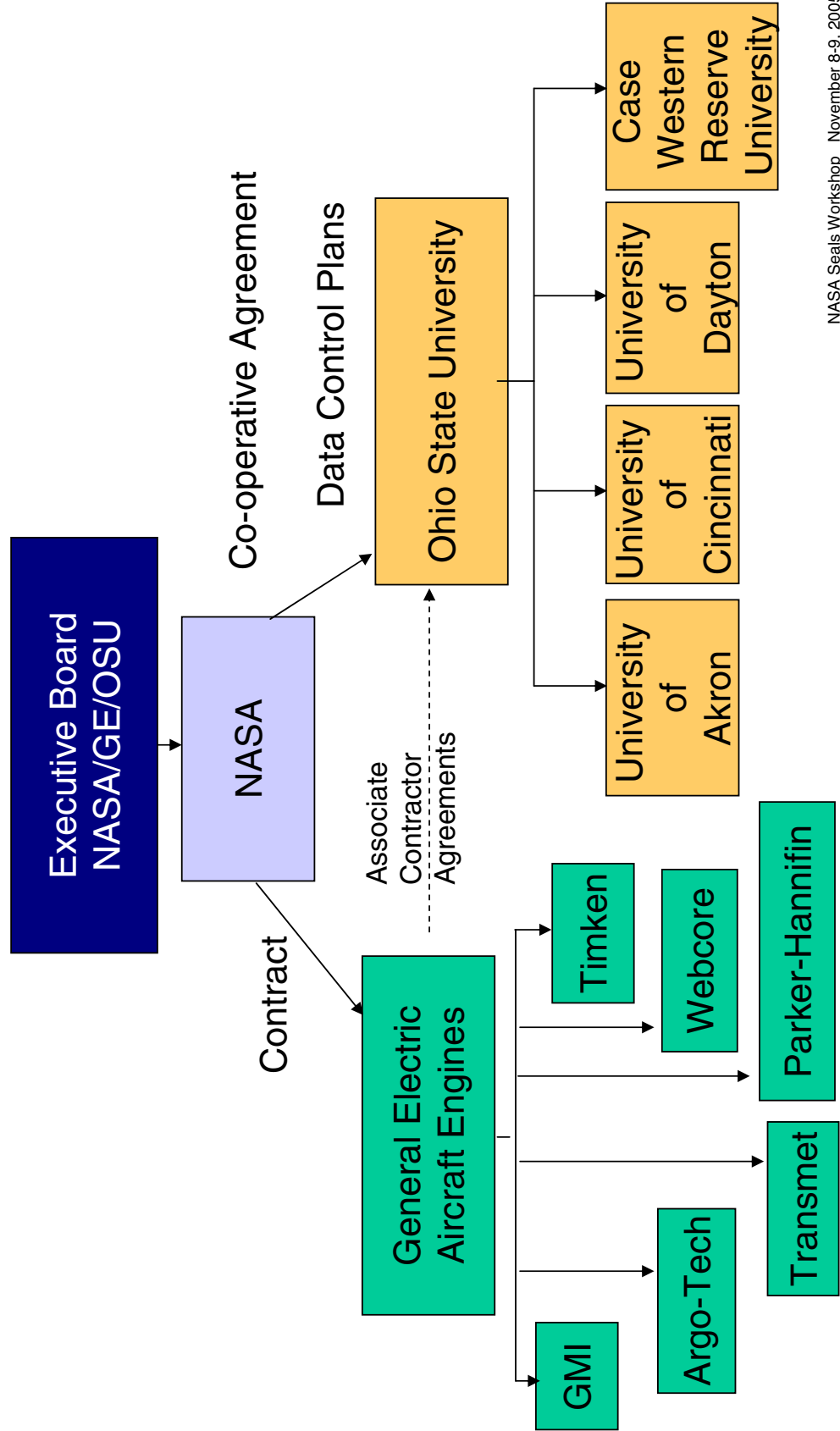
State-wide coalition focused on research and development aimed at three aircraft engine-related goals:

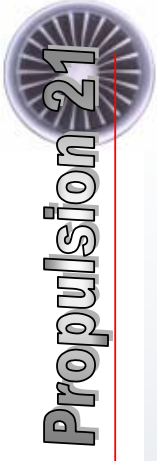
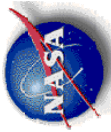
- more **energy efficient**
- **quieter**
- more **reliable**





## Management Structure





## Propulsion 21 Technologies

### **Turbine Engine Prognostics**

- Disk Life Meter
- Sub-System Health Management

### **Active Controls for Emissions and Noise reduction**

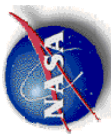
- Intelligent Combustor
- Active Noise Reduction

### **Active Structural Control**

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

### **Modeling, Analysis and System Studies**

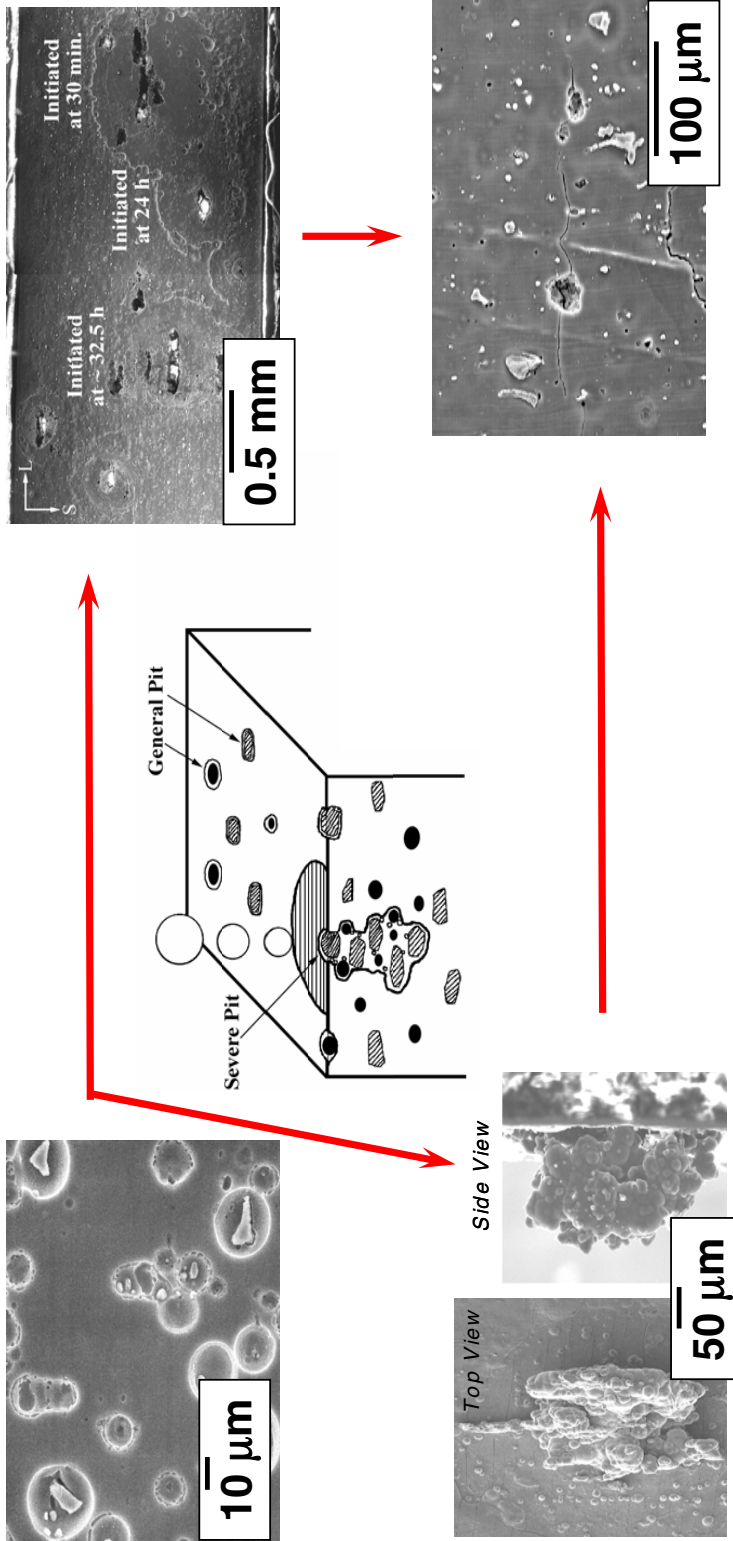
- System Studies



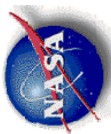
## Disk Life Meter

### Objective:

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



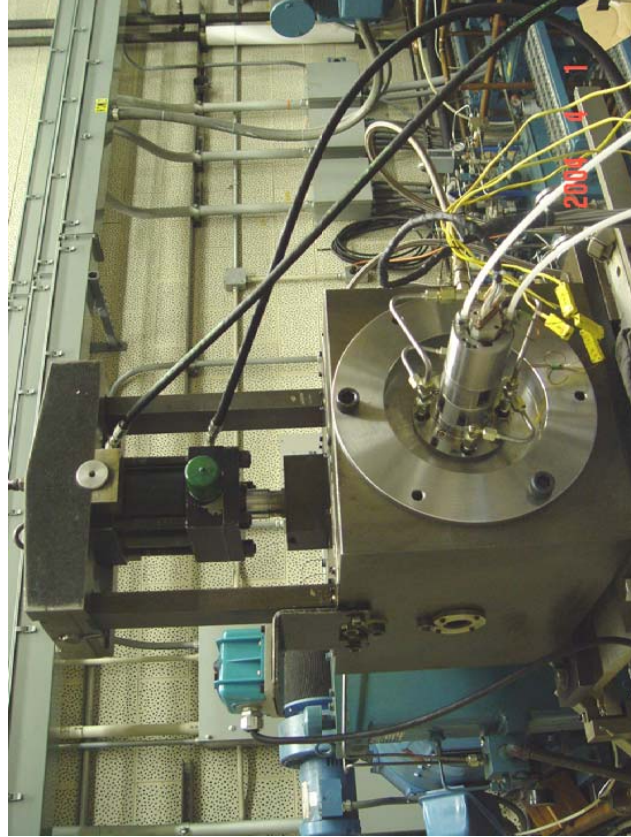
Pit Formation and Growth Now Need to Be Understood



## Sub System Health Management

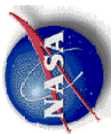
### **Objective:**

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

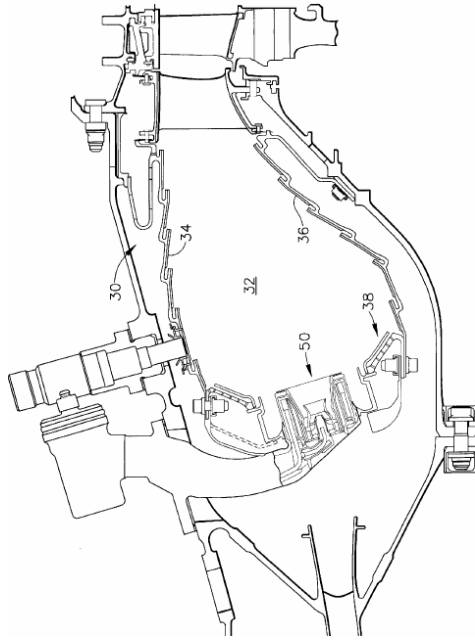




## Intelligent Combustor

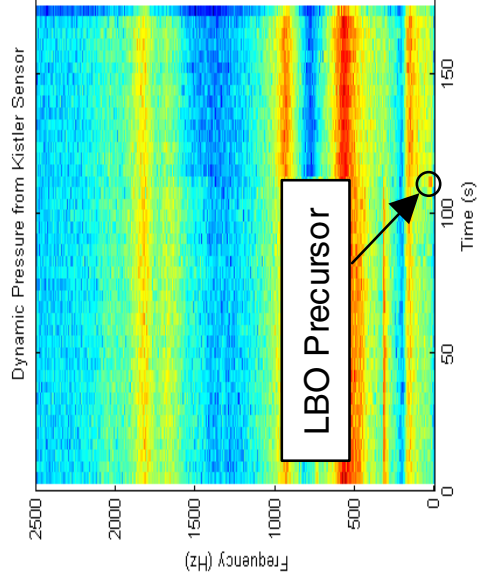
### Objective:

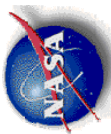
Develop a combustor incorporating advanced diagnostics and active combustor control to reduce NOx emissions by 85% relative to 1996 ICAO standards, while retaining the performance of existing combustors.



New swirler concepts

Lean blow-out precursor identification

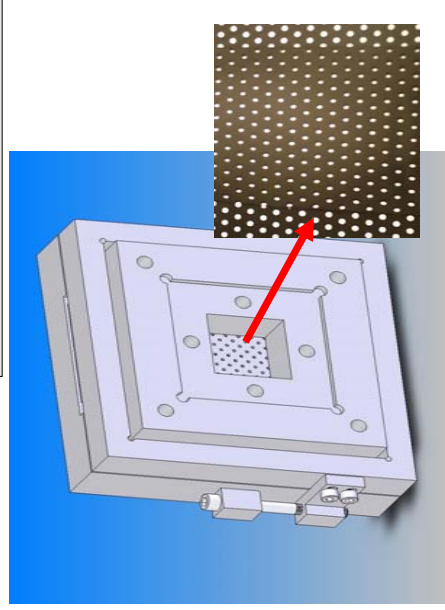
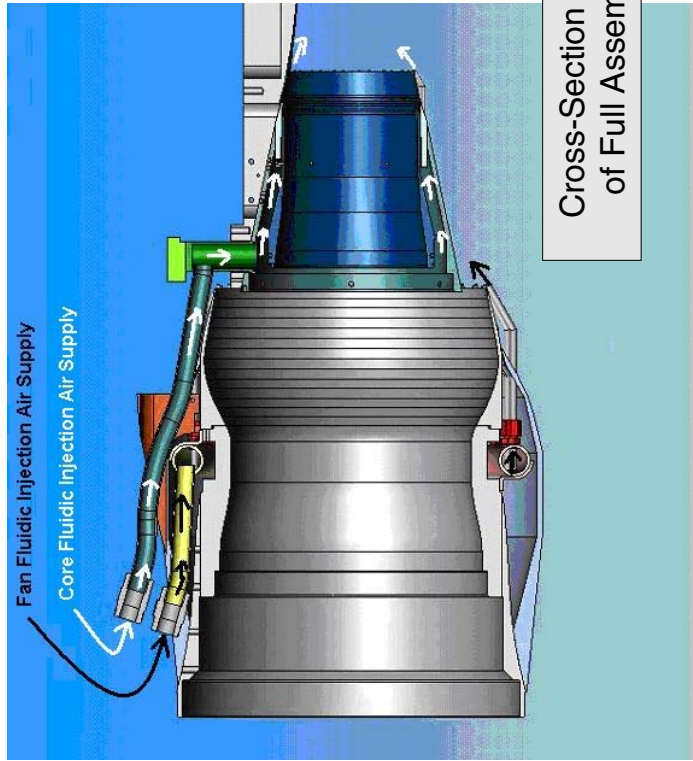




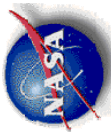
## Active Noise Control

### **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.



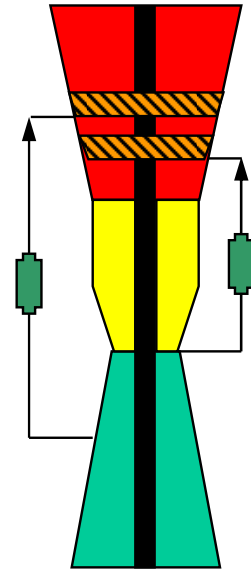




## Turbine Cooling Control

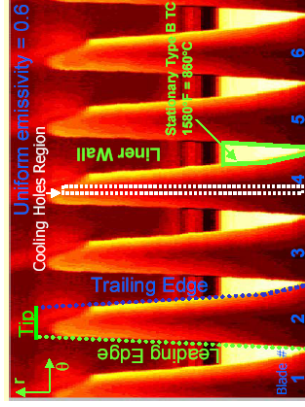
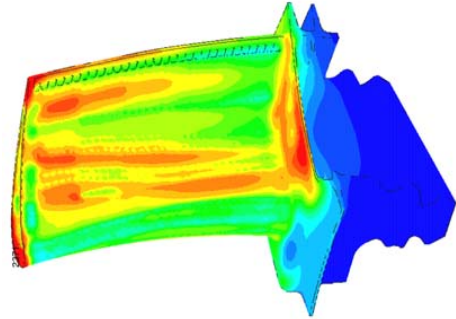
### Objective:

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.

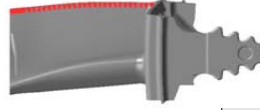


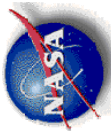
Thermal Management & 3D System Simulation

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



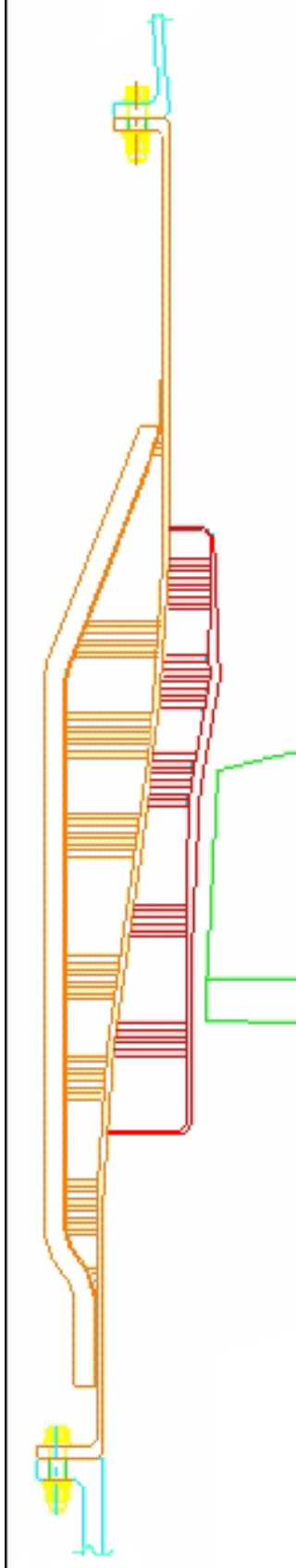
Sensors for Active Control & Prognostics



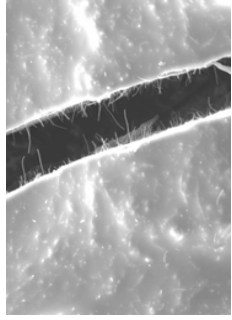


## Smart Containment System

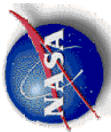
**Objective:**  
Develop an innovative “smart” softwall containment system that capitalizes on the anisotropic nature of composites.



Conceptual design of smart containment system

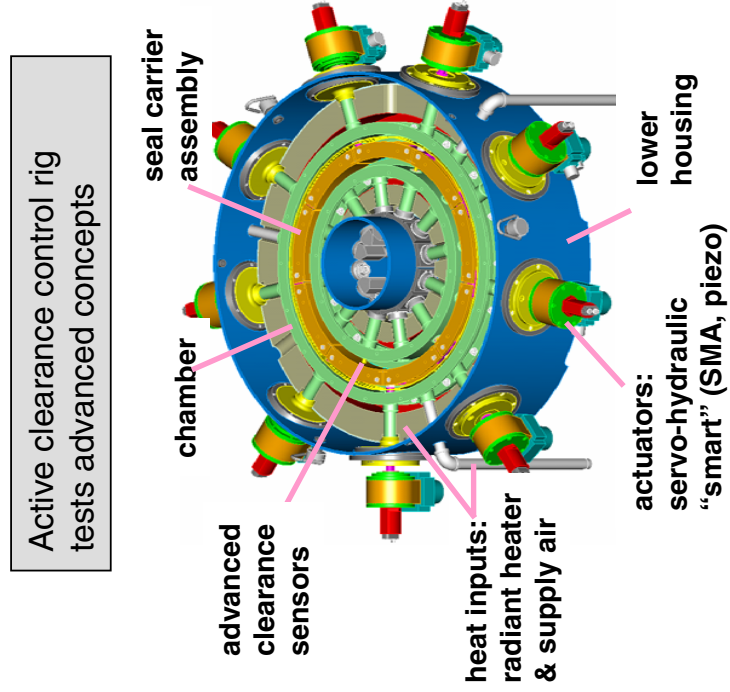
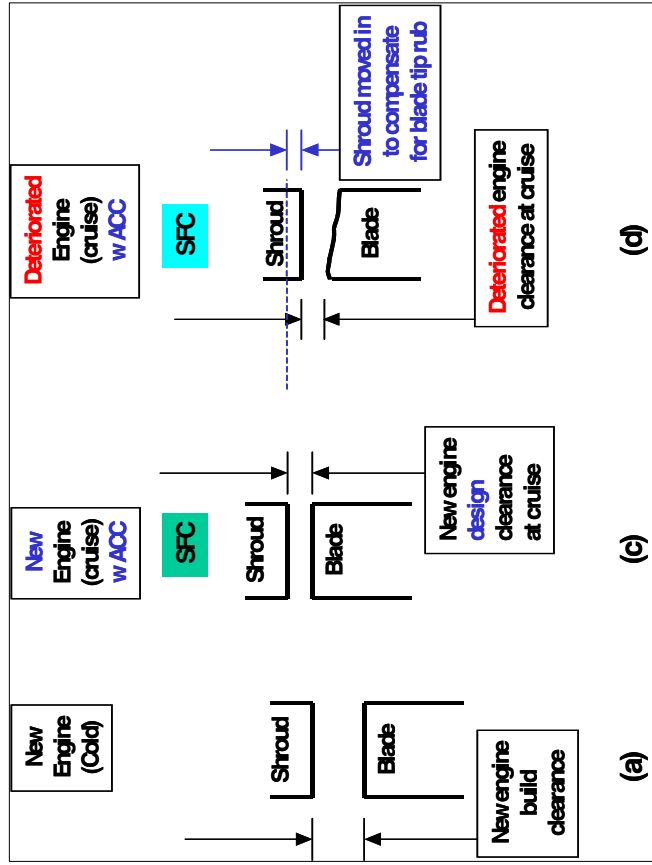


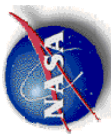
Nanofiber circuit diagnostic grid



## High Pressure Turbine (HPT) Clearance Control

**Objective:**  
Develop an HPT clearance control system that can adapt to changing environment/requirements.





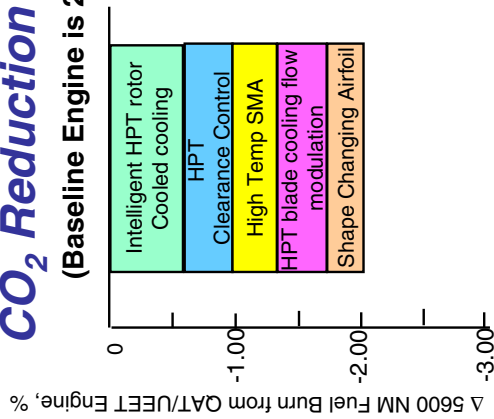
## System Studies

### Objective:

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

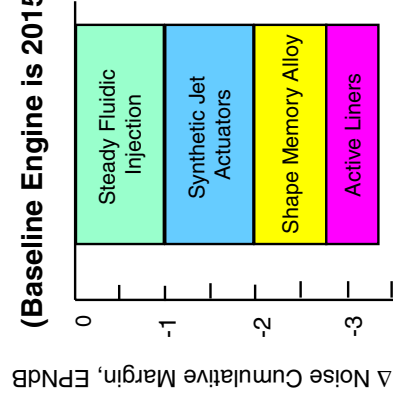
### CO<sub>2</sub> Reduction (Fuel Burn)

(Baseline Engine is 2015 QAT/UEET)



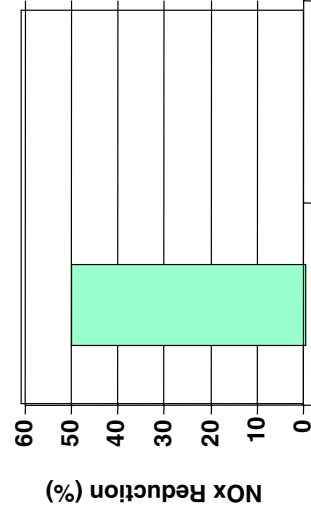
### Noise Reduction

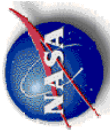
(Baseline Engine is 2015 QAT/UEET)



### NOx Reduction

(Baseline Engine is 2015 QAT/UEET)





## Summary

- **Propulsion 21 technologies contribute to reducing CO<sub>2</sub> and NO<sub>x</sub> 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**