Chapter 2

RISKS: A QUALITATIVE DISCUSSION

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The question of whether and how the U.S. aerospace industry could finance advanced air transport programs arises because such programs are easily seen to be risky. Indeed, the financial failure of the Concorde program demonstrates what happens when a new-technology commercial aircraft design proves to be inadequate.

The Concorde cost over $3.25 billion (in current dollars, beginning in the early 1960's) to develop and produce, but only **16** planes (rather than the few hundred needed to break even) were ever built. Concordes in use have cost the two airlines that fly them, British Airways and Air France, several hundred million dollars in operating losses since the initial flights in 1976. Furthermore, the British Government has written off over $300 million in loans it provided to British Airways to purchase Concordes.[1]

The Concorde sold poorly because between the time it was designed and the time it was initially produced, fuel efficiency and noise suppression became much more important to airlines. Moreover, restrictions on routing due to noise and sonic boom, rising fuel costs and relatively high fuel consumption, and limited seating capacity have made Concordes generally uneconomical to fly. This chapter will examine the risks involved in advanced air transport programs to provide perspective on the decisions and mechanisms for financing advanced supersonic transport (AST) and advanced subsonic transport (ASUBT) programs.

[1] "*Egalite* May Ground the Costly Concorde," *Business Week*, Sept. 28, 1981.

A venture is considered risky if there is a high probability of financial loss, even if there is also a high probability of financial success. More technically, the riskiness of a business venture is evaluated overall in terms of the distribution of probabilities for different levels of profitability. To understand why ventures such as advanced air transports are risky, it is useful to examine different sources of risk, which can be grouped into technological, market, and financial categories.

TECHNOLOGICAL RISK

Technological risk is the risk that efforts to develop new technologies will not yield anticipated results. A new technology may fail to work at all, it may not perform to specification, or it may be too expensive to be used profitably. Technological risk is primarily of concern during the development and testing (generic and specific research and development (R&D)) stages of an aircraft program.

Investment in generic R&D is risky because the technologies involved are unknown or poorly understood. Applications—and therefore return on investment—for the products of generic R&D are uncertain, partly because at this stage a plan for an eventual new airplane is lacking, Specific R&D and production also contain elements of technological risk, but this risk is controlled by use of modern design and testing procedures that make comprehensive testing economical and minimize the chance of failure, and by the practice of designing-in safeguards against materials or component failures. On the other hand, because specific R&D is more expensive than generic R&D, there is significant financial exposure to risk.

Technological risk has traditionally been a relatively minor concern for commercial aircraft programs because they have drawn on military aircraft technologies. Technologies developed for the military are more or less proven when transferred to commercial applications, and are therefore less risky than technologies specially developed for commercial aircraft. Unlike most air transports in use, ASUBT or AST projects may benefit little from military experience. For example, there are no supersonic military transports, while the smaller military aircraft that do fly supersonically are incapable of the long-range supersonic cruising that would be necessary in a commercial air transport.

The uncertainties associated with ASUBT and, in particular, AST technologies would lead aircraft and engine manufacturers to prefer to move slowly in developing the new planes, in part to accomplish relatively large amounts of R&D. The more that is learned about a technology through R&D (or practical experience) the less likely are manufacturers to lose money using it. However, there is no reason to expect that ASUBTs or ASTs would be unusually prone to post-certification problems, in part because the Federal Aviation Administration would be expected to require especially rigorous testing for certification. Major postcertification problems with commercial aircraft have been rare to nonexistent for over 20 years (although there have been postcertification problems with jet engines which have made post-certification research necessary).

Even if new technologies perform to specification, they may still prove unsatisfactory in comparison with other technologies in meeting customer needs, especially if those needs change. This problem afflicted the Concorde. Because of the oil price increases of the 1970's, that aircraft proved to be too fuel inefficient relative to contemporary subsonic planes. It was sufficiently noisy that the Federal aircraft noise regulation "FAR 36" was made applicable to supersonic (as well as subsonic) planes. Finally, several countries refused to allow Concorde flights over their land, largely to avoid sonic booms generated during supersonic flight. The possibility that a given set of technologies may fail to be competitive with other technologies reflects the interaction between technological and market risks.

MARKET RISK

Market risk is the risk that new aircraft will not sell. The failure to sell can be either a temporary or a fundamental problem. During the early years of planning or production, it may be difficult or impossible to distinguish between temporary or fundamental sales problems. This uncertainty appears to have been heightened by airline deregulation. The implications of airline deregulation for aircraft sales in the long term are uncertain. In the short term, demand for commercial aircraft appears to be reduced, primarily because of depressed airline profits associated with greater competition (coupled with worldwide recessions). Deregulation may also cause depressed demand for new aircraft if route system changes and financial problems lead airlines to sell off their equipment, increasing the supply of used aircraft.

Temporarily slow aircraft sales tend to occur when potential customer airlines have financial problems. This can occur frequently because airline profits are very sensitive to airline competition and because most airline operating costs are essentially fixed, limiting financial flexibility in response to changes in travel demand.[2] Airline finances are particularly vulnerable to economic recessions, which depress air travel demand. Consequently, aircraft sales and profits are sensitive to recessions that take place several years after an aircraft program is begun, since leadtimes for airplane production are long.

Although changes in airline finances brought about by economic conditions or other factors may be temporary, the inability of aircraft manufacturers to secure enough orders to sustain acceptable production rates may lead manufacturers to postpone or cancel commercial aircraft projects. For example, McDonnell Douglas and Fokker recently ended a joint production plan for a small commercial transport because the market weakened.

Fundamentally slow sales signal a problem with the product concept. Problems with the concept may arise from market changes following product development which result in new demands for capacity, range, or other attributes; new regulations; or too much similarity to other aircraft to generate profitable sales volume. For example, industry analysts believe that the Lockheed L-1011 has been unprofitable in part because it is too

[2] Nawal K. Taneja, *The Commercial Airline Industry,* 1976.

similar to the McDonnell Douglas DC-10 to generate adequate sales.[3] Some analysts believe that market risk may be greater for jet engines than for airframes because engines have longer lead-times and require more speculative decision-making.

The pace of aircraft sales depends in part on how the timing of product introduction accords with airline equipment buying cycles, which generally last **5** to 10 years. Airlines buy new aircraft to allow growth in service, to replace obsolete or inefficient aircraft in use, and to increase productivity. The age of existing aircraft, the introduction of new technology, and economic conditions are among the factors influencing aircraft buying cycles. Airlines with financial difficulties may choose to reengine and recondition existing planes as a less expensive alternative to buying new planes, although refurbished equipment is generally technologically inferior to newer equipment.

Substantial aircraft buying soon before the introduction of an advanced air transport would provide aircraft manufacturers with cash to ease new-product production burdens, but it would also leave airlines less able and (perhaps) less willing to buy advanced air transports. Extensive aircraft buying during the **1980's** (the Aerospace Industries Association anticipates $100 billion to $140 billion (1980 dollars) in aircraft sales to the non-Communist world during the decade) could inhibit sales of advanced air transports, if available, during the 1990's.[4]

On the other hand, technology development, growth in air travel and aircraft demand (as projected in *Part 1: Advanced High Speed Aircraft)*, and increased perceived willingness of air travelers to pay for high-speed travel could stimulate demand for advanced air transports by the 2000-10 period, when ASTs, in particular, are more likely to be made available. Aircraft buying patterns during the early 1980's and projections for future buying, together with relevant technology developments, will influence planning for advanced air transports.

Whether (and when) the airlines would buy advanced air transports depends on the perceived contribution of such planes to airline competitive strengths and profitability. Market success of an ASUBT would depend on its perceived operating cost advantages over other subsonic aircraft, given its higher expected purchase price. It would also depend on the degree to which its design is tailored to specific air travel markets and on the suitability of that design to evolving air travel needs and costs.

By contrast, the market success of an AST would depend on the narrow appeal of potentially higher productivity on relatively long routes, given its higher purchase and (given capacity) operating costs. Supersonic airplanes can make more flights during a given period than subsonic airplanes. Consequently, supersonic flight allows airlines to generate more seat-miles per hour (the airline units of production) with fewer planes for a given seating capacity. * Experts believe that ASTs maybe twice as productive as subsonic jets with comparable seating capacity, and even more productive with larger seating capacity. By contrast, the Concorde provides relatively small productivity improvement because it is relatively small (90 to 100 seats), Relatively large seating capacities may be necessary if ASTs are to generate sufficient operating profits to offset relatively high purchasing costs. '

Studies conducted by the aviation industry suggest that AST purchase prices may be 2½ times greater than ASUBT prices. However, if ASTs are twice as productive as subsonic planes, including ASUBTs, so that half as many planes are needed for a given level of traffic, airlines would require only **25** percent more capital to purchase an AST

'Although the Airbus A-300 is also similar to the DC-10, U.S. industry representatives argue that it has been successful because Airbus Industrie has been able to offer relatively favorable financing. See *The Challenge of Foreign Competition,* Aerospace Research Center, Aerospace Industries Association of America, Inc., December 1981.

[4] *The Challenge of Foreign Competition.* op cit.

*Airplane productivity can grow through increases in capacity and/or speed, The transition from propeller to jet aircraft allowed both capacity and speed increases; the introduction of wide-body jets raised capacity. An AST would increase speed. It may be the only means of improving airplane productivity in the next few decades.

'Scientists and engineers have been examining concepts for multi-lobe and multi body configurations for ASTs as means of boosting seating capacity. See Domenic J. Maglieri and Samuel M. Dolly high, 'We Have Just Begun to Create Efficient Transport Aircraft, " in *Aeronautics & Astronautic,* February 1982.

fleet instead of an ASUBT fleet.' Although higher purchase prices for ASTs increase the negative cashflow from aircraft purchases, greater productivity— specifically, increased numbers of flights in a given period of time—can accelerate the recovery of investment. However, as experience with the Concorde demonstrates, new aircraft designs can be more productive without being more profitable than older aircraft designs. How quickly an airline can recover its investment depends on the operating characteristics and costs of specific aircraft.

The profitability of ASTs in use will depend in part on the number of routes available for supersonic flight, and especially on fuel efficiency at both supersonic and subsonic speeds. Note that the Concorde is relatively fuel inefficient at subsonic speeds, both because of high fuel consumption and low passenger load, which imply high fuel costs per seat-mile. Given past and expected future growth in fuel prices, fuel efficiency is of special concern for AST development and market prospects.

Because supersonic planes use more fuel than otherwise comparable subsonic planes, any increase in fuel price raises operating costs by a larger percentage for supersonic planes than for subsonic planes. Fuel costs for commercial airplanes today are about 31 percent of total operating costs (operating costs plus interest on long-term debt less depreciation and amortization), compared with 13 percent in 1970,[7] Concorde fuel costs are substantially higher because it uses three to four times the amount of fuel per seat-mile as contemporary wide-body jets.[a] Although current technology for variable-cycle engines already provides for better fuel efficiency in any speed range than does Concorde technology, the ultimately feasible fuel efficiency will depend on the findings of additional engine and airframe structure R&D, desired cruise speeds, and desired levels and technologies for noise suppression.

Finally, the market success of an AST depends on the range of fares needed to fly it profitably, and on the feasibility of charging such fares. At today's fuel costs, the Concorde would require a 150-percent surcharge over subsonic economy fares; the U.S. Supersonic Transport (SST) would have required a 50-percent surcharge to provide the same return on investment (excluding subsidies) as a subsonic wide-body. The difference between surcharges reflects primarily improvements in technology, which suggest to some analysts that further technology improvements could further reduce or even eliminte fare surcharges for ASTs.[9]

Aircraft manufacturers maintain (and airline operators have not disputed) that an AST would function profitably at fares that are up to 20- to 30-percent higher than subsonic fares. They estimate that an AST with total operating costs about 20- to 30-percent higher than those of long-range subsonic planes would be feasible in the 1990's, given appropriate R&D in the 1980's.[10]

Premium fares for ASTs are conceptually justified by the added service in the form of time saved by travelers. Although surveys show that many people would be willing to pay more to fly faster, it is not known whether enough people would actually pay enough to justify purchase and sale of several hundred ASTs if premium fares are necessary for economical flight.

Experience with the Concorde is of little value for gaging customer response to alternative AST fares. The small size and inferior technology of the Concorde necessitate higher fares than an AST would require to be profitable, and so few Concordes are in use that it is difficult to generalize about their appeal to travelers on different routes. Economic AST fares comparable to subsonic fares may be desired by airlines to increase customer appeal and to avoid criticisms that arose during the SST debates—that the SST was designed for wealthy travelers only.

[6]Herbert T. Spiro and John R. Summerfield, "Finance and Program Alternatives for Advanced Air Transport Vehicle Program, " prepared under contract for OTA.

[7]Air Transport Association data. Note that, for Boeing 747 wide-body jets, fuel costs comprised 24 percent of direct operating costs in 1973 and 60 percent in 1981. See Maglieri and Dolly high, op. cit.

[8]Maglieri and Dolly high, op. cit.

[9]Maglieri and Dolly high, op. cit.

[10]Spiro and Summerfield, op. cit.

FINANCIAL RISK

Financial risk is the probability of getting unsatisfactorily low return-or loss—on investment. Because both technological development and market trends influence levels of return, financial risk captures the influence of both technological and market risk (see fig. 2).

There is a large amount of financial risk in aircraft development because aerospace company financial performance varies over several cycles, all of which are subject to uncertainty. The basic cycle is the product cycle for each program. Programs begin to make money after production begins and sales revenues flow in, If different aircraft manufacturers offer planes that are relatively similar, the one that secures the most initial orders is more likely to be profitable.

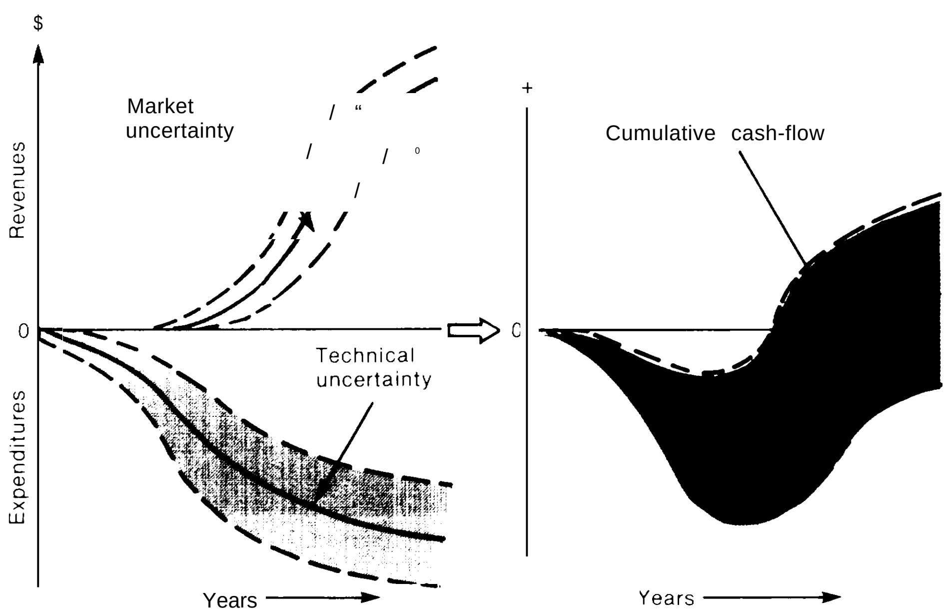
Initial orders are important because airlines typically place subsequent orders for models already owned, rather than different models, in order to save on training, maintenance, and service costs. " However, even with an airplane that sells well, it usually takes 10 to **15** years for the manufacturer to recover his investment. * To stimulate the market during that period, commercial aircraft manufacturers typically develop derivative models after the first few years of a program, an activity that requires additional investments.

Because airplane programs last several years, manufacturers may lose money on aircraft sales if operating costs rise significantly due to inflation, materials shortages, changes in the rate of production, or other factors. For example, industry analysts attribute the losses suffered by Lockheed on the L-1011 (over $1.2 billion between 1971 and 1980 alone) in part to increases in manufacturing costs arising from the acceleration of production during shortages of skilled labor and materials. Such shortages, together with increases

1‘ *The Challenge of Foreign Competition,* op. cit.

● Note that, since production costs per unit decline over time, aircraft manufacturers typically account for profits on an average-cost basis (anticipated total production costs divided by anticipated total production volume). This practice boosts apparent (accounting) profits during the early production stages, when real costs are high relative to revenues.

Figure 2.—Typical Cash Flow Curves and Their Sensitivity to Uncertainty



SOURCE: Herbert T. Spiro and John R. Summerfield, "Finance and Program Alternatives for Advanced Air Transport Vehicle Program," Contract report prepared for the Office of Technology Assessment, October 1979 in development costs for derivative aircraft and other factors, have also been cited by McDonnell Douglas in explaining losses for the DC-9 aircraft program. ASUBT or AST projects may involve additional financial risk because they entail extensive use of new manufacturing processes, which may give rise to new or unexpected costs.

The effects of individual projects on manufacturer cashflow are offset by the effects of other projects at different stages of development and production. Nevertheless, overall profits remain sensitive to unpredictability in military and commercial order cycles. Profits of aircraft manufacturers are also sensitive to the business cycle, both through its effects on customer airlines (lower profits due to lower passenger volume and higher costs of capital inhibit aircraft purchasing) and through its effects on the costs of doing business (inflation in materials and labor costs and higher costs of capital raise aircraft program costs).