D18

HOST STRUCTURAL ANALYSIS PROGRAM

OVERVIEW

by

R. H. Johns, Subproject Manager

Hot section components of aircraft gas turbine engines are subjected to severe thermal-structural loading conditions, especially during the start-up and take-off portions of the engine cycle. The most severe and damaging stresses and strains are those induced by the steep thermal gradients induced during the start-up transient. These transient stresses and strains are also the most difficult to predict, in part because the temperature gradients and distributions are not well known or readily predictable, and also because the cyclic elastic-viscoplastic behavior of the materials at these extremes of temperature and strain are not well known or readily predictable.

A broad spectrum of structures-related technology programs is underway to address these deficiencies. The problems are being addressed at the basic as well as the applied level, including participation by industry and universities as well as in-house at NASA Lewis. In addition to the HOST structural analysis program, some related program elements are being supported through our Base R&T program.

One element of the structures program is developing improved time-varying thermal-mechanical load models for the entire engine mission cycle from start-up to shutdown. The thermal model refinements will be consistent with those required by the structural code including considerations of mesh-point density, strain concentrations, and thermal gradients. Models will be developed for the burner liner, turbine vane and turbine blade. One aspect of this part of the program is a thermal data transfer module recently developed which automates the transfer of temperatures from available heat transfer codes or experimental data sets to the structural analysis code. Another part of the program is an automated component-specific geometric modeling capability which will produce 3-D finite element models of the components. Self-adaptive solution strategies will be developed and included to facilitate selection of appropriate elements, mesh sizes, etc.

Another major part of the program is the development of new and improved nonlinear 3-D finite elements and associated structural analysis programs, including the development of temporal elements with time-dependent properties to account for creep effects in the materials and components. Two contracts were recently signed to accomplish these developments. Improved constitutive modeling methods to facilitate improved prediction of cyclic thermomechanical viscoplastic material behavior are also under development. Experimental facilities to aid in developing and verifying theories and models are currently being established in-house at Lewis.

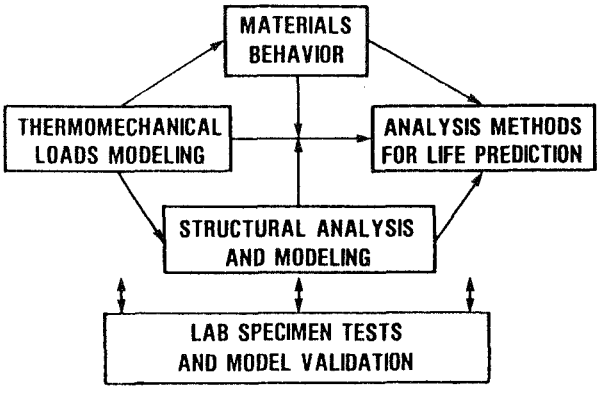
Further explanation and details about the various structures program elements mentioned above are given in the following write-ups.

STRUCTURAL ANALYSIS...IT'S ROLE IN HOST

GOAL:

DEVELOP AND VALIDATE INTEGRATED TIME-VARYING THERMOMECHANICAL LOAD MODELS, COMPONENT-SPECIFIC AUTOMATED GEOMETRIC MODELING AND SOLUTION STRATEGY CAPABILITIES, AND ADVANCED INELASTIC ANALYSIS METHODS INCLUDING PLASTICITY AND CREEP EFFECTS FOR NONLINEAR ANISOTROPIC FINITE ELEMENT STRUCTURAL ANALYSIS AND DESIGN COMPUTER CODES FOR TURBINE ENGINE HOT SECTION COMPONENTS

PROGRAM INTEGRATION



PROGRAM ELEMENTS:

- THERMAL/STRUCTURAL DATA TRANSFER MODULE
- THERMAL/MECHANICAL LOAD/MISSION AND COMPONENT-SPECIFIC STRUCTURAL MODELS
- 3-D INELASTIC ANALYSIS METHODS
- BURNER LINER CYCLIC RIG (STRUCTURAL ASPECTS)
- HIGH TEMPERATURE STRUCTURES LABORATORY

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HOST

STRUCTURAL ANALYSIS PROGRAM

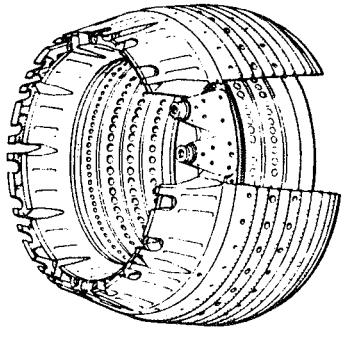
OBJECTIVE:

TO DEVELOP AND VALIDATE INTEGRATED TIME-VARYING THERMAL/MECHANICAL LOAD MODELS, COMPONENT-SPECIFIC AUTOMATED GEOMETRIC MODELING AND SOLUTION STRATEGY CAPABILITIES, AND ADVANCED INELASTIC ANALYSIS METHODS AND CONSTITUTIVE MODELS, INCLUDING PLASTICITY AND CREEP EFFECTS, FOR NONLINEAR, ANISOTROPIC, FINITE ELEMENT STRUCTURAL ANALYSIS AND DESIGN COMPUTER CODES.

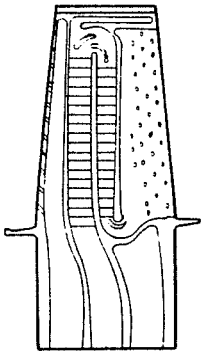
STRUCTURAL ANALYSIS

PROGRAM ELEMENT	FISCAL YEAR 81	82	83	84	85	86	87	EXPECTED RESULT
THERMAL DATA TRANSFER		(C)						COMPUTER MODULE LINKING THERMAL AND STRUCTURAL ANALYSES
COMPONENT SPECIFIC MODELING			(C)			▼		COMPONENT-RELATED, TIME VARYING, THERMAL-MECHANICAL LOAD HISTORY & GEOMETRIC MODELS
3-D INELASTIC ANALYSIS			(C)		▼			ADVANCED 3-D INELASTIC STRUCTURAL/ STRESS ANALYSIS METHODS AND SOLUTION STRATEGIES
LINER CYCLIC RIG		(IH)						BURNER STRUCTURAL/LIFE EXPERIMENTS
HIGH-TEMPERATURE STRUCTURES LAB			(IH)					INTEGRATED EXPERIMENTAL /ANALYSIS RESEARCH
MATERIAL BEHAVIOR TECHNOLOGY		(IH)						CONSTITUTIVE THEORY & MODELING METHODS

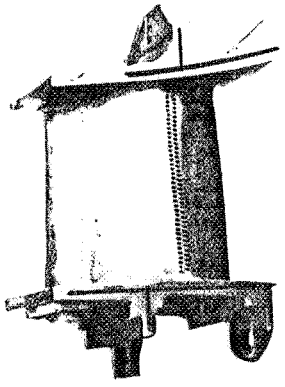
HOT SECTION COMPONENTS REQUIRING 3-D INELASTIC ANALYSIS



COMBUSTOR LINER



TURBINE BLADE



TURBINE VANE

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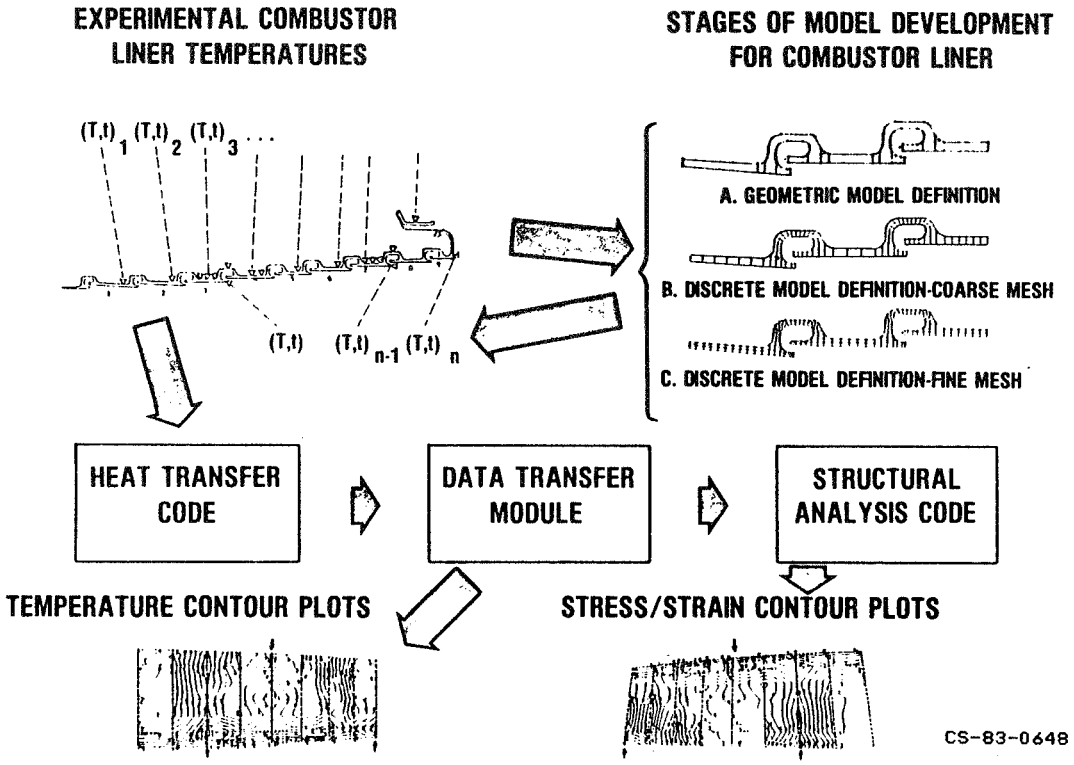
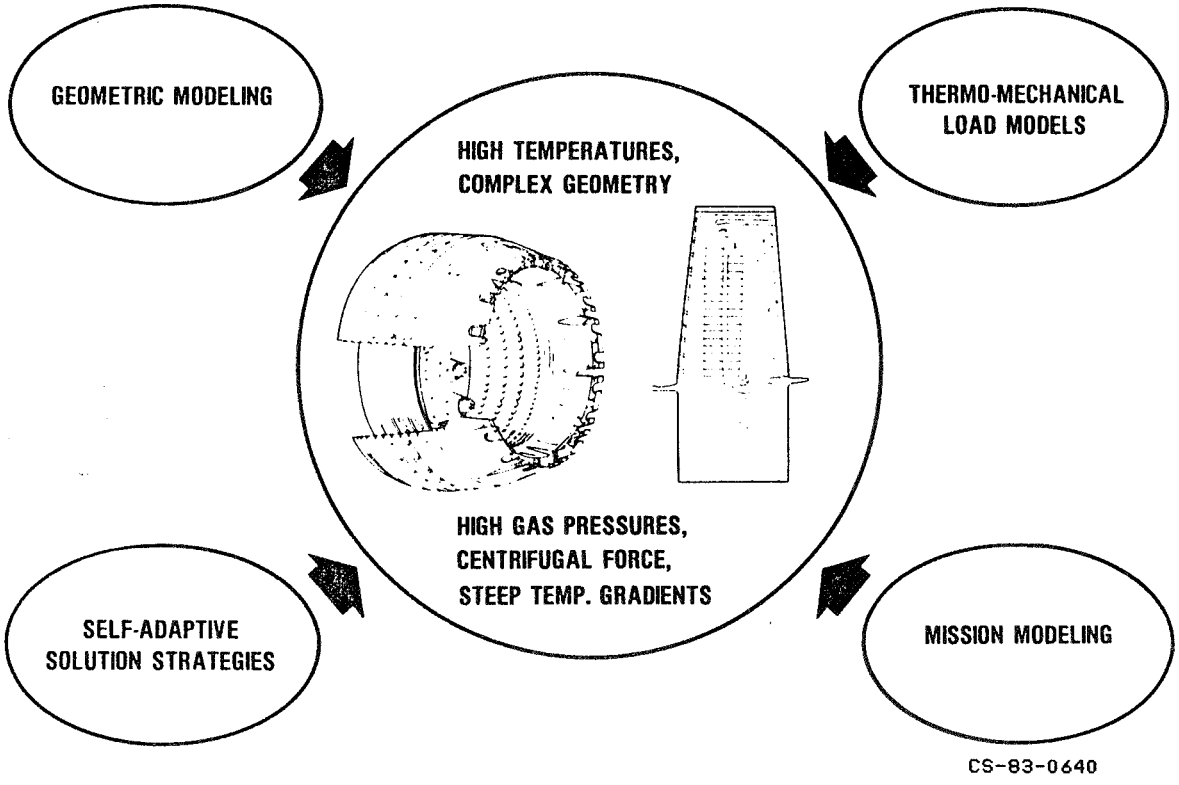
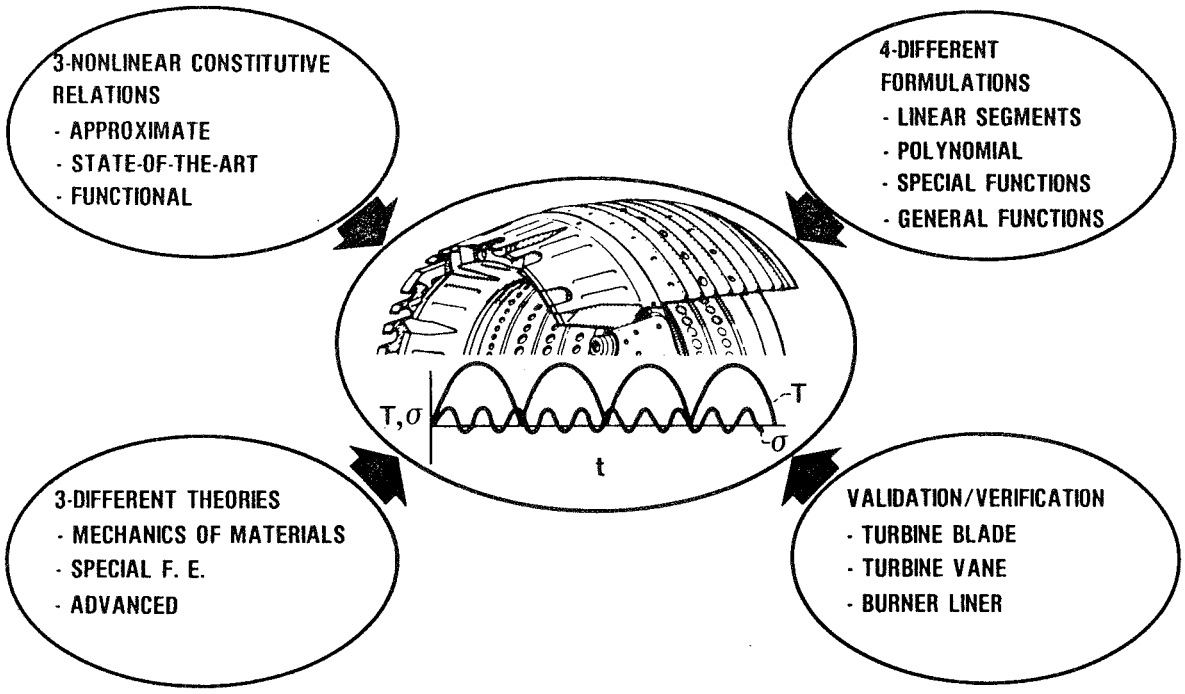
BURNER LINER THERMAL LOAD TRANSFER MODULE (HOST)



COMPONENT—SPECIFIC MODELING (HOST)



3-D INELASTIC ANALYSIS (HOST)



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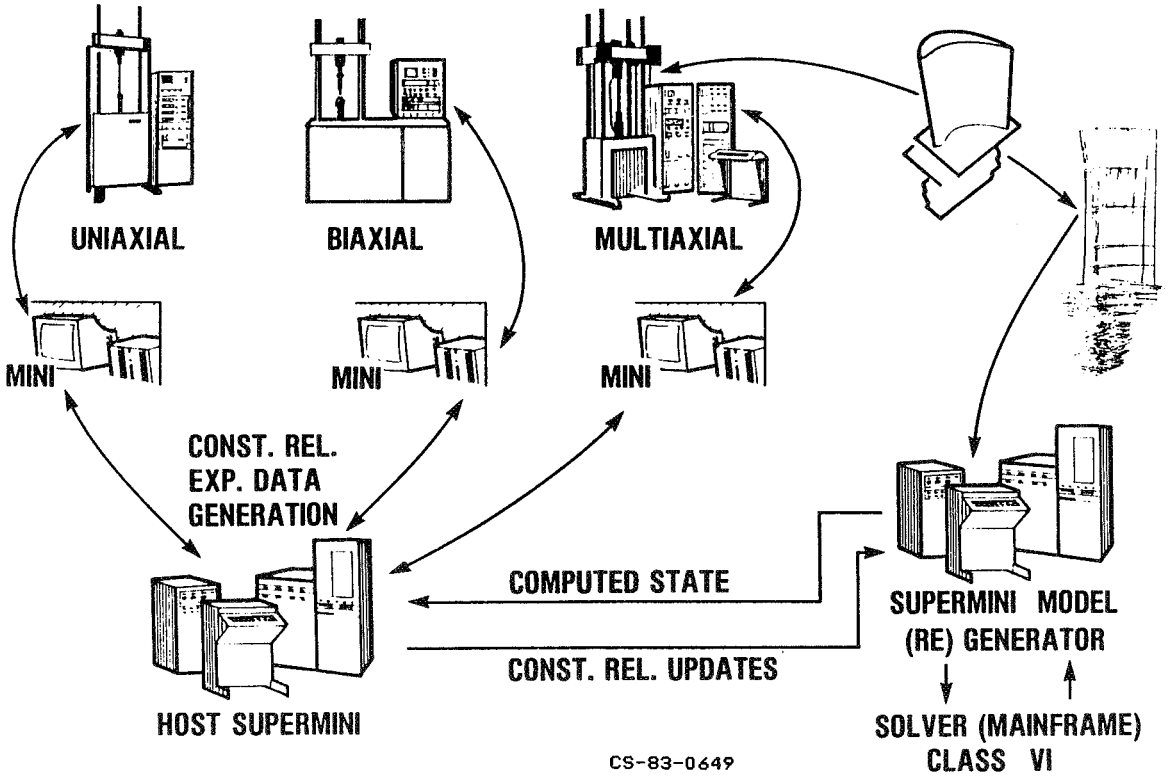
AUTOMATED HIGH TEMPERATURE STRUCTURES RESEARCH LABORATORY



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TURBINE ENGINE HOT SECTION TECHNOLOGY
STRUCTURES ANALYSIS SESSION

AGENDA

OVERVIEW	R. H. JOHNS, LeRC
THERMAL/STRUCTURAL DATA MODULE	R. J. MAFFEO, G.E.
COMPONENT SPECIFIC MODELING	M. L. ROBERTS, G.E.
3-D INELASTIC ANALYSIS METHODS	E. S. TODD, P & W
3-D INELASTIC ANALYSIS METHODS	R. L. McKNIGHT, G.E.
LINER CYCLIC LIFE RIG	R. L. THOMPSON, LeRC
QUARTZ LAMP RIG	D. F. SCHULTZ, LeRC