AIRFRAME MATERIALS FOR HSR

Thomas T. Bales
Materials Division
NASA Langley Research Center

High-Speed Research Workshop
Williamsburg, Virginia
May 14-16, 1991

Airframe Materials for HSR

Element Description

REQUIREMENT:

Advanced airframe materials and structures for achieving critical weight, durability and performance requirements for HSCT.

TECHNOLOGY NEED:

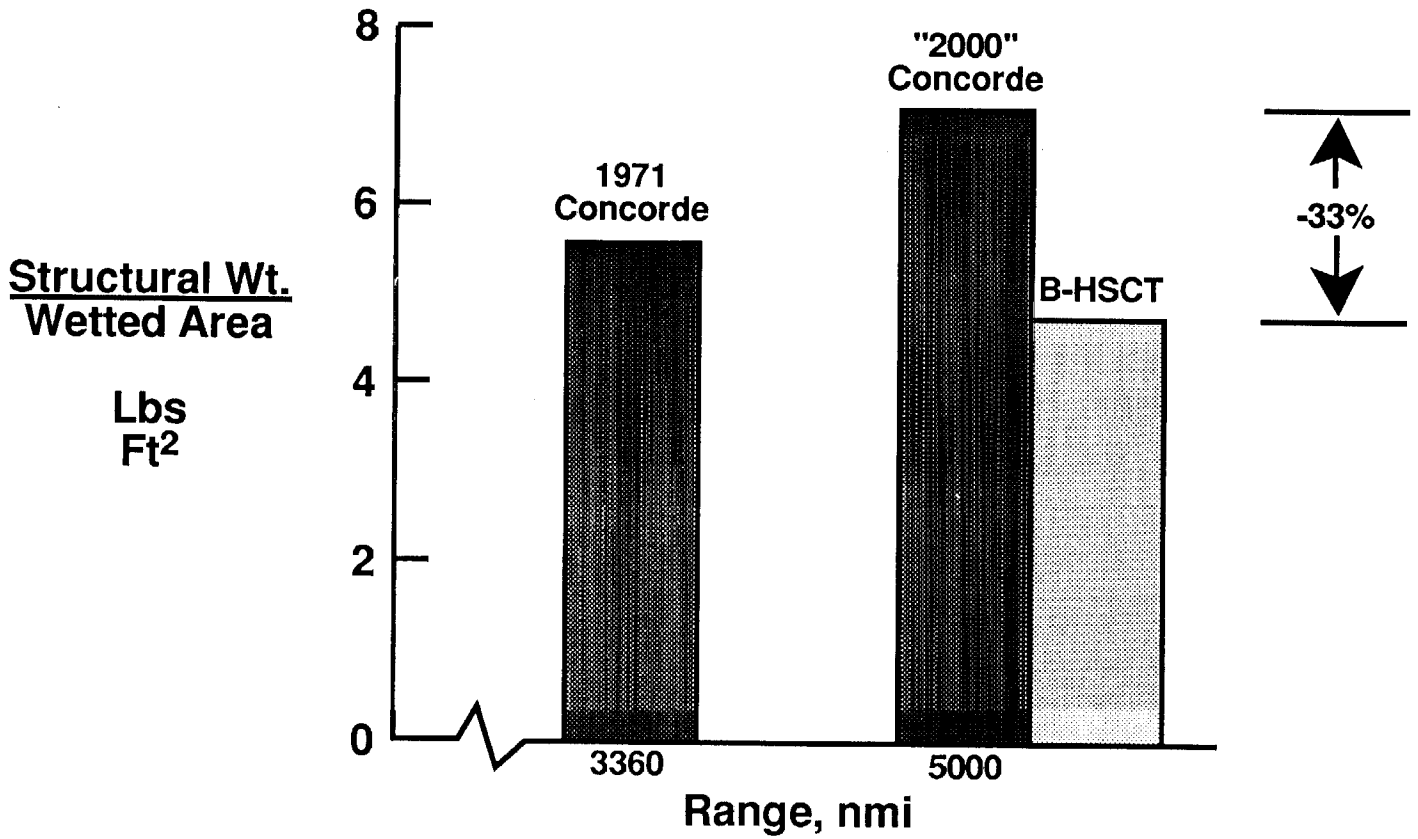
A. Structural weight ≤4.5 pounds per sq. ft. of wetted area

B. Materials with 60,000 hour life at elevated temperature - up to 400°F at M=2.5

C. Accelerated aging test methodology to predict long term performance of advanced materials

Airframe Materials for HSR

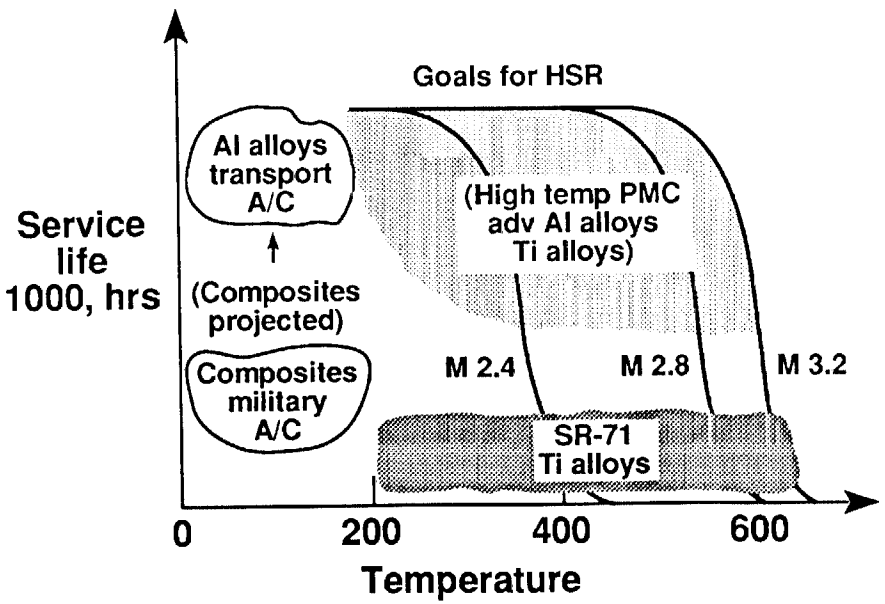
The Challenge



HSR AIRFRAME MATERIALS TECHNOLOGY

Key Issue

No long-term, high-temperature materials data base for HSCT airframes (60,000-hr design life, 120,000-hr fatigue life)

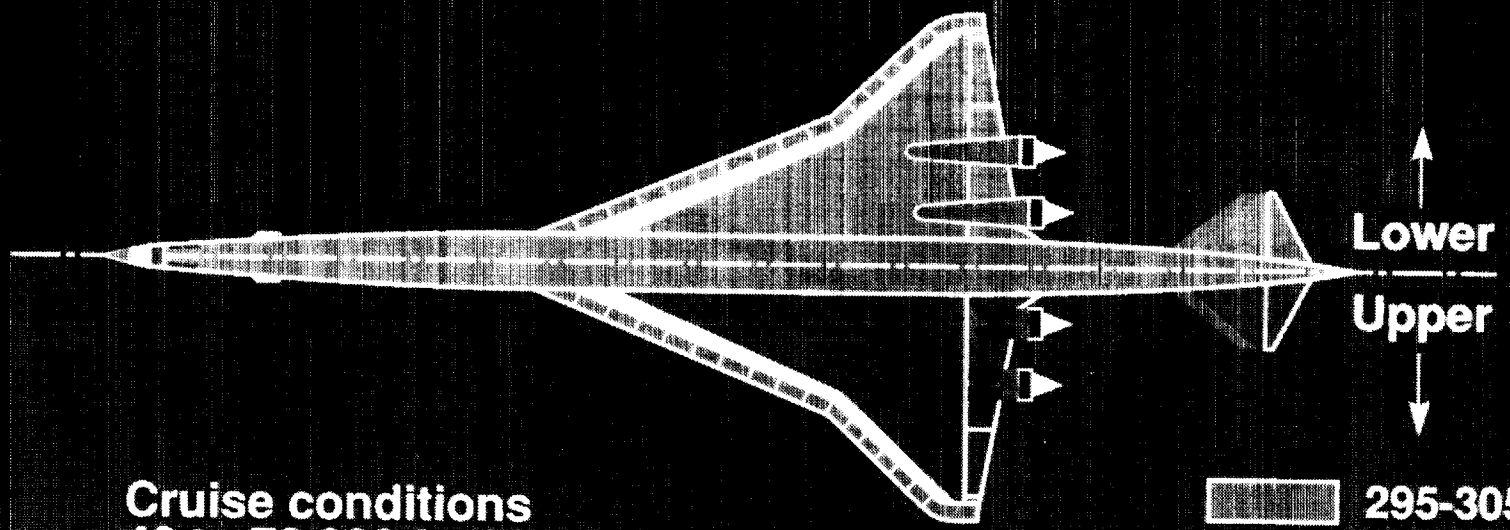


Key technology needs

- Life prediction methodology
  - Accelerated test procedures
  - Long-term flight simulation durability
- Demonstrated 300°- 500°F polymer matrices, adhesives and sealants for ≥ 60,000-hr lifetimes
- Demonstrated 300°- 600°F lightweight metals and metal matrix composites for ≥ 60,000-hr lifetimes

SKIN TEMPERATURES FOR M 2.4 TRANSPORT

Painted surface

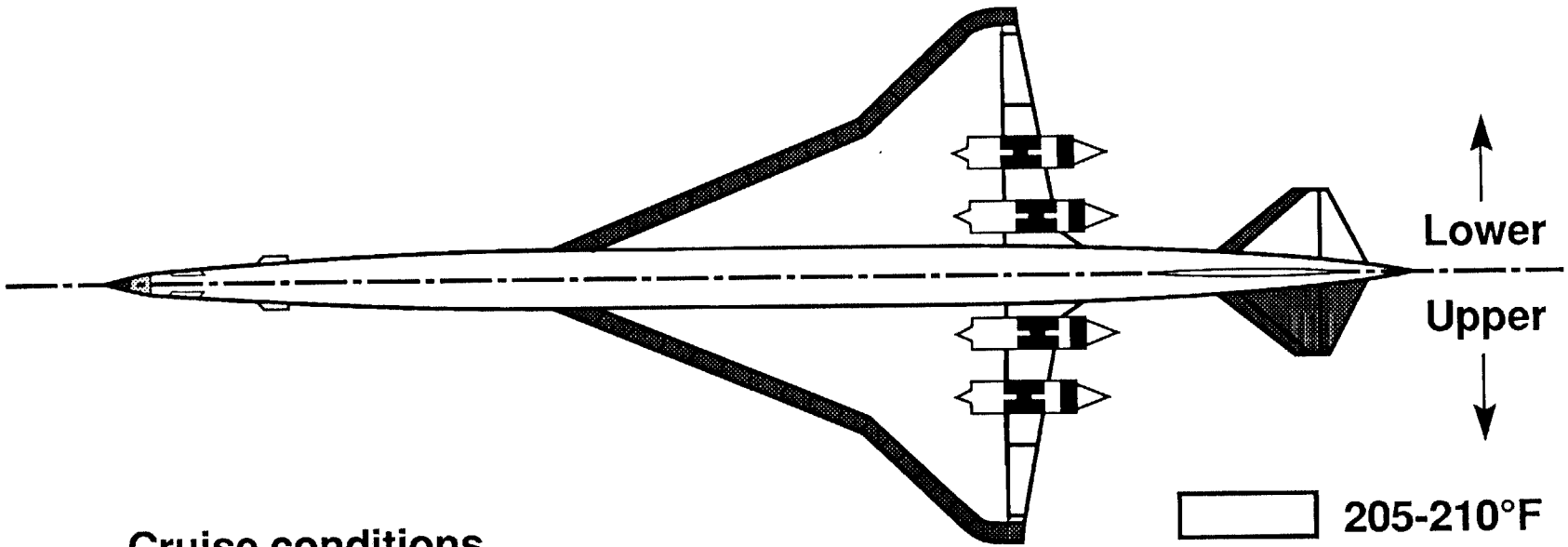


Cruise conditions
40 to 70,000 ft altitude
U.S. std. day

295-305°F
305 315°F
315-345°F
345-370°F

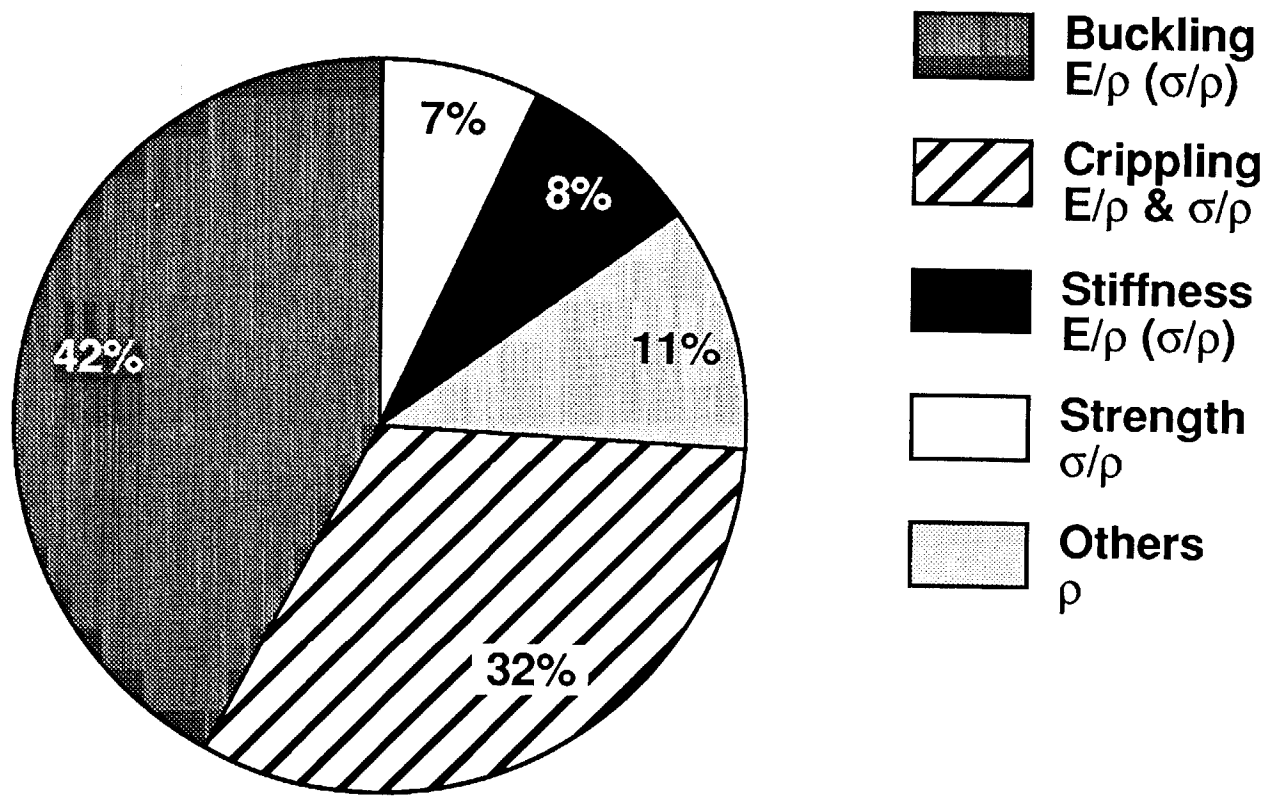
SKIN TEMPERATURES FOR M 2.0 TRANSPORT

Bare surface



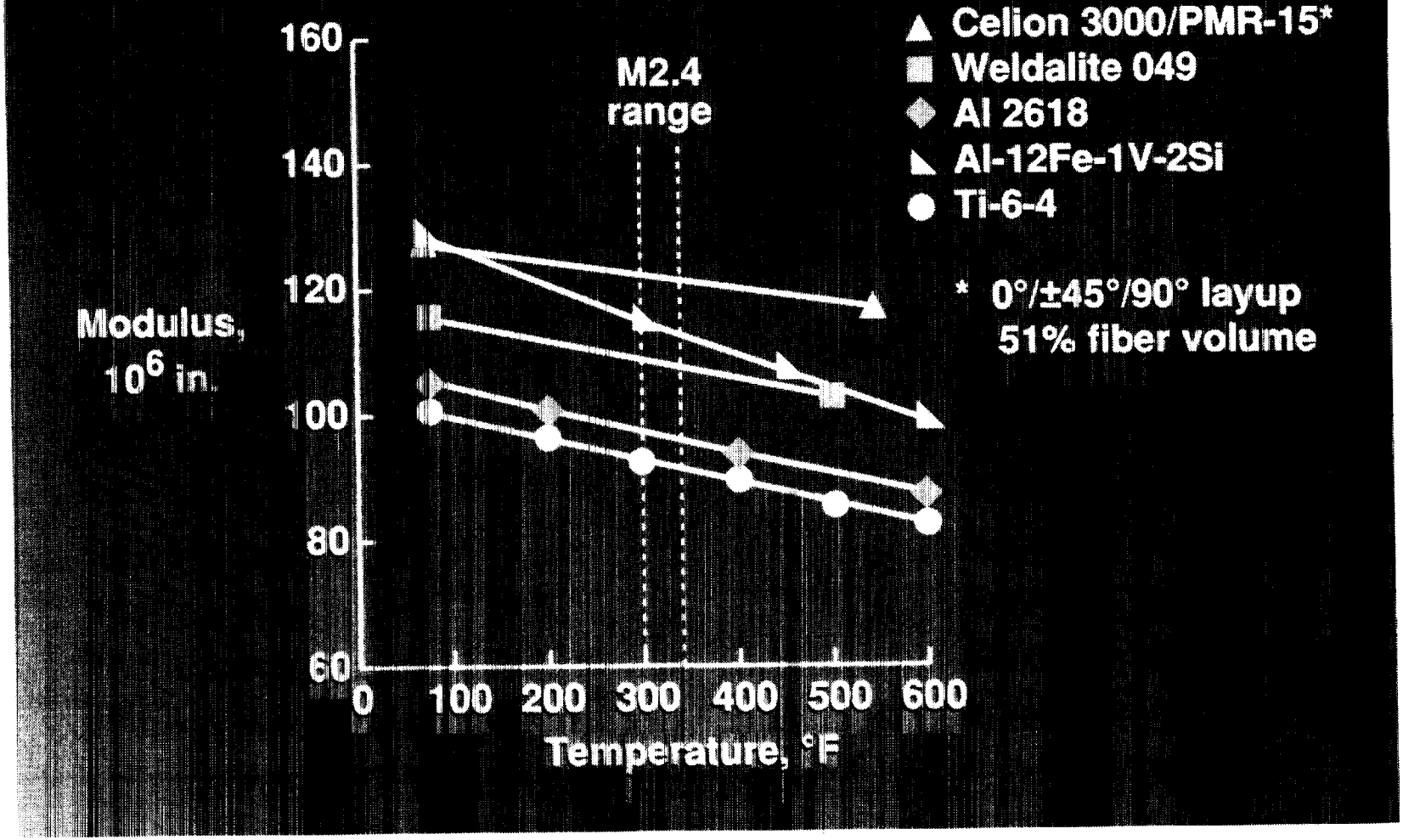
Cruise conditions
40 to 70,000 ft altitude
U.S. std. day

FAILURE MODE WEIGHT DISTRIBUTION FOR HSCT (DOUGLAS)



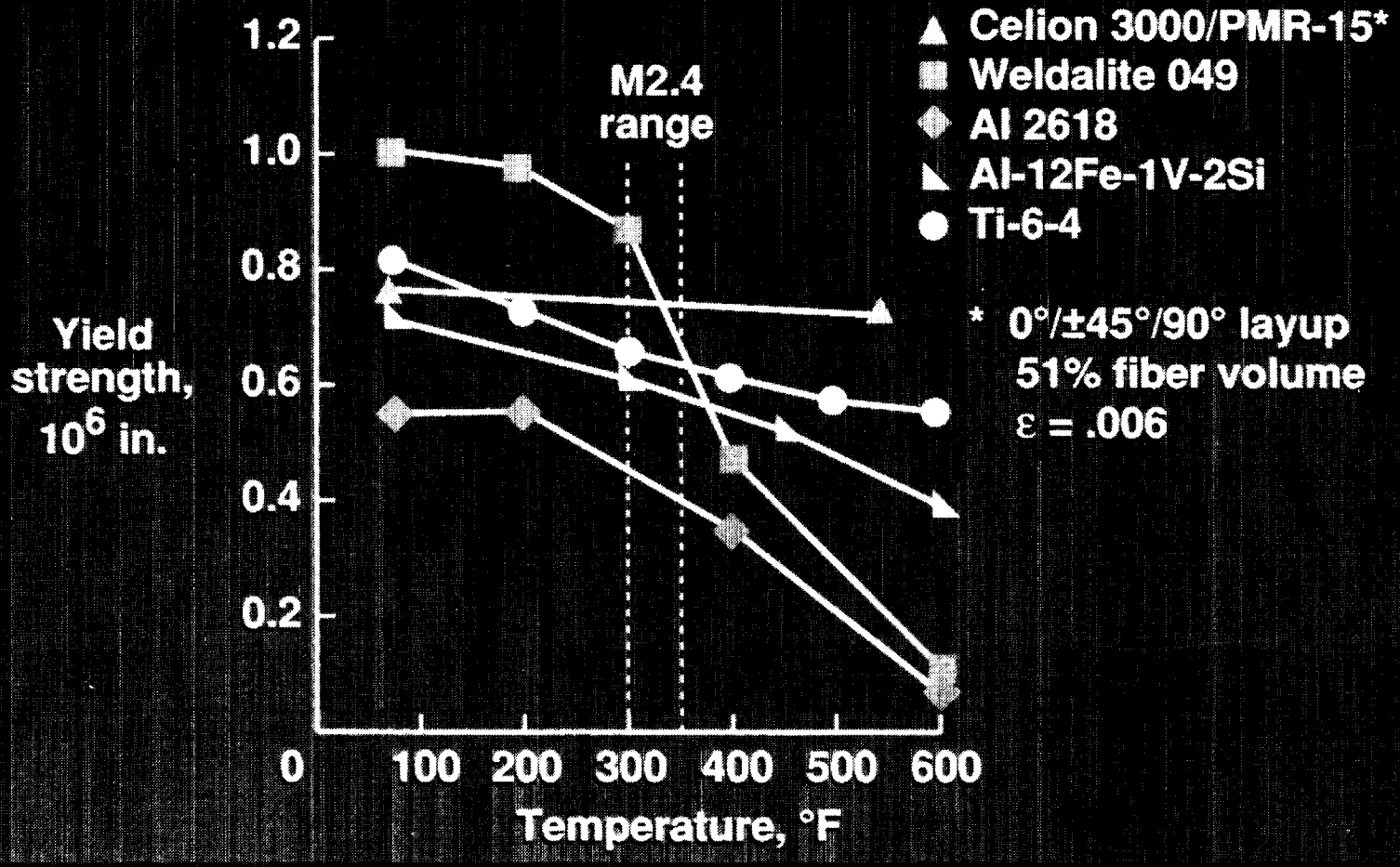
Primary Structure Weight Breakdown

SPECIFIC TENSILE PROPERTIES AS A FUNCTION OF TEST TEMPERATURE



SPECIFIC TENSILE PROPERTIES AS A FUNCTION OF TEST TEMPERATURE

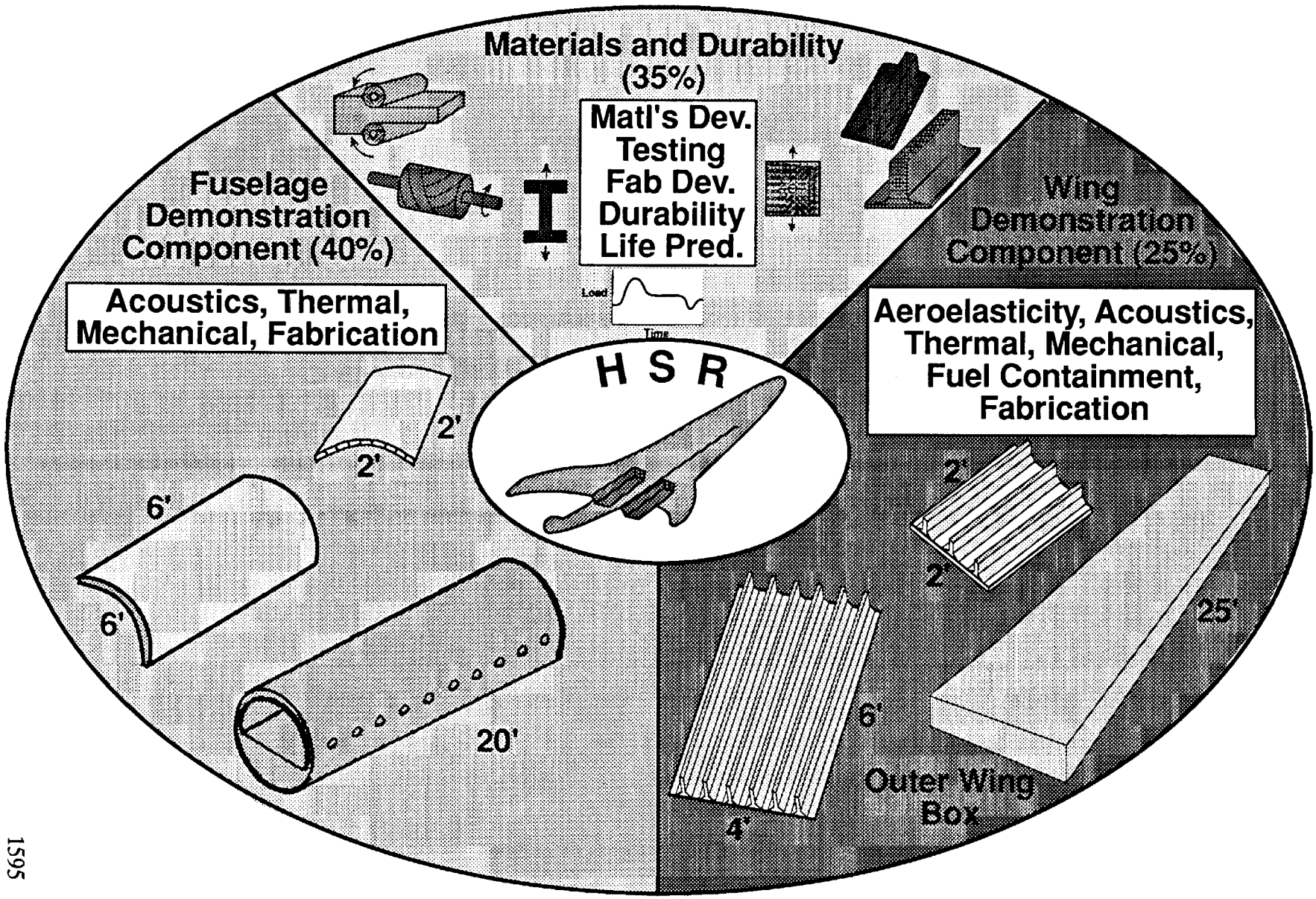
100 hours exposure at test temperature



Candidate Resins for HSCT

- Bismaleimides including toughened versions
- PMR-15 including modified versions
- Polyimides (thermoplastics, semi-crystalline TP)
- Poly(arylene ether)s
- Emerging systems (e.g. benzocyclobutenes)

Airframe Materials for HSR



Airframe Materials for HSR

Prime Candidate Airframe Materials

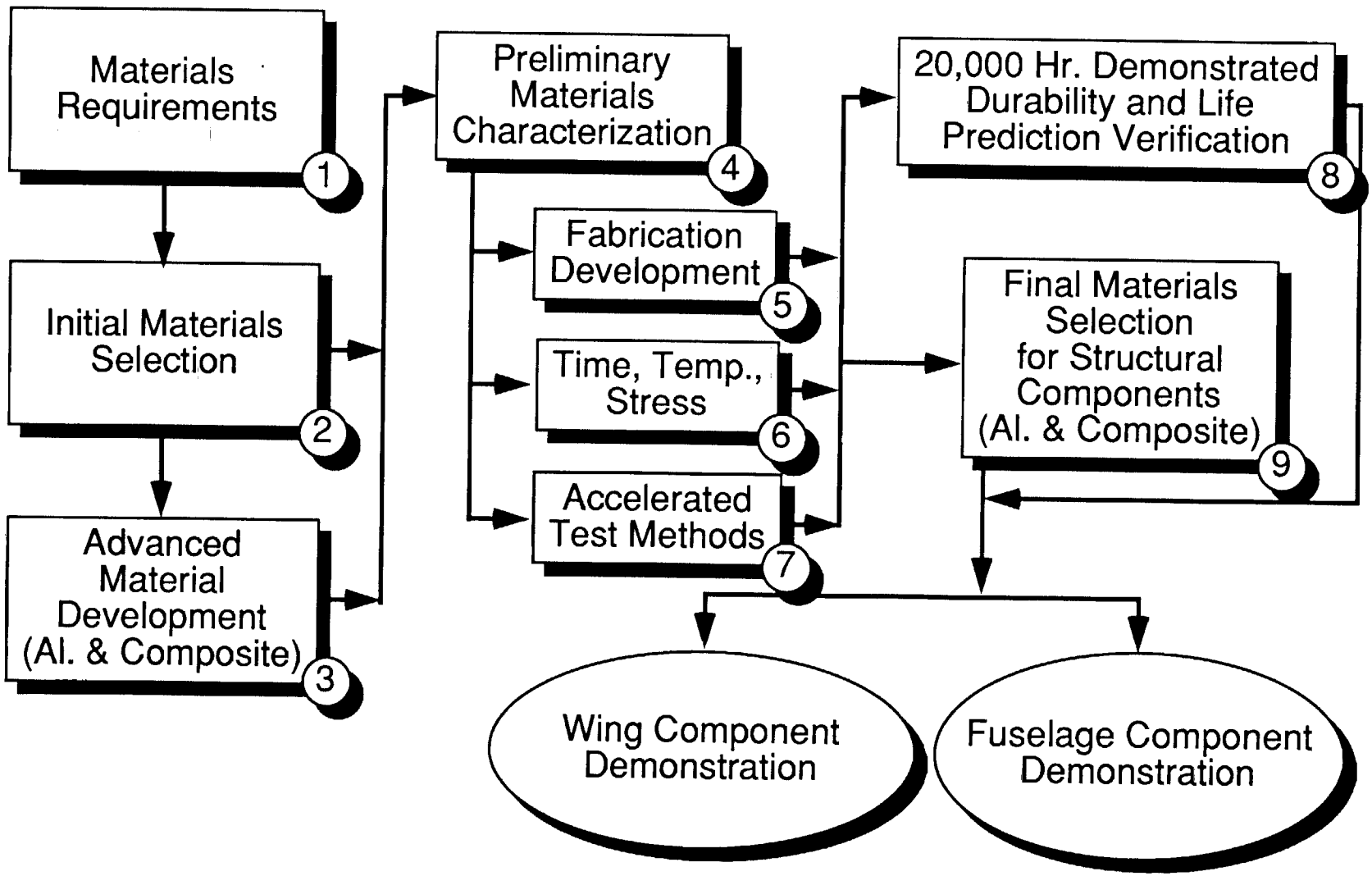
- High Temperature Composites
  (3/4 Program)

- High Temperature Aluminum
  (1/4) Program

Airframe Materials for HSR

B. Materials and Durability

Approach



Airframe Materials for HSR

B. Materials and Durability

1 Material Requirements

2 Initial Material Selection

3 Advanced Materials Development

4 Prel. Materials Characterization

5 Fabrication Development

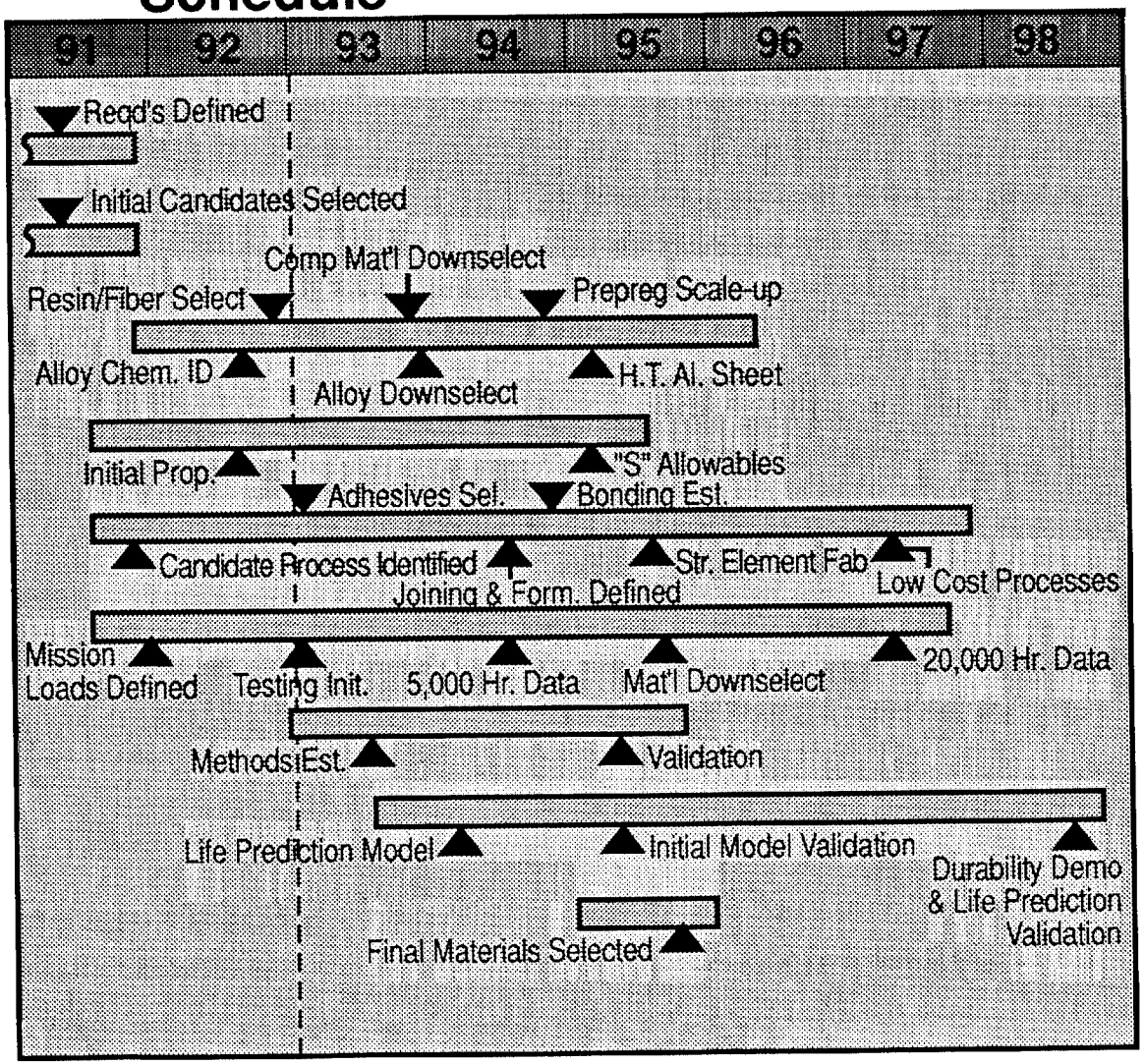
6 Time, Temp., Stress Testing

7 Accelerated Test Methods

8 Durability/Life Prediction

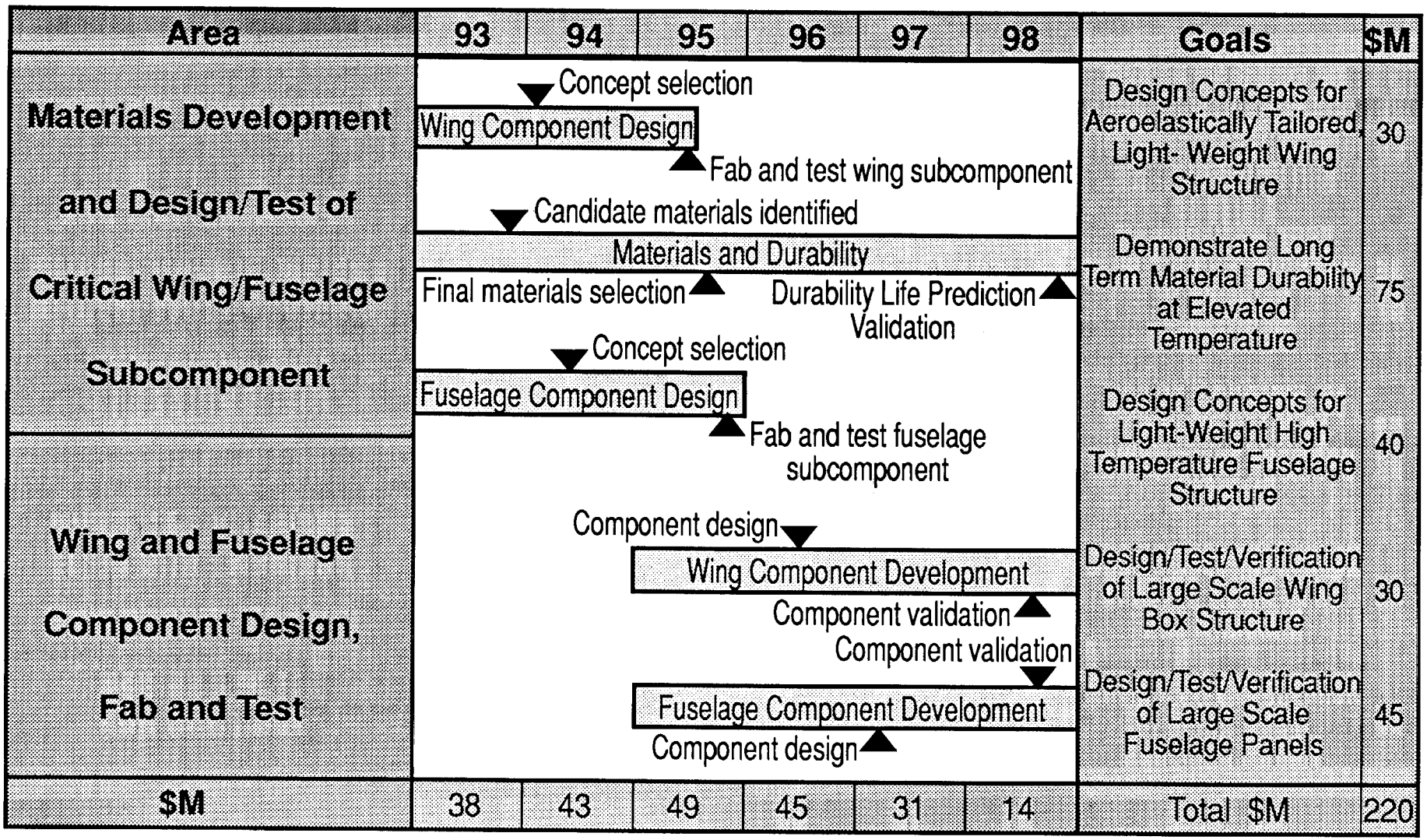
9 Materials Selection for Wing and Fuselage Components

Schedule



Airframe Materials for HSR

High Speed Research Program - Phase II Schedule



Airframe Materials for HSR

GOAL:

Verified materials and structural concepts that meet performance requirements for HSCT

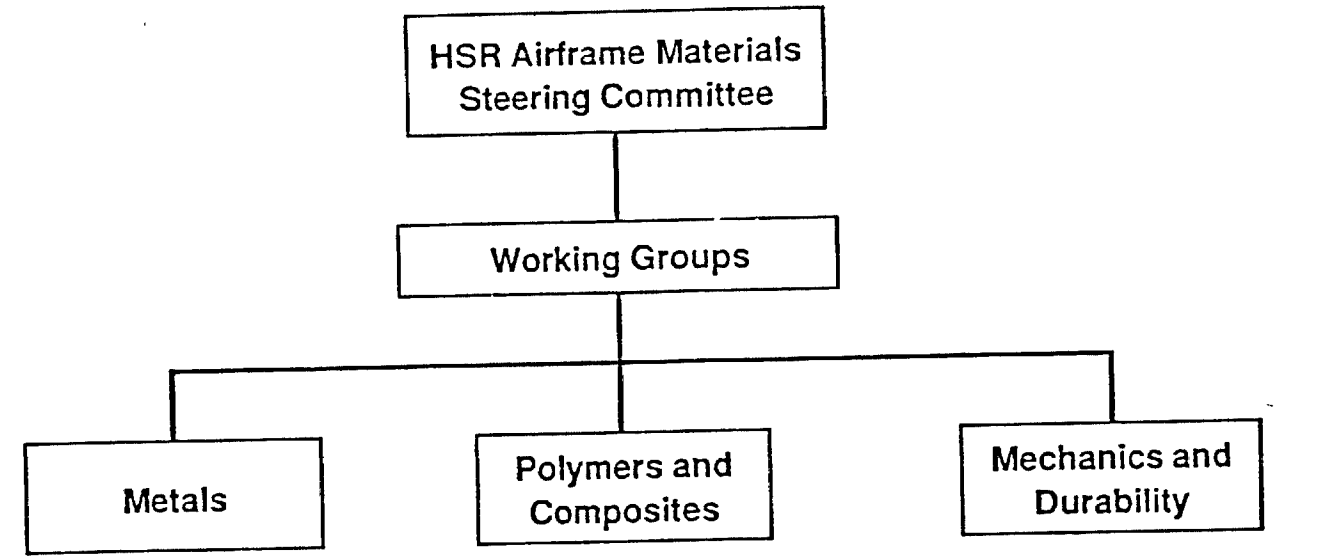
DELIVERABLES:

- Aluminum alloy and resin matrix composite materials with long term durability at 400°F and ≥20% strength/stiffness improvement compared to titanium.
- Light weight (≤4.5 lbs./ft^2) cost-effective structural concepts for wing and fuselage
- Accelerated aging test methodology for predicting long term durability of materials.

AIRFRAME MATERIALS FOR HSR

Status

- Resources from the ACT program rolled over to initiate HSR Materials Program
- Working groups in metallics, polymeric composites and durability established with representation from NASA, airframers, material producers, and universities
- Trade studies being conducted by Boeing and Douglas to define material requirements
- Screening of commercially available materials (metal and composites) initiated in-house
- Upgrade of test facilities for durability program and material characterization initiated



Steering Committee

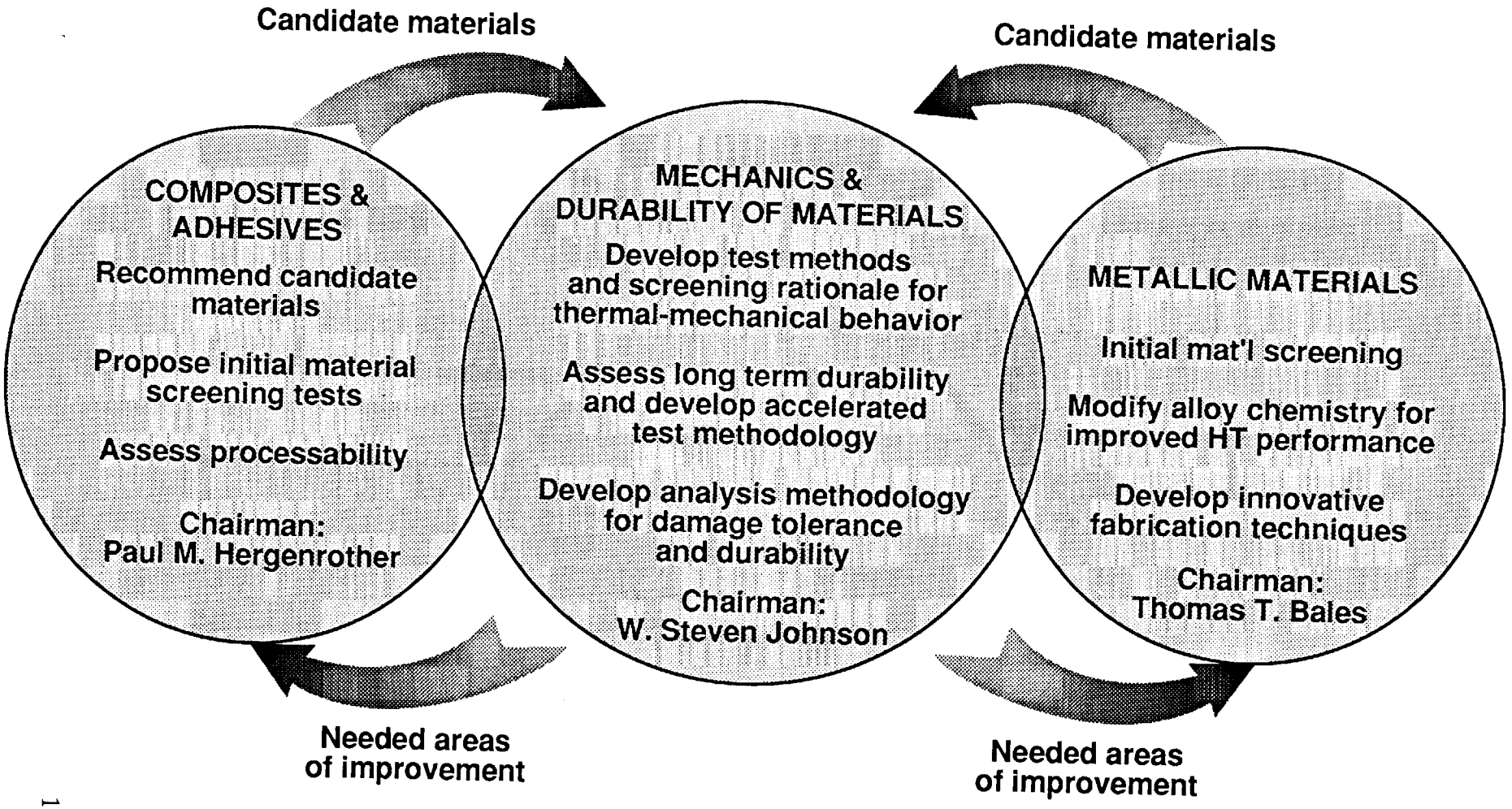
- Provide guidance to NASA on overall airframe materials program including technical thrusts, implementation strategy, allocation of resources, coordination and advocacy

Working Groups

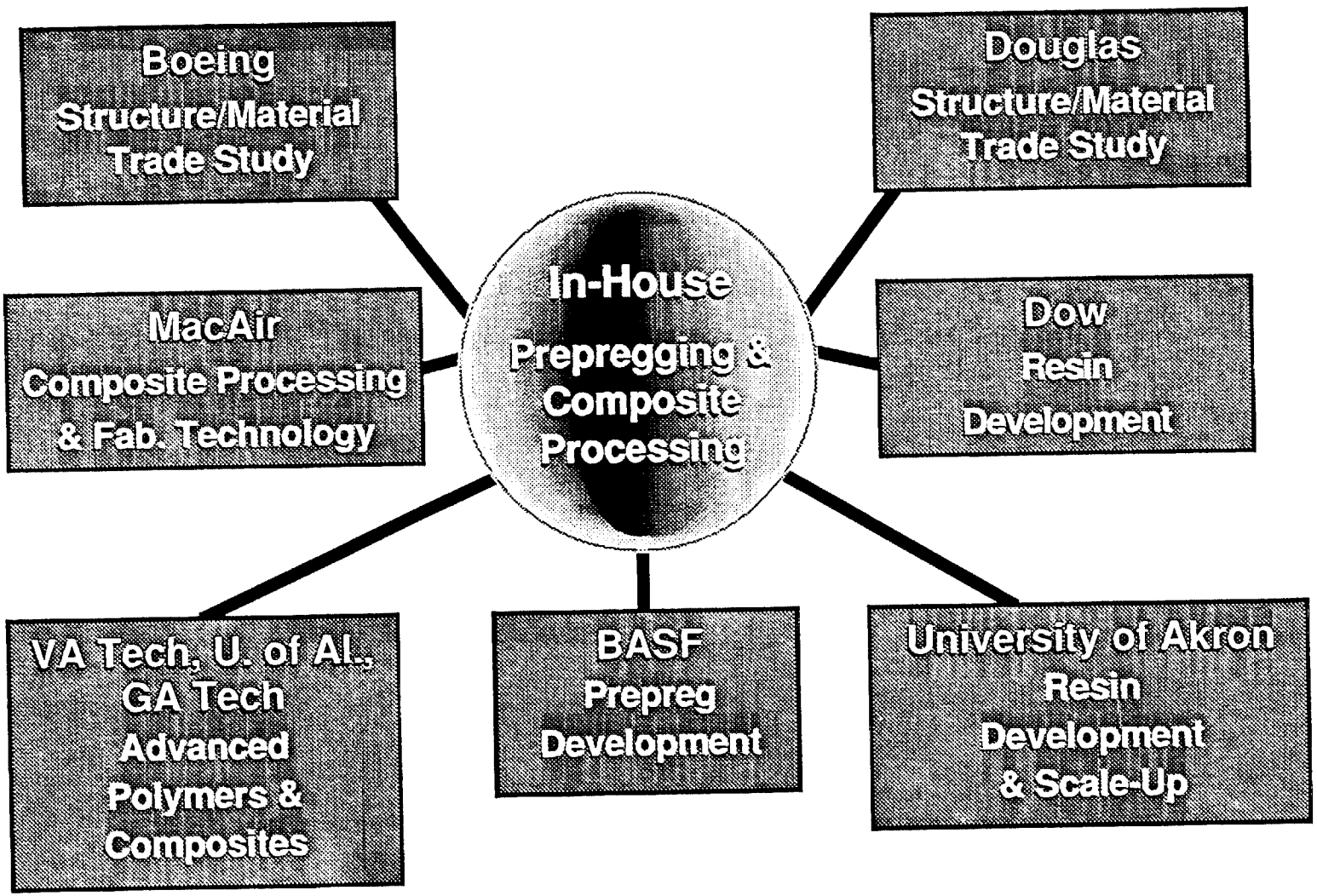
- Assist NASA in planning research thrusts in metals, composites and mechanics including identification of key technology needs, implementation strategy, teaming arrangements, coordination between government, airframes, and material suppliers, and testing and analyses activities

HSCT STRUCTURAL MATERIALS DEVELOPMENT/EVALUATION PROGRAM

NASA-LaRC/Industry Working Groups



HIGH SPEED CIVIL TRANSPORT
Composites



AIRFRAME MATERIALS FOR HSR

Procurement Strategy

- NASA Research Announcements (NRA) - February 1992
  - Material systems modification
  - Process development
  - Understanding of materials degradation
- Omnibus Task Contracts - May 1992
  - Material and design requirements
  - Fabrication technology
    - Structural Elements
    - Built-up components

AIRFRAME MATERIALS FOR HSR

Concluding Remarks

- Materials may prove to be an enabling technology for an economically viable HSCT
- Both resin matrix composites and metallics are considered viable candidates for HSCT
- Airframe materials program needs to be accelerated to meet projected materials selection date