MAKING AIRCRAFT FASTER, BETTER, AND CHEAPER

Setting Priorities for NASA's Aeronautics Program

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Much of the success that the U.S. aircraft industry has enjoyed in this century can be traced to the research and development efforts of the National Aeronautics and Space Administration (NASA) and its predecessor, the National Advisory Committee on Aeronautics. In late 1992 a committee of the National Research Council (NRC) released a report that describes how NASA should focus its current aeronautics research and development (R&D) program to help U.S. aircraft and engine companies meet the challenges of the next century and stave off increasingly sophisticated foreign competition. The report, *Aeronautical Technologies for the Twenty-First Century* (*1*), discusses important technologies that the committee believed should be given greater emphasis in the NASA aeronautics program and recommends that NASA work more closely with industry and academia in developing and validating those technologies.

Although some of the committee's recommendations were controversial and went counter to NASA's current plans, there was much in the report on which NASA and the aeronautics industry could agree, most notably the statement: "The attention paid to civil aeronautics in the NASA budget is not commensurate with the importance the industry plays in the nation's economy" (*1*, p. 7).

This is particularly true when NASA's aeronautics and its space R&D budgets are compared. According to information published by the Aerospace Industries Association and the U.S. Commerce Department, U.S. civilian space-related sales accounted for approximately $3.4 billion in 1990, whereas NASA devoted nearly $5.1 billion to space-related R&D. In contrast, U.S. shipments of civil aircraft, engines, and parts accounted for more than $33 billion in 1990, but the 1990 NASA budget for aeronautics R&D was only $889 million (which included research into military aircraft) (see Figure 1).

To remedy this situation, the current NASA administrator, Daniel Goldin, stated in December 1992 in a speech given to the American Institute of Aeronautics and Astronautics (AIAA): "It has become crystal clear that it is time to make the first 'A' in NASA a capital letter again—and give aeronautics the attention it deserves."

Some aspects of the rationale used to set the priorities for NASA's aeronautics R&D efforts for the remainder of this century and into the next are addressed in this article.

The Current State

For most of the post-World War II period, the United States has been the dominant player in supplying the world's airlines with aircraft and engines. U.S. companies had a virtual stranglehold on the subsonic transport market until the mid-1980s when the European consortium, Airbus Industrie, began to capture significant market share (see Figure 2).

According to the Congressional Research Service, every $1 billion in sales of transport aircraft supports almost 35,000 jobs throughout the U.S. economy. In 1990 U.S. companies shipped $22 billion worth of transport aircraft alone. Combine these two statistics and it is clear that there are

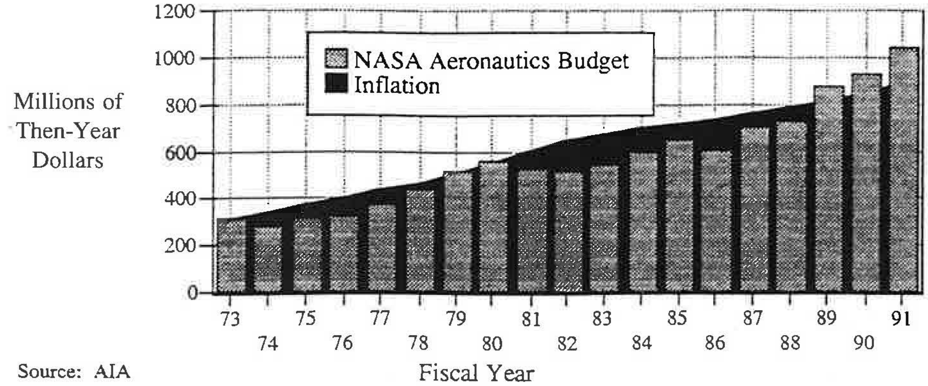

FIGURE 1 NASA's aeronautics budget for fiscal years 1973–1991.

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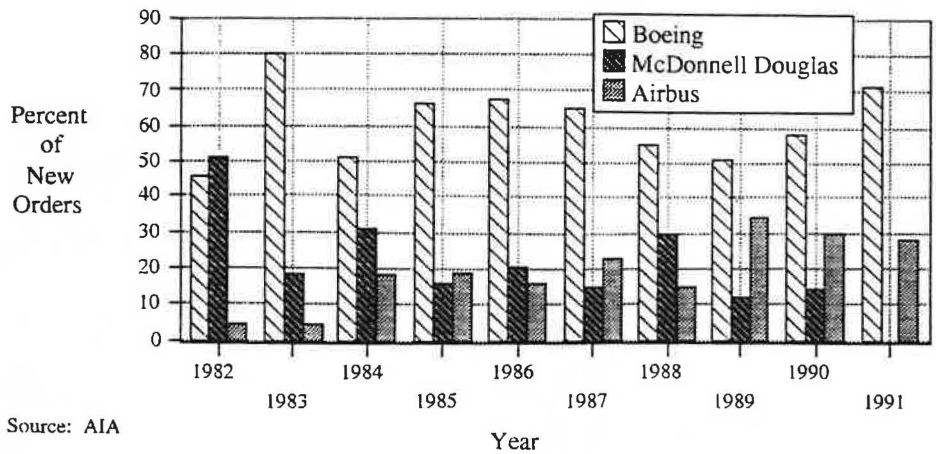

FIGURE 2 Commercial transport orders, 1982–1991.

a great many jobs at stake. Furthermore, these jobs are some of the highest-paid, highest-skilled manufacturing jobs in the world. It is no surprise, therefore, that most major industrialized nations either are now participating in aircraft manufacturing or plan to do so in the near future. In many cases, participation in manufacturing is the price of entry into these emerging markets.

The declining U.S. market share has been blamed by some on "unfair subsidies" provided by the European governments that sponsor the Airbus consortium. Others look at Boeing's continued strong performance and simply fault McDonnell Douglas for failing to take the necessary steps to remain competitive. Regardless of the reasons, Airbus has continually improved the capability and quality of its aircraft to the point that its current products match—and in some cases exceed—the technological capability of U.S.-produced aircraft. It may have been true that in the early 1980s Airbus needed government intervention to survive, but it is not the case as we approach the mid-1990s.

There are many pieces to the puzzle of global competitiveness, including better management and more favorable tax and trade policies. All of these factors must be considered if the overall U.S. market share is to regain its previous level. History has shown, however, that the nation that has stayed at the forefront of technology, and has been most effective at applying new technologies, has been the leader regardless of other factors. Until recently the technological leader in civil aeronautics has been the United States, in large part because of efforts by NASA to provide the needed technology in a form that could be readily used to produce commercial products.

A recent report prepared by a special team of NASA managers and researchers has addressed this issue. The report of the Special Initiatives Team on Technology Transfer contains a series of findings and recommendations for changing NASA's culture to facilitate technology transfer, including the conclusions that (a) processes for technology transfer within NASA are too slow to meet industry's needs, and (b) technology is not sufficiently developed to reduce technical risk to industry caused by the costs and mission objectives.

Although NASA has traditionally done a better job of transferring its technology to the aeronautics industry than to other segments of the economy, Administrator Goldin said in a news release accompanying the report: "NASA has the reputation of being the leader in technology transfer, but this position has eroded. Our successes are modest compared to the amount of technology we generate. Our attitude that the transfer of our valuable technology will 'just happen' is no longer acceptable. It must be proactively sought and given the highest priority."

The NRC report echoes this sentiment, as follows: ". . . without strong cooperation between commercial interests, universities, and government to define the technologies with the greatest potential payoff, and to work in a concerted fashion toward their development, U.S. standing in aeronautics will continue to erode" (*1*, p. 4).

The Future Market

According to estimates made by NASA, the market in 2000 for a new fleet of supersonic transports will be approximately 315,000 passengers per day, increasing to 510,000 per day in 2010. This is the segment that the U.S. industry and NASA hope will be captured by an American supersonic aircraft dubbed the High-Speed Civil Transport (HSCT).

Estimates are that yearly worldwide revenue passenger miles (RPMs) will increase from 1.2 trillion in 1990 to more than 2 trillion in 2000, and to approximately 3 trillion by 2010. Assuming that an HSCT will have a range of about 6,500 nautical miles, it is likely to capture approximately 1.2 trillion of the available 3 trillion RPMs in the year 2010.

In other words, by 2010 the worldwide market will likely be split approximately 40 to 60 between HSCT and conventional subsonic transport aircraft (see Figure 3). It is important to note, however, that these market projections depend heavily on the assumptions made regarding the operation of supersonic aircraft, particularly the generation of sonic booms over populated areas.

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The issue of sonic boom generation determines, in large part, the upper limit of the market for HSCT. Designers may eventually be able to mitigate the effects of sonic boom, but the present state of the art has not advanced enough to provide confidence that the first generation of HSCTs

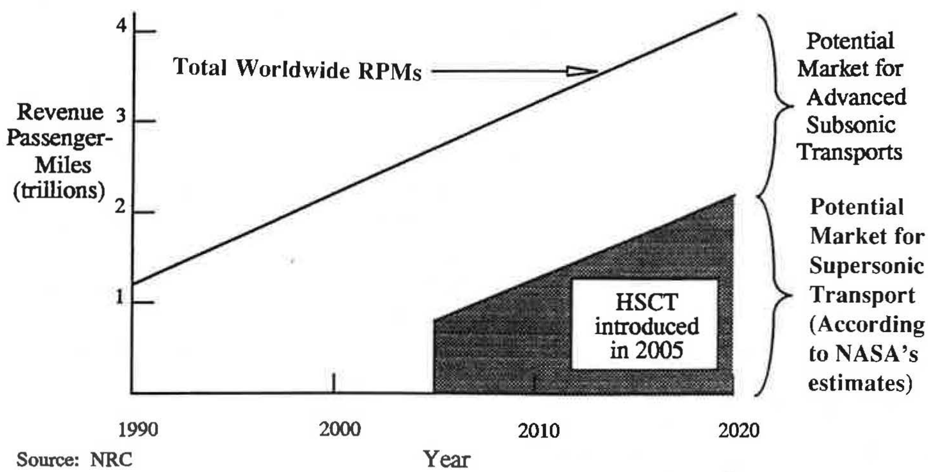

FIGURE 3 Potential air travel future market.

will be able to fly unobtrusively over populated areas. It has been suggested that, particularly in some parts of the developing Third World, local authorities may look less harshly at sonic booms if the alternative is expanded commerce. It is impossible to imagine, however, that in the developed world sonic booms as we currently think of them will ever be allowed to become routine.

Early HSCT studies considered the possibility of flying subsonically over populated areas. Unfortunately, designers do not believe that an HSCT can be economically viable if it must fly long distances at subsonic speeds—the requirements imposed by two drastically different flight regimes produce too many performance penalties to make such an aircraft economical. Given these difficulties, the approach currently being taken by the researchers and designers planning the HSCT is to restrict flights to unpopulated areas; the remaining routes will continue to be serviced by subsonic aircraft. Thus, as is indicated in Figure 3, until overland supersonic flight is possible, there will be a robust market for both HSCT and advanced subsonic transport aircraft.

What should NASA do to help the United States capture as much of these future markets as possible, and how should the priorities be set to ensure that the nation gets the most for its investment? To ignore HSCT is to risk abdicating that segment of the market to foreign competitors who are already working on the necessary technologies. However, there are also a great many technologies that could provide a significant competitive edge for the next generation of U.S. subsonic aircraft. The NRC report discusses possible advances in subsonic aircraft in detail and outlines the scientific and technological challenges that face the HSCT.

The Case for High-Speed Civil Transport

NASA Administrator Goldin spent several months at the end of 1992 in discussions with executives of all the major aircraft companies, asking them what they thought NASA's role in aeronautics should be. The answer he received was that HSCT should be NASA's primary emphasis because the industry itself does not have the resources to solve the associated scientific and technical problems. NASA has been receptive to this view because of its traditional role in researching and building cutting-edge systems, as well as its traditional practice of using such advanced concepts as "flagships" to provide visibility and credibility for the aeronautics program as a whole.

In his December speech to the AIAA Goldin said about the HSCT: "It's risky. There are no certain results. But no other step we can take is as critical to America's efforts to restore market share, provide manufacturing jobs, and regain the leading edge in aeronautics, as high-speed research."

He added: "I believe making it [HSCT] a highly visible NASA program is one way to bring about significant change and reinforce the message to America that NASA is back in the game."

A successful HSCT development program will give the United States a leg up in the global competition for the market that is projected for HSCT. It will also serve as a source of pride and prestige by ensuring that the United States is the world's technological leader. A robust HSCT program also lays the groundwork for a continued strong aeronautics program within NASA well into the next century because it gives aeronautics the visibility it deserves. All of these are good reasons for NASA to go ahead with current plans to address the unresolved issues associated with commercially viable supersonic transports.

According to the NRC report, those unresolved issues include the effects a fleet of HSCTs will have on the depletion of the ozone layer, the noise associated with takeoff and landing, sonic boom, and the overall economic viability of HSCT. It is hoped that by bringing all of NASA's capabilities to bear, and using the complementary capabilities of industry and academia, these problems can be solved. Of the approximately $93 million spent on HSCT-related research in 1992, almost $60 million went to environmental research. Another $19 million went for propulsion research to reduce fuel consumption and reduce potentially harmful engine emissions. The NRC report suggests keeping HSCT funding at approximately current levels until these important problems are solved.

The Case for Advanced Subsonics

Despite the benefits of HSCT and the clear role for NASA in solving the associated scientific and technological problems, the NRC committee and others present a case for making advanced subsonics technology NASA's primary emphasis. The NRC committee suggests maintaining HSCT spending at about the current level and using the majority of the remaining resources, including any increases in the overall budget, for advanced subsonic research and technology development.

As seen in Figure 3, the future market will most likely be split 40 percent for HSCT and 60 percent for subsonic transports, at least until overland supersonic flight is possible. This market split, combined with the belief that a commercially viable and environmentally compatible HSCT is a somewhat riskier venture than the aircraft manufacturers believe, leads many to the conclusion that NASA and its partners in industry should concentrate at least as much effort on the "evolutionary" advances needed to maintain a competitive edge in subsonics as that spent pursuing the "revolutionary" advances necessary for HSCT.

For example, the NRC committee concluded that with a concerted effort to provide evolutionary advances in structures and materials, propulsion and power generation, aerodynamics, and human factors, NASA could help generate a 25 percent decrease in the fuel consumption of a new generation of subsonic aircraft. Given that fuel costs typically make up nearly 18 percent of an airline's direct operating costs, a 25 percent decrease in fuel costs could mean a 4.5 percent boost to an airline's bottom line. Because a well-run airline operates on a profit margin of between 3 and 5 percent, such a boost could provide a significant competitive edge to a manufacturer that offers such an aircraft.

New technologies in which NASA is currently involved can provide significant advances in all areas of subsonic aircraft design and operation to reduce cost and improve performance. The NRC report recommends evolutionary advances in areas such as high-lift, low-speed flight, using advanced concepts such as laminar flow control, new uses of composite materials, new subsonic propulsion concepts such as advanced combustors, new avionics and control systems to reduce demands on the crew and to enhance the usefulness of the information available in the cockpit, and research on the interaction of humans with the advanced hardware and software systems that are likely to appear on the next generation of aircraft.

Some U.S. aircraft and engine manufacturers claim that they are capable of making these evolutionary advances themselves and thus would prefer not to have NASA involved in anything other than the most basic research. Others have welcomed the idea of an expanded role for NASA in developing and validating new subsonic technologies. Of course, all parties welcome an expanded effort within NASA to transfer these technologies to U.S. industry faster and in a form that is more readily applicable to production aircraft.

If NASA does not make an effort to provide these needed advances, and if U.S. industry lacks the resources to do so on its own, our foreign competitors will continue to capture market share regardless of the success or failure of HSCT.

The NRC committee believes that NASA's role should include a significant increase in both basic research and more immediately applicable development and validation efforts. This is in part because, according to the Aerospace Industries Association, corporate R&D funding is actually dropping in real terms rather than increasing despite—or perhaps because of—the unprecedented competition from well-capitalized foreign competitors in the advanced subsonic transport market. According to the NRC committee, if NASA does not make an effort to provide these needed advances, and if U.S. industry lacks the resources to do so on its own, our foreign competitors will continue to capture market share regardless of the success or failure of HSCT.

Making a Case for HSCT and Advanced Subsonics

The NRC committee has recommended that "NASA should emphasize the development of advanced aeronautical technologies in the following order: (1) advanced subsonic aircraft, (2) supersonic aircraft" (*1*, p. 6).

This recommendation stems from the committee's view that advanced subsonic aircraft will continue to provide the bulk of the future transport market and that there are many advances to be made that will provide U.S. manufacturers with a significant competitive edge. However, the report also states: "At the same time, the potential future market for HSCT is significant, and NASA should continue research on noise, sonic boom, and emissions, and should be on the forefront of the technology research and development required to bring about a technically and economically viable HSCT. In short, it is vital that an appropriate balance be struck between programs with immediate benefits to the nation and those that lay the groundwork for the future" (*1*, p. 6).

In other words, advanced subsonic research versus supersonic research is not really an either/or proposition. The NRC committee believes that if NASA is to do a credible job of helping the U.S. aeronautics industry maintain its standing in the world, both the revolutionary advances needed to make HSCT a reality and the evolutionary advances needed to maintain competitiveness in subsonics must be realized.

Finally, it is the belief of the committee that, if NASA and the U.S aircraft industry make a conscientious effort to put forth a case for both HSCT and advanced subsonics research, there will be a receptive audience in the new administration and Congress. In doing so, the NRC committee believes that it is important not to assume that only one of these efforts will find funding. Even in these times of difficult budget choices, a robust aeronautics program can be traced directly to the jobs it has produced in the past and the likelihood of continued job creation in the future. The NRC committee believes that if a conscientious case is made for both, policy makers will act appropriately.

Reference

1. *Aeronautical Technologies for the Twenty-First Century.* Commission on Engineering and Technical Systems, National Research Council, Washington, D.C., 1992.