The Computing & Interdisciplinary Systems Office

Annual Review and Planning Meeting
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Aircraft Engine Systems

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Computing and Interdisciplinary Systems Office
Glenn Research Center

2002 CISO Review

Aircraft Engine Systems

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Organization

Office of Aerospace Technology (Code R)
Dr. Jerry Creedon, Associate Administrator (HQ)

Revolutionize Aviation Theme Area
Terry Hertz, Program Director (HQ)

Vehicle Systems Program
Richard Wlezien (HQ) — *Level 1*

Aerospace Propulsion and Power Program
Dr. Gary Seng (NASA GRC) — *Level 2*

Propulsion Fundamental Research Project
Pete McCallum (NASA GRC) — *Level 3*

Turbine Engine Simulation
Joe Veres (NASA GRC) — *Level 4*

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Vision and Objective

The objective is to develop the capability to numerically model the performance of gas turbine engines used for aircraft propulsion. This capability will provide turbine engine designers with a means of accurately predicting the performance of new engines in a system environment prior to building and testing. The 'numerical test cell' developed under this project will reduce the number of component and engine tests required during development. As a result, the project will help to reduce the design cycle time and cost of gas turbine engines. This capability will be distributed to U.S. turbine engine manufacturers and air framers. This project focuses on goals of maintaining U.S. superiority in commercial gas turbine engine development for the aeronautics industry.

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General Description

This project will develop computer modeling and simulation capabilities that are of long-term strategic importance to future subsonic and supersonic propulsion. This research is mainly computational and aimed at developing modeling capabilities that could offer significant reductions in design and development cost of next generation subsonic and supersonic propulsion systems. This will enable the designers of new engines to use physics-based predictions of engine performance early in the design process. The Navier-Stokes flow simulations will enable detailed modeling of component aerodynamic interaction effects on engine performance. Key unknowns will be predicted such as radial profiles of flow conditions at component boundaries that are typically unknown to the designer until after the first engine is built and tested. Multi-disciplinary interaction effects on engine performance will also be modeled. This will help to reduce the reliance on component test data and also reduce the number of engine design-build-test iterations.

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Schedule / Milestones

	FY02	FY03	FY04	FY05
3-D Turbofan Engine Simulation	1	3	4	6
CIAPP Cycle Code Development	2		5	7

1. **3-D flow simulation of an aircraft turbofan engine in under 15 hours of CPU wall clock time using APNASA turbomachinery code and the National Combustion Code (NCC)**
2. **CIAPP cycle code enhanced with a Visual Based Syntax assembly of complete engine**
3. **Demonstrate CIAPP V2.0 to automate zooming to the 3-D steady-state aero-thermal engine simulation**
4. **Demonstrate prototype of a 3-D unsteady turbomachinery simulation in turbofan engine**
5. **Demonstrate prototype "intelligent engine" using CIAPP cycle code coupled to controls code**
6. **Demonstrate prototype of a 3-D multidisciplinary simulation in turbofan engine**
7. **Demonstrate CIAPP V3.0 to automate zooming for 0-D to 3-D multi-disciplinary engine simulation using APNASA / NCC and structural / thermal codes**

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FY02 Accomplishments

- 3-D flow simulation of the GE90 turbofan engine has been successfully run in under 15 hours of CPU wall clock time using the APNASA and NCC codes. This was a Strategic Implementation Plan (SIP) fiscal year 2002 milestone for NASA GRC (01A6.1).

- CIAPP V1.5 thermodynamic cycle code has been enhanced with a Visual Based Syntax assembly of complete engine.

  Phase 3 Meeting was held on March 13, 2002. The results were presented in the area of high fidelity simulations and lessons learned from coupling of high fidelity and multi-disciplinary codes.

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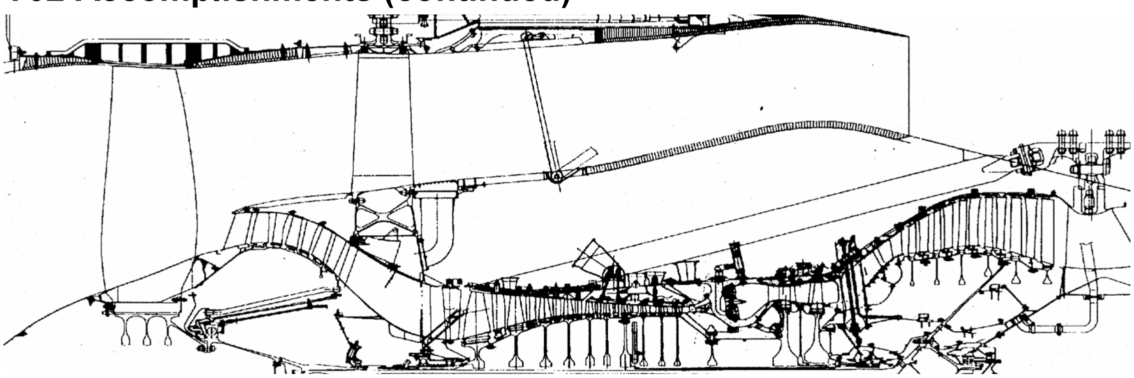
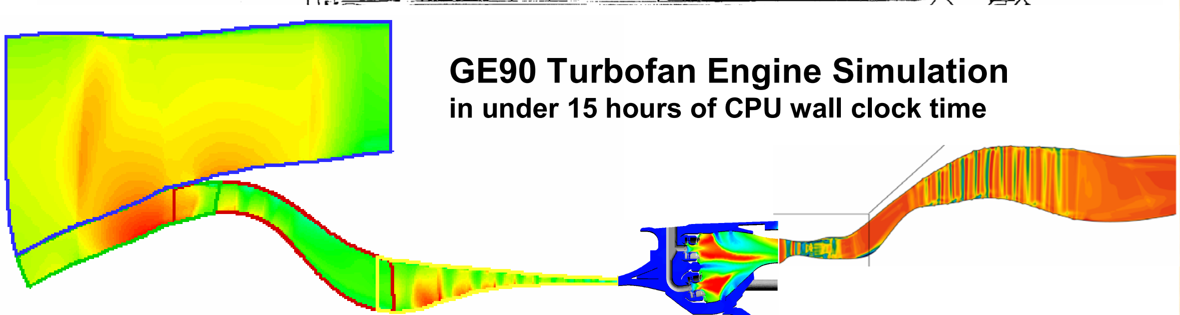
FY02 Accomplishments (continued)



GE90 Turbofan Engine Simulation
in under 15 hours of CPU wall clock time



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FY03 Plans

Demonstrate CIAPP V2.0 to automate zooming to the 3-D steady-state aero-thermal engine simulation of the GE90 turbofan engine.

The CIAPP V2.0 code and the 3-D engine component simulations with APNASA and NCC will generate "mini maps" around the operating point of interest for the engine components. These maps will be passed back to the CIAPP thermodynamic cycle code, which will then be run to convergence (*see flow chart next page*).

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FY03 Plans (continued)

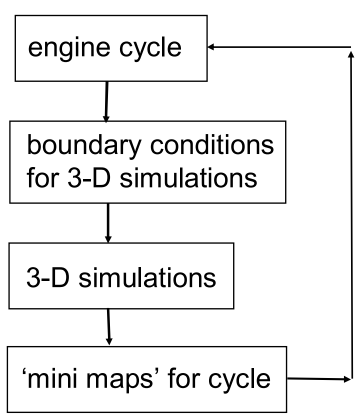
Iteration (n)

The engine cycle code (CIAPP V2.0) will be run at the operating point of interest using 'initial guess' component maps

Cycle will generate 0-D BC's for the fan, LP and HP compressors, combustor and LP and HP turbines.

CIAPP V2.0 will spawn execution of 3-D component simulations (fixed inlet profiles)

3-D simulations will create 'mini maps' around operating point of interest, and pass the maps to the cycle code



Iteration (n+1)

The engine cycle run with new 'mini-maps'

Cycle generate new 0-D BC's

CIAPP V2.0 spawn execution of 3-D simulations with real inlet radial profiles

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Technical talks to follow:

"High Fidelity Simulation of the GE90 Turbofan Engine"
Mark G. Turner (AP Solutions / University of Cincinnati)

"NCC Simulation of the GE90 Combustor"
Andrew Norris (OAI)

Engine Simulation Team	
Mark G. Turner	Compressor and turbine simulations with APNASA
Rob Ryder	Combustion simulations with NCC, grid generation
Andrew Norris	Combustion simulations with NCC, code coupling
John Adamczyk	APNASA turbomachinery flow code
Nan-Suey Liu	National Combustion Code (NCC)
John Gallagher	Combustor CAD geometry
John Reed	Thermodynamic cycle of GE90 engine with CIAPP
Scott Townsend	Code coupling toolkit development
Bill Pavlik	CIAPP engine cycle model

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Summary

The GRC SIP Milestone number 01A6.1 has been successfully achieved in FY02. The title of the milestone is:

"Turbofan Flow Path Simulation"

The full primary flow path simulation of a modern two spool turbofan engine has been achieved running on hundreds of processors in less than 15 hours of CPU wall clock time.

A paper have been presented at the 2002 Joint Propulsion Conference titled:

"High Fidelity 3D Turbofan Engine Simulation with Emphasis on Turbomachinery-Combustor Coupling", AIAA-2002-3769

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