Chapter IX

COMPETITIVE CONSIDERATIONS AND FINANCING

The costs of a new commercial aircraft program—research, development, and production—are very large. In the case of an advanced supersonic transport (AST), no one really knows the cost, though estimates range from $6 billion to $10 billion in 1979 dollars. The figure could be much larger. Much of the investment is essentially independent of the number of aircraft built, so that scaling back production plans is not an option for reducing the financial risks.

A particular drawback is that a very large investment must be made even before testing has proceeded far enough to verify the technical soundness and performance of the product. Figure 19 shows how much an initial investment must be made before there is any possibility of a return. On the positive side, although the negative cashflow trough is very deep, it is followed in the later years of a successful program by large positive cash flows.

Figure 19 also indicates how initial investments have been escalating over time. The Douglas Aircraft Planning Department has estimated that since the 1940's these costs have risen at about 11 percent annually in constant dollars, the result largely of growing size and complexity of various aircraft. (For example, the cost per *pound* has escalated from $83 for the DC-3 to $6,300 for the DC-10 in constant 1975 dollars.[1]) By comparison, the net worth of the company has *only* grown at an annual rate of 6.6 percent. The discrepancy gives a crude measure of the ability of the company to finance new programs. As another example, the DC-10 front-end costs were 155 percent of Douglas equity, though the same costs for the DC-6 were 42 percent.

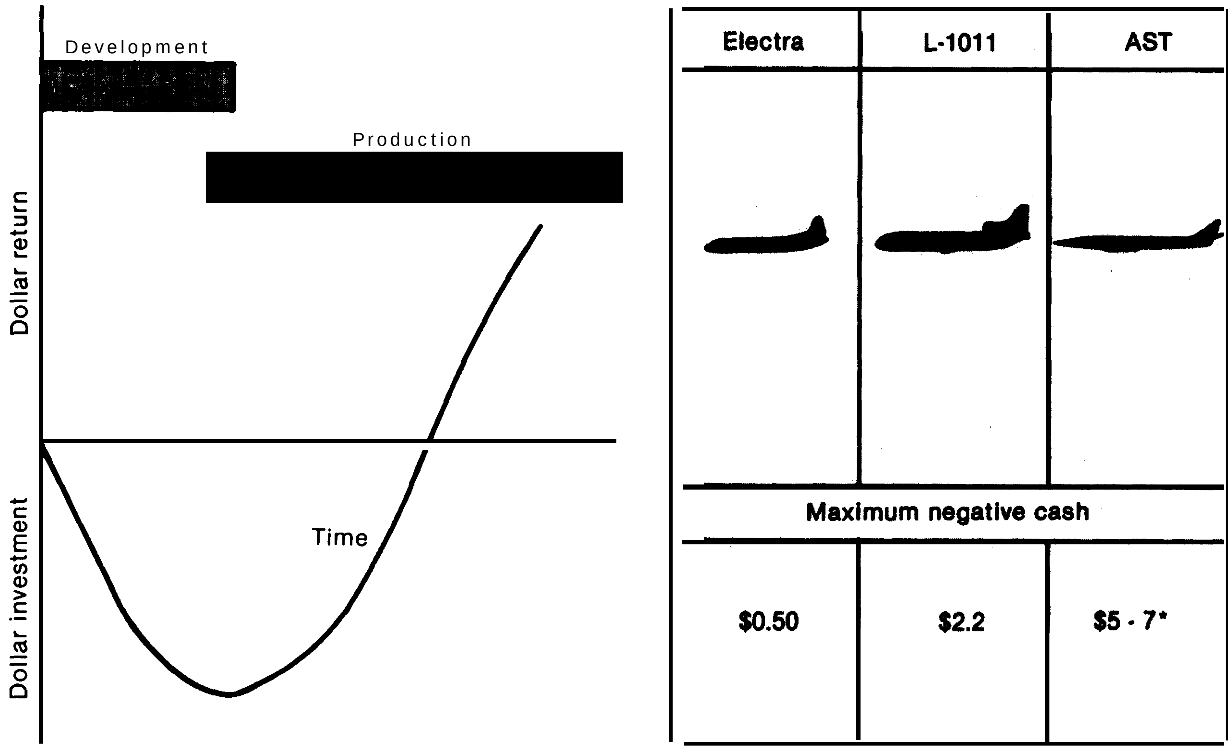
The magnitude of the required investments and the delay in any substantial returns would induce a company to time any new program to take advantage of positive cash flows from prior programs to help finance the initial costs of new ones. The periods of positive cash flows—and relatively smaller commitments of technical skills—are the "windows of opportunity" for a commercial aircraft manufacturer. Determining when such "windows of opportunity" are likely to occur is important in the intelligent pacing of any precursor technological readiness programs.

The magnitude of the required investments would either limit or preclude the possibility of two new aircraft programs being started at the same time by one company, or possibly by the entire industry. Thus, from the industry's perspective, a new supersonic aircraft program must be seen as competing directly with new subsonic aircraft programs. The freedom of the developer is impinged by the fact that the next "window of opportunity" is at least a decade or so in the future. Developers of large new commercial aircraft are motivated to act in accord with what they perceive as their long-term interests, not to assume high risks for the sake of flaunting technological glamour.

Current financing trends are making it increasingly difficult, and perhaps impossible for a single company to undertake a large new commercial aircraft program. The sheer size of the financial commitment required to enter the supersonic transport market means there will not be many competitors, even if ways, such as subcontracting and consortium arrangements, are found to mitigate the financial burdens. Whereas there is the potential for many entrants in the general aviation and small transport market in countries around the world, the potential competitors for an AST market are only from a few of the most technologically advanced nations and from a few industrial organizations. (Of course, the list of potential collaborators is much larger.) It should be remembered that competition offers its own set of risks: the potential for one economically successful program

[1]A. J. Gellman and J. P. Price, *Technology Transfer and Other Public Policy Implications of Multi-National Arrangements for the Production of Commercial Airframes*, NASA CR-159890, July 1978.

Figure 19.—Typical Aircraft Cash Flow Curve (billions of 1976 dollars)



*$6 billion to $10 billion, in 1979 dollars.
SOURCE: OTA Working Paper, Lockheed California Co , January 1979.

of, say, 400 aircraft might, with two competitors in the field, turn into two more expensive and/or unsuccessful programs of perhaps 150 aircraft each.

Balancing the forbidding size of development investments is the prospect that it pays to be the first to introduce a major new kind of aircraft. It is often observed that a large proportion of orders for a new aircraft are placed within the first several years before and after its introduction. Certainly, if an AST, reasonably competitive with subsonic aircraft, were introduced by one airline on a route, enormous pressure on competing airlines to follow suit would ensue. If the competitors fail to follow the lead, they stand to lose a major share of their markets. An airline can only afford to wait for a second offering if a later aircraft is sufficiently superior to recapture the lost competitive advantage.

Another reason that the first manufacturer to offer a new aircraft product will stand to gain is that airlines prefer operating a homogeneous fleet. A mixture of airplanes not of the same basic technical family complicates maintenance and parts inventory and demands a more diverse standing array of labor skills—all of which increase costs. Thus, though there are simplifications here, once an airline has committed itself to a given aircraft, only the very marked superiority of an alternative will induce the airline to switch to other manufacturers for subsequent orders as the fleet expands. The risks of a homogeneous fleet, such as greater vulnerability if flaws appear in the chosen aircraft, do not appear to deter this inclination toward a high degree of homogeneity.

Once any manufacturer commits to production and begins accepting orders for a new AST, in an international market where sales and competition are not constrained politically, the "window" for a second competitor with only a marginal technical advantage may be open for a very short time, perhaps less than 2 years. How long the "window of opportunity" is kept closed after this initial opening depends on the rate of growth of both the market and the increment of technical, and therefore economic, superiority the later aircraft might embody.

The time and expense required to build a technological base will depend on the degree of advancement set as a goal. No U.S. manufacturer now feels the necessary technology is available and sufficiently validated to prudently commit billions of dollars for an AST development and production program. What further degree of advancement is necessary to meet environmental standards and reasonably assure an economically successful aircraft is still a matter of judgment, although attention has been devoted to defining the investment in money and time required to fill the existing deficiencies. The National Aeronautics and Space Administration's (NASA) technology validation program that has emerged, described in chapter II, could cost $0.6 billion to $1.9 billion depending on various suggested plans and require from 5 to 8 years to complete.

The large financial demands and the need to ensure a large market for the aircraft are pressures to spread the manufacturing, and possibly some of the development costs, of an AST internationally. This can be accomplished either by extensive subcontracting or through the formation of some kind of consortium. For nations where the state partially or wholly controls both airlines and aircraft manufacturing there is a motivation to exert pressure for a quid pro quo: "I will buy your airplane instead of X's, if you will let us manufacture the hyperthrockels."

One consideration in regarding such internationalization would be technology transfer licensing. Another would be cost. The impact of a multinational program would probably be to raise the price of development on account of the costs of coordinating and bridging the distance between participants. In addition, sharing the program would probably attenuate the balance-of-payments impact of each aircraft. On the other hand, an internationally diffused program would enlarge the assured market which might offset any such reduction in the balance-of-payments impact.

IDENTIFICATION OF THE TECHNOLOGY

The military has traditionally been of great service to the commercial aviation industry. For one thing, the military has led in researching and developing aircraft technology and has been responsible for such developments as all-metal construction, radar, navigation systems, high-strength lightweight materials, and various jet engines (the JT3, JT8, C-5 which led to the CF-6, and also the B-1 which led to the CFM-56).[2,3] Furthermore, the military has enhanced the economic viability of the commercial sector by ordering a large number of transport aircraft, such as, in the past, the DC-3, DC-4, and DC-6, the Constellation, and to a lesser extent the KC-135 and B-707, and, in the present, modifications of the DC-10 (KC-10 tanker), B-707 (AWACS), B-737, and DC-9.

However, the situation has changed. The military is no longer leading the way in aircraft developments and thus spinoffs to commercial aircraft areas have been reduced or eliminated. The main reason for this change is that the goals of military aircraft are no longer compatible with those of commercial transports. What this means is that if it is desired to keep improving the U.S. technology base, other ways of supporting aeronautical technology should be considered.

For subsonic aircraft, improvements are expected to continue in propulsion-system efficiency (through higher temperatures and pressures achieved by advances in metallurgy and materials), noise suppression, structures and weight technology (through composites, increased use of titanium, and advanced fabrication techniques such as superplastic forming), and aerodynamics (through airfoils, winglets, and active controls). Improvements are also an-

[2] "Future of Aviation," Committee Report, House Science and Technology, U.S. Congress, October 1976.

[3] "Research and Development Contributions to Aviation Progress (Washington, D.C.: Federal Aviation Administration, 1972)."

Photo credit Boeing Aircraft Co

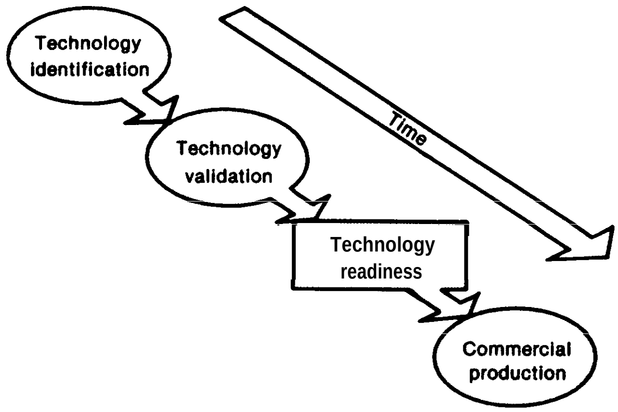
B-707– AWACS

ticipated with respect to cost, safety, and maintenance.

If the Government's role in funding research for subsonic technology continues as it has in the past, there will be further technological advancements in subsonic aircraft, Some funds will continue to be used to assess far-term technologies—generally the high-risk technology items—including composite primary structures, laminar flow control, advanced avionics, and alternative fuels. Industry R&D funds are primarily directed at near-term technologies applicable to both new aircraft and derivative versions of existing aircraft. These include: active controls, composite secondary structures, aerodynamics, and improved applications of current high-bypass-ratio engines.

In the supersonic area both NASA and the aerospace industry have been involved with improving the "state-of-the-art" for supersonic aircraft. As discussed in chapter II, NASA has proposed a supersonic cruise research (SCR) program divided into four phases, shown in figure 20. Two initial phases, of technology identification and validation, led to a phase of technology readiness—and a decision whether to precede with any commercial aircraft production. To date, approximately 90 percent of the SCR program funds have been allocated to technology identification and the question now is how much should the Federal Government invest in the validation and readiness phases. The potential technology solutions include blended wing/body designs, further propulsion improvements (coannular nozzles, advanced inlet design), improved noise suppression, titanium sandwich construction, increased structural efficiency, active controls, advanced flight controls, flight management systems, and greatly

Figure 20.— Phases of Advanced Transport Development (SCR)



SOURCE: NASA · OAST, "A Technology Validation Program Leading to Potential Technology Readiness Options for an Advanced Supersonic Transport," September 1978.

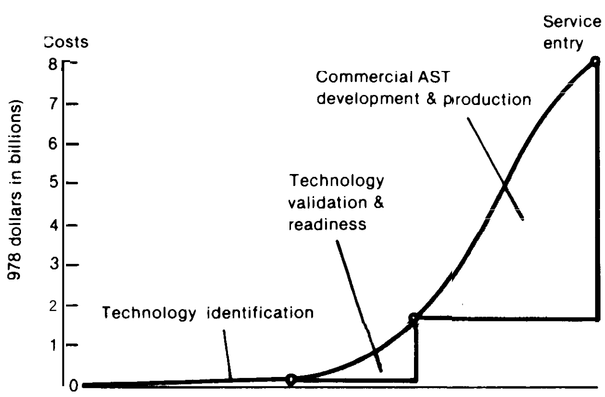
improved aerodynamic efficiency at subsonic and supersonic speeds. Along with the variable-cycle engine concept, these technology solutions could provide a basis for achieving the desired economically viable and environmentally acceptable AST. However, as discussed in chapter II, work is only beginning on validating these advanced elements, identified in the first phase of technology research.

ALTERNATIVE STRATEGIES

The immediate issue is not a go or no-go decision on an AST, but rather the selection of a desired level of commitment to technology readiness. (Such readiness in the context of an assumed $8 billion total program is shown graphically in figure 21.) Selection must weigh the attractiveness of future possibilities that a given level of technology might create or maintain against the cost of achieving such readiness.

One strategy would be to concentrate on the subsonic market and not attempt to compete

Figure 21.— Cost of a Representative AST Program



SOURCE. F E Mclean, OTA Working Paper, "Advanced High-Speed Aircraft."

with a supersonic aircraft—the base case discussed earlier. This strategy would be appropriate if a significantly worse energy situation in the 1980's makes an AST less attractive. It would also be appropriate, regardless of energy considerations, if the potential competitors of the United States also hold back from significant investment in technological advancement. If a new foreign supersonic transport were introduced without benefit of further advancement in technology, it may well capture enough of the market to be successful—say, $20 billion—but it is less likely to be so successful as to make the subsonic market unattractive.

The no-supersonic strategy has the great short-term advantage of saving the money that would be invested in technological development. However, its risk is long-term. If a supersonic transport were developed and it were sufficiently successful, it could capture the lion's share of the market. Once there is a successful supersonic, the market for a third-generation aircraft could very well expand tremendously, especially if over land supersonic flights were permitted. If the United States refused to join the market at an early point, it would find it both difficult and expensive to catch up. Among other impediments, it would be very hard to train a new generation of specialists with competence in supersonic technology. How difficult and how expensive such catching up might be has not been evaluated.

The second strategy open to the United States would be the opposite of the above—a commitment to a fairly vigorous supersonic technology development program of perhaps $100 million to $150 million annually. This path could lead to a U.S. AST program or a major U.S. role in a cooperative international program. The ramifications of these possibilities have already been discussed. The risk is that the investment might lead to nothing except perhaps application of the technology to subsonics, military aircraft, or space transport.

The third alternative might be called the hedge strategy. The United States might invest a certain amount—perhaps $50 million per year—in technological R&D. Such a strategy could serve as an adequate base to negotiate a cooperative international program. It also would retain the option of future acceleration as a basis for a U.S. program.

It seems plausible that, whichever strategy is taken, the industry response would roughly parallel the national program. A vigorous supersonic R&D program sponsored by the Federal Government would probably evoke a much larger private sector financial commitment than a weak effort at the Federal level. The national "signal" is very important to the aircraft manufacturers.

If some commitment is made to a supersonic program, it would appear that there is no short-run alternative to continuing the past and current practice of funding NASA. As noted, NASA has a relatively modest SCR program underway, funded at about $10 million annually.

In the long run, however, there may be preferable approaches for the continued development of aeronautical technology. Such alternatives have not yet been seriously identified and evaluated, but certain principles that should guide the identification of alternatives should be noted. Any alternative should ensure a healthy competitive posture for the aircraft industry. It should also encourage innovation.

Any alternative to the NASA arrangement should seek to internalize the costs of aeronautical research to the air system. This would require, first, identifying appropriate sources of funds and, second, determining the best method for their allocation. The former is probably easier to accomplish than the latter. For example, each one-tenth of a cent levy on each domestic revenue passenger-mile would provide $200 million annually. Defining an allocation process would take time. However, in this and other regards relating to an alternative to the NASA research program, the general principle of limiting Government involvement should be followed.

BEYOND TECHNOLOGY READINESS

During the conduct of this study, concern was expressed about the manner in which the phase following technology identification, validation, and attainment of technology readiness would be funded. Though this area is addressed as a subsequent activity of this study, it is relevant here to present several alternatives which may be appropriate under different circumstances for financing the development and production of advanced supersonic aircraft:

- A U.S. aircraft manufacturer could undertake the effort as a private venture and have suppliers develop components on a risk basis in the same manner as the large subsonic transports are now developed. In addition, funds could be obtained through advanced payments by the airlines.
- It may be possible for several U.S. manufacturers to combine efforts or to form an independent organization supported by

several companies involved in the technology development phase. If two or more U.S. companies combined efforts, they would run the risk of antitrust threats which would have to be removed before this option could be considered, A recent NASA publication discusses some of the antitrust policy questions. It states:

> Among the most significant barriers to the formation of both domestic and multinational consortia is antitrust policy. The U.S. Department of Justice is not presently receptive to the suggestion that there may be a need for rationalization of the commercial airframe industry without which effective market competition may be reduced in the long run and U.S. interests may suffer materially in several ways. The only means currently available to a firm contemplating participation in any consortium to ascertain formally the acceptability of that consortium to the antitrust authorities is the Business Review Procedure of the Department of Justice. However, even a positive opinion by the Justice Department does not grant a permanent exemption from prosecution. The competitive impact of any proposed cooperative arrangement will be gauged by the Department of Justice primarily by: 1) the extent to which market competition in the United States between commercial airframe producers would be foreclosed in both the short term and the long term, and 2) the way in which the arrangement proposes to treat the issue of technology transfer. The competitive effects of proposed airframe consortia are largely indeterminate ex ante, particularly in the long run. However, given the present and prospect, both multinational and all U.S. consortia have *at least* as great a likelihood of enhancing competition as of thwarting it.[4]

- The possibility also exists for a collaborative effort between a U.S. company and one or more. foreign companies or governments. A principal reason for such a consortium would be to reduce the amount of money committed unilaterally to finance a new aircraft project through sharing the costs, benefits, risks, and responsibilities.

[4] A. J. Gellman, op cit

NASA has offered various motives for becoming involved in either intranational or international consortia:

> The mechanism of a consortium can be expected to reduce the resources required for the development, production, and marketing of a transport aircraft below what would be required if any individual participant were to undertake the project alone. However, the consortium device will probably increase markedly the total resources required for its project. Neither multinational consortia with U.S. participation nor all-U. S. consortia automatically imply either a reduction or an increase in domestic aerospace employment opportunities, in either the short run or long run. Each case must be analyzed on its own merits.

For example, some may argue that if *a* U.S. and foreign manufacturer formed a consortium, a certain amount of employment would be lost to foreign countries. However, it may be argued that, if such participation served to strengthen the domestic industry, a net improvement in employment could result in the future. A case in which this would apply would be one in which a U.S. manufacturer saw a potential for a family of aircraft, but would not engage in this venture on its own.

> The primary motive of U.S. firms for considering participation in multinational consortia is the enhancement of their individual financial resources. The consortium mechanism might also provide a means for a U.S. firm to pursue contemporaneously more than one transport aircraft development project. Preservation of market access is a secondary, but perhaps at times important, motive for commercial airframe manufacturers to join multinational consortia.[6]

While this discussion is by no means exhaustive, it does indicate some potential ways in which consortia can aid in the AST programs.

This chapter has only preliminarily addressed some of the major financing concerns with respect to validating the technology and developing and producing ASTs into commercial service. The intent was not to evaluate options for financing but only to suggest some alternatives.

[5] Ibid

[6] Ibid

A further examination of the alternatives as well as possible funding mechanisms is planned as a subsequent activity in this assessment, to be documented in a later report "Financing and Program Alternatives for Advanced High-Speed Aircraft."

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