STRUCTURES DIVISION

STRUCTURAL MECHANICS BRANCH

NASA
Lewis Research Center

COMPUTATIONAL STRUCTURAL MECHANICS
ENGINE STRUCTURES COMPUTATIONAL SIMULATOR

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NASA LEWIS RESEARCH CENTER

NASA WORKSHOP ON COMPUTATIONAL STRUCTURAL MECHANICS
NASA LANGLEY RESEARCH CENTER
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COMPUTATIONAL STRUCTURAL MECHANICS FOR ENGINE STRUCTURES

- o Investigate Unique Advantages of Parallel and Multi Processors For:
  - Reformulating/Solving Structural Mechanics
  - Formulating/Solving Multidisciplinary Mechanics

- o Develop "Integrated" Structural System Computational Simulators For:
  - Predicting Structural Performance
  - Evaluating Newly Developed Methods
  - Identifying/Prioritizing Improved/Missing Methods Needed

THE COMPUTATIONAL STRUCTURAL MECHANICS (CSM) PROGRAM AT LEWIS ENCOMPASSES (1) FUNDAMENTAL ASPECTS FOR FORMULATING AND SOLVING STRUCTURAL MECHANICS PROBLEMS AND (2) DEVELOPMENT OF INTEGRATED SOFTWARE SYSTEMS TO COMPUTATIONALLY SIMULATE THE PERFORMANCE/DURABILITY/LIFE OF ENGINE STRUCTURES.

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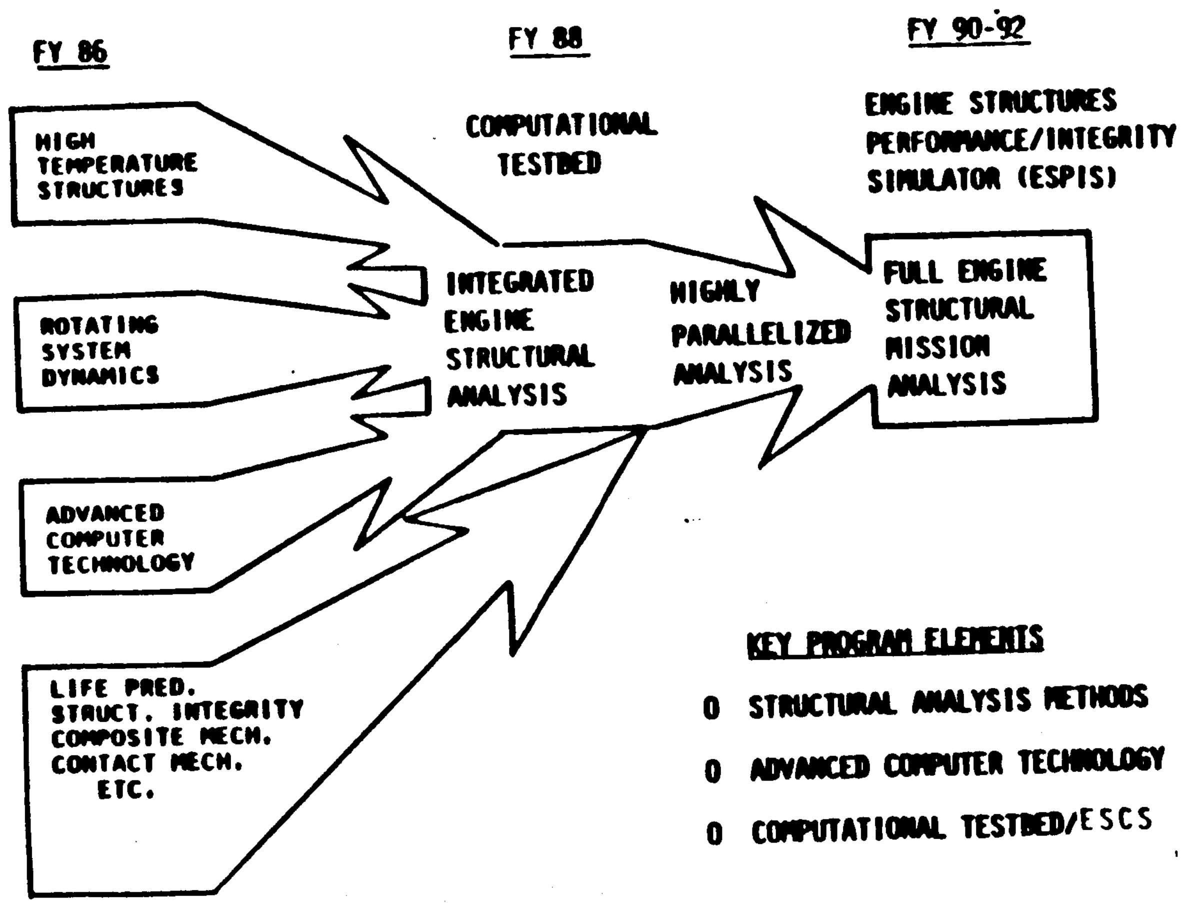

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KEY PROGRAM ELEMENTS

- O STRUCTURAL ANALYSIS METHODS
- O ADVANCED COMPUTER TECHNOLOGY
- O COMPUTATIONAL TESTBED/ESCS

THE GENERAL CONTENT OF THE CSM LEWIS PROGRAM PLAN IS SUMMARIZED IN THE ACCOMPANYING BLOCK DIAGRAM. THE LONG-RANGE OBJECTIVE OF THE PROGRAM IS THE FULL ENGINE STRUCTURAL SIMULATION.

COMPUTATIONAL STRUCTURAL MECHANICS

IDENTIFIED METHODOLOGY - IMPROVED/MISSING

- o BOUNDARY ELEMENTS FOR 3-D INELASTIC ANALYSIS
- o BOUNDARY ELEMENTS FOR HOT FLUID/STRUCTURE INTERACTION
- o EFFICIENT HYBRID ELEMENTS
- o ADAPTIVE TRANSITIONAL FINITE ELEMENTS
- o COMPUTATIONAL COMPOSITE MECHANICS
- o COMPUTATIONAL CONTACT MECHANICS
- o COUPLE COMPUTATIONAL SIMULATION WITH OPTIMIZATION

AN IMPORTANT PART OF THE CSM FOR ENGINE STRUCTURES PROGRAM IS THE IDENTIFICATION OF METHODOLOGY WHICH NEEDS IMPROVEMENT AND/OR IS MISSING. THIS METHODOLOGY INCLUDES SEVERAL KEY ELEMENTS AS LISTED IN THE ACCOMPANYING CHART.

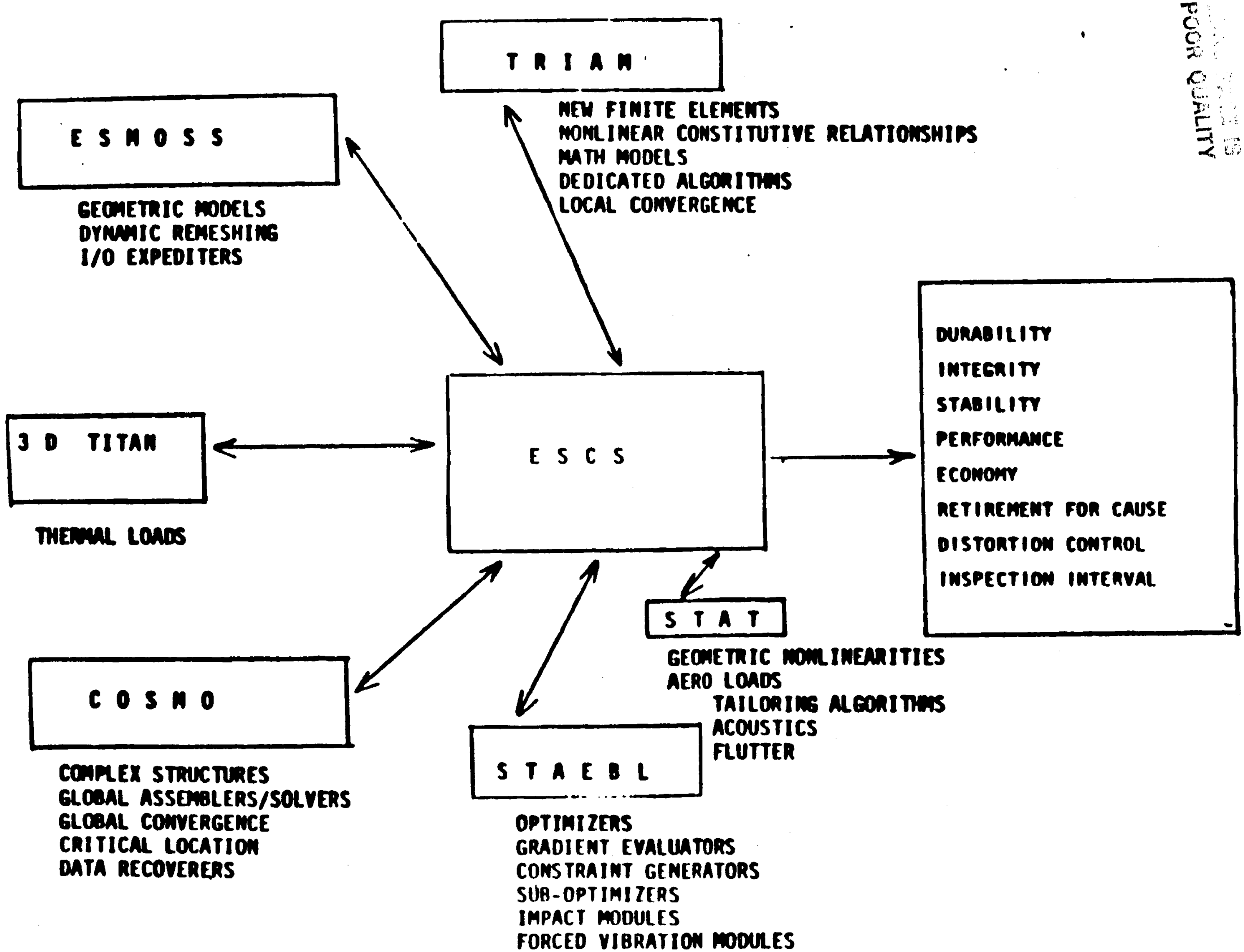
COMPUTATIONAL STRUCTURAL MECHANICS

IDENTIFIED METHODOLOGY - ALTERNATE

- o PROBABILISTIC/STOCHASTIC:
  - VARIATIONAL PRINCIPLES FOR PROBABILISTIC FINITE ELEMENT
  - PROBABILISTIC STRUCTURAL ANALYSIS METHODS
  - PROBABILISTIC FRACTURE MECHANICS
- o ALTERNATE FORMULATIONS:
  - MULTI-PARALLEL PROCESSORS FOR MULTI-DISCIPLINE MECHANICS PROBLEMS
  - SPECIALTY FUNCTIONS FOR SINGULAR MECHANICS PROBLEMS
  - COUPLED CONSTITUTIVE RELATIONSHIPS
  - DEDICATED EXPERT SYSTEMS

ANOTHER IMPORTANT PART OF THE CSM PROGRAM IS TO IDENTIFY ALTERNATE METHODLOGY FOR COMPUTATIONAL SIMULATION SUCH AS (1) PROBABILISTIC FOR QUANTIFYING THE ACERTAINTIES WITH ALL VARIABLES/PARAMETERS OF STRUCTURAL ANALYSIS/DESIGN AND (2) ALTERNATE METHODS/APPROACHES FOR FORMULATING STRUCTURAL MECHANICS PROBLEMS.

ENGINE STRUCTURES COMPUTATIONAL SIMULATOR (ESCS)



A MAJOR PART OF THE LEWIS CSM PROGRAM IS THE DEVELOPMENT OF ENGINE STRUCTURES COMPUTATIONAL SIMULATOR (ESCS). ESCS INTEGRATES DISCIPLINE SPECIFIC METHODOLOGY AND COMPUTER CODES DEVELOPED UNDER RESEARCH AND TECHNOLOGY PROGRAMS.

AEROSPACE TECHNOLOGY DIRECTORATE

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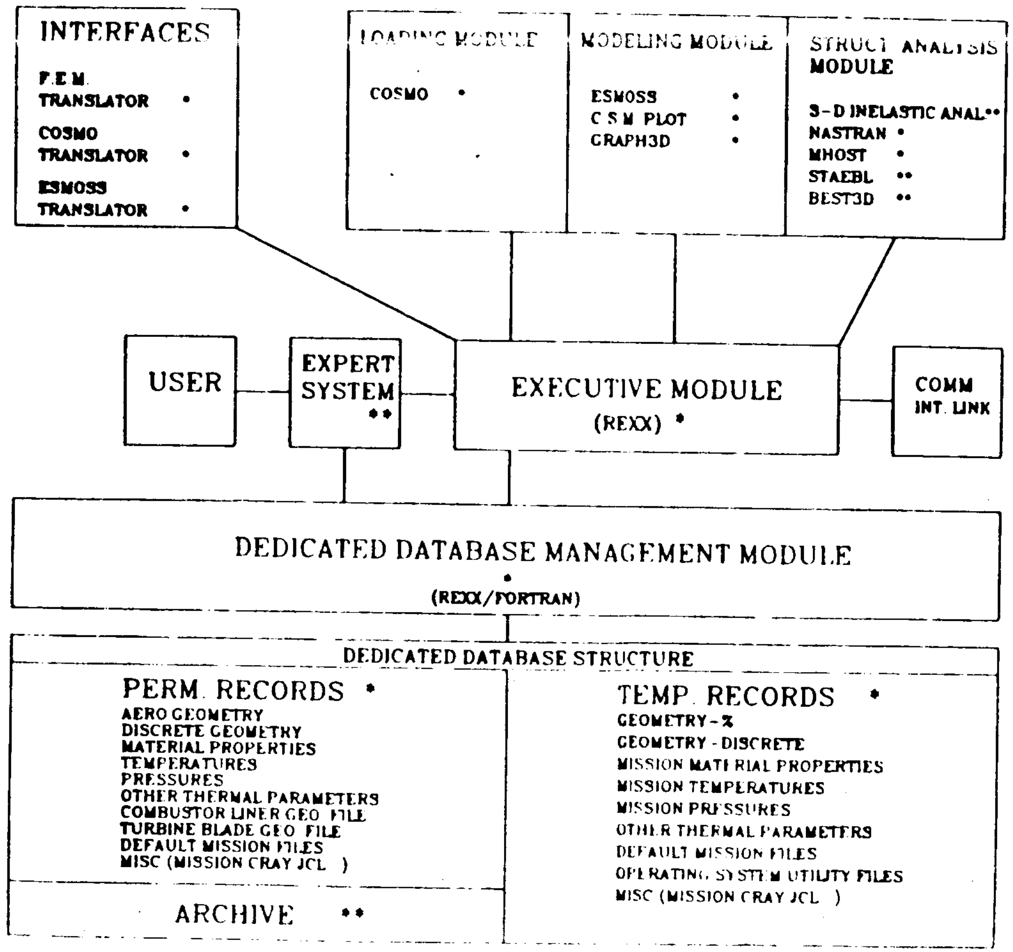
SIMULATOR ARCHITECTURE OF THE SOFTWARE SYSTEM



• - PRELIMINARY VERSION AVAILABLE

•• TO BE INSTALLED

ESCS IS MODULAR WITH AN EXPERT SYSTEM DRIVEN EXECUTIVE MODULE. IT INCLUDES INTERFACING MODULES, A DATABASE AND ITS MANAGER. A SCHEMATIC OF THE ESCS PRESENT STATUS CONFIGURATION IS SHOWN IN THE ACCOMPANYING CHART.

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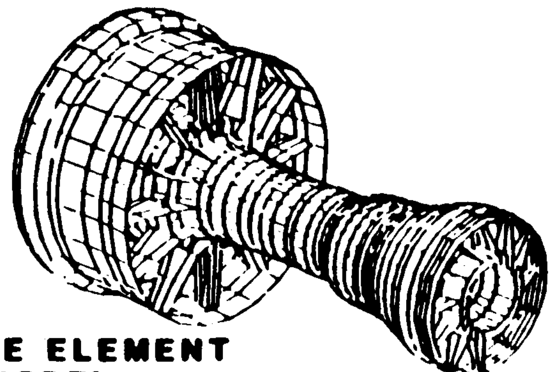
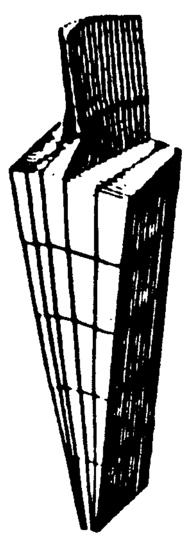
ENGINE STRUCTURES COMPUTATIONAL SIMULATOR

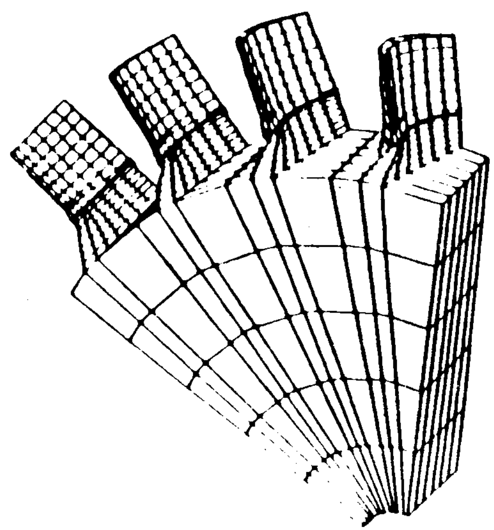
ENGINE



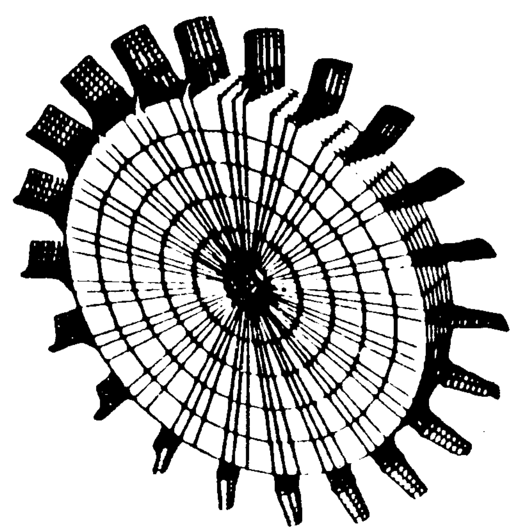
FINITE ELEMENT MODEL



BLADE



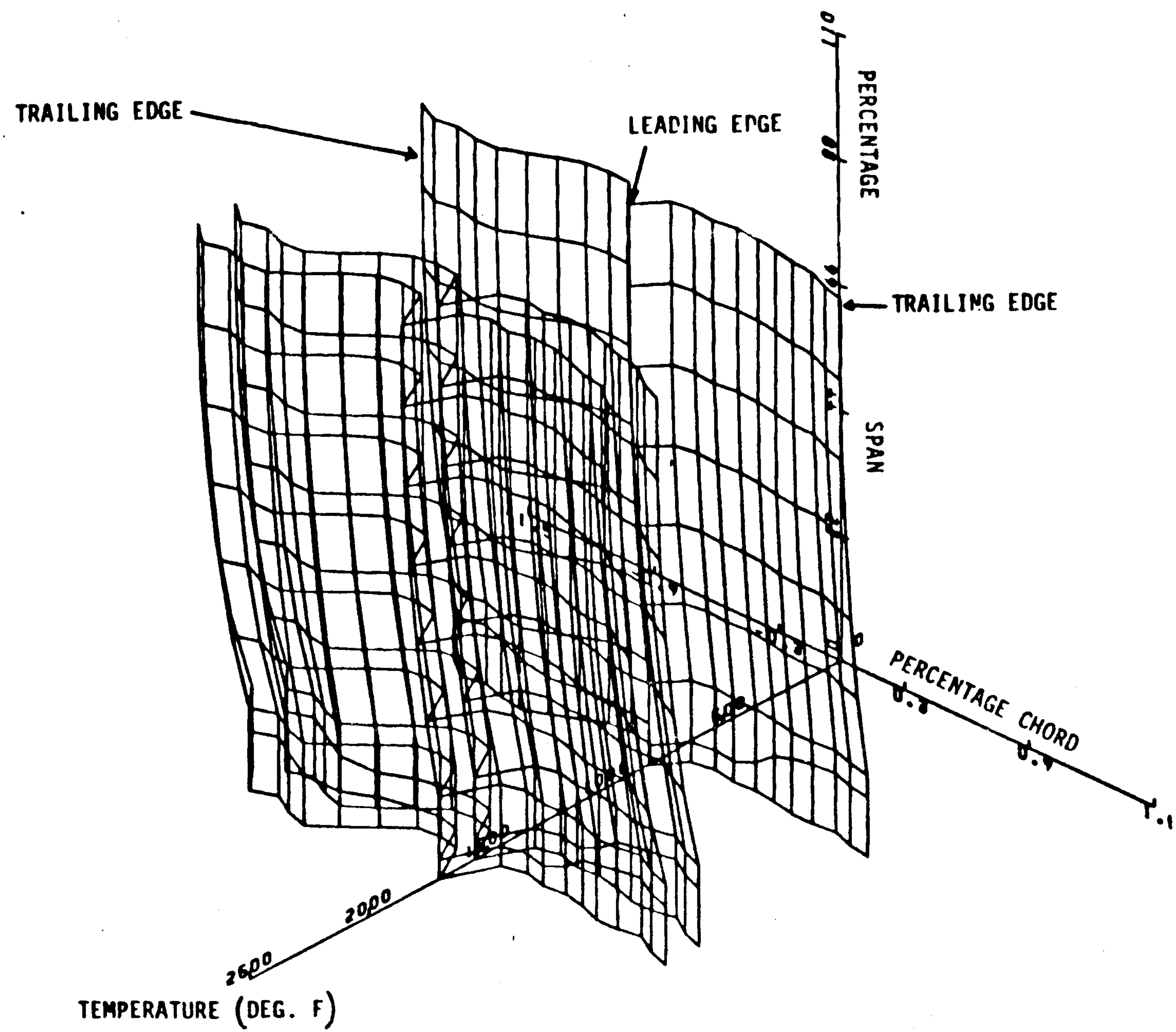
ROTOR SECTOR



ROTOR STAGE

ESCS IS CONFIGURED TO COMPUTATIONALLY SIMULATE THE STRUCTURAL PERFORMANCE OF ENGINE STRUCTURES: (1) SUBCOMPONENTS, (2) COMPONENTS, (3) SUBASSEMBLIES, (4) ASSEMBLIES AND (5) INTEGRATED SYSTEMS FOR MISSION SPECIFIED REQUIREMENTS.

SURFACE TEMPERATURE PROFILE FOR TURBINE BLADE



THE LOADS ON THE BLADES (TEMPERATURES, PRESSURES AND ROTATING SPEEDS) ARE DETERMINED BY AN ENGINE LOADS MODULE (COSMO IN THE ESCS SCHEMATIC). THIS MODULE IS BASED ON ENGINE THERMODYNAMICS. THE TEMPERATURES AND PRESSURES ARE PREDICTED ON THE SURFACE AT USER SELECTED SPAN STATIONS. THE ACCOMPANYING CHART IS A TYPICAL EXAMPLE FOR TEMPERATURES. THE BLADE HAS BEEN UNFOLDED FOR 3-D PLOTTING PRESENTATION.

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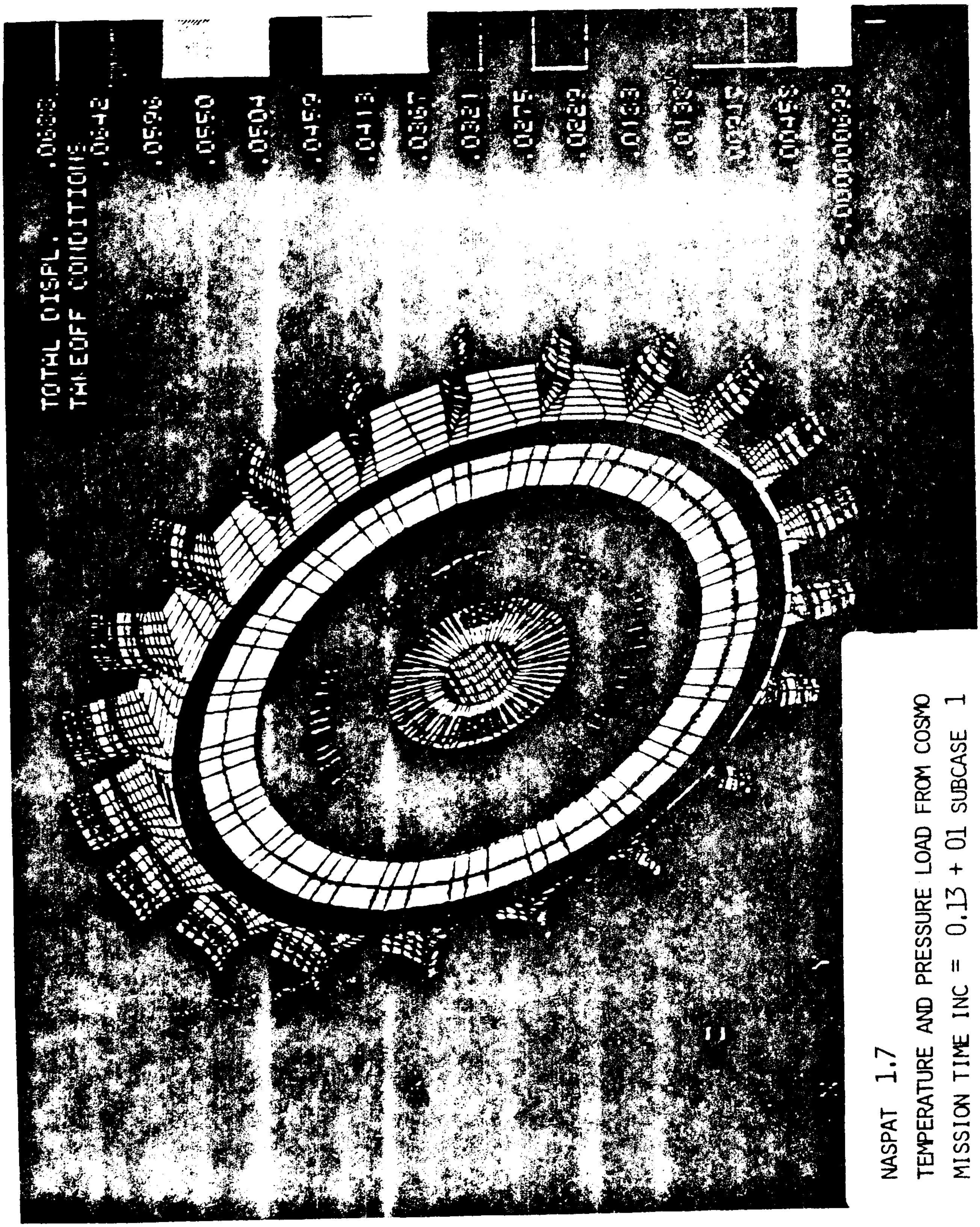
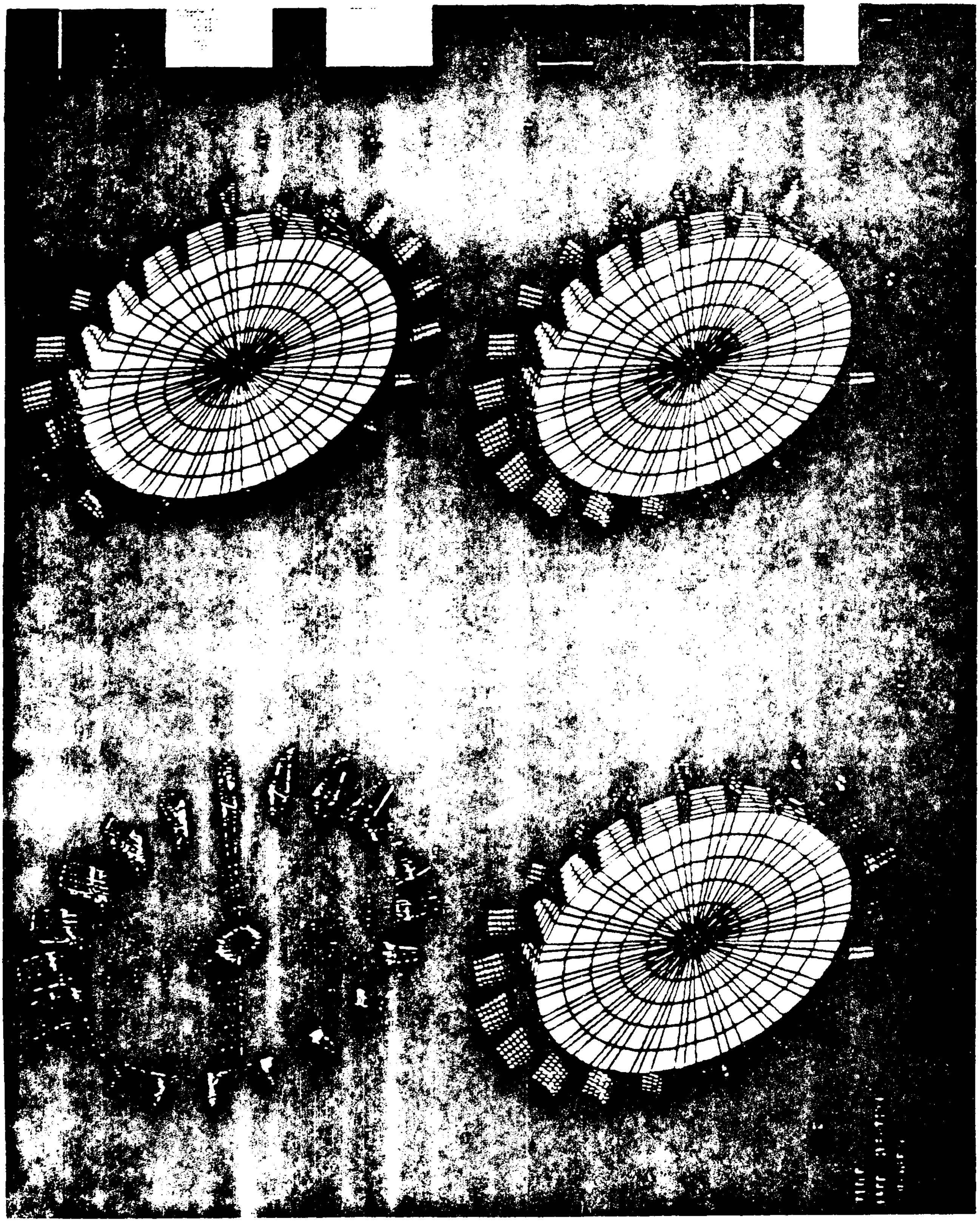


NASPAT 1.7
TEMPERATURE AND PRESSURE LOAD FROM COSMO
MISSION TIME INC = 0.13 + 01 SUBCASE 1

C-2

THE PRESSURE IS SIMILARLY REPRESENTED IN A 3-D PLOT.



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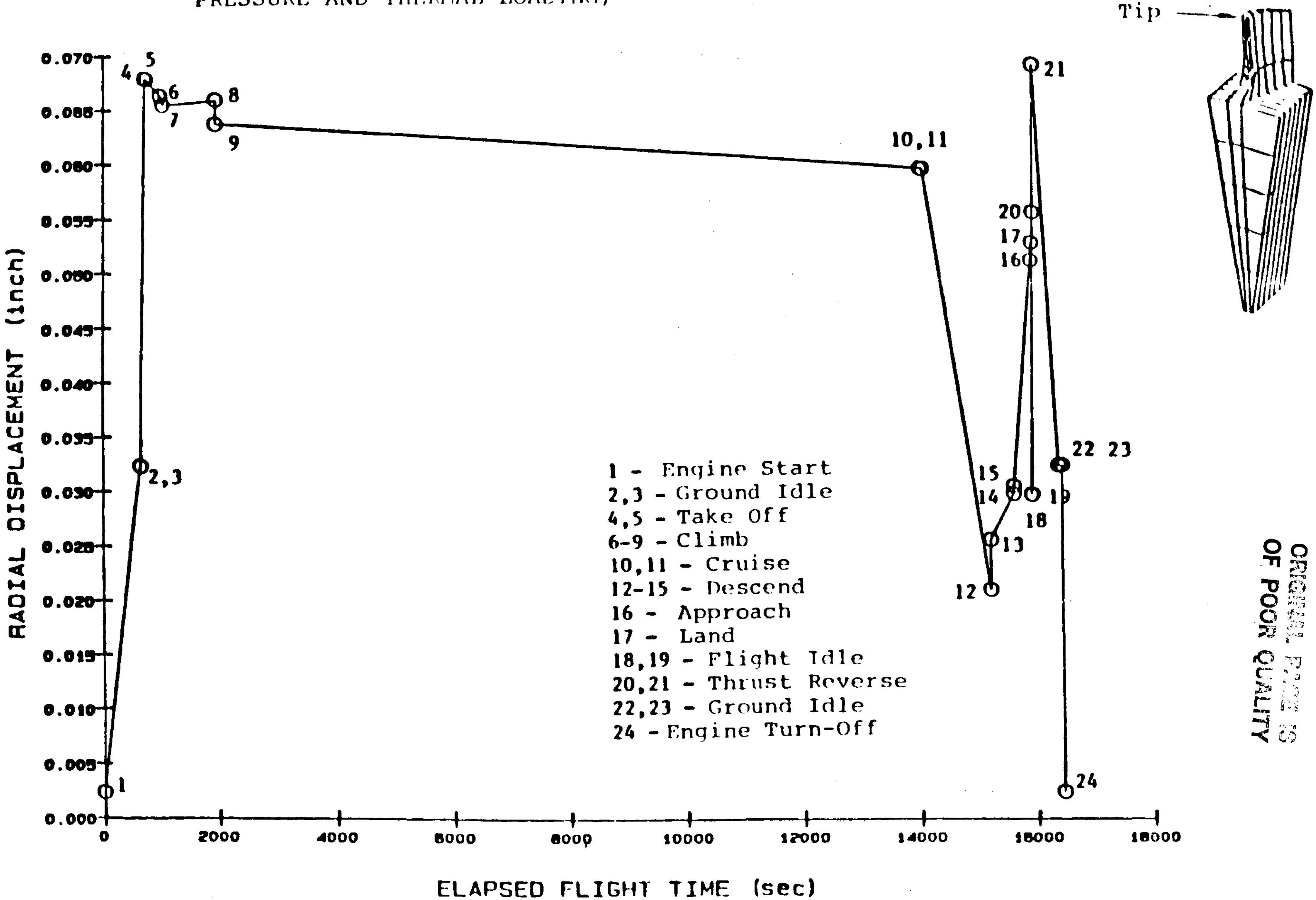
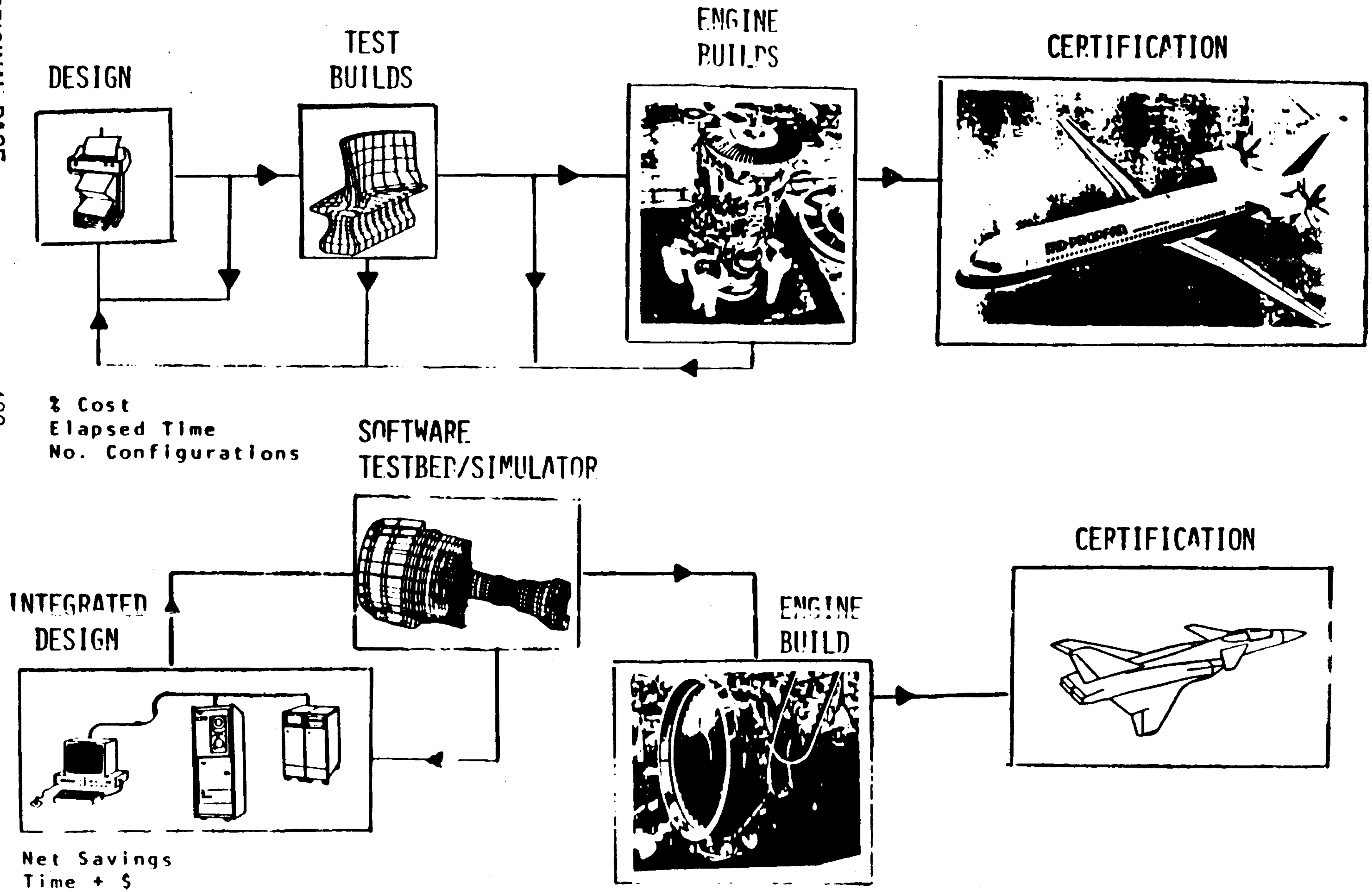
THE STRUCTURAL RESPONSE CAN BE PREDICTED THROUGHOUT THE MISSION. REPRESENTATIVE RESULTS FOR BLADE-TIP RADIAL DISPLACEMENT ARE SHOWN GRAPHICALLY AT IDENTIFIABLE STAGES DURING THE FLIGHT.

MHOST AS A MODULE IN THE ENGINE STRUCTURES COMPUTATIONAL SIMULATOR (CSM)

(RADIAL DISPLACEMENT OF LEADING EDGE TIP UNDER PRESSURE AND THERMAL LOADING)



THE LONG RANGE OBJECTIVE OF THE ESCS IS TO PROVIDE A COMPUTATIONAL SIMULATION THAT PARALLELS AND REPLACES, IN PART, THE CURRENT DEVELOPMENT METHODS WHICH MAKE EXTENSIVE USE OF EXPERIMENTAL PROCEDURES.



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POTENTIAL BENEFITS TO AEROSPACE INDUSTRY

- REDUCED DEVELOPMENT TIME AND COSTS
- FEWER DEVELOPMENT ENGINE BUILDS
- LONGER LIFE COMPONENTS
- REDUCFD LIFE CYCLE COSTS ON COMPONENTS
- REDUCED COMPONENT AND ENGINE WEIGHT
- IMPROVED ENGINEERING PRODUCTIVITY
- INCREASED PERFORMANCE

THE ANTICIPATED BENEFITS OF ESCS ARE SUMMARIZED, QUALITATIVELY, IN THE LAST CHART.