High Speed Civil Transport

Vital Investment in America's Future
What is the HSCT?

The HSCT, as currently being designed by Boeing and McDonnell Douglas, is an airplane that will transport more than 300 passengers in a three-class arrangement over 5,000 nmi at Mach 2.4 cruise. It is expected to deliver excellent supersonic and subsonic cruise performance, with low emissions and reduced noise levels. Designed to operate with current fuels from existing airports, the airplane will provide decades of reliable service.

Advanced Technologies Essential

Because successful HSCT development is absolutely dependent upon advanced technology, the HSCT team is pursuing unprecedented technologies related to low-emission combustors, noise suppressors, high-temperature composite airframe materials, high-lift aerodynamics, and advanced engine materials. Other technology initiatives include high-speed aerodynamics, supersonic inlets, and advanced avionics and flight deck systems.

When the HSCT market matures, key technologies must be available. The technology leader will become the world market leader.

<table>
<thead>
<tr>
<th>Current Baseline Airplane</th>
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<tbody>
<tr>
<td>Maximum takeoff weight, lb</td>
<td>750,000</td>
</tr>
<tr>
<td>Fuselage length, ft</td>
<td>310</td>
</tr>
<tr>
<td>Wing span, ft</td>
<td>330</td>
</tr>
<tr>
<td>Tri-class seating, passengers</td>
<td>309</td>
</tr>
<tr>
<td>Cruise speed, Mach</td>
<td>2.4</td>
</tr>
<tr>
<td>Design range, nmi</td>
<td>5,000</td>
</tr>
<tr>
<td>Takeoff field length, ft</td>
<td>11,000</td>
</tr>
<tr>
<td>Approach speed, kn</td>
<td>155</td>
</tr>
</tbody>
</table>

Twice as Productive as Today's Subsonics—Double the Payload (Same Distance) or Twice the Range (Same Payload)
Building upon the engine design base of GE and P&W, the HSCT is the logical next step in the evolution of supersonic propulsion systems. U.S. industry, working with NASA, is focused on designing an environmentally friendly aircraft and engine.

Emissions Technology Promising
In scale model testing, P&W and GE have identified and demonstrated combustor concepts that reduce NOx levels (oxides of nitrogen that impact ozone) 80-90% through precise control of the burning process and combustion time. Atmospheric studies have been conducted by leading scientists throughout the world for a range of aircraft operational scenarios. The predictions indicate the possibility of relatively small effects of low-NOx combustor emissions on atmospheric ozone.

Noise Goals Achievable
An HSCT must satisfy current FAR 36 Stage 3 airport noise requirements and produce no boom over populated areas, i.e., be 75% quieter than the Concorde. Design studies and small-scale testing show that by applying computational fluid dynamics design codes, innovative mixing approaches, high-lift aircraft wing designs, and refined aircraft operational procedures, the noise goals can be met.
Because an HSCT engine will operate at near-maximum temperature during most of its flight cycle—at levels higher than today's subsonic turbofans—new materials and processes are needed. A NASA-led team of companies and universities is focusing on developing and testing propulsion materials that can withstand temperatures approaching 3000°F. GE and P&W are working to develop ceramic matrix and intermetallic matrix composites for use in the hot section and exhaust nozzle. Significant improvements in fiber strengths and component designs that are matched to the composite materials have been demonstrated. Other key materials research initiatives have also been identified and are underway.

**Durable, Producing Airframe Structures**

Graphite/bismaleimide tape, stiffened skin panel, precured stringers, and frames bonded to the skin

Graphite/bismaleimide tape, sandwich panel with titanium honeycomb core, and precured frames with fail-safe chord

**Airplane Materials Enhance Performance**

To satisfy strength and stiffness requirements for aircraft configurations, structural sizing is being established through the application of finite-element analysis and high-speed computers; results are being incorporated into airplane performance predictions. Real-time exposure to expected load and temperature profiles on test samples and structural elements are being used to demonstrate long-term durability. A design-build approach will help ensure that materials and structural design yield an efficient, producible, cost-effective aircraft. Significant investment in new plants, equipment, and processes is needed to make these new materials a commercial reality.

**Materials Research Progressing**

- Composite honeycomb skin panels with composite substructure
- Titanium honeycomb skin panels with composite substructure
- Full-depth composite honeycomb panels

**NASA Program Well-focused**

<table>
<thead>
<tr>
<th>Phase I: Enabling technology</th>
<th>Phase II: Technology validation</th>
<th>Phase III: Product development by industry</th>
</tr>
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<tbody>
<tr>
<td>1990</td>
<td>1996</td>
<td>2000</td>
</tr>
<tr>
<td>2005</td>
<td></td>
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**NASA Research Initiatives Enable Industry Product Investment**

- Material systems risk analysis: Studies indicate robust designs, reduced temperatures/low penalty
- Ceramic matrix composites: Initial fiber strength meeting goals, designs match material capabilities
- Intermetallic/metal matrix composites: Significant improvements in fiber strength, evaluation methodology established
Airplane Materials Enhance Performance

To satisfy strength and stiffness requirements for aircraft configurations, structural sizing is being established through the application of finite-element analysis and high-speed computers; results are being incorporated into airplane performance predictions. Real-time exposure to expected load and temperature profiles on test samples and structural elements are being used to demonstrate long-term durability. A design-build approach will help ensure that materials and structural design yield an efficient, producible, cost-effective aircraft. Significant investment in new plants, equipment, and processes is needed to make these new materials a commercial reality.

NASA Program Well-focused

NASA has long been integral to the development of enabling technologies that benefit the aviation industry. With the increased concern about U.S. competitiveness, the agency is playing a key role in helping the industry maintain its world leadership position. In fact, what NASA does in aeronautical R&D over the next several years will define the industry’s future well into the next century.

In the HSR program, NASA has worked with industry to outline a well-focused plan for developing long-lead, high-risk technologies that form the foundation for the HSCT. The success of the current environmental technology research has paved the way for advancement to the component technology and system economic validation phase.

NASA investment in the early- and mid-1980s positioned U.S. industry to fund the multibillion dollar technology research program needed for the current new family of high thrust commercial engines. Similarly, the HSR program can serve as a catalyst for the HSCT, reducing the risk so private industry can have the confidence to spend tens of billions of dollars for new engine and airplane development—and to bring the HSCT to market.

**NASA Research Initiatives Enable Industry Product Investment**

**HSR Program Milestones**

**Environmental/Regulatory**
- Initial National Research Council (NRC) emissions program assessment
- Combustor concept

**Propulsion**
- Engine cycle
- Critical materials

**Airframe**
- Preliminary materials
- Structural concept

**Significant**
- Improved intermetallic/metal matrix composites
  - Significant improvements in fiber strength
  - Evaluation methodology established
Why a High Speed Civil Transport?

Three decades ago, a British/French consortium produced the Concorde, which has delivered reliable service to millions of passengers for over 20 years. Today, however, the 1960s-technology aircraft is environmentally incompatible and has limited economic appeal.

<table>
<thead>
<tr>
<th>Concorde</th>
<th>HSCT</th>
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<tr>
<td>Entry into service</td>
<td>1969</td>
</tr>
<tr>
<td>Market</td>
<td>North Atlantic</td>
</tr>
<tr>
<td>Range, mi</td>
<td>5000</td>
</tr>
<tr>
<td>Passengers</td>
<td>100</td>
</tr>
<tr>
<td>Takeoff weight, lb</td>
<td>200,000</td>
</tr>
<tr>
<td>Noise requirement</td>
<td>FAA 36 Stage 2</td>
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<tr>
<td>Emissions, g/kg</td>
<td>75</td>
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Industry projections say that, around the turn of the century, the market will support the launch of a second-generation supersonic airplane—the High Speed Civil Transport (HSCT). To be successful, it must be economically competitive with subsonic aircraft while meeting stringent environmental requirements.

Considerable Market Potential

World population and economic growth, coupled with lower real travel costs and growing discretionary income, indicate that air traffic will double by 2000. On HSCT international routes—North America-Asia, North America-Europe, and Europe-Asia—demand is expected to grow from 315,000 passengers per day in 2000 to 607,000 by 2015.

For a 10-20% fare premium over today's subsonic aircraft, HSCT passengers could reach their destinations 50-60% more quickly, as well as more comfortably. Greater payload-range flexibility would improve aircraft productivity 80-100%. Each airplane would cost more, but fewer would be needed to deliver the same number of revenue passenger miles. In addition, operational flexibility and airport utilization would be enhanced, because routes could be served more efficiently and new departure/arrival times could be opened up at existing airports.

Our Challenge: Environmental Friendliness, Economic Viability

Because current technology is inadequate to meet HSCT requirements, a well-focused, fully funded technology development program is vital to enable industry to launch an aircraft development and certification program within the next eight years. As part of its High Speed Research (HSR) program, NASA has been working with The Boeing Company, GE Aircraft Engines, McDonnell Douglas, and Pratt & Whitney since 1991 to conduct enabling technology research and validation.
Results Promising, Additional Investment Critical

We are on the verge of developing a successful supersonic commercial transport for the traveling public, but much work remains to turn today’s promise into tomorrow’s reality.

Because it’s not a question of if the HSCT will be developed, but who will do it and when, the ability of U.S. industry to launch a program by 2001 must be protected.

Now is the time to invest to ensure that our industry continues to be the leading exporter. Full funding of HSCT technology research is vital to the competitiveness of the U.S. aviation industry. The technologies developed can also have major impacts on subsonic commercial aircraft, as well as provide spin-off benefits for numerous other industries.

The HSCT is truly a global transportation system—one in which U.S. industry should take a leadership role.

HSCT Team

• NASA  • Boeing  • GE Aircraft Engines
• McDonnell Douglas  • Pratt & Whitney

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