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FORUM***HIGH SPEED CIVIL TRANSPORTATION***

Walker L. Ross

This paper explores the research and development of high-speed transportation for commercial travel that is currently taking place at several research centers. The paper delves into wind tunnel testing of the airframe and development of new engines that will power high-speed aircraft faster, quieter, and more economically than previous supersonic transports. Noise pollution and possible damage to the environment are significant hurdles to be overcome in the development of this aircraft. The paper will discuss the vision of high-speed travel and the challenges to achieve the dream of economic high-speed travel. Achieving these objectives make the possibility of high-speed air travel a reality.

America's traveling public dreams of high-speed air travel with reduced flight time and maintaining today's fares. America's leading research engineers are convinced they can make these dreams reality. High-speed travel is a dream that has been around for over 30 years. Devoted research scientists dreaming of better mousetraps, or faster aircraft in this case, will not let the project die.

In an overview statement from the High-Speed Systems office at NASA Glenn Research Center, Dr. R. Shaw (1999), said, "Early in the next century, American-made supersonic airliners traveling at twice the speed of sound will carry millions of passengers each year around the world. To bring that dream to life, NASA is developing the technology needed to make a High Speed Civil Transport (HSCT) cost effective, reliable, and environmentally compatible" (p. 1).

The Boeing Company's history concerning the Supersonic Transport (SST), reveals the following:

On New Year's Eve 1966, after more than 14 years of study, design work and competition, the federal government selected Boeing to build the prototype for the country's first supersonic transport (SST). Twenty-six airlines ordered 122 of the transports. The final design featured a double-jointed, needle-shaped nose that would drop during takeoff and landing for improved pilot visibility. Government funding was withdrawn in 1971 before the prototype was finished. However, the Boeing

SST fostered advances in supersonic transportation, leading to the High Speed Civil Transport project (Boeing, 1999, p. 1).

This research indicates there were many obstacles in the early stage of the project's development.

In 1966 the cost to build and operate the SST aircraft was simply not practical, nor were there friendly attitudes conducive to the SST's being built. Environmentally, the SST aircraft was not deemed a winner. In addition to the costs of development and operation of the SST, damage to the ozone layer and noise pollution were factors considered that made its development unsuitable. Those were some of the reasons that lead the United States and the Soviets to withdraw from the development of the SST before it ever got off the ground (Boeing, 1999, p. 1).

Today research engineers look differently at the idea of operating an aircraft at supersonic speeds. The dream lives on in the minds of the traveling public as well as with research scientists. Siuru and Busick (1994), describe these issues in their statement:

There is no getting around the fact that faster airplanes are more costly to build and operate. When you fly at supersonic or hypersonic speeds, more sophisticated propulsion systems, materials, flight controls, and just about everything else are needed. At supersonic speeds, engines guzzle tremendous amounts of fuel, and maintenance becomes much

more complex because of the stresses and temperatures put on exotic materials. . . .cost jump, sometimes by an order of magnitude (p. 25).

As more and more countries are developing world economies, the natural consequence is that more and more people are choosing air travel to conduct business, and to travel for pleasure. For this project to be a successful reality, it is apparent that these travel needs have to be met. According to Siuru and Busick (1994):

A future SST would have to overcome some pretty significant hurdles, both fiscal and technological. To be a business success, some studies show that a future SST would have to carry 250 to 300 passengers at Mach 2 and Mach 3, cover twice the range of the Concorde, and do it for one-seventh the cost per passenger mile—a pretty tall order (p. 154).

Dan Goldin, NASA's Administrator, spoke at the Glenn Research Center concerning technological goals. He gave additional support to the idea of SST travel in his recent address, "Objective: High Speed Research." In that address, he discussed the idea of maintaining a leadership position in the aeronautical community and reducing travel time to the Far East and Europe by as much as 50 percent:

Simply put, the U.S. must bring to market products that dramatically benefit the traveling public at affordable levels and do so without harming our environment. Since the sound barrier was broken 50 years ago, most modern fighter aircraft have the capability to fly faster than the speed of sound. However, today's supersonic engines cannot meet international standards for a clean and quiet community. To bring this capability to commercial air travel, a number of technical barriers must be overcome. Among NASA's technology goals for removing the environmental and economic barriers are: (1) quiet supersonic engines able to meet subsonic aircraft noise standards; (2) clean supersonic engines with emissions 75 percent lower than today's aircraft; and (3) low-cost materials and structural concepts for affordability. The result will revolutionize overseas air travel (Mercure, 1999, p. 1).

Research reveals the fact that there is more attention being given to the possibilities of a commercial supersonic airliner than one might realize. In 1990, NASA, under the leadership

of the NASA Langley Research Center, began an ambitious effort called the High-Speed Research (HSR) Program. According to Shaw (1999), ". . . Boeing and its Douglas Products Division (formerly McDonnell Douglas), joined in this effort to develop a plane, . . . that will transport more than 300 passengers in a three-class arrangement over 5,000 nautical miles at Mach 2.4 cruise." At that speed, ". . . a trip from Los Angeles to Tokyo, for example, will only take just over four hours instead of 10 hours on subsonic airplanes." This HSR program further addresses the challenges: "Emissions effects on the atmosphere, airport noise, and sonic boom; all will have to be solved for a supersonic transport aircraft to fly" (Shaw, 1999, p.1).

Developing engines that will give required propulsion and at the same time satisfy the noise limit regulations of today's subsonic transports is proving to be a major challenge. In the article, "No Noisy Neighbor," on NASA's web page, Dr. Shaw comments: "To get acceptable sound levels, designers want an engine that has low exhaust velocity at takeoff, much like today's high-bypass turbofans which make a low throbbing hum. Yet a supersonic engine must have good supersonic cruise performance." The same article states, "Factors such as takeoff weight, emissions, and noise levels are used to compare the contenders." These facts state: ". . . mandate a high-velocity, turbojet-like cycle; exactly the opposite of the characteristics that reduce noise" (Shaw, 1999, p.2).

In exploring the development of these new propulsion systems research indicates it is possible to achieve all the desired requirements and still meet all the limitations of the environment. However, this engine will not appear overnight, but will require continued testing like the research currently underway at several research centers. Referring to an article written for NASA's Critical Components web site, Graber (1999), states, "The goal is to develop the technologies that would contribute to a combustor design with an emission index (EI) level no greater than 5 grams (g) of nitrogen oxides (NOx) per kilogram (kg) of fuel burned at supersonic cruise conditions" (p. 1).

The study of how air will flow around and over the aircraft while it is in flight is another challenge to be met in the design of this high-speed aircraft. Research engineers have to pay special attention to the characteristics of sonic boom when the aircraft is flying beyond the speed of sound. If a shock-free aircraft can be developed, this project will have a much better

opportunity becoming a reality. Research supported by NASA Langley Research Center, under the grant NAG 1-1518, "Nonlinear Stability of Supersonic Jets", is another phase of the considerable research being conducted. Bhat, Seiner, and Tiwari (1995), make the following evaluation: "The stability calculations have been performed for different frequencies and mode numbers over a range of jet operation temperatures. Comparisons are made, where appropriate, with the solutions to Rayleigh's equation (linear, inviscid analysis with the assumption of parallel flow). The comparison of the solutions obtained using the two approaches show very good agreement" (p. 1).

The traveling public can be confident that many hours of research are being conducted at NASA Glenn Research Center, General Electric Aircraft Engines, and Pratt & Whitney to develop the new engines early in the next century, and a new chapter in the history of American air transportation will begin (Shaw, 1999, p.2).

In designing new aircraft one of the most useful tools is the wind tunnel simulation test. Just as the name suggests, the wind tunnel is a large tube that is capable of housing a model of the airframe to be tested. Air is then blown across this model at various speeds while computers record how the airflow affects the aerodynamic properties of the model.

In the article, "After the Test – Final Thoughts," many of the results of the wind tunnel test were revealed. Fanny Zuniga (1998), a member of the High-Speed Research Team (HSR), gives the following account: ". . . we spent the first few weeks after the test checking over all the data, and made corrections, for example, the effect of the wind tunnel walls. After all the data is compiled and checked, we post it on the internet for all the other members of HSR to study" (p. 1).

Wind tunnel tests play a major role in the design and development of any new aircraft. Zuniga (1998), describes how wind tunnel walls effect can make a difference in the aerodynamic loading of the aircraft control surfaces. "Normally, air flows freely around an object, such as an airplane, but in a wind tunnel, the walls block some of the flow that tries to go around the model which gives a slightly different effect than in free air" (p. 1).

This project is a huge investment for one company to undergo alone. For this reason the HSR members have agreed to protect this very sensitive data and not to share it with the general public, which will help ensure the United States aerospace industry will maintain a competitive edge in the

development of this aircraft (Zuniga, 1998, p. 1).

Two of the important items learned from the test that Zuniga (1998) was able to share with the general public were, ". . . which flaps on the wings give us the best performance at takeoff and landing conditions, and the effectiveness of the control surfaces to make sure this kind of aircraft can be flown safely" (p. 1).

Concluding the report, Zuniga (1998), states, "Basically, we will continue to test and study this airplane to convince ourselves that we can build one that is safe, affordable, and environmentally friendly. Hopefully, if we are successful in our endeavors, affordable supersonic travel and cargo delivery will be available early in the next century" (p. 1).

As an airline pilot for the past 32 years, I have experienced many changes in the design and ergonomics of the flight decks of the planes I have flown. I have experienced flying basic instrumentation and flight controls of the early DC-3 aircraft to the glass display and the computer driven fly-by wire flight controls of today's airliners. Having operated these different flight deck designs, I have witnessed the commercial transport industry's continued production of safe and efficient aircraft. In a summary of a symposium on aviation psychology, Palmer, Rogers, Press, Latorella, and Abbot (1995), describe some of the concerns pilots have when operating these highly automated aircraft. The technical report, "Crew-Centered Flight Deck Design Philosophy for High-Speed Civil Transport Aircraft" states, "Automated systems have become more complex and numerous, and often their inner functioning is partially or fully opaque to the flight crew" (p. 1). There has really never been any doubt or argument over their next statement, "While pilots remain ultimately responsible for mission success, performance of flight deck tasks has been more widely distributed across human and automated resources" (p. 1). In conclusion, Palmer, Rogers, Press, Latorella, and Abbott make the following statement, "These concerns must be addressed, in part, with an explicit, written design philosophy focusing on human performance and systems operability in the context of the overall flight crew/flight deck system (i.e., a crew-centered philosophy)" (p. 1).

In my experience, the aviation industry over the past 30 years has been an exciting endeavor. After this research, all indications point to an exciting future as we venture into the twenty-first century. Those of us in the aerospace community look forward to the possibilities of high-speed travel. As the

Administrator of NASA Dan Goldin (1999), stated, “. . . our responsibility to the American public is to ensure that NASA’s work in science and technology sustains United States leadership in civil aeronautics and space” (Mercure, 1999a p. 2).

Many technology transfers must take place in order for this high-speed commercial transportation to become a reality. Noise reduction, ozone depletion, and public support continue to be important hurdles to overcome. Public opinion, economic and social benefits, and a viable need are critically important.

John Hunt (1989), Counselor for Civil Aviation British Embassy (US), states the following in reference to high speed travel: “Building on continuing work to improve intergovernmental collaboration on the economic regulation problems would similarly help, and High-Speed Civil Transportation in particular, as well as the industry in general” (p. 159).

It is quite apparent that this high-speed civil transportation

project is so enormous it will be difficult for any one company or country to manage alone. Since this aircraft will make the distance between countries much shorter, it is essential that governments work together. Intergovernmental connections are critically important Hunt (1989), remarks: “The crucial considerations here are that no one country or jurisdiction should attempt to set its own standards independent of those being evolved in other countries to which an HSCT might be expected to operate” (p. 159).

Based on the findings of this research, the author believes that high-speed civil transportation will become a reality in the twenty-first century. With this information, the reader can determine, along with this researcher, that research engineers at NASA-Glenn, NASA-Langley, NASA-Ames, and The Boeing Company strive to lead the world in the development of high-speed travel. With the combined efforts of all elements of the aviation field, the United States will maintain its status as a global leader in aeronautics and space. □

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