ADVANCED TRANSPORT TECHNOLOGY PROGRAM

GENERAL DYNAMICS
Convair Aerospace Division
EXPEDITE THE DEVELOPMENT OF ADVANCED TECHNOLOGY TO INSURE THAT THE NEXT GENERATION OF LONG-HAUL TRANSPORT AIRCRAFT WILL BE COMPETITIVELY SUPERIOR IN THE WORLD'S AIRCRAFT MARKET IN TERMS OF PERFORMANCE, ECONOMICS, SAFETY, AND COMFORT WHILE ATTAINING ACCEPTABLE LEVELS OF NOISE AND POLLUTANTS EMISSIONS.
REWARDS OF NEW TECHNOLOGIES

REDUCTION IN FUEL CONSUMPTION

PROGRESS TOWARDS QUIET ENGINE

DIRECT OPERATING COST TREND
ADVANCED TRANSPORT TECHNOLOGY

COMPARATIVE AIRCRAFT COSTS

- 1970 TECHNOLOGY
  - B747
  - DC10-30

- Cost: $ in Million

- SEATS

ATT +10% B707-320C

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19 May 71
ADVANCED TRANSPORT TECHNOLOGY

DIRECT OPERATING COST BENEFITS

(5000 n. mi Stage Distance)

![Diagram showing direct operating cost benefits across different seat numbers for various aircraft models. The diagram includes points for B707, B707-320C, ATT, DC10-30, and B747 with their respective seat counts and cost benefits. The graph is plotted with seat number on the x-axis and direct operating cost in cents per seat mile on the y-axis. The cost benefits are indicated with percentage reductions.]
# Advanced Transport Technology

## Direct Operating Cost Breakdown

Competitive Aircraft at 5000 N. Mi.

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Flyaway Cost</th>
<th>D.O.C. - $ Per N. Mi.</th>
<th>$/ Seat N. Mi.</th>
</tr>
</thead>
<tbody>
<tr>
<td>B707 - 320C (135 SEATS)</td>
<td>$10.0M</td>
<td>CREW: 0.280, FUEL &amp; OIL: 0.414, INSURANCE: 0.096, MAINT.: 0.437, DEPR.: 0.382, TOTAL: 1.609</td>
<td>1.19</td>
</tr>
<tr>
<td>B707 - 1970 Propulsion (135 SEATS)</td>
<td>$10.5M</td>
<td>CREW: 0.275, FUEL &amp; OIL: 0.347, INSURANCE: 0.097, MAINT.: 0.448, DEPR.: 0.388, TOTAL: 1.555</td>
<td>1.15</td>
</tr>
<tr>
<td>DC10 - 30 AT M = 0.82 (270 SEATS)</td>
<td>$17.5M</td>
<td>CREW: 0.308, FUEL &amp; OIL: 0.573, INSURANCE: 0.167, MAINT.: 0.721, DEPR.: 0.634, TOTAL: 2.403</td>
<td>0.89</td>
</tr>
<tr>
<td>B747 AT M = 0.84 (356 SEATS)</td>
<td>$22.2M</td>
<td>CREW: 0.326, FUEL &amp; OIL: 0.751, INSURANCE: 0.212, MAINT.: 0.919, DEPR.: 0.799, TOTAL: 3.007</td>
<td>0.84</td>
</tr>
<tr>
<td>ATT AT M = 0.97 (195 SEATS)</td>
<td>$15.0</td>
<td>CREW: 0.249, FUEL &amp; OIL: 0.429, INSURANCE: 0.123, MAINT.: 0.583, DEPR.: 0.477, TOTAL: 1.861</td>
<td>0.95</td>
</tr>
</tbody>
</table>
# Potential Aircraft/Mission Applications for Supercritical Wing Technology

<table>
<thead>
<tr>
<th>Aircraft Type</th>
<th>Potential Benefits</th>
<th>Conventional Airfoil</th>
<th>Supercritical Airfoil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strategic Bomber</strong></td>
<td>- Cruise Speed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- Cruise &amp; Refuel Altitude</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Tactical Fighter/Bomber</strong></td>
<td>- Cruise Speed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- Maneuver</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Air Superiority Fighter</strong></td>
<td>- Maneuver</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- Buffet</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Transport/Tanker</strong></td>
<td>- Cruise Speed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- Cruise Altitude</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- R.T Vel Envelope (Speed, Alt.)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>High Altitude Reconnaissance</strong></td>
<td>- Max Ceiling</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- Cruise Speed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- Buffet</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Cruise Speed**
- $C_D$ @ Cruise
- $M/L_0$

**Cruise Efficiency**
- $Mach$

**Maneuver**
- Increased Energy
- Increased Load Factor

**Buffet**
- $C_L$
- $C_D$
- $Mach$

**Cruise Altitude & Max Ceiling**
- Alt.
- Lift $\propto M^2$
- Mach

*Figure* 274-YO2224
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ADVANCED TRANSPORT TECHNOLOGY
POTENTIAL APPLICATIONS FOR ADVANCED COMPOSITE MATERIALS

<table>
<thead>
<tr>
<th>STRATEGIC BOMBER</th>
<th>POTENTIAL BENEFITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TACTICAL FIGHTER/BOMBER</td>
<td>• WEIGHT SAVINGS</td>
</tr>
<tr>
<td>AIR SUPERIORITY FIGHTER</td>
<td>• DESIGN FREEDOM AND INNOVATION</td>
</tr>
<tr>
<td>TRANSPORT/TANKER</td>
<td>• IMPROVED FATIGUE LIFE</td>
</tr>
<tr>
<td>HIGH ALTITUDE RECONNAISSANCE</td>
<td>• LOWER MAINTENANCE COSTS</td>
</tr>
<tr>
<td></td>
<td>• BETTER RELIABILITY</td>
</tr>
<tr>
<td></td>
<td>• REDUCED LIFE CYCLE COSTS</td>
</tr>
<tr>
<td></td>
<td>• IMPROVED RANGE</td>
</tr>
<tr>
<td></td>
<td>• BETTER ALTITUDE PERFORMANCE</td>
</tr>
<tr>
<td></td>
<td>• MORE MANEUVERABILITY</td>
</tr>
</tbody>
</table>
DESIGN OBJECTIVES
Load Relief

CRUISE
SPANWISE LOAD DISTRIBUTION... FOR BEST INDUCED DRAG

HIGH LOAD FACTOR TIP WASHES OUT TO REDUCE BENDING MOMENTS...

... FOR LOWEST STRUCTURAL WEIGHT
ADVANCED TRANSPORT TECHNOLOGY

EFFECT OF COMPOSITES ON D.O.C.

<table>
<thead>
<tr>
<th>AIRPLANE</th>
<th>GROSS WT.</th>
<th>OP. EMPTY WT.</th>
<th>FUEL WT.</th>
<th>PAYLOAD</th>
<th>AIRFRAME</th>
<th>ENGINES</th>
<th>AVIONICS</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>WITHOUT COMPOSITES</td>
<td>436,500 lb.</td>
<td>215,300 lb.</td>
<td>179,200 lb.</td>
<td>42,000 lb.</td>
<td>$11.4M</td>
<td>$2.58M</td>
<td>$0.8M</td>
<td>$14.78M</td>
</tr>
<tr>
<td>WITH A COMPOSITE WING &amp; EMPENNAGE</td>
<td>391,000 lb.</td>
<td>186,000 lb.</td>
<td>163,000 lb.</td>
<td>42,000 lb.</td>
<td>$11.6M</td>
<td>$2.46M</td>
<td>$0.8M</td>
<td>$14.86M</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DIRECT OPERATING COST $/n. mi.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WITHOUT COMPOSITES</td>
</tr>
<tr>
<td>CREW</td>
<td>0.253</td>
</tr>
<tr>
<td>FUEL &amp; OIL</td>
<td>0.553</td>
</tr>
<tr>
<td>INSURANCE</td>
<td>0.123</td>
</tr>
<tr>
<td>MAINTENANCE</td>
<td>0.605</td>
</tr>
<tr>
<td>DEPRECIATION</td>
<td>0.472</td>
</tr>
<tr>
<td>$/ n. mi.</td>
<td>2.006</td>
</tr>
<tr>
<td>$/ Seat n. mi.</td>
<td>0.935</td>
</tr>
</tbody>
</table>

Δd. o. c. = - 5%
ADVANCED TRANSPORT TECHNOLOGY
POTENTIAL APPLICATIONS FOR H/GT PROPULSION ADVANCEMENTS

- HIGH MCRIT / LOW DRAG NACELLES
  - Transonic / Low Altitude Penetration Bomber
  - Strategic Transport

- ENGINE CYCLE DEVELOPMENT
  - Long Range Strategic Missile Launcher
  - Long Range Military Transport / Tanker

- ENGINE NOISE SUPPRESSION
  - V / STOL Aircraft for Urban Airports
  - Quiet Close Support Aircraft
  - Increased Utility of Land Near Airports
  - May Allow Night Maintenance Engine Runs
ADVANCED TRANSPORT TECHNOLOGY

EFFECT OF CHANGES IN L/D RATIO OR S.F.C.

D.O.C.

$/N.Mt.

% CHANGE IN S.F.C. (OR L/D RATIO)

INCREASE IN L/D

DECREASE IN S.F.C.

+11%

+5

-5

-10%
ADVANCED TRANSPORT TECHNOLOGY

SENSITIVITY OF ROI WITH L/D OR S.F.C. CHANGE

INDIRECT OPERATING COST CONSTANT

PERCENTAGE IMPROVEMENT IN RETURN ON INVESTMENT COMPARED WITH M=0.82 CONVENTIONAL TRANSPORT

IMPROVED L/D OR S.F.C.

WORSE L/D OR S.F.C.

M=0.82 TRANSPORT (SCALED DC10-30)

10%

1% 2% 3% 4% 5%

5% 4% 3% 2% 1%
<table>
<thead>
<tr>
<th>MANNED AIRCRAFT SYSTEM TYPE</th>
<th>RELAXED INHERENT STABILITY</th>
<th>IMPROVED FLIGHT PATH CONTROL</th>
<th>ACTIVE CONTROL OF STRUCTURAL MODES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Short-Haul Transport</td>
<td>Reduced Cruise Drag</td>
<td>Possible Application</td>
<td>Improved Fatigue Life and Ride Quality</td>
</tr>
<tr>
<td>Low Level SAC Penetrator</td>
<td>Possible Application</td>
<td>DLC Enhances Response of Large Flexible Vehicles Approach</td>
<td>MLC and Gust Alleviation Relaxes Strength Requirements, Other Benefits in Fatigue Life, Ride Quality, etc.</td>
</tr>
<tr>
<td>Air Superiority Fighter</td>
<td>Enhanced Maneuver Capability</td>
<td>Precision Weapons Delivery, Enhanced Maneuverability</td>
<td></td>
</tr>
<tr>
<td>STOL (and VTOL during transition)</td>
<td>Technology applicable to basic control problem</td>
<td>DLC Useful in Low Speed Approach</td>
<td>Application Dependent upon Intended Mission</td>
</tr>
<tr>
<td>High Altitude Cruise Vehicle (Low Wing Loading)</td>
<td></td>
<td>DYC Useful in Low Speed Approach</td>
<td>Gust Loads Relaxed by Active Suppression</td>
</tr>
</tbody>
</table>
ATT AVIONICS TECHNICAL CONTRIBUTIONS

• AREA NAVIGATION AND COLLISION AVOIDANCE
  • Improved safe handling of large volume terminal and enroute flow and handling of mixed aircraft types such as Conventional/STOL/VTOL.

• AUTOMATIC LANDING SYSTEMS
  • Provide all-weather Category III type landing capability for both commercial and military aircraft.

• INFLIGHT DATA RECORDING, SYSTEM SELF-TEST, AND DATA HANDLING
  • Automated collection of large quantities of data will yield economic improvements in aircraft servicing and maintenance.

• FLIGHT MANAGEMENT, DATA COMPUTATION AND DISPLAYS
  • Extension and improvement of present capabilities in the area of time of flight and fuel utilization.
APPLICATIONS OF ADVANCED TRANSPORT TECHNOLOGIES

• SHORT HAUL COMMERCIAL TRANSPORT
  • USE SCW FOR LOWER WEIGHT AND BETTER BLOCK SPEEDS
  • GUST ALLEVIATION FOR BETTER RIDE AT HIGHER SPEEDS
  • IMPROVED OPERATING COSTS

• STOL TRANSPORTS (Commercial and Military)
  • USE HIGH INSTALLED THRUST TO GO FASTER
  • LOW NOISE LEVEL AND EMISSION DEVICES

• NAVY HIPAAS
  • USE BETTER MANEUVER CAPABILITY OF SCW AT HIGH M.
  • COMPOSITES FOR LOWER WEIGHT AND COST

• STRATEGIC BOMBERS
  • IMPROVE SUBSONIC L/D WITH SCW
  • COMPOSITES FOR LOWER WEIGHT AND COST
  • GUST ALLEVIATION FOR STRUCTURE IMPROVEMENTS
  • PROPULSION IMPROVEMENTS FOR BETTER RANGE

• VTOL TRANSPORTS
  • COMPOSITES FOR LOWER WEIGHT AND COST
  • SUPERCRITICAL WING FOR HIGHER CRUISE SPEEDS
  • LOWER NOISE LEVEL AND EMISSION DEVICES
  • FLY-BY-WIRE CONTROL SYSTEMS
ADVANCED TRANSPORT TECHNOLOGY
Areas of Concern

- GROWTH — WITH AREA RULE
- DEEP STALL — PROBLEMS WITH REAR ENGINES
- DOUBLE CURVATURE — WHAT IS ITS COST?
- SPEED & ALTITUDE — HOW MEASURED AT MACH 1?
- SHORT HAUL — MAY BE BEST APPLICATION
- ROI — IS IT BEST OBTAINED BY SPEED, OR BY LOWER WEIGHT & COST?
- TECHNOLOGIES — HOW MANY & WHICH TO BE INCORPORATED?