INTEGRATED AIRFRAME TECHNOLOGY: the Future of Advanced Composites

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TRANSPORTATION BEYOND 2000

Engineering Design for the Future

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NASA Langley Research Center, Hampton, VA

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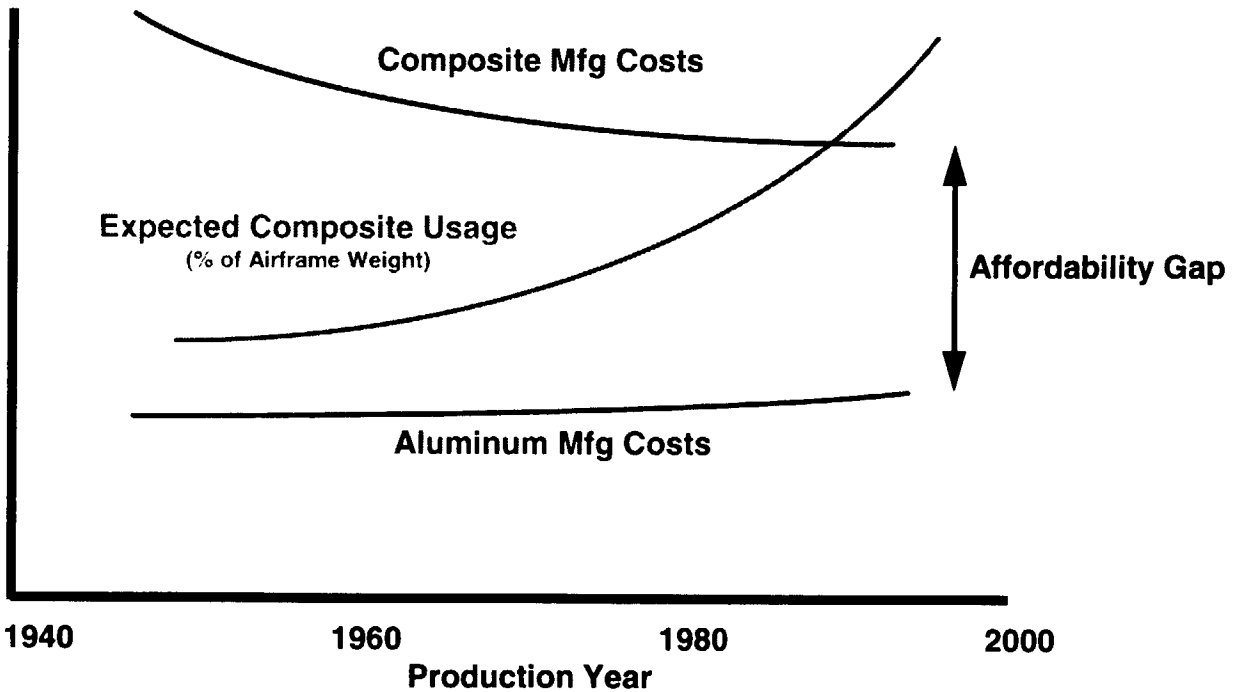
Cost Trend

- Increased Demand for Performance with a Decreasing Tolerance for Cost



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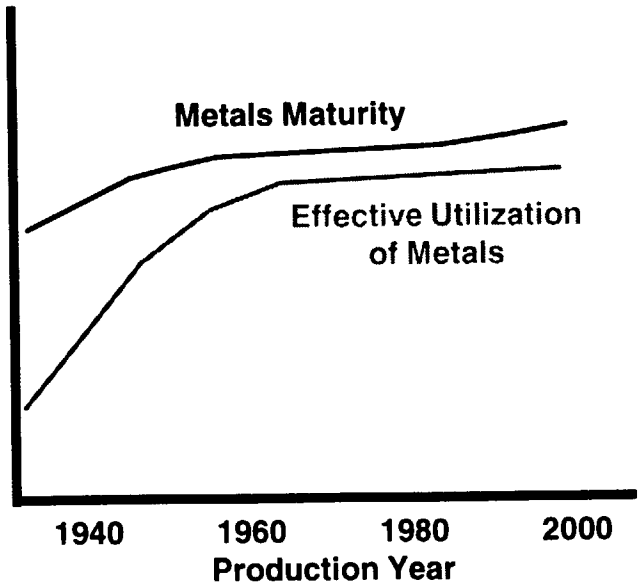
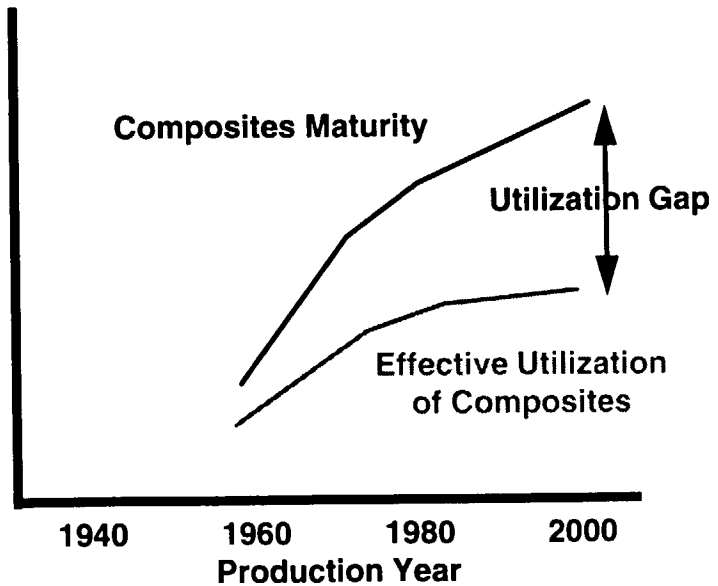
Technology Trend

- A gap exists between the potential of advanced composites and our ability to effectively utilize them (cost/weight)





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The Challenge

- Airframes must provide ever increasing performance at an ***affordable*** cost
- ***Breakthrough*** cost reduction compared to current airframe technology
- Design and Manufacturing ***Integration...***

Strategy

- ***A new paradigm:*** revolution in the integration of design and composite manufacturing
- ***System level focus:*** must provide space for innovation, primarily composites
- Tie to real aircraft ***performance*** needs
- Small, creative, ***highly focused*** team
- ***Interdependent*** Issues: Design, Tooling, Fab, Assy
- Must build to demonstrate ***feasibility***, ***path to production***

Integrated Airframe Paradigm

- Three Facets of Integration:
  - Integration of components to form fewer, larger, globally complex components
  - Integration of design with composite material unique characteristics and material forms
  - Integration of design with cost effective attributes of existing and emerging manufacturing technologies

Integrated Airframe Paradigm

- Multi-Functional Components
- Fastenerless Assembly
- Structure-as-Tooling
- Highly Tailored, Continuous Load Paths
- Marry Design with Fab / Assy
- Integral Wing / Fuselage
- Electron Beam Curing, Fiber Placement, Large Scale Resin Infusion
- ***Expand Traditional Solution Space***

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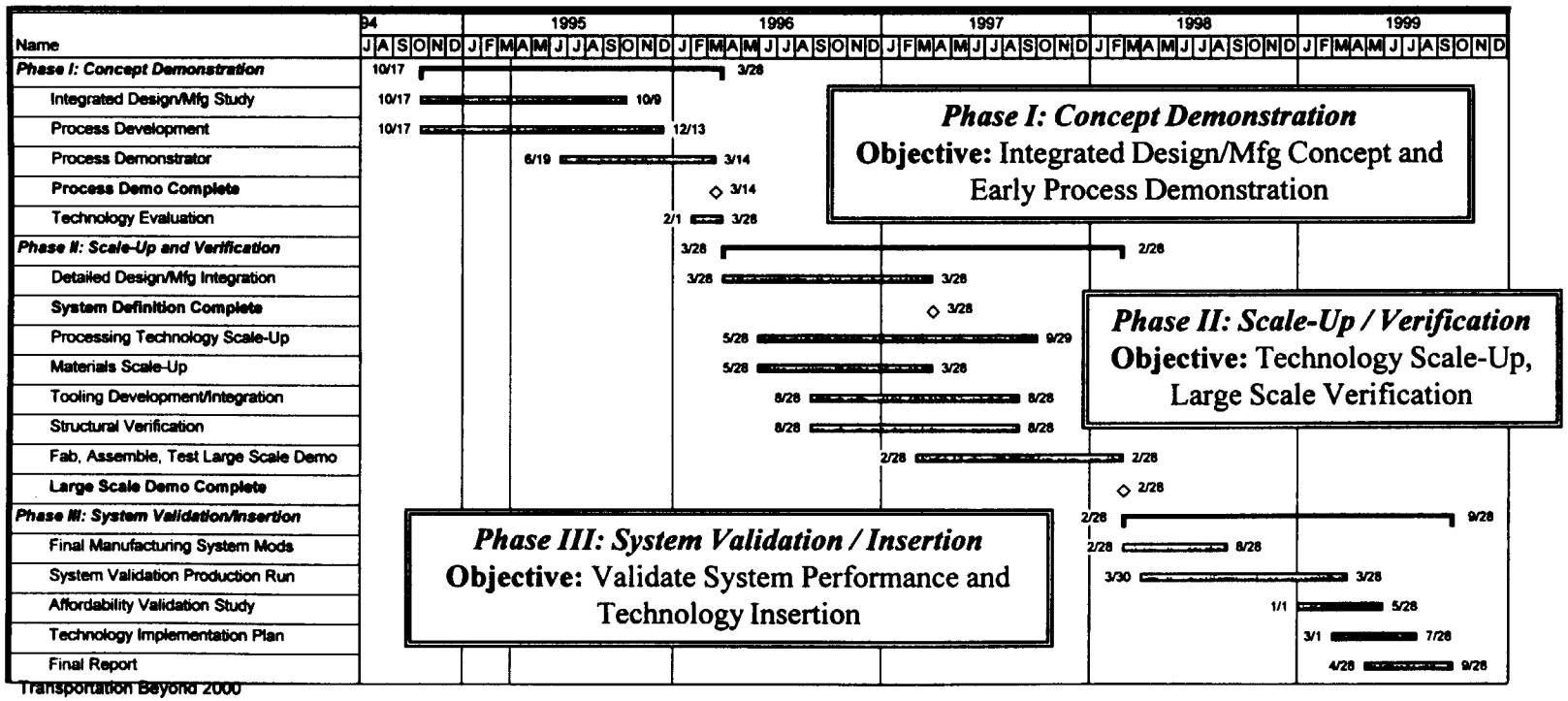
IATA Mission Statement

*Develop and Demonstrate a **System** which Integrates Composite Specific Design Approaches with Cost Effective Manufacturing Technologies to Produce **Affordable**, High Performance Carbon **Composite** Aircraft Structures in **Prototype or Production** Quantities*



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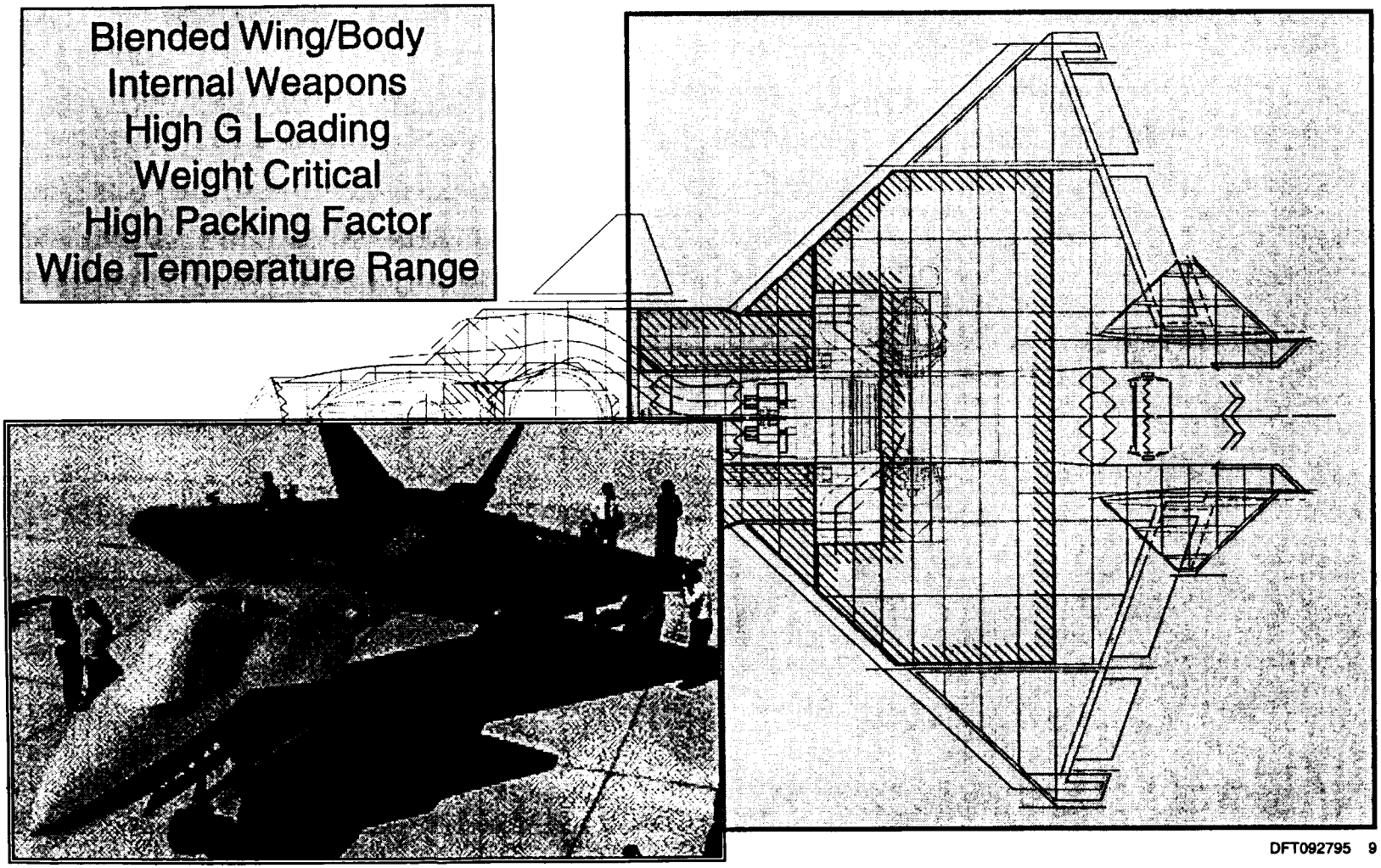
JAST/ASTOVL
Configuration 140

- Blended Wing/Body
- Internal Weapons
- High G Loading
- Weight Critical
- High Packing Factor
- Wide Temperature Range



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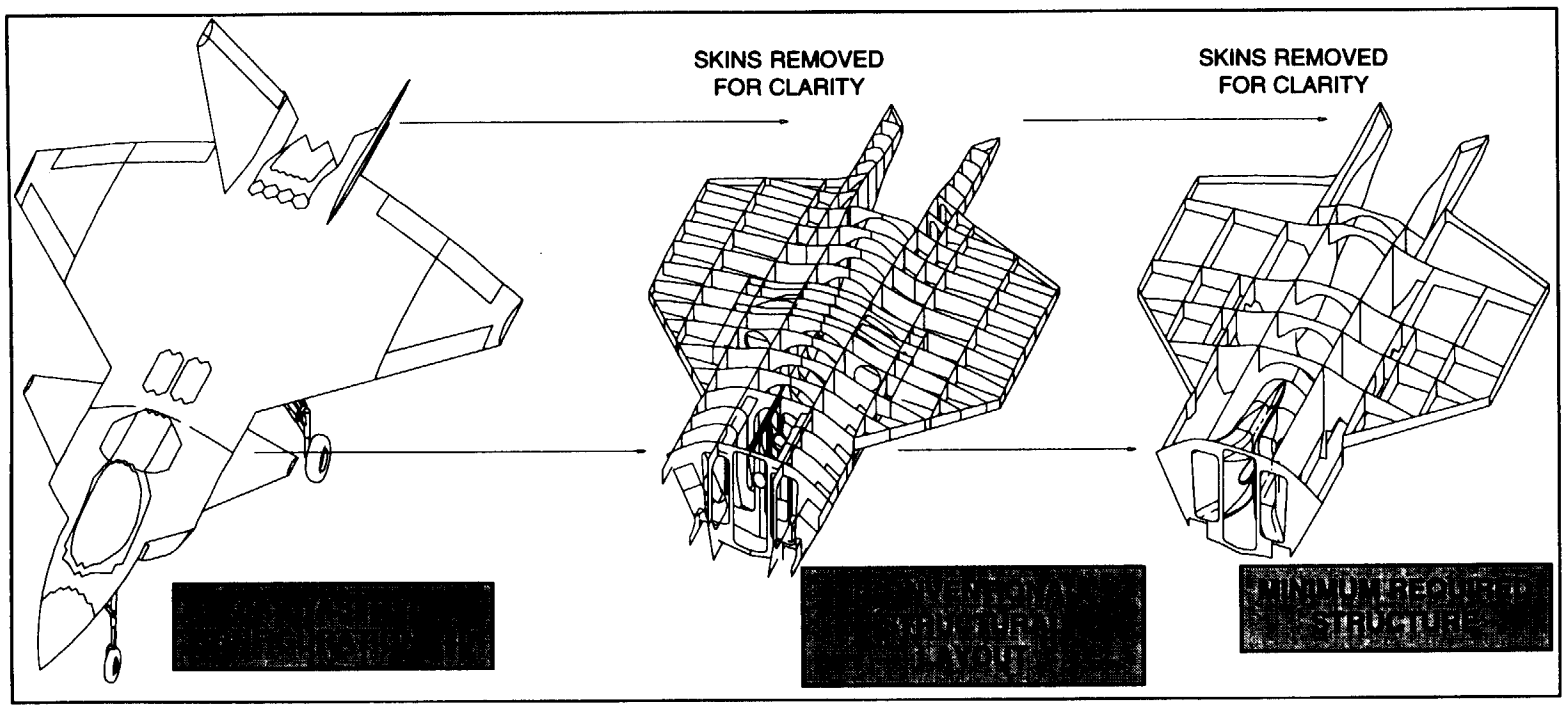
IATA Design Space

- A component must "earn its way" onto the airframe
- Multi-functional structure



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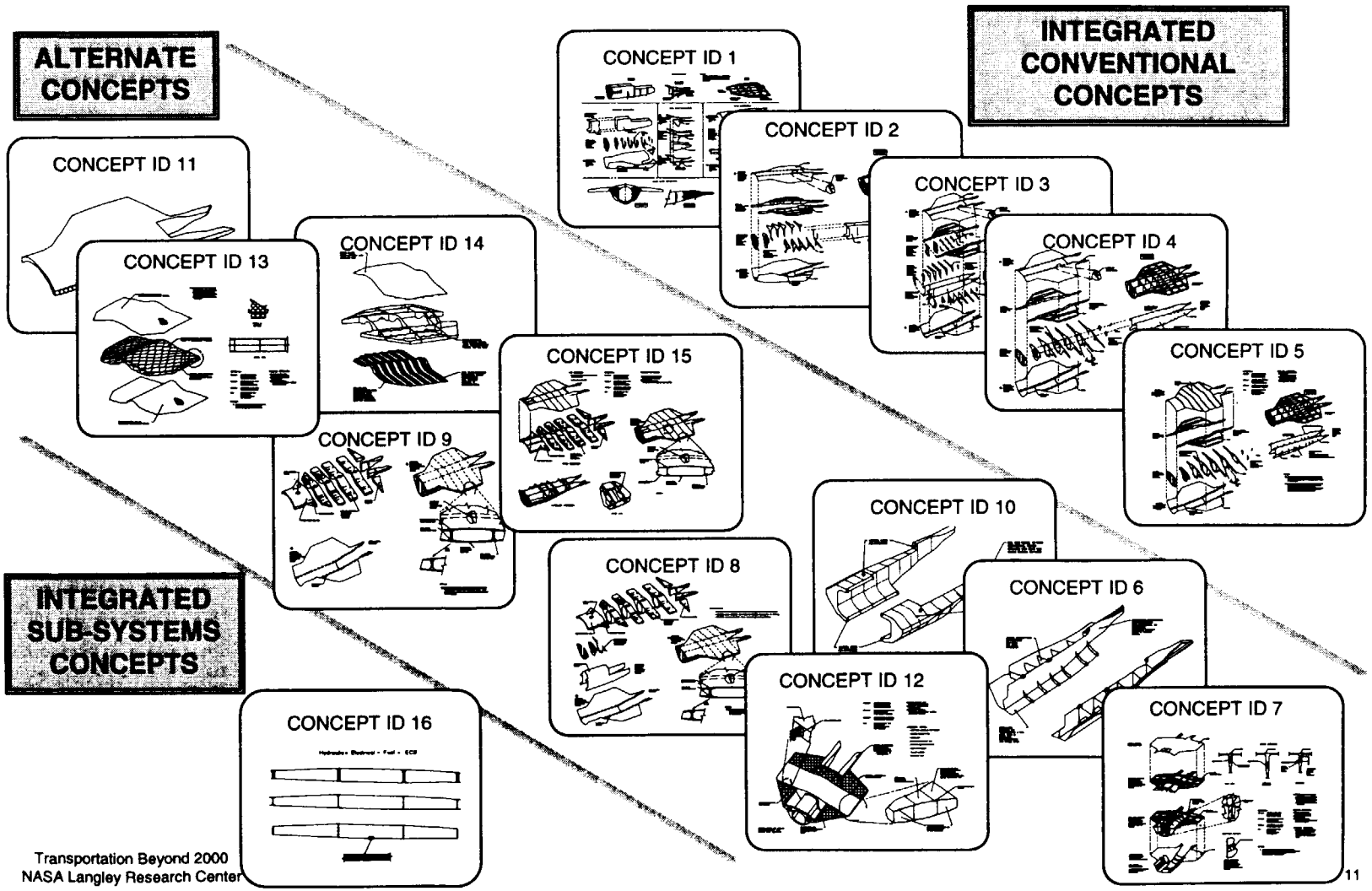
Preliminary Concepts



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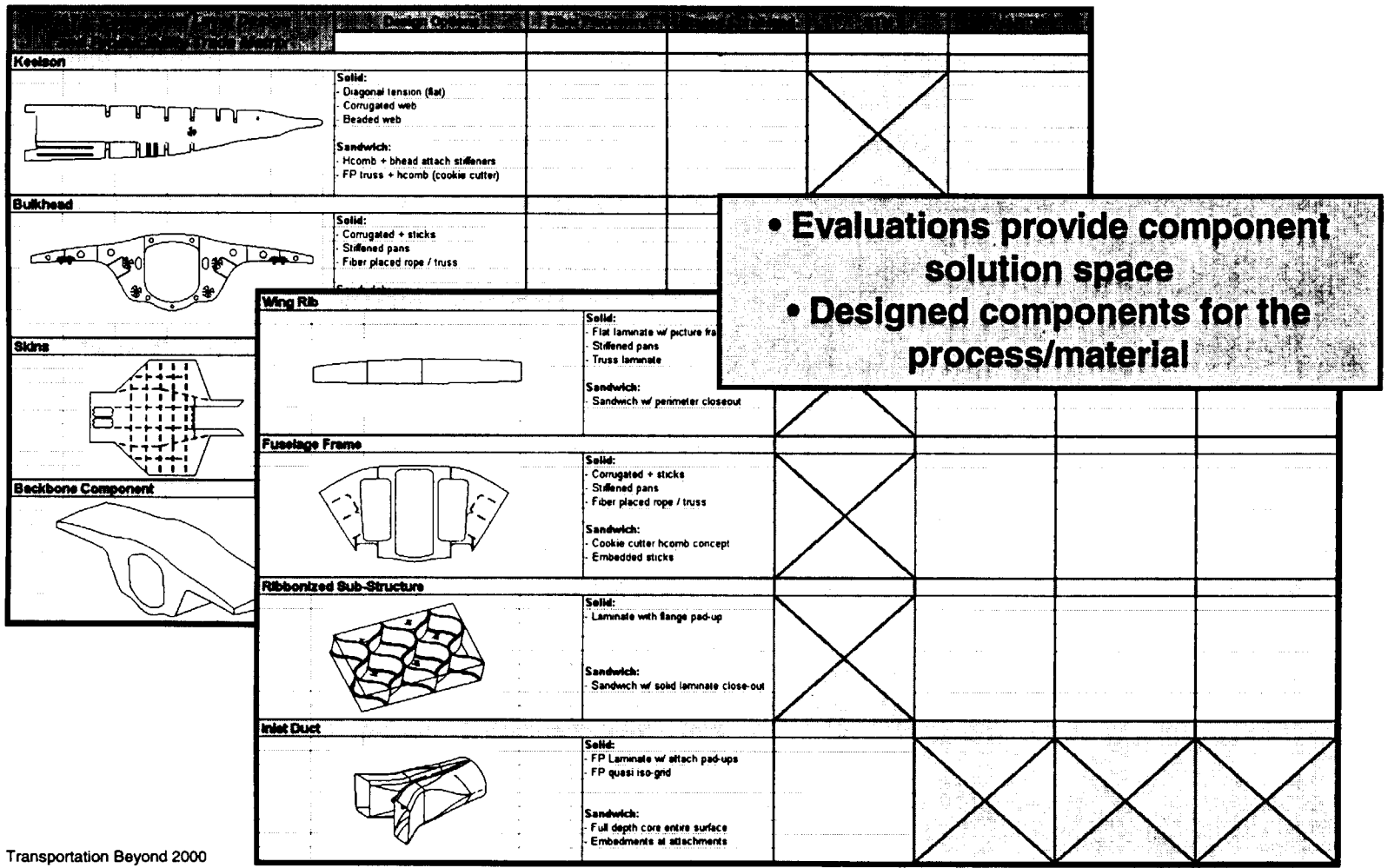
Component Level Design/Manufacturing



• Evaluations provide component solution space
• Designed components for the process/material

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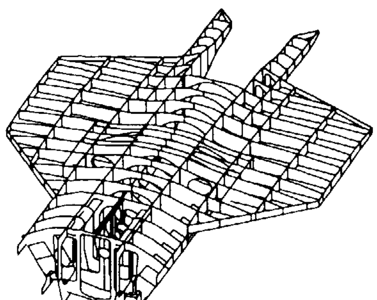
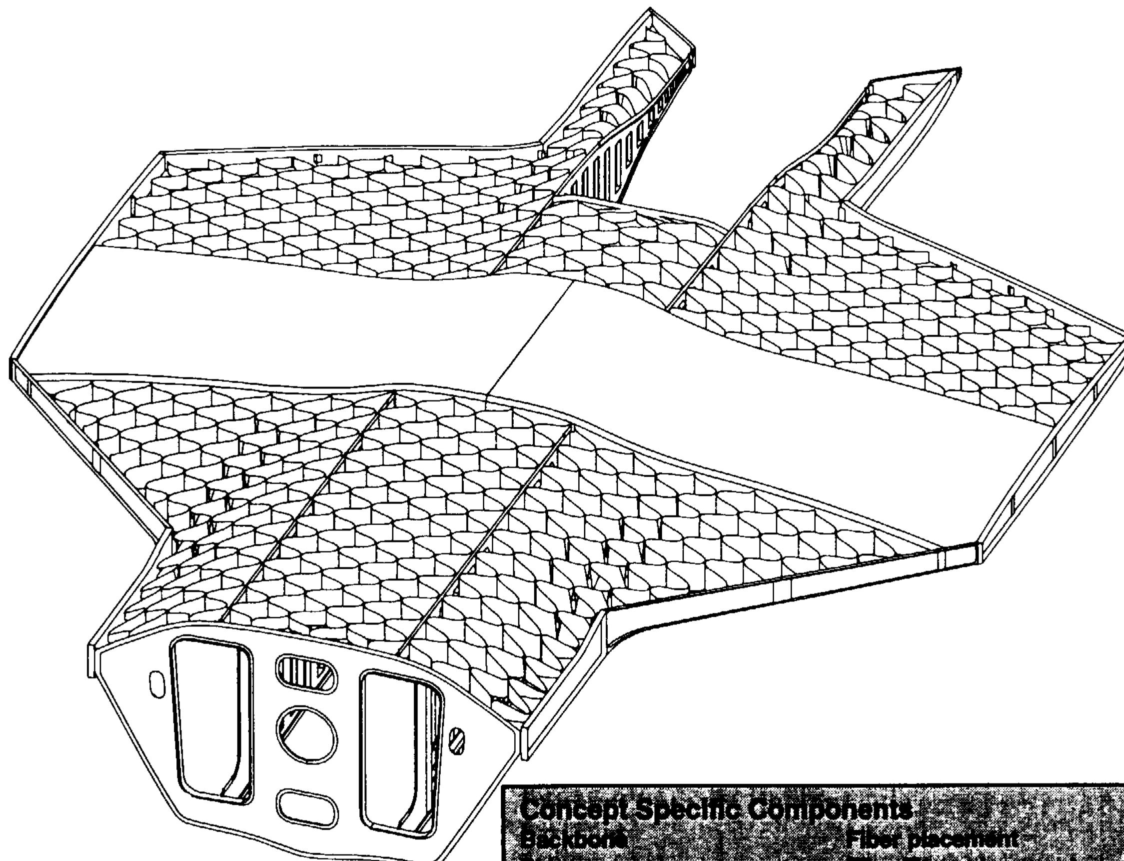
Backbone Concept



JAST / ASTOVL
Config. 140:
Conventional Structure



Concept Specific Components	
Backbone	Fiber placement
Skins	Fiber/Tape placement
Ribbonized Sub-Struc.	Auto RTM
Keelson	Auto VARTM
Assembly	Co-bond, Thermal, E-Beam

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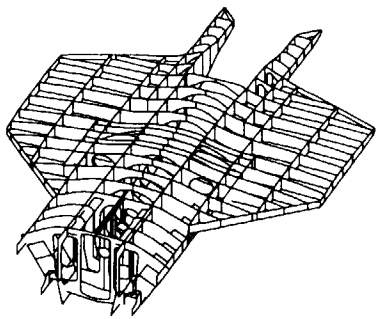
Over/Under Bending Concept



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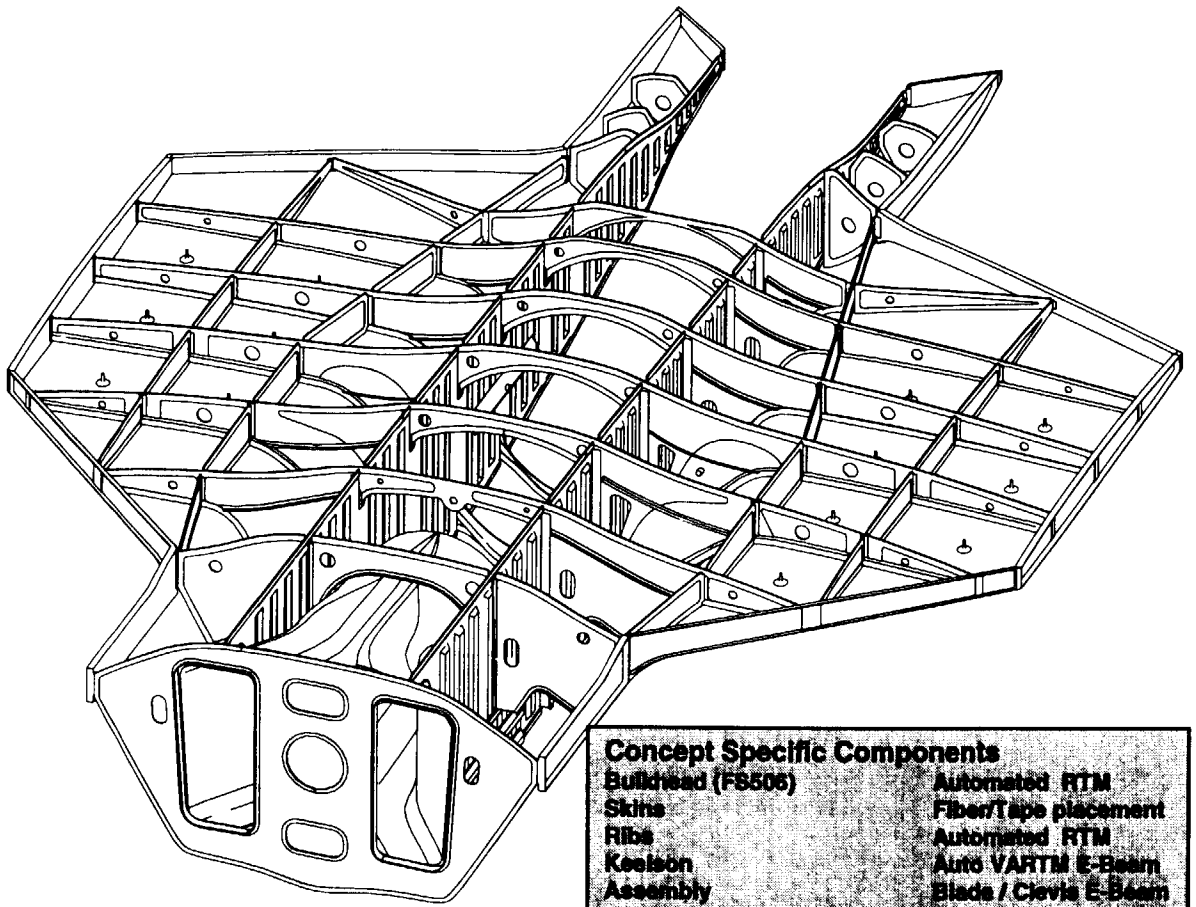
Config. 140
Conventional Structure



Concept Specific Components	
Bulkhead (FS506)	Automated RTM
Skins	Fiber/Tape placement
Ribs	Automated RTM
Keelson	Auto VARTM E-Beam
Assembly	Blade / Clevis E-Beam

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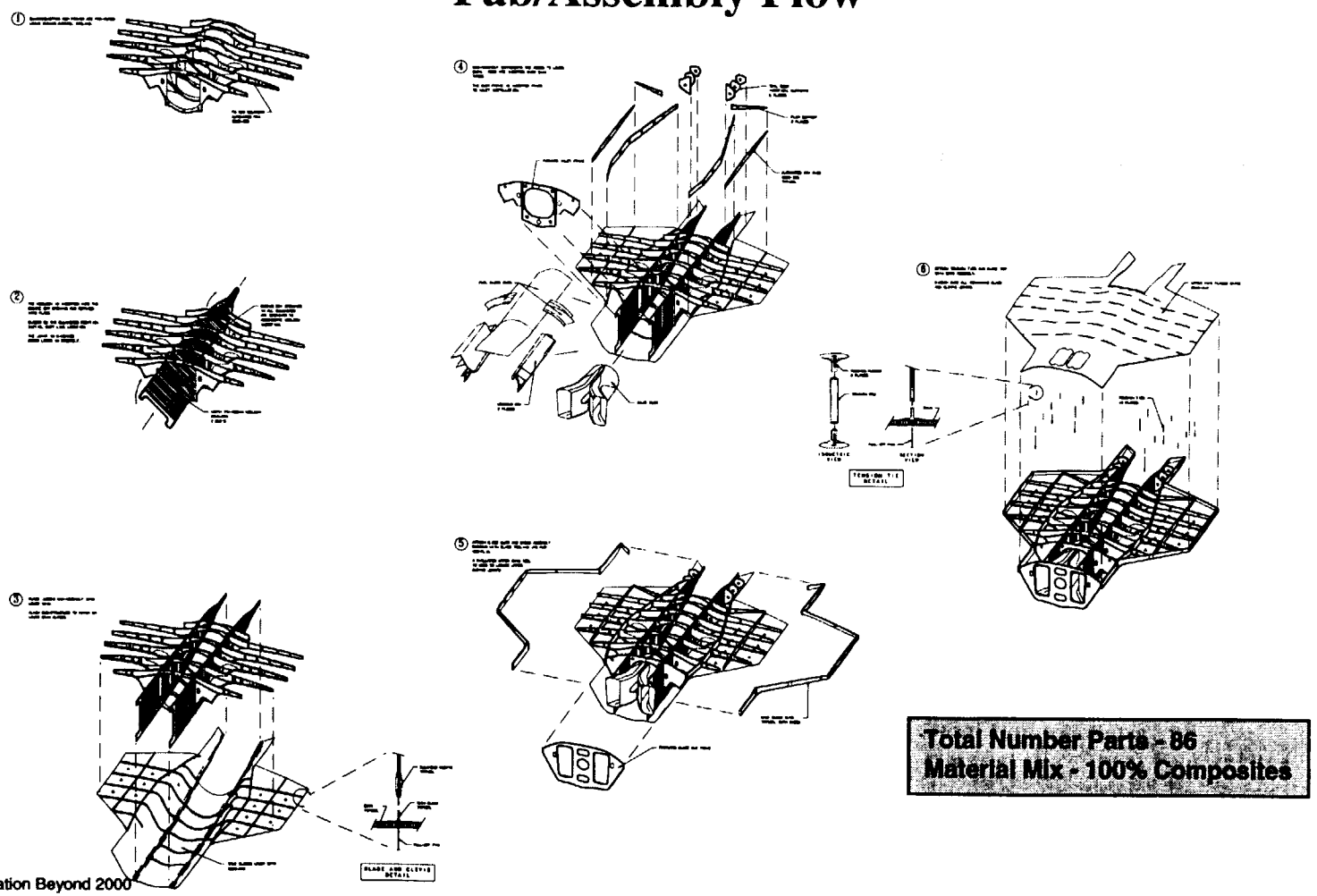
Over/Under Bending Concept

Fab/Assembly Flow



Total Number Parts - 86
Material Mix - 100% Composites

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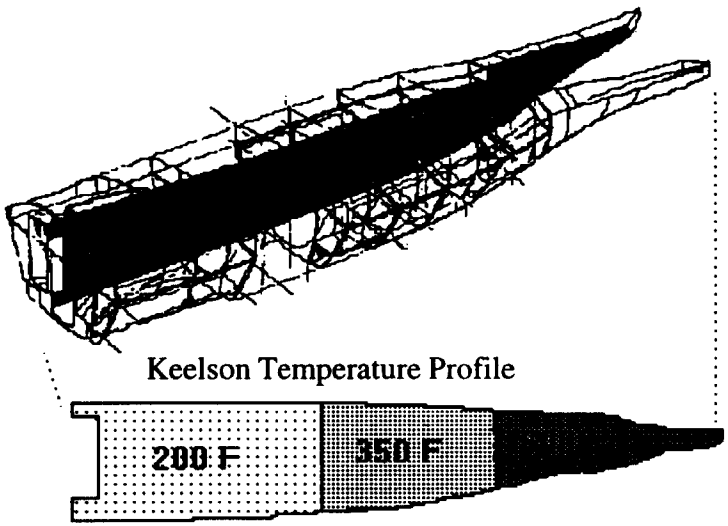
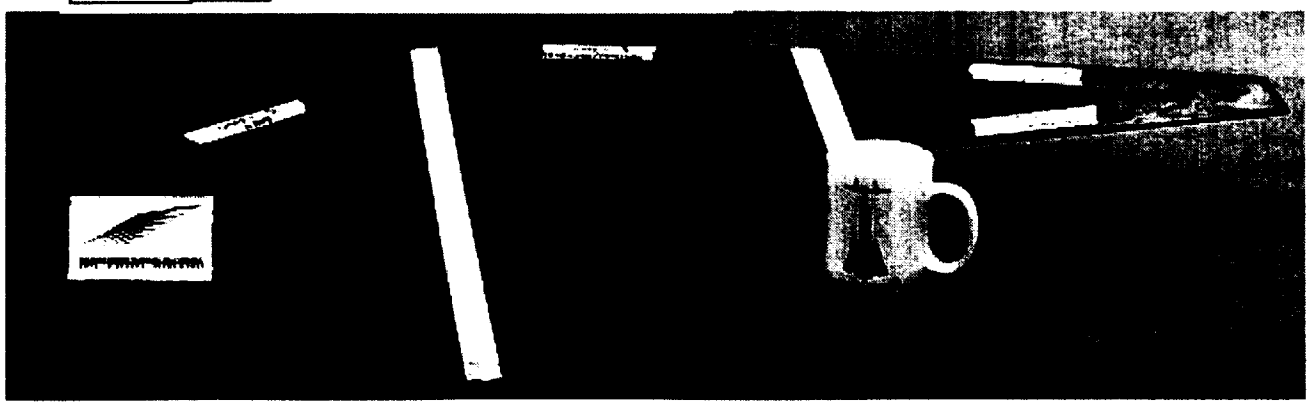
Multi-Resin Structure Capability

- **First application of Multiple Service Temperature Resins in a Single Continuously Reinforced Component**



- Panel 1 Multi-Resin (Continuous Fabric)
  - Tg 400 F - FW3 Radical Polymerization
  - Tg 480 F - FW3/BMI4 (50/50)
  - Tg 570 F - BMI4 Radical Polymerization
- Panel 2 Multi-Resin (Continuous Fabric)
  - Tg 280 F - Cationic Polymerization
  - Tg 570 F - Radical Polymerization
  - Tg 390 F - Cationic Polymerization
- Panel 3 Multi-Resin (Interleaved Laminate)
  - Tg 280 F - Cationic Polymerization
  - Tg 570 F - Cationic Polymerization



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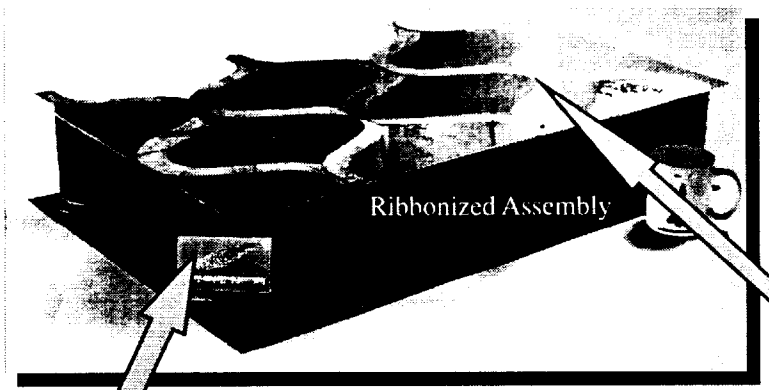
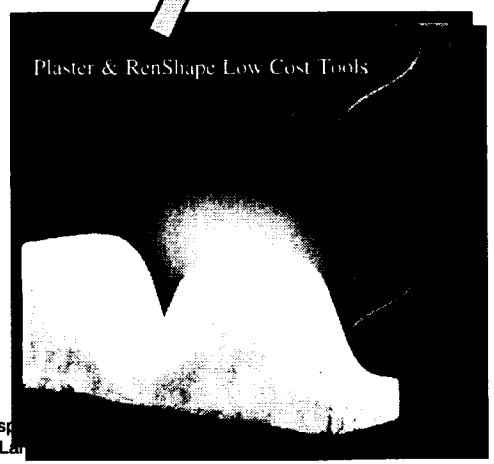
Ribbonized Sub-Structure Feasibility Assembly



Industry Firsts with Electron Beam Resins & Prepreg Fabrics

- **VARTM**
- **Stage Cure**
- **Conformable & Deep Draw Fabrics with VARTM process**
- **Bonded Assembly**
- **Low Cost Tooling**



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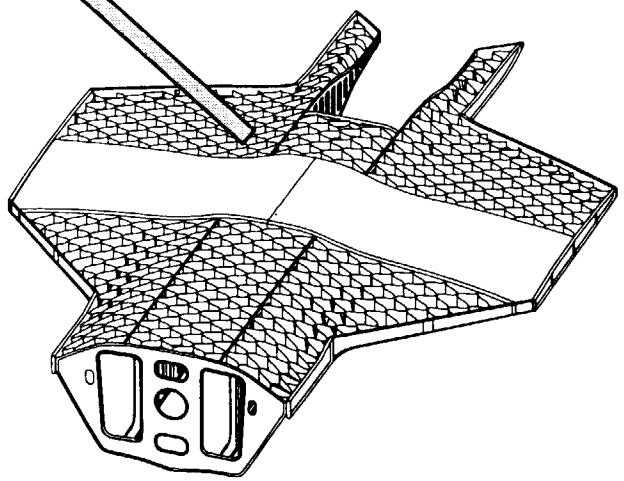
Backbone Concept



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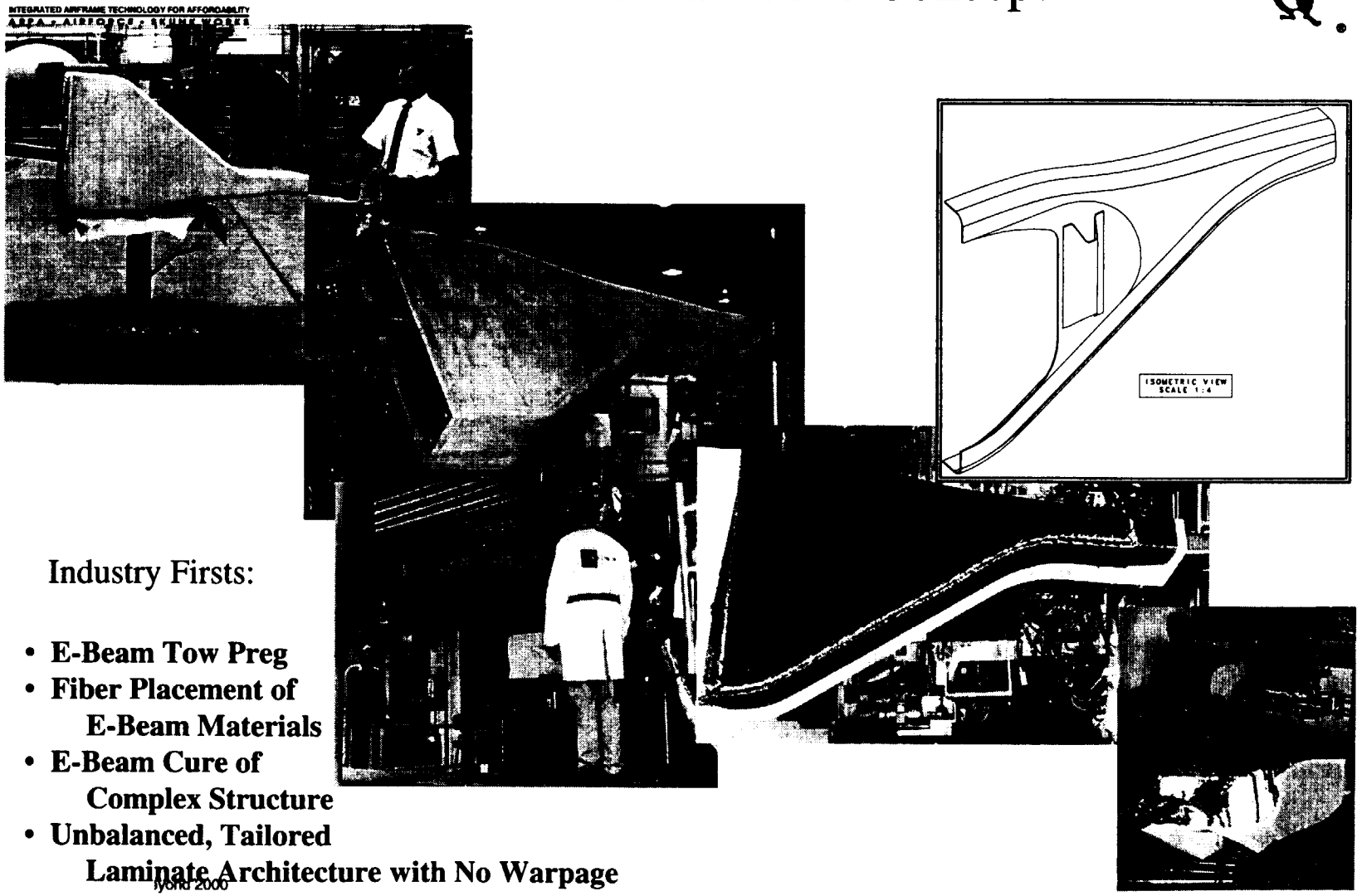
Fiber Placed Backbone Concept

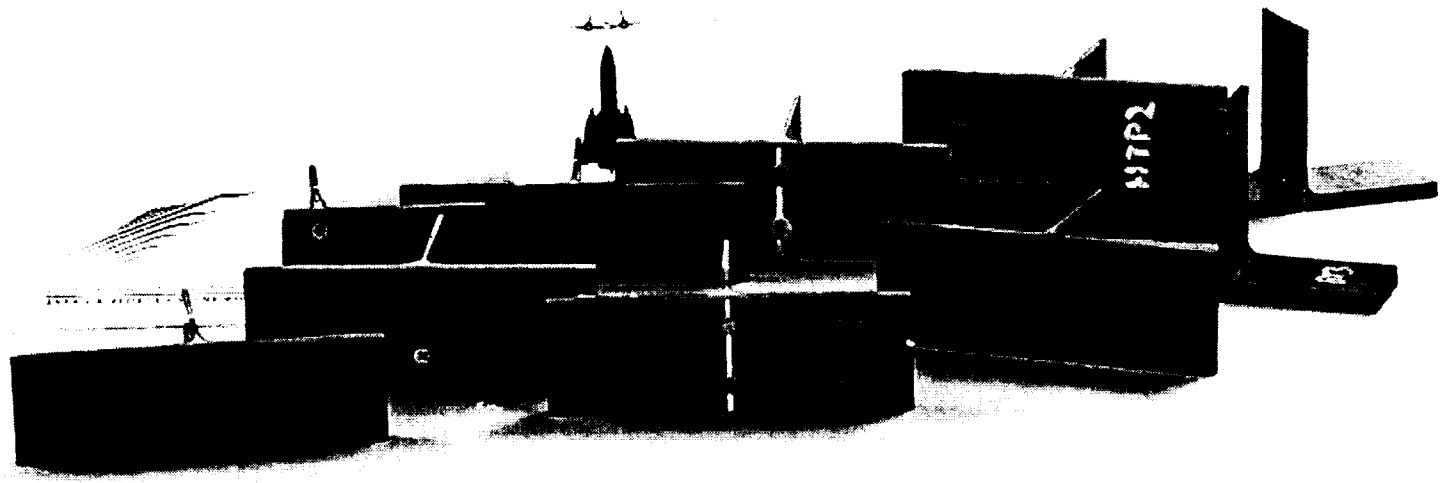


Industry Firsts:

- **E-Beam Tow Preg**
- **Fiber Placement of E-Beam Materials**
- **E-Beam Cure of Complex Structure**
- **Unbalanced, Tailored Laminate Architecture with No Warpage**

Fastenerless Assembly Approaches

- Fastenerless Assembly of Multiple Components
- Direct Reinforcement of Classic Composite Failure Modes
- Applicable to Co-Cure, Co-Bond, Sandwich, or Solid Laminate Approaches
- Current Focus on Blade/Clevis Low Tolerance Assembly Scenario



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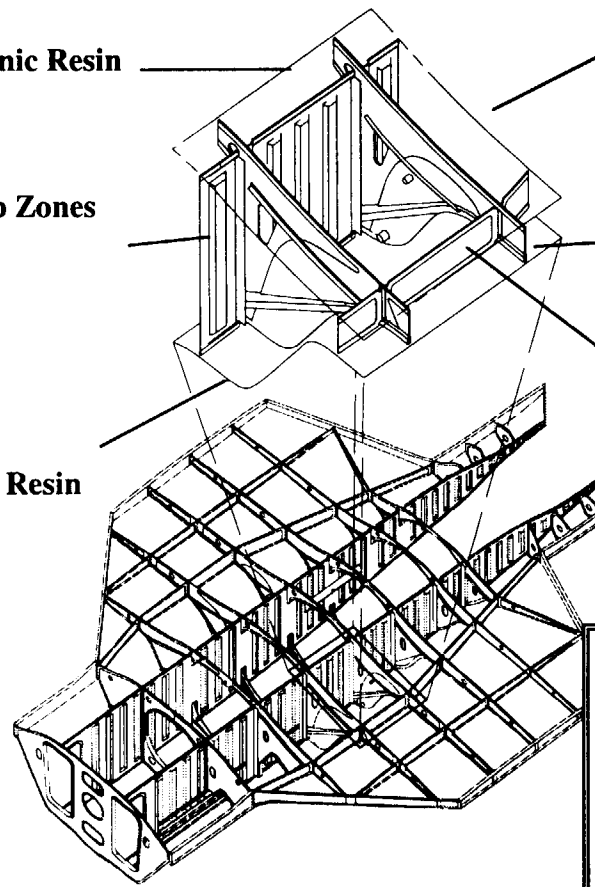
Full Scale Process Demonstration Assembly

Fiber Placed Upper Skin
Electron Beam Cured: Cationic Resin
Alliant TechSystems

VARTM Keelson Multi-Temp Zones
Electron Beam Cured:
Cationic B & C Resins
Skunk Works/AECL

Fiber Placed Lower Skin
Electron Beam Cured: Cationic Resin
Alliant TechSystems



Low Tolerance, Fully
Bonded Assembly Approach

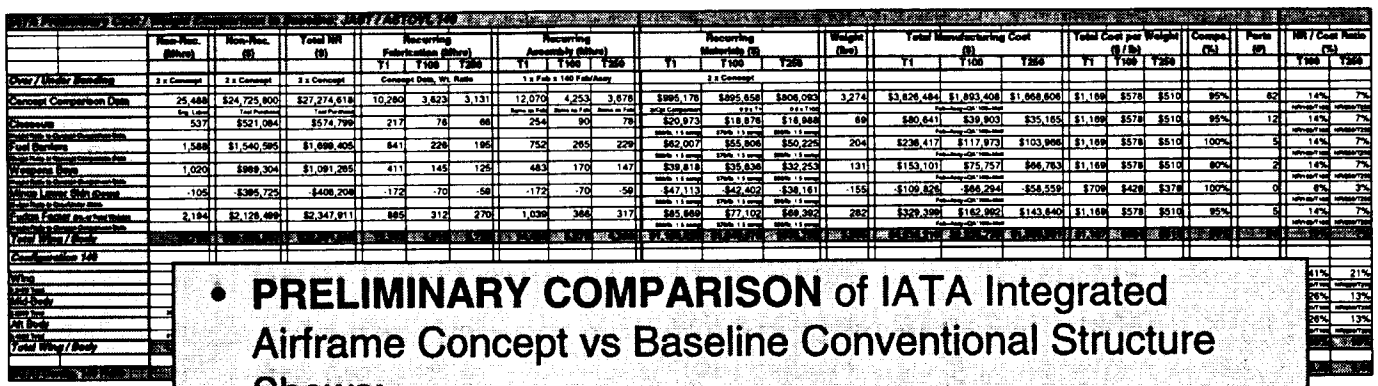
RTM Bulkhead 506
Highly Tailored Loads
Thermoset Materials
DOW-UT

Hand Lay-up Ribs
Thermoset Materials
Skunk Works

Design Features Demonstrated

- Full Scale: 5 cubic foot section
- Blade/Clevis Assembly
- Integral Tailored Load Paths
- Hard Point Integration
- Sandwich Construction
- Most complex, highly loaded section

Payoff Potential



- **PRELIMINARY COMPARISON** of IATA Integrated Airframe Concept vs Baseline Conventional Structure Shows:
  - 56% Manufacturing Cost Reduction (unit 250)
  - 11% Weight Reduction (baseline 10% less than metallic)
  - 95% Composites vs 28%
  - 3 to 1 part count reduction
  - Key cost advantages not accounted for:

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Innovations/Path to Production

- ***Integrated Design***
- E-Beam Curing & VARTM
- E-Beam Curing & Fiber Placement
- Large Scale Resin Infusion (RTM/VARTM)
- Fabrication of Very Large Structure
- Fastenerless Assembly
- High Temperature Materials/Applications
- Hi-Shear Sandwich Construction
- Slotted Tab Assembly
- Integral Multi-Resin Structure
- Direct Web Reinforcement
- Multi-Cure Assembly Approach
- Snap-Fit Assembly Approach
- Energy Absorbing Fuel Cell Tension Ties
- Ribbonized Wing Sub-Structure
- Tailored Laminate Architectures

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Vision of Future

- Accomplish Paradigm Shift
- System Level Integration
- Composites More Affordable Then Metals
- Achieve Performance Potential
- Smart Structures: Active and Passive
- Integrated Sub-Systems
- Diverse Application to Structures in General