The Computing & Interdisciplinary Systems Office

Annual Review and Planning Meeting
October 9-10, 2002

Dr. John K. Lytle

Computing and Interdisciplinary Systems Office
Glenn Research Center

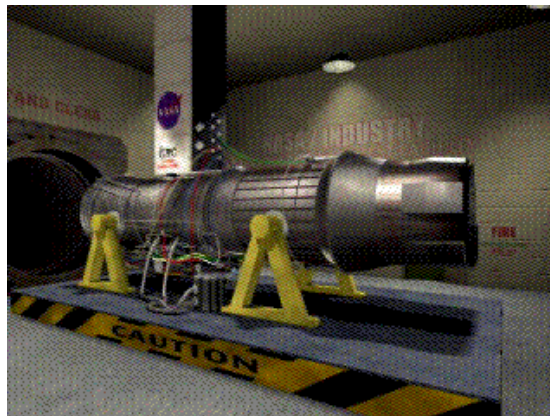*2002 CISO Review*

Outline

- **Vision and Objective**
- **General Description**
- **Schedule**
- **Customer Survey Results**
- **FY02 Accomplishments**
- **FY03 Milestones**
- **Future Direction**
- **Agenda**

2002 CISO Review

The Vision

Develop an advanced engineering analysis system that enables high-fidelity, multi-disciplinary, full propulsion system simulations to be performed early in the design process….
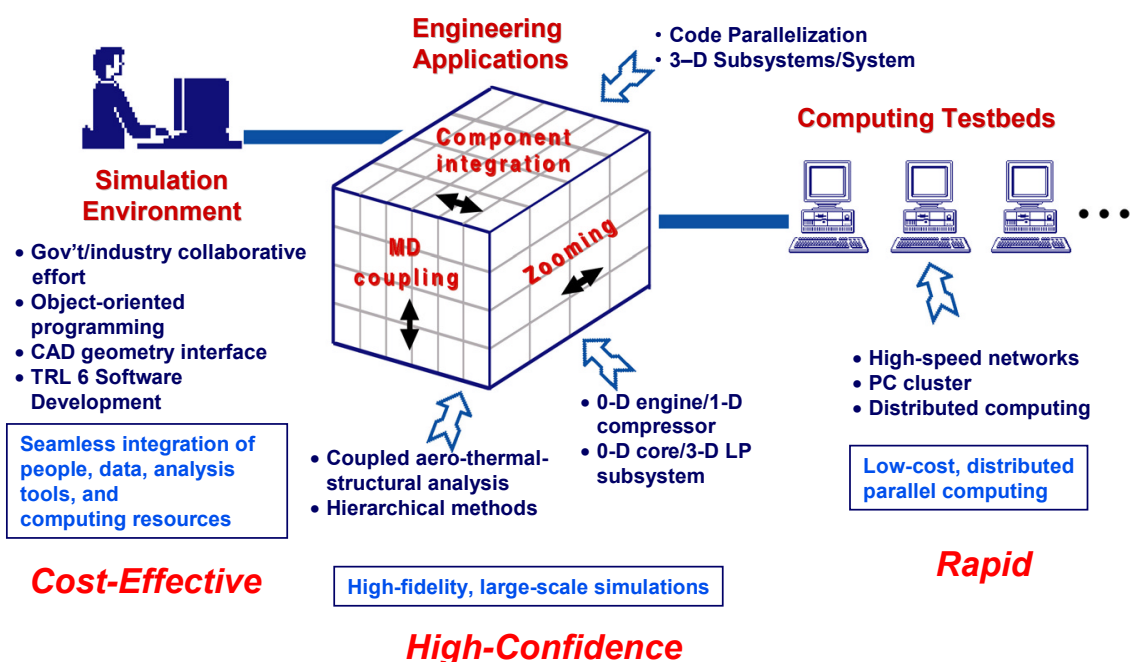

…a virtual test cell that integrates propulsion and information technologies…

To enable rapid, high-confidence, cost-effective design of revolutionary systems. (AST Goal 3: Pioneering Revolutionary Technology)
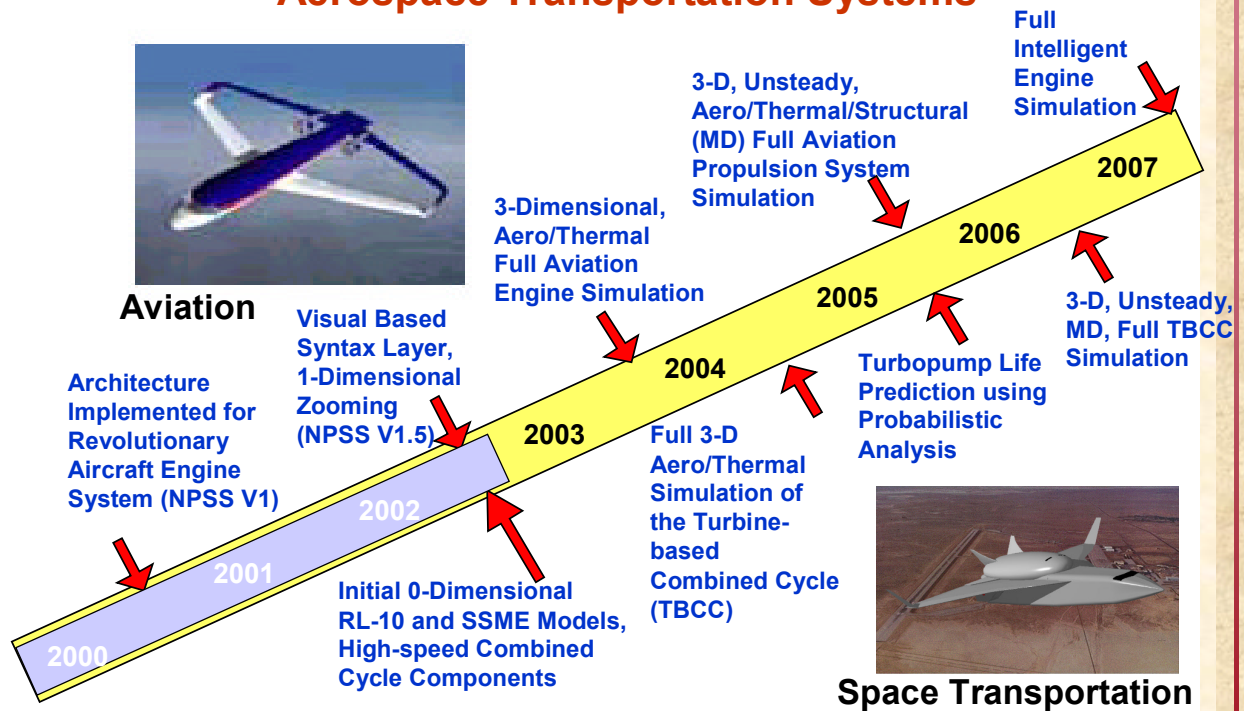

Major Elements of Virtual Testing

Engineering Applications

- Code Parallelization
- 3–D Subsystems/System

Computing Testbeds

Component integration

MD coupling

Zooming

Simulation Environment

- Gov't/industry collaborative effort
- Object-oriented programming
- CAD geometry interface
- TRL 6 Software Development

Seamless integration of people, data, analysis tools, and computing resources

- Coupled aero-thermal-structural analysis
- Hierarchical methods

- 0-D engine/1-D compressor
- 0-D core/3-D LP subsystem

- High-speed networks
- PC cluster
- Distributed computing

Low-cost, distributed parallel computing

Cost-Effective

High-fidelity, large-scale simulations

Rapid

High-Confidence

NPSS Development Plan to Support Advanced Aerospace Transportation Systems

Aviation

Architecture Implemented for Revolutionary Aircraft Engine System (NPSS V1)

Visual Based Syntax Layer, 1-Dimensional Zooming (NPSS V1.5)

3-Dimensional, Aero/Thermal Full Aviation Engine Simulation

3-D, Unsteady, Aero/Thermal/Structural (MD) Full Aviation Propulsion System Simulation

Full Intelligent Engine Simulation

2000 2001 2002 2003 2004 2005 2006 2007

Initial 0-Dimensional RL-10 and SSME Models, High-speed Combined Cycle Components

Full 3-D Aero/Thermal Simulation of the Turbine-based Combined Cycle (TBCC)

Turbopump Life Prediction using Probabilistic Analysis

3-D, Unsteady, MD, Full TBCC Simulation

Space Transportation

Software Development Strategy

Software Products
NPSS V1   **V 1.5**

NPSS

component interfaces   BYPASS   component interfaces

INLET

0-D 2-D 0-D 2-D 1-D 3-D

2000 2001 2002 2003 2004 2005 2006
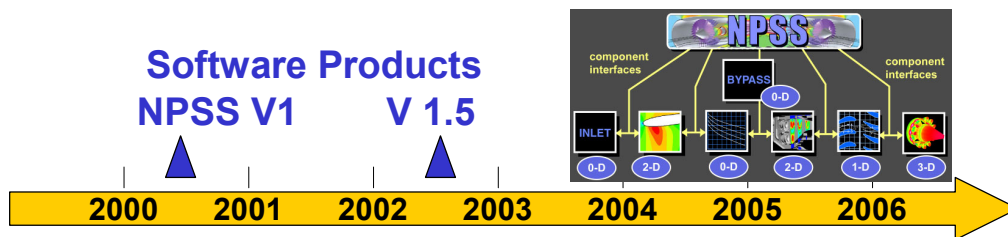
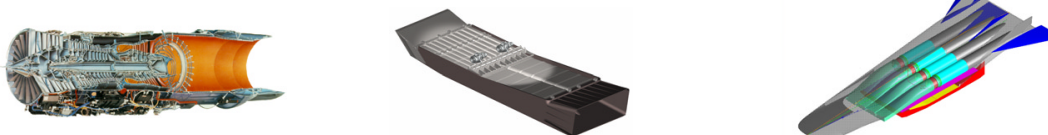**Developers Kit: Tools for Integrating Legacy Code into the NPSS Engineering Environment**

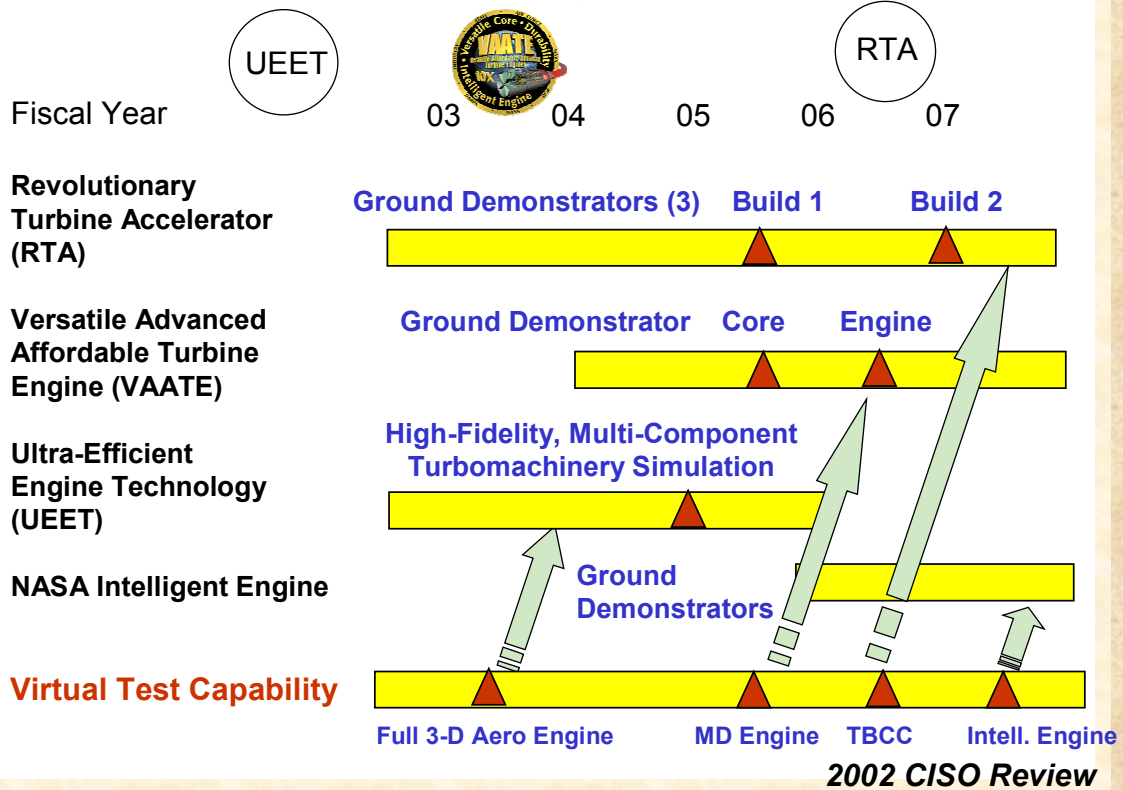•CICT Information Environments
•CICT Computing, Networking, and Testbeds

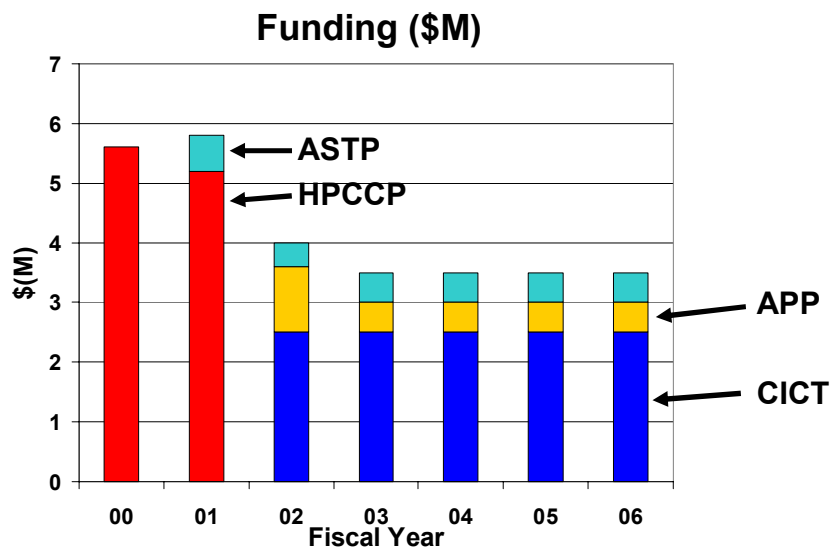**3-D Prototype Simulations & Infrastructure**

•CICT Grand Challenges
•Aerospace Propulsion and Power Base
•Space Transfer and Launch Technology

Virtual Testing
Opportunities to Impact Major National Programs

UEET   VAATE   RTA

Fiscal Year   03   04   05   06   07

Revolutionary Turbine Accelerator (RTA)
Ground Demonstrators (3)   Build 1   Build 2

Versatile Advanced Affordable Turbine Engine (VAATE)
Ground Demonstrator   Core   Engine

Ultra-Efficient Engine Technology (UEET)
High-Fidelity, Multi-Component Turbomachinery Simulation

NASA Intelligent Engine
Ground Demonstrators

Virtual Test Capability
Full 3-D Aero Engine   MD Engine   TBCC   Intell. Engine

2002 CISO Review

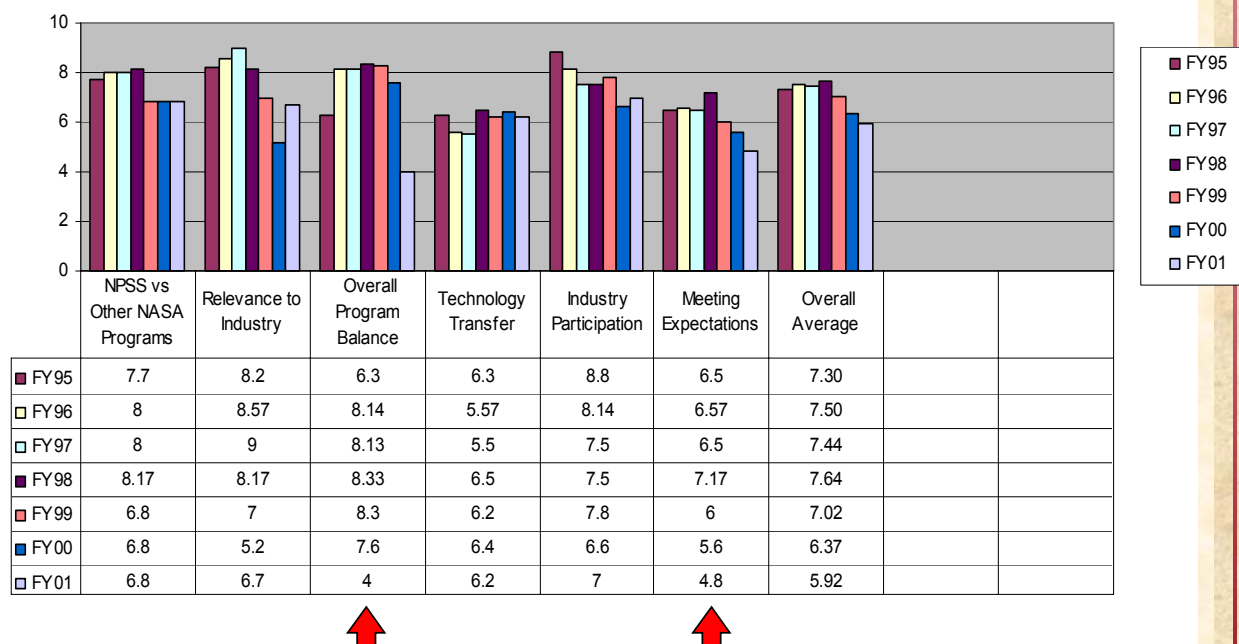---

Programmatic Support

Funding ($M)

← ASTP
← HPCCP
← APP
← CICT

HPCCP - High Performance Computing and Communications (Revolutionize Civil Aviation)
APP - Aerospace Propulsion and Power (Revolutionize Civil Aviation)
ASTP - Advanced Space Transportation Program (Advanced Space Transportation)
CICT - Computing, Information, and Communications Technology (Pioneering Revolutionary Technology)

2002 CISO Review

OVERALL NPSS PROGRAM RATINGS

	NPSS vs Other NASA Programs	Relevance to Industry	Overall Program Balance	Technology Transfer	Industry Participation	Meeting Expectations	Overall Average
FY95	7.7	8.2	6.3	6.3	8.8	6.5	7.30
FY96	8	8.57	8.14	5.57	8.14	6.57	7.50
FY97	8	9	8.13	5.5	7.5	6.5	7.44
FY98	8.17	8.17	8.33	6.5	7.5	7.17	7.64
FY99	6.8	7	8.3	6.2	7.8	6	7.02
FY00	6.8	5.2	7.6	6.4	6.6	5.6	6.37
FY01	6.8	6.7	4	6.2	7	4.8	5.92

Consistent Themes from Customer Survey

- **Concern over strong emphasis placed on these (rocket) capabilities at the expense of air breathing simulations**

- **We would be more interested in using Engineering Application and High Performance Computing tools if they were more readily deployed into our system…**

- **The development of this environment to support high fidelity components has not been as effective as desired.**

- **The current approach of trying to coalesce an approach from a variety of different, company proprietary approaches does not appear to be leading to an effective plan that benefits all NPSS members.**

- **Release policy prohibits widespread acceptance.**

Selected FY02 Highlights

- **Received two major awards**
  - NorTech
  - R&D 100
- **Completed prototype of first integrated 3-D aero simulation of the primary flow path of a large turbofan engine.**
- **Released NPSS V1.5 with visual assembly of complete propulsion system, zooming to 1-dimensional analysis, CORBA security, and rocket engine component modules.**
- **Demonstrated coupling objects for an object-based multi-disciplinary simulation using ADPAC and ANSYS.**
- **Demonstrated a 400:1 speed-up using the Lattice Boltzmann method with 500 processors to simulate a transonic compressor cascade.**
- **Completed a 3-D simulation (VULCAN) using distributed computing resources via CORBA over the Information Power Grid.**
- **NPSS Release Policy signed by NASA Headquarters.**

2002 CISO Review

FY03 Major Milestones

- **Automate execution of the 3-dimensional engine simulation through integration with the 0-dimensional simulation**
- **Complete 0-dimensional models of the advanced combined cycles for the space transportation**
  - Rocket-based combined cycle
  - Turbine-based combined cycle
- **Complete multi-disciplinary, unsteady simulation of a turbopump for rocket engine applications.**
- **Complete multi-disciplinary simulation of the integrated forebody, inlet and combustor of a high-speed vehicle and propulsion system.**
- **Demonstrate coupling high fidelity aerospace application codes using CORBA on the Information Power Grid.**
- **Develop data translation and system solver objects supporting multi-component simulations**
- **Implement commercialization space act agreements for NPSS V1.X**

2002 CISO Review

Future Directions

- **Despite substantial funding reductions in FY 02, NASA will continue to invest in an advanced engineering environment for propulsion.**
- **Increased emphasis on completing Developers Kit to bring in high-fidelity, multi-disciplinary analysis tools.**
- **Identify and cultivate commercialization opportunities for NPSS V1.x**
- **Work through the Propulsion System Technical Committee to address issues associated with reduction in support for Aeronautics applications. Need Executive Committee Help.**
- **Establish stronger partnerships with related Programs**
    - **DOE Accelerated Strategic Computing Initiative**
    - **DOD Versatile Affordable Advanced Turbine Engine Program**
    - **NASA Ultra-Efficient Engine Technology Program**
    - **NASA Advanced Space Transportation Program**

Propulsion System Technical Committee

Dr. M. J. Benzakein	General Manager, Advanced Engineering Programs	GE Aircraft Engines
Dr. Arun K. Sehra	Director of Aeronautics	NASA Glenn Research Center
Mr. Gerald (Scott) Cruzen	Director, Advanced Technology	Williams International
Mr. Ted Exley	Director of Advanced Programs	Teledyne Continental Motors
Mr. Jeff Jenson	Division Director of Business Development	The Boeing Co./Rocketdyne Propulsion & Power
Professor Awatef Hamed	Dept. of Aerospace Engineering	University of Cincinnati
Professor Wesley L. Harris		Massachusetts Institute of Technology
Ms. Sandra Hoff	Chief Power Systems Division	Aviation Applied Technology Directorate
Mr. Robert J. May Jr.	Executive Director	Air Force Research Lab
Mr. John Meier	Director, Advanced Programs	Honeywell
Mr. J. Walter Smith	Engineering Director, Compression Systems Module Center	Pratt & Whitney
Mr. Jan Syberg	Propulsion Technology Leader, Phantom Works	The Boeing Co.
Dr. Ronald York	Chief Operating Officer	Allison Advanced Development Co.
Mr. John R. Arvin	Vice President Programs	Allison Advanced Development Co.

Agenda

- **Simulation Environment**

- **Engineering Applications**

- **Cost-effective Computing Testbeds**

2002 CISO Review