Financing and Program Alternatives for Advanced High-Speed Aircraft

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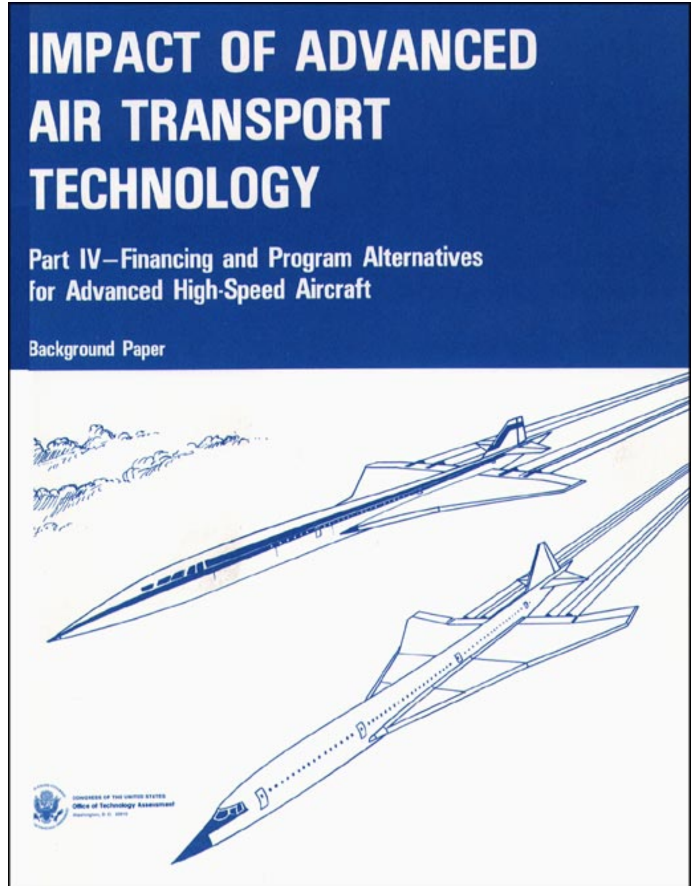

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Foreword

This background paper examines the potential financial and managerial barriers to carrying out—at some future date—a large-scale program to create a new high-speed, long-range commercial air transport employing new technology. It is the fourth and final segment of a broad assessment of the economic, environmental, energy, societal, and safety aspects of technological advances that might occur in several types of transport aircraft. Specifically, it supplements the earlier OTA report, "Impacts of Advanced Air Transport Technology: Part I—Advanced High-Speed Aircraft."

This paper examines the technological, market, and financial risks such a venture would entail and the ability of the U.S. aerospace industry to assume them. In this context, a number of financing and management options have been identified that should be examined further if such a program is given serious consideration.

The overall assessment had its origins in a request by the House Committee on Science and Technology that OTA examine the implications of the possible widescale introduction in the future of advanced high-speed aircraft. OTA initiated a broad and long-term exploration of the potential for advanced air transport technology, both passenger and cargo. In addition to advanced high-speed aircraft, both subsonic and supersonic, the overall assessment includes those aircraft used in providing service to small communities and in transporting air cargo.

In doing this study of financing and program alternatives, OTA was assisted by an advisory panel and a working group, each comprised of individuals from the private sector, representatives from Government agencies, the aerospace industry, public interest groups, financial institutions, and universities. These individuals and their respective organizations contributed greatly to the outcome of this report.

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INTRODUCTION

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The U.S. aerospace industry and the U.S. Government have conducted research over the past two decades to develop advanced-technology supersonic, as well as subsonic, commercial air transports. Since the initiation of the U.S. Supersonic Transport (SST) program in the early 1960's, Congress has repeatedly debated the desirability of, and the appropriate level for, Federal funding of research and development (R&D) directly relevant to civil aircraft applications.

The appropriateness of Federal involvement in the development of a civil supersonic air transport has been at the heart of those debates. Although funding for supersonic technology development and certain other areas of aviation research with civil applications was virtually eliminated in the Federal budget for fiscal year 1982, it continues to be addressed in Federal budget planning and evaluation.

A major concern for Congress in evaluating past and proposed Federal investments in R&D relevant to commercial aerospace has been whether aerospace firms can translate the results of Government-assisted research into viable commercial aircraft programs, Because of the expected high costs and high risks of producing advanced-technology air transports, it is uncertain whether and how U.S. aircraft manufacturers could produce them. Future decisions by Congress about funding civil aerospace R&D will depend on how the financial capacity of the aerospace industry is perceived.

This background paper provides perspective on the implementation of advanced air transport programs by examining such issues as associated risks, industrial organization, and financing capacity. It addresses the business and financial aspects of developing and producing advanced air transports. It then outlines alternative approaches to managing and financing advanced air transport programs, including alternative ways for the Government to encourage and assist such programs, if desired. The technological challenges and expectations for advanced air transports have been described in the master report of this OTA project, *Impact of Advanced Air Transport Technology, Part 1: Advanced High-Speed Aircraft.*

BACKGROUND

Advanced air transports would differ significantly from subsonic and supersonic aircraft in use today. An advanced supersonic transport (AST) would offer superior speed, passenger capacity, noise suppression, fuel efficency, and overall performance compared with current supersonic transports (the British-French Concorde and the Soviet TU-144). It would require structural materials, manufacturing processes, propulsion systems, and controls different from those of subsonic counterparts.

An advanced subsonic transport (ASUBT) would differ from contemporary subsonic transports by incorporating new structural materials, manufacturing processes, and propulsion systems, plus improved aerodynamics and controls. It would offer substantially better fuel economy (perhaps 30 percent better per seat-mile) than a contemporary wide-body jet. Differences between ASTs, ASUBTs, and their predecessors would affect virtually all aspects of their development and production programs,

Aircraft programs comprise several stages. The first involves generic or basic R&D, which explores and validates basic design and technology concepts. Generic R&D is much less expensive than the next stage, specific R&D, in which specific product concepts are developed, and the third stage, tooling and other preparation for production. Specific R&D is the most expensive stage, involving the fabrication of prototypes and repeated testing of designs and prototypes over several years. [1]

During the specific R&D stage, manufacturers consult with potential airline customers on desired design and performance characteristics, develop specifications, and seek orders for proposed planes. After a design and set of specifications are selected, facilities and production tooling are ordered in preparation for production. The cost of production tooling for conventional aircraft programs has been one-third to one-half that of (specific) development costs. [2]

Revenues typically begin to flow through progress payments when orders are placed, followed by additional progress payments and payment of the balance on delivery, although in some cases airlines lease new aircraft from the manufacturers. As figure 1 shows, new aircraft programs become very costly in their early stages, as spending increases sharply during the first few years.

Industry experts believe that an advanced supersonic air transport program could cost up to $6 billion to $11 billion (1980 dollars) over a 10- to 15-year period. By contrast, recent programs for transports using contemporary subsonic technology cost about $2.5 billion, including $1.5 billion for the airframe plus up to another $1 billion for the engine (current dollars, through the 1970's).[3] The actual magnitude of initial investment necessary depends on many factors—such as the size of the aircraft, initial order levels and production rates, inflation and productivity, mode of financing, and the timing and extent of design changes.

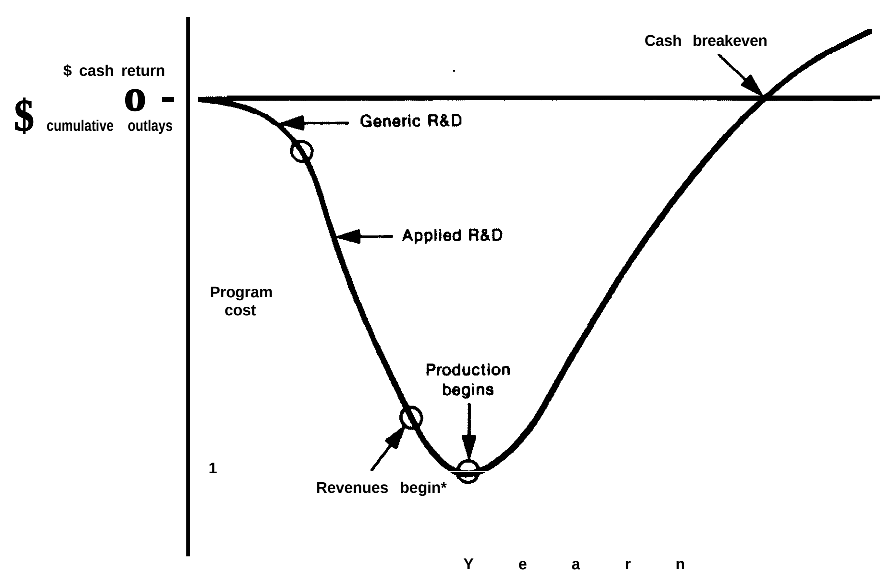
The investment would go primarily for specific R&D and preproduction expenses. Some generic R&D has already been conducted under the sponsorship of the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD), beginning with the U.S. SST program and subsequently through such programs as the NASA Supersonic Cruise Research and

[1] Harman L. Butler, Jr., et al., "The Aerospace Industry Re-Revisited, " in *Financial Analysts Journal,* July-August 1977.

[2] Butler, op. cit.

[3] See, for example, "Aerospace Industry Survey: Basic Analysis, " prepared by Robert Spremulli for Standard & Poor's, Apr. 3, 1980; and reports in trade and business journals,

Figure 1.—Cumulative Cash Flow Curve for Commercial Air Transport Program



*Advance payments commence prior to production

SOURCE Herbert T Spiro and John R Summerfield, "Finance and Program Alternatives for Advanced Air Transport Vehicle Program, contract report prepared for the Off Ice of Technology Assessment, October 1979

Variable Cycle Engine programs. Research since the SST was canceled has substantially improved several technologies, but additional research and substantial development efforts would be necessary for either an AST or an ASUBT program.[4]

Although industry analysts expect that advanced air transports, and in particular ASTs, would be more expensive to produce than conventional aircraft, it is impossible to be sure of a cost differential at this time, several years prior to planning for specific advanced air transport projects. Relatively high costs for advanced air transports, especially for ASTs, would stem in part from the use of new manufacturing processes, plant, and equipment. Using new production technologies involves additional startup costs.

[4]Domenic J. Maglieri and Samuel M. Dollyhigh, "We Have Just Begun To Create Efficient Transport Aircraft," in *Aeronautics & Astronautics*, February 1982.

On the other hand, progress in aircraft manufacturing technologies, including adoption and refinement of computer-aided design and manufacturing systems and other productivity-enhancing developments, would tend to offset cost increases associated with advanced air transport technologies. Although industry analysts have been concerned about declining productivity in the aerospace industry over the past few years, growth in the capabilities and use of computerized automation during the 1980's could improve aerospace industry productivity and lower the costs of undertaking an advanced air transport program. [5]

[5]See, for example, U.S. Department of Commerce, U S. *Industrial Outlook 1981*, 1981.

Chapter 2

RISKS: A QUALITATIVE DISCUSSION

Chapter 2

RISKS: A QUALITATIVE DISCUSSION

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.[8] 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.

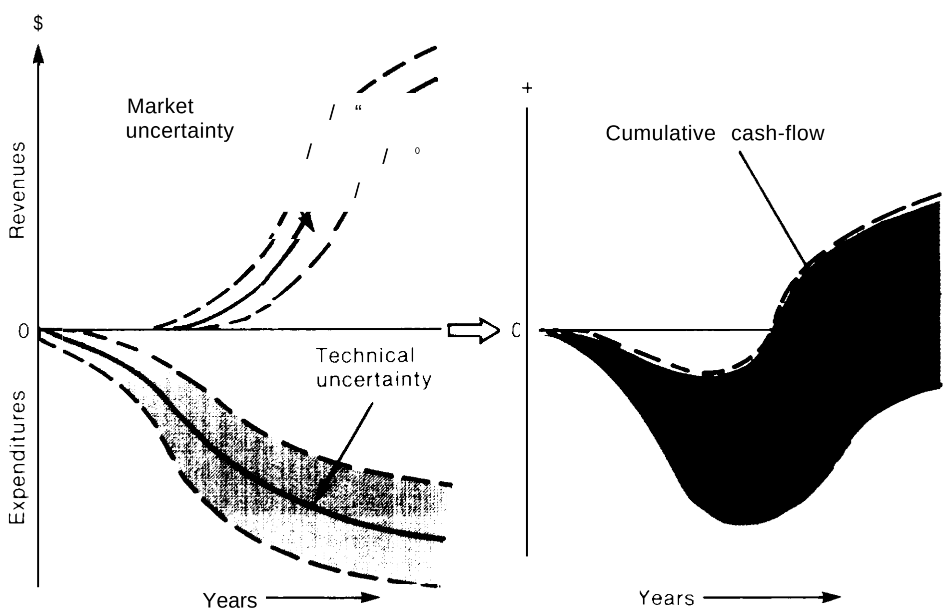
Initial orders are important because airlines typically place subsequent orders for models already owned, rather than different models, in order to save on training, maintenance, and service costs. " However, even with an airplane that sells well, it usually takes 10 to **15** years for the manufacturer 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).

Chapter 3

INDUSTRIAL ORGANIZATION

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INDUSTRIAL ORGANIZATION

The feasibility and the optimal form of an advanced supersonic transport (A ST) or advanced subsonic transport (ASUBT) program depend on the attributes of the commercial aircraft industry and, in particular, that segment of the industry which produces air transports, as opposed to commuter or general aviation aircraft. The commercial aircraft industry is a subset of the aerospace industry, which serves three markets: Government (primarily military) aerospace, commercial aerospace, and nonaerospace products. The structure of the aerospace industry—dominated by a small number of large firms—has evolved in response to conditions in the aerospace markets and characteristics of aerospace production. These conditions and characteristics and the industry structure which results from them, described below, may constrain the undertaking of advanced air transport projects.

HISTORICAL OVERVIEW

The history of commercial air transport manufacturing has been marked by market volatility and financial difficulties. Of the many financial losses suffered by major aerospace firms in the postwar period, most have been attributable to commercial operations. Financial distress arising from commercial operations during the 19.50's was largely due to aircraft design flaws and uncertainty about how the commercial air transport market would develop. During the mid and late 1960's, design problems were rare, but financial challenges grew, even for the leading manufacturers, with the cost of doing commercial aerospace business: solving technical problems was expensive; growth in sales volume, inflation, and numbers of accidents raised product liability insurance costs; growth in sales to foreign airlines necessitated investments in global airplane service networks; and input shortages during Viet Nam War mobilization caused operating losses in commercial operations.

Although a new generation of commercial aircraft, the wide-body jets, was launched in the late 1960's, encouraging one firm, Lockheed, to reenter the commercial aircraft market (temporarily, as it proved), only Boeing has profitably produced commercial air transports during the past several years. Consequently, any appeal this market might offer to new entrants has been declining over time,

Because of sharp increases in the costs and risks of aircraft development and production, coupled with slower growth in funding for aeronautical research and development (R&I)), new commercial models have been introduced less frequently over time. [1] The slowdown in technology change for commercial aircraft following the introduction of jets reflects both technological maturation, which makes economical innovations relatively difficult to achieve, and restraint in Government support for aerospace R&D. During the 1970's, industry analysts began to think that rising development, production, and advertising costs raised unit prices so much that competing aircraft programs might no longer be practical.[2] Today, while Boeing is undertaking two (related) new aircraft programs and Lockheed is preparing to leave the commercial air transport market, McDonnell Douglas may concentrate on upgrading its current aircraft models (see table 1).

Although some firms serve only the Government aerospace market, major commercial aircraft producers also depend heavily on Government aerospace business. In 1980, for example,

[1] U.S. Department of Defense, National Aeronautics and Space Administration, and Department of Transportation, *Research and Development Contributions to Aviation Progress (RADCAP)*, 1972.

[2] See, for example Jacques S. Gansier, "The U.S. Aircraft Industry: A Case for Sectoral Planning," in *Challenge*, July-August 1977; and "The Next Commercial Jet . . . It," *Business Week*, Apr. 12, 1976.

Table 1 .—Commercial Air Transport Deliveries: Product Variation and Program Overlap-Among Manufacturers

Year ending 12/31	Boeing					McDonnell Douglas					Lockheed			Convair			Fairchild		Airbus
	707	720	727	737	747	DC-6	DC-7	DC-8	DC-9	DC-10	Constellation	Electra	L-1 011	440	660	890	F-27	FH-227	A-300
1956						39	67				43			57					
1957						44	123				77			79					
1958	7					62	57				29	12		21			25		
1959	73					1		21			5	107		14			41		
1960	63	24						91				24		5	15		14		
1961	11	61						42				21			49		8		
1962	30	30						22							9	22	7		
1963	28	6	6					19							14	15	6		
1964	32	6	95					20									5		
1965	54	9	112					31	5								12		
1966	77	6	135					6	69								3	27	
1967	113	5	115	4				41	155								3	35	
1968	111		160	105				102	193									6	
1969	59		115	114	4			85	122									2	
1970	19		54	37	92			33	51										
1971	10		33	29	89			13	43	13									
1972	3		41	22	30			4	24	52			17						
1973	11		92	17	28				21	57			39						
1974	21		91	41	21				48	46			41						4
1975	7		91	51	20				35	43			25						9
1976	3		61	41	27				44	19			16						13
1977	3		67	25	20				16	12			11						15
1978	3		118	40	32				20	18			8						15
1979	1		136	77	67				39	35			14						25
1980			131	92	73				25	40			24						37
1981			94	108	53				77	19			28						37

SOURCES Aerospace Industries Association, Airbus Industrie.

the Government accounted for 59 percent of Lockheed's sales, 56 percent of McDonnell Douglas', and 17 percent of Boeing' s,' Besides aircraft, Government spends on such aerospace products as missiles, helicopters, spacecraft and other space equipment, and also military ships and submarines, some of which are produced by aerospace firms,

Government spending has historically fueled product and market development for the aerospace industry. A recent Government study found that of 51 significant technological advances in U.S. aviation between **1925** and 1972, 35 were sponsored by the military and 45 were funded by military and/or other Government agencies.[4] Government-sponsored aeronautical R&D or production programs contributed to all of the U.S. commercial transports in use during the 1970's, although only about one-fourth of these aircraft were derived from a military plane programs The contribution of Government-sponsored programs to airplanes that will be introduced in the 1980's is believed to be quite small, however, reflecting a slowdown in the development of military aircraft technology that is transferable to commercial aircraft. [6]

The magnitude of Government business is such that the Government effectively controls the number and growth of aerospace firms overall. Moreover, the Federal Government has several times provided extraordinary aid to financially troubled aerospace firms. The Glen L. Martin (now part of Martin Marietta), Northrop, Grumman, and Lockheed companies, for example, have benefited from Government loans or loan guarantees.[7] However, although dollar spending has grown absolutely, financial support by the Federal Government has declined in relative terms.

The Government share of aerospace sales (defined to include Federal expenditures for aerospace R&D and procurement) had declined from **85** percent in 1955 to 44 percent in 1980. * The Govern-

[3]Arnold Bernhard & Co Inc , Value 1 ine Investment Survey.
[4]RADCAP, op cit
[5]RADCAP, op. cit.

[6]Aerospace Industries Association of America, Inc., Aerospace Research Center, *The Challenge of Foreign Competition*, December 1981
[7]Charles B. Bright, *The Jet Makers*, 1978.
*The Government share of aerospace sales ranged between 71 to 84 percent in the 1960's and between 45 to 71 percent in the 1970's.

ment share of aerospace R&D spending has fallen less, from around 90 percent in the early 1960's to around 76 percent in the late 1970's.[8] Finally, the Government also owns large portions of aerospace company plant and equipment used in support of Government aerospace activities, although that proportion, too, has fallen over time.

[8] Aerospace Industries Association of America, Inc, *Aerospace Facts and Figures 1981 82,* July 1981

STRUCTURAL CHANGE

The history of the aerospace industry provides perspective on the prospects for future developments. Since World War II, the structure of the industry has changed dramatically in three ways: firms have diversified and integrated horizontally, vertical integration has declined, and the number of firms has declined.

Diversification is the entering of new lines of business. It is usually a means of reducing financial risk and enhancing the likelihood of firm survival. Through diversification, firms offset cash flow irregularities of one line of business with the different patterns of another line, making cash flow for the firm as a whole less variable and the risk of financial loss for the firm as a whole less than it is for a single line of business. Diversification thus provides insurance for firms undertaking risky projects.

Diversifying within a product class (horizontal integration) and some other forms of diversification also enable more efficient operation, where fixed costs can be allocated across a larger volume of products. Aerospace firms that produce a variety of aircraft can, for example, lower unit costs by spreading shared-cost items over several airplane lines.

Aerospace diversification has taken several forms: increase in the variety of aircraft, aerospace products, and/or defense products manufactured; development of expertise in technologies and manufacturing processes related or similar to aerospace production; and involvement in businesses totally unrelated to aerospace. It has been achieved through firm growth and through mergers and acquisitions.

Aerospace firms began to diversify in the 1950's as military funding (provided directly through research and production contracts and indirectly through Government investments in plant and equipment) waned in the aftermath of World War II and then the Korean War. The volatility and low profit margins of Government business through the 1960's induced aerospace firms to shift their sales mixes away from military sales and toward commercial and nonaerospace lines (see table 2). During the 1970's, changes in Government procurement activities favorable to aerospace firms apparently dampened that trend. Diversification was also stimulated by the development of new technologies for aircraft and other related defense hardware and systems. Although industry analysts believe that diversification has helped aerospace firms survive and grow, specific efforts have not always been successful. *

After World War II, another major change in the organization of the industry was a decline in vertical integration brought about in response to growth in the costs, risks, and complexity of aircraft manufacture. Vertical integration is in this context the production of inputs (materials, components, parts, subassemblies, systems, etc.) to a firm's principal products.** The more a firm is vertically integrated, the less it relies on suppliers, and vice versa. Suppliers presently conduct about half of the total manufacturing activity involved in airframe manufacturing programs.[9] Thus, for example, there are over 1,300 companies involved

* General Dynamics, for example, has lost millions of dollars on its Quincy (Mass.) shipyards; Grumman has lost money because of problems with its Flxible subsidiary's buses and Boeing has had problems with its Vertol subsidiary's light-rail vehicles

** Integrating supply activities is called backward integration, as contrasted with forward integration or integrating distribution activities. Many firms and industries integrate vertically to reduce costs by gaining better information about inputs; by eliminating costs associated with developing, maintaining, and purchasing from supplier networks; and by enhancing control over their economic environment.

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

Table 2.—Pattern of Diversification, Early 1960's (X) and Later (Y)

	Field of Diversification									
Company	Military aircraft	Missiles	Space	R&D	Electronics/communications	Shipbuilding/marine	Other transportation	Commercial aircraft	Construction	Other
Boeing	X	X	Y	—	Y	Y	Y	X	Y	Y
Douglas[a]	X	X	Y	—	Y	—	—	X	—	Y
Fairchild	Y	[b]	Y	—	Y	—	—	X	—	Y
General Dynamics	X	X	Y	X	X	X	Y	X	X	Y
Grumman	X	Y	Y	—	Y	Y	Y	—	Y	Y
Lockheed	X	X	Y	X	X	X	—	X	—	Y
Northrop	X	[c]	—	X	X	—	—	—	Y	—

[a]Merged with McDonnell in 1967.
[b]Fairchild's missile contracts had been canceled by the sixties.
[c]Northrop abandoned large missiles as a prime after Snark, but does missile avionics now.

SOURCES: Charles D. Bright, *The Jet Makers*, Lawrence, Kans.: The Regents Press of Kansas, 1978; *Moody's Industrial Manual*, 1981.

as primary suppliers in the Boeing 757 program, with many others involved as secondary suppliers (see table 3 and fig. 3). The growth of subcontracting changed the structure of the aerospace industry by adding and strengthening new layers.

Vertical integration in the aerospace industry is not high for several reasons: First, production of many inputs to aircraft manufacture is sufficiently complex that it is more efficient for some suppliers and subcontractors to specialize in the production of particular inputs than for aircraft manufacturers to produce both the inputs and the final products/aircraft, Second, profitable production of some aircraft inputs requires larger volumes than a single manufacturer would demand.

Third, the aircraft business is sufficiently risky and costly that reducing costs and risks by relying on suppliers and subcontractors enables aircraft manufacturers to do more business—take on more risks—than they could do alone. This is one of the reasons that cooperative ventures between manufacturers and subcontractors and among manufacturers have become more common. Fourth, subcontracting also reduces aircraft manufacturing risks by changing the nature of input costs. Buying rather than manufacturing inputs makes some otherwise fixed costs variable (they change with the volume of production), reducing the risk of financial loss in the event that sales volume is less than anticipated.

Another important trend in the industry is a decline in the number of major firms whose primary business is aerospace. This trend is consistent with industry domination by large firms. While there were **20** major aerospace firms in the 1950's, there were 15 by the late 1960's and only 7 conducting primarily aerospace business by the late 1970's: Boeing, Lockheed, McDonnell Douglas, Grumman, General Dyamics, Fairchild Industries, and Northrop.[10] While there were five leading commercial aircraft manufacturers in the 1950's, there were two (Boeing and Douglas) in the 1960's. A third (Lockheed), which reentered the commercial aircraft market in the 1970's, is preparing to cease commercial aircraft manufacturing by the mid-1980's. Worldwide, there are only three additional leaders in commercial air-

[10]Hartman L. Butler, Jr., et al., "The Aerospace Industry Re-Revisited," in ***Financial Analysts** Journal*, July-August 1977

Table 3.—Manufacturer' Reliance on Subcontractors: The Case of Boeing's 767 and 757 Programs

767

Major body sections 43, 45 and 46 Wing to body fairings Main landing gear doors Wing in-spar ribs	Civil Transport Development Corp. Japan
Wing control surfaces Wing trailing edge flaps and leading edge slats Wingtips Elevators Vertical tail rudder and radome	Aeritalia, Italy
Main landing gear	Pneumo Corp.'s Cleveland Pneumatic Co Cleveland, Ohio
Nose landing gear	Colt Industries' Menasco, Inc. Burbank Calif.
Wing center section Adjacent lower fuselage section	Grumman Aerospace Corp. Bethpage N Y
Engine struts	General Dynamics, Convair Div. San Diego, Callf.
Engine nacelle primary nozzles and plugs	TRE Corp Astech Div. Santa Ana. Calif.
Rear fuselage of Section 48	Canadair Ltd., Montreal, Canada
Horizontal stabilizer	LTV Corp.'s Vought Corp. Dallas, Tex.
Inertial reference system	Honeywell, Inc., Avionics Div. Minneapolis, Minn.
Ž Autopilot flight system ● Radio distance magnetic indicator ● Electronic fit Instrument system	Rockwell International Collins Air Transport D iv. South Bend, Ind.
Wheels and brakes	Bendix Corp. Brake and Strut Div. South Bend, Ind
"Engine thrust management system	General Electric Co Aircraft Equipment Div. Binghamton N Y
Hydraulic flight control actuators	Parker Hannifin Corp.'s Bertea Group Irvine, Calif
Auxiliary power unit	Garrett Corp.'s AlResearch Manufacturing Co. Phoenix, Ariz.
Primary engine Instrument package	General Electric Co. Aircraft Equipment Div. Wilmington, Maas.
* Flight management computer system * Air data computer "Air data (instruments	Sperry Rand Corp.'s Sperry Flight Systems Phoenix, Ariz.
" Air-conditioning and cabin temperature control system * Cabin pressure control system Pneumatic drive assembly	Garrett Corp.'s AiResearch Manufacturing Co. Torrance, Calif.
Environmental control air supply system	United Technology Corp.'s Hamilton Standard Windsor Locks, Corm.
Autopilot hydraulic servo actuators	Moog Inc., Aerospace Div. East Aurora, N.Y.
* Electric power generating system	Sundstrand Corp. Electric Power Div. Rockford, Ill
Spoiler hydraulic power control actuators	Teijin Seiki Co Gifu, Japan
Wing trailing edge gear boxes	Kawasaki Heavy Industries Ltd. Jet Engine Di.v Akashi, Japan
Wing-leading edge and trailing edge flap rotary actuators Stabilizer trim gear boxes	Western Gear Corp. Lynnwood. Calif.
*Windshield	International Pilkington Group Triplex Safety Glass Birmingham, England
Flight deck side windows	Sierracin Corp. Sylmar Div. Sylmar, Calif.
Thrust-reverser actuator	Pneumo Corp.'s National Water Lift Co Kalamazoo, Mich.
" Ram air turbine	Sundstrand Corp. Sundstrand Aviation Mechanical Rockford, Ill
Stab trim control module	E. Systems, Salt Lake City, Utah
Antiskid/autobrake system	Hydro-Aire, Burbank Calif
Proximity switch system	Eldec, Lynnwood Wash
Crew seats, Captain and 1st Officer	Weber Burbank Calif
Evacuation slides	Sargent Industries Los Angeles Calif
Lighted pushbutton switches	Master Special! /es Costa Mesa, Calif
Lights Navigation Navlanti-collision Wing Illum egress Aircraft position indication	Midland Ross Grimes Div. Urbana Ohio
Fuel quantity indication system	Honeywell Minneapolis, Minn.

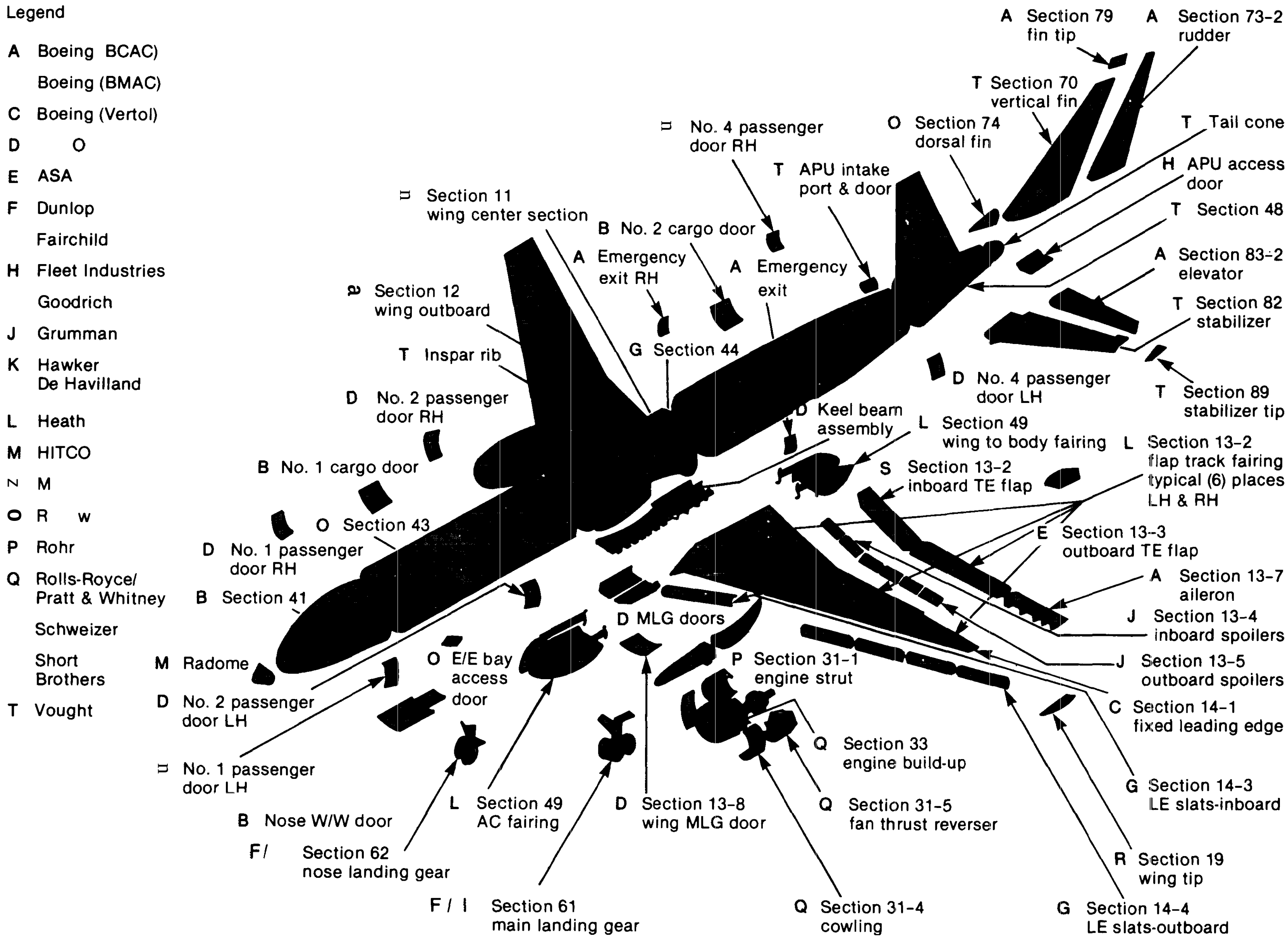
757

Wing center Section, keel beam	Avco Aerostructures Div. Nashville, Term
Major part of body Section 44	Fairchild Republic Co Farmingdale, N.Y.
Fuselage Sect Ions 43, 46	Rockwell International Corp. Tulsa Div., Tulsa Okla.
Horizontal stabilizer, including leading edges and stabilizer tips Vertical tail, including leading edge, fuselage Section 48	Vought Corp., Dallas, Texas
Inboard trailing-edge flaps	Short Brothers, Ltd. Belfast Northern Ireland
Wing in-spar ribs	Hawker de Havilland Sydney Austrailia
Outboard wing trailing edge flaps	Construcciones Aeronauticas S A (CASA) Madrid, Spain
Main and nose landing gear	Menasco, Inc. Burbank, Calif.
Electro-hydraulic spoiler actuators	Bendix Corp. Electro-Dynamics Div. North Hollywood, Calif.
Air supply systems	Garrett Corp. Los Angeles, Calif.
Lights Nav/anti collision Wing illum., egress Aircraft position indication	Midland Ross Grimes Div Urbana, Ohio

'Agreements cover items common, and ordered for, both the 757 and 767

SOURCES: Richard D. O'Lone, "Boeing Facing New Set of Challenges," *Aviation Week and Space Technology, Nov. 12, 1979.*

Figure 3.—Many Subcontractors and Suppliers Work on a Single Program: Some Major Subcontracts for the Boeing 757



SOURCE: "757 Effort Involves 1,300 Companies," *Aviation Week and Space Technology*, Feb. 22, 1982.

craft manufacturing: British Aerospace, Fokker, and the Airbus Industrie consortium.[11]

The number of subcontractors has also fallen as subcontractor firms— typically smaller companies—have gone out of business or been acquired by larger companies. Many smaller subcontractors have left the aerospace business because they could not afford to modernize facilities, train personnel, or operate profitably given the unstable flow of aerospace work and, according to some, the requirements of Government regulations.[12]

The Standard and Poor's Aerospace Industry Survey provides a measure of the number of major firms in the U.S. aerospace industry. It lists 5 airframe manufacturers, 15 subcontractors and systems suppliers, 2 propulsion and engine suppliers, **6** diversified firms, **3** general aviation firms and 3 shipbuilders.[13] Several hundred more firms, primarily small suppliers, make up the rest of the industry. *

The number of firms that can efficiently supply a product depends on production costs and market size. The commercial aircraft market is relatively small in terms of annual unit sales volume, with limited potential for growth. On average, U.S. manufacturers sell fewer than **350** commercial transports annually. Production of aircraft is sufficiently costly that during the several years when a model is produced, **200** to **500** airplanes—a large number relative to annual demand —must be sold (at or above a model-specific annual rate) for a manufacturer just to break even on a given model.

Costs of producing aircraft are minimized when individual manufacturers can produce in large volumes because of scale economies and learning-curve effects. Production is said to involve economies of scale when unit costs decline as the rate of production is increased, either for a particular product or within a particular plant or set of plants. Production is said to involve learning-curve effects where experience with a particular product or production process enables unit costs to fall as accumulated production volume increases. Unit aircraft costs may fall by up to 15 to **20** percent after initial production volume is doubled. Learning-curve effects in aircraft manufacture depend largely on learning by labor, because there are many intricate labor operations in aircraft production, with which workers become proficient over time, and because both technical and production staffs are often learning how to work with new technologies. Finally, individual firms overall learn and benefit through involvement in aircraft manufacture over time, a phenomenon that advantages older aerospace firms.

The trends and circumstances described above have supported the evolution of a concentrated industry led by a group of large firms. Scale economies and learning-curve effects enable large firms to produce with lower unit costs than small firms; large firms involved in several lines of business require large amounts of capital; and scale economies, large capital needs, high risks, and intertemporal learning benefits all inhibit new firms from entering into aircraft manufacturing.

In addition to these factors, growth in foreign competition also serves to promote an industry characterized by relatively few large firms or other economic entities, including consortia. Growth in foreign aircraft competition, particularly from foreign production consortia such as Airbus Industrie, is a major concern of U.S. aerospace firms. Foreign commercial aircraft sales have diminished U.S. aircraft sales to foreign airlines and, to a smaller extent, to U.S. airlines. Sales of aircraft to foreign customers are a major concern of domestic aircraft manufacturers, because since the early 1970's over half of both unit and dollar sales of U.S.-made aircraft have been for export. s

[11] *The Challenge of Foreign* **Competition,"** op. cit

[12] Alton K Marsh, "Subcontractors Shrink. ing Base of Industry," in *Aviation Week* **and Space** *Technology,* July 20, 1981

[13] Robert Spremulli, "Aerospace Industry Survey: Basic Analysis," for Standard & Poor's, Apr. 3, 1980.

*According to the 1977 Census of Manufacture, there are 151 companies in the "Aircraft Industry" (SIC 3721), 226 in the "Aircraft Engines and Engine Parts Industry" (SIC **3724**), 678 in the "Aircraft Equipment, Not Elsewhere Classified, Industry" (SIC 3728) and 78 in the three industries devoted to missiles and space equipment

[14] *The Jet Makers,* Op. cit with reference to data and analysis compiled by the RAND Corp.

[15] U. S Department of Commerce, *U S Industrial Outlook 1981, January 1981*

Industry representatives maintain that the loss of sales to foreign manufacturers reflects at least in part the efforts of foreign governments to promote sales of foreign-made aircraft within their countries of origin and within other countries through trade agreements and other arrangements. These practices may become less common with implementation of the Civil Aircraft Agreement, which came out of the recent Tokyo Round of Multilateral Trade Negotiations.[16]

Regardless of the reasons behind the growth in sales of foreign aircraft, increased competition in aircraft sales raises market risks for all aircraft programs and reduces the number likely to be viable. U.S. manufacturers of aircraft and aircraft engines have begun to participate in cooperative research and production ventures with foreign firms to improve access to foreign customers as well as to share costs and risks (see ch. 4). U.S. firms not only undertake new projects with foreign partners (e. g., the General Electric and SNECMA (France) engine production partnership, CFM International), they also work with foreign firms in lesser subcontractor and supplier roles (see table 3).

The U.S. commercial aircraft industry may contract further because of growth in manufacturing costs, competition from foreign manufacturers, and continued financial problems, Firms in a small, or smaller, industry may be more efficient and financially healthier, but they may not command enough resources to pursue an especially high-cost, high-risk commercial air transport program alone, The current trend toward cooperative ventures between U.S. and foreign aerospace firms suggests that individual firms may be unable to manage even more conventional programs on their own.

[16] *The Challenge of Foreign Competition,* op. cit,

Chapter 4

FINANCING

Chapter 4
FINANCING

High risks have affected the mix of capital sources and the amount and cost of capital raised by the aerospace industry. This section examines the experience of aerospace firms in raising capital.

OVERVIEW

Firms finance new projects from internally and externally generated funds. Internally generated funds come primarily from operations and include such quantities as net income and depreciation, retained earning, and deferred taxes. * Externally generated funds come from borrowing (debt), sale of stock (equity), and advance or progress payments from customers. In borrowing, a firm essentially buys capital, while in issuing stock, a firm essentially sells portions of itself. The cash provided by advance and progress payments is not treated for acccounting purposes as capital, although it is invested by manufacturers.

Raising capital has costs. The cost of internally generated funds for- a particular project is the foregone profit expected from alternative projects. This (opportunity cost is not paid out in real resources, however. The cost of borrowed funds is the interest charged. Because firms must pay interest according to a fixed schedule, debt imparts financial risk, which is an implicit cost to the firm. Final l}, the cost of equity is a share of company profits, paid through dividends. Real resource (and implicit) costs usually make external capital more expensive than internal capital.

Aerospave firms generally have more difficulty raising funds externally than firms s in other industties because investment in them is relatively risky. Al though, as measured by such ratios as return on equity or return on total capital invested,** aerospace firms have been relatatively profitable, subtantial uncertainty about their financial performance in the future makes them seem risky to investors. Lenders and investors as a class are risk-averse—they discriminate against investments with relatively large probabilities of relatively large losses, and they require the promse of high returns (e. g., high interest rates) in exchange for exposing their funds to high risks. The problematic standing of aerospace firms in capital markets is illustrated by such commonly used indices as bond ratings and "beta" statistics.

Bond (and other credit) ratings reflect the perceived ability of firms to generate funds internally and thereby repay lenders. The typically mediocre bond ratings for aerospace firms displayed in table 4 suggest that lenders are skeptical about the financial prospects of aerospace firms. To compensate for the higher risks in lend-

Table 4.—Aerospace Firm Bond Ratings, 1981 (Moody's)

Company	Rating
Boeing	A
McDonnell Douglas	Ba
Lockheed	B
Fairchild Industries	Ba
General Dynamics	Aaa (Gov't guaranteed)
Grumman	B
General Electric	Aaa
United Technologies (Pratt & Whitney)	Aa & A (subordinated)

Key to Moody's ratings

Aaa	Best quality
Aa	High quality
A	Higher medium grade
Baa	Lower medium grade
Ba	Possess speculative elements
B	Generally lack characteristics of a desirable investment
Caa	Poor: may be in default
Ca	Speculative to a high degree, often in default
C	Lowest grade

SOURCE: *Moody's Industrial Manual*, 1981, Lawrence D. Schall & Charles W. Haley, *Introduction to Financial Management*, 1977

*The [illegible] plants [illegible] or subsidiaries, although [illegible]

**Note that [illegible] because there is relatively little [illegible] aerospace companies with [illegible] industry ing to them, aerospace firms must pay higher interest rates on debt than better rated firms; debt is essentially less available to them than to other, better rated firms. Note that an aerospace unit of a diversified corporation may have easier (if indirect) access to external capital if the corporation as a whole has a good credit rating. For example, General Electric, which has a large jet engine manufacturing unit, has a top, Aaa bond rating from Moody 's.

The beta statistic provides an indication of the riskiness of a particular investment relative to the investment market overall, based on historical data for financial performance. * The investment market as a whole has a beta of one. A stock beta greater than one signifies that return on investment for the stock will both rise and fall faster than for the market; a beta less than one signifies slower response of a stock's returns to changes in market value. As a cross-industry study shows, and table 5 displays, industries differ in average riskiness as measured by betas. Among industries, aerospace is relatively risky, though significantly less risky than its chief commercial customers,

*Other measures are necessary to evaluate risk not associated with market behavior. The beta statistic is calculated by dividing the variance of the excess return on the market portfolio into the covariance between the excess return on the security being studied and the excess return on the market portfolio, It measures the sensitivity of the excess return of the security to the excess return on the market portfolio, where the "excess return" is the difference between the period rate of return for the security or the market portfolio and the period rate of return on riskless assets. See, for example, William F. Sharpe, Chapter Six of Investments (Prentice-Hall, Inc., 1978) for a more detailed explanation.

Table 5.–Average Stock Beta Values by Industry, 1966-74

Industry	Beta value	Industry	Beta value
Air transport	***1.80***	Energy, raw materials	1.22
Real property	1.70	Tires, rubber goods	1.21
Travel, outdoor recreation	1.66	Railroads, shipping	1.19
Electronics	1.60	Forest products, paper	1.16
Miscellaneous finance	1.60	Miscellaneous, conglomerate	1.14
Nondurable, entertainment	1,47	Drugs, medicine	1.14
Consumer durables	1,44	Domestic oil	1,12
Business machines	1,43	Soaps, cosmetics	1.09
Retail, general	1.43	Steel	1,02
Media	1.39	Containers	1,01
Insurance	1.34	Nonferrous metals	0,99
Trucking, freight	1.31	Agriculture, food	0,99
Producer goods	1.30	Liquor	0,89
Aerospace	1.30	International oil	0.85
Business services	1.28	Banks	0.81
Apparel	1.27	Tobacco	0.80
Construction	1,27	Telephone	0.75
Motor vehicles	1.27	Energy, utilitles	0.60
Photographic, optical	1.24	Gold	0.36
Chemicals	1.22		

SOURCE Barr Rosenberg and James Guy, "Prediction of Beta From Investment Fundamentals *Financial Analysts Journal* ***32,*** No 4, July/August 1976, pp 6270 the airlines. Aerospace stock betas published in the Value Line Investment Survey are generally greater than one, indicating that most aerospace firm stocks are perceived to be relatively risky investments (see table **6).**

Table 6.–Aerospace Stock Beta Values by Company, 1981

‘Company	Beta value
Boeing	1.25
McDonnell Douglas	1.2
Lockheed	1.75
Fairchild Industries	1.3
General Dynamics	1.3
Grumman	1.3
Martin Marietta	1.1
Rockwell International	0.95

SOURCE ***Value Line Investment Survey***

SOURCES OF FUNDS

Aerospace firms rely on different sources of funds to different extents. The exact contribution of internal sources of funds, in particular, is not always apparent from published financial statements because aerospace firms use somewhat anomalous accounting procedures which affect the recognition of revenues and expenses, the treatment of startup expenses, and the construction of balance sheets.[1] Nevertheless, it is possible to make some observations as to the relative importance of different sources of funds to aerospace firms.

Net Income

Net income is the amount of money available from operations after deducting costs of production, administrative costs, interest, depreciation, and taxes. In current dollars, net income for the seven major aerospace firms identified earlier first exceeded $1 billion in 1979; it fell to about $718 million in **1981.** Net income for Boeing, McDonnell Douglas, and Lockheed together was about **$361** million in **1981** (see table 7).

Net income trends across the industry have been erratic. Because of the cyclical nature of aerospace business, sales and/or net income often decline. Several firms have experienced losses (negative net income) during the postwar period and the group of seven major firms experienced aggregate losses in both 1960 and 1970.[2] Losses on commercial operations alone have been common, although they have often been offset by profits from Government and nonaerospace operations. Boeing, McDonnell Douglas, and Lockheed together lost about **$6** billion (current dollars) on civil aircraft programs over the last two decades. * Particular company losses can be attributed to technological problems (primarily during the **1950’s),** sales problems (including contract cancellations), and/or operating inefficiencies. Fluctuating net income levels and occasional losses inhibit accumulation of cash for future operations and raise the cost of external funds because they make a company seem risky.

Note that expenses for R&D, whether charged to a specific project or to overhead, are generally expensed (written off as incurred). Since R&D is a major expense item for aerospace firms, this practice significantly lowers both net income and taxes. Indeed, substantial R&D expenses may more than offset positive earnings, creating an accounting loss,

[1] Hartman L Butler Jr., et al., “The Aerospace Industry Re-Revisited,” in *Financial Analysts Journal* July -August 1977.

[2] Ibid.

*Personal communication with Wolfgang Demisch, aerospace industry analyst with Morgan Stanley & Co., Inc.

Table 7.— Net Income of Major Aerospace Companies (in millions)

	Boeing	McDonnell Douglas	Lockheed	General Dynamics	Grumman	Northrop	Fairchild Industries	Total
1966 ...,.	$ 76.1	$(21.3)	$ 58.9	57.8	$26.1	$11.4	$ 4.8	$ 213.8
1967	83.9	7.5	54.4	55.3	21.5	13.7	5.3	241.6
1968	83.0	98.5	44.5	38	19.0	17.1	3.2	303.3
1969 ...,.	10.2	79.7	(32.6)		22.1	19.7	6.6	108.7
1970	22.1	5.5	(187.8)	(6.9)	20.3	17.8	6.4	(127.6)
1971	22.4	20.4	(40)	21.6	(18.0)	11.0	6.6	24
1972	30.4	97,6	(7.2)	24.6	(70)	11.1		92.7
1973 ...,. . . .	51.2	133,3	(18)	39.3	28.2	11.6	(2.3)	279.3
1974	72.4	106,7	23.2	52.2	32.9	18.1	6.0	311.5
1975.	76.3	85.6	45.3	84.5	23.5	24.7	3.2	343.1
1976.	102.9	108.9	38.7	99.6	23.6	35.9	4.9	414.5
1977. ..,.....	180.3	123,0	55	103.4	32.4	66.2	9.6	569.9
1978.	322.9	161.1	64.9	(48.1)	20	88.4	24.5	633.7
1979, ...	505.4	199.1	56.5	185.2	19.6	90.3	42.5	1098.6
1980.	600.5	144.6	27.6	195.0	30.7	86.1	54.5	1139.0
1981 ...,. . . .	473.0	176.6	(288,8)	124.1	20.5	47.9	64.4	617.7

SOURCES Hartman L Butler, Jr, et al., "The Aerospace Industry Re-vesited:' Financial Analysts Journal July-August 1977, corporate annual reports

Finally, note that the ratio of net income to sales, a measure of profitability, is low for aerospace firms relative to other industries overall and to all manufacturing corporations combined (see table 8). This means that aerospace firms derive less cash from current operations to apply to new projects than other firms. Increases in net-income-to-sales for commerical air transport manufacturers after 1976 imply that the cash contribution of current operations increased; by the same measure, the cash contribution of current operations decreased between 1979 and 1981.

Depreciation

Depreciation charges for plant and equipment are a source of internal funds to a company otherwise making a profit because they lower tax payments. The size of depreciation charges depends on the amount and timing of investments in depreciable facilities. * During 1981, facilities depreciation charges for Boeing, McDonnell Douglas, and Lockheed totaled about $490 million.

Depreciation is typically a much more limited source of funds for aerospace firms than net income or other sources. This is largely so because those firms invest relatively little in depreciable facilities (about **$988** million for Boeing, McDonnell Douglas, and Lockheed in 1981, for example) compared with other major manufacturing firms. Instead, they invest relatively large sums in R&D. Boeing, McDonnell Douglas, and Lockheed together spent more on R&D than on new facilities in 1981, for example. By contrast, depreciation is much more important for financing airlines, which make relatively large investments in equipment (primarily aircraft and parts). A study of airline financing patterns found that depreciation typically contributed **30** to 40 percent of major U.S. airline funds between 1951 and 1974.[3]

Deferred Taxes

Since the mid-1970's an important source of aerospace funds has been tax deferrals associated with the use of the completed contract method of cost accounting for tax purposes. The Internal Revenue Service developed the completed contract regulations (see the Code of Federal Regulations, vol. **26,** sec. 1.451-3) for commercial construction, shipbuilding, aerospace, and certain other manufacturing industries between 1971 and 1976.

The regulations were developed to remedy tax accounting problems arising from the substantial uncertainty in costs, prices, and income for work

*Aerospace firms cannot depreciate for tax purposes facilities purchased or provided by the Government.

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

Table 8.– Net Profit After Taxes as a Percentage of Sales

Year	All manufacturing corporations	Non-durable goods	Durable goods	Aerospace [a]
1960	4.4%	4.8%	4.0%	1.4%
1961	4.3	4.7	3.9	1.8
1962	4.5	4.7	4,4	2.4
1963	4.7	4.9	4.5	2.3
1964	5.2	5.4	5.1	2.6
1965	5.6	5.5	5.7	3.2
1966	5.6	5.5	5.6	3.0
1967	5.0	5.3	4.9	2,7
1968	5.1	5.3	4.9	3,2
1969	4.8	5.0	4.6	3.0
1970	4.0	4.5	3.6	2.0
1971	4,1	4.5	3.8	1.8
1972	4,4	4.6	4.3	2.4
1973	4,7	5.0	4,5	2.9
1974	5.5	6.4	4.7	2.9
1975	4.6	5.1	4.1	2.9
1976	5.4	5.5	5.2	3.4
1977	5,3	5.3	5.3	4.2
1978	5,4	5.4	5.5	4.4
1979	5,7	6.1	5,2	5.0
1980	4.8	5.6	4.0	4.3
1981	4.7	5.2	4.2	4,3

[a]Based on a sample of Standard Industrial Classification codes 372 and 376 corporations having as their principal activity the manufacture of aircraft guided missiles and parts

SOURCE Aerospace Industries Association, from Federal Trade Commission data

Net Income as a Percent of Sales for Major Manufacturers

Company	1975	1976	1977	1978	1979	1980	1981
Boeing	2.1	2.6	4.5	5.9	6.2	6.4	4.8
McDonnell Douglas	2.6	3.1	3,5	3.9	3.8	2.4	2,4
Lockheed	1.3	1.2	1.6	1.9	1.4	0.5	–5.6

SOURCES Standard &Poor Industry Survey Aerospace Basic Analysis (April 3,1980) corporate annual reports (1980 and 1981).

performed under long-term contracts. They allow aerospace (and other) firms to defer recognition of income, deduction of direct and certain indirect costs, and payment of taxes associated with long-term manufacturing contracts (Government or commercial) until the tax year in which the contract is completed. Other related cost items (primarily for overhead) are expensed during the years prior to contract completion.

Both the deferral of income recognition and the expensing of certain costs reduce taxable income and taxes payable in the years prior to contract completion. Moreover, the deferral of tax payments can raise the effective aftertax return on investment of manufacturers using completed contract cost accounting.[4]

Although the full impact of completed contract cost accounting is not obvious from published financial statements, which often reflect different accounting procedures than statements prepared for tax purposes, industry analysts estimate that the top dozen aerospace firms (in terms of sales) have gleaned about $5 billion in cash through tax deferrals primarily associated with Government contract work since the mid-1970's, and that loss

[4]U.S. Department of the Treasury, "General and Technical Explanation of Tax Revisions and Improved Collection and Enforcement Proposals," Feb. 26, 1982

of tax deferrals could reduce industry cash by at least 25 percent. * This evaluation reinforces the notion that aerospace firms have difficulty raising cash through "normal" channels. The current Congress is contemplating modifying these regulations to increase tax revenues.

Retained Earnings

Retained earnings represent the accumulation of past earnings retained for investment in firm activities (rather than dispersed to shareholders). At the end of 1981, Boeing, McDonnell Douglas, and Lockheed together reported having about $2.5 billion in retained earnings, $349 million less than end-of-1980 levels. Aerospace firms reinvest less capital from retained earnings than do other manufacturing industries. For example, while retained earnings comprises about 37 percent of total assets for all manufacturing firms combined in the fourth quarter of 1981, they were about 23 percent of total assets for aerospace firms. * *

Debt

Borrowing is the major means of external aerospace financing. Because aerospace sales and profits are cyclical, borrowing can even out the flows of funds necessary to meet development and production spending schedules. The following passage from the 1980 Boeing annual report brings out the important role of debt:

> It was a year in which many of our airline customers were adversely affected by the combined impact of recessionary and inflationary trends . . . an extremely competitive market . . . record interest rates and escalating fuel prices. As a result, demand slackened for the 727 and 747 commercial jet transports . . . Such reductions come at a time when substantial inventory buildup to support the 757 and 767 programs is required, when expenditures for plant and equipment to support current commitments and future growth continue at a high level, when increased investment must be planned to support the high level of Government business being projected, and when increased customer financing must be provided for . . . the reduced delivery rates have changed projections as to the level and timing of external financing that may be required. As a consequence, the previously established bank revolving credit agreement was increased . . . the company sold . . . convertible subordinated debentures . . . The company is also considering requesting a further increase in its . . . bank revolving credit agreement and may engage in additional financing . . .

Firms may borrow to satisfy overall capital needs or to fund particular projects. Boeing, for example, obtained a $2.25 billion standby line of credit in part to support its two new commercial air transport programs (the Boeing 757 and 767). An advanced air transport program would be so expensive that dedicated funding is likely to be necessary.

A review of financial statements shows that aerospace firms borrow in a variety of ways, including lines of bank credit, notes payable, convertible subordinated debentures (debt instruments that can be converted into stock), mortgages, and lease obligations. Convertible subordinated debentures (bonds that can be converted into common stock within a designated period of time) have helped aerospace firms (and airlines) get financing that might not have been available with straight debt (or equity) because the flexibility they afford the lender lessens the risk of lending to these firms.

The use of long-term debt has grown for both aerospace firms and airlines with the cost of new aircraft. Short-term debt holdings (for periods of up to 1 year) of aerospace firms have also increased periodically. Table 9 lists 1980 debt holdings of the seven major aerospace firms. Increasing use of debt implies an increasing burden of debt servicing costs. In 1981, for example, Boeing, McDonnell Douglas, and Lockheed paid $19.3 million, $69.8 million, and $186.2 million respectively in interest costs.

*Personal communication with Wolfgang Demisch, aerospace industry analyst, Morgan Stanley & Co., Inc.

* *In contrast, the ratio of retained earnings to total assets was about 36 percent for motor vehicle and equipment manufacturers and for manufacturers of other durable equipment during the fourth quarter of 1981, See the "Quarterly Financial Report for Manufacturing Corporations, " prepared by the Federal Trade Commission, for the first quarter of 1982 (published June 1982).

Table 9.—Aerospace Firm Long-Term Debt Holdings

Long-term debt outstanding	Amount	Interest rate
Boeing		
Convertible subordinated debentures	$250 roil.	8 7/8°/0
Notes payable	90.1 roil.	6 3/8°/0, 5°/0, other
Stand-by credit agreement	1.5 bil.	
McDonnell Douglas		
Convertible subordinated debentures	$ 47.2 roil.	4¾%
Notes and lease-purchase obligations	28.7 roil.	
Lockheed		
Convertible subordinated debentures	$101.1 roil.	4 1/4°/0
Notes payable and other	738.5 roil.	
Credit agreement	850 roil.	Over prime, London Interbank offered rates
General Dynamics		
Installment purchase notes	$ 14.2 mil.	9%
Other notes	18.9 mil.	
Credit agreements	170 roil.	
Subsidiary credit agreements	73 roil.	
Other subsidiary debt	301.1 roil.	
Grumman		
Convertible subordinated debentures	$ 18.4 roil.	4¼%
Convertible subordinated debentures	75 mil.	11%
Lease-secured installment notes	17.1 mil.	7-22 1/4%
Lease obligations	2.6 mil.	2-9 3/4°/0
Notes and mortgages	15.5 roil.	7/8 - 11 °/0
Revolving credit agreement	103. roil.	Over prime rate
Fairchild Industries		
Convertible subordinated debentures	$ 0.99 roil.	9 3/40/0
Convertible subordinated debentures	13.6 roil.	9 3/4°/0
Notes payable and other	97.7 roil.	
Credit agreements	140 roil.	Over prime, London Interbank offered rates
Northrop		
Promissory notes	$ 10.5 roil.	7 1/8°/0
Notes payable	2,5 roil.	61 /4°/0, 9 7/8°/0
Capital lease obligations	6.4 roil.	

SOURCE Moody's ***Industrial*** **Manual, 1981**

Equity

Aerospace firms have issued stock in the past, but they cannot easily raise additional capital through stock now for three reasons. First, aerospace stocks have had limited appeal to investors because of erratic performance and high risk. Aerospace stocks have historically sold at price-earnings (P-E) multiples well below average (although between late 1979 and early 1980 aerospace P-Es exceeded the industrial average). Low P-E multiples generally signify that investors deem the market values of aerospace firms to be low, because future earnings are anticipated to be low and financial risks are anticipated to be high. Second, unless aerospace firms can maintain substantial growth, the concern to avoid diluting stockholders' equity (resulting in lower earnings per share and making the stock less attractive) limits their ability to issue additional shares. Equity can be more expensive than debt because, with dilution, higher returns must be paid on equity to attract capital. Third, stock prices have been depressed for several years, limiting the amount of money that can be raised through stock.

Advance and Progress Payments

Advance and progress payments are an important source of funds, primarily for work done on Government projects. Progress payments on Government contracts have nominally covered 80 percent of most contract costs (coverage was raised to 90 percent in late 1981), although there is evidence that actual cost coverage may be about 20 percent less (because of delays in recording of costs, billing, and payment).[5] Advance payments for commercial programs have typically amounted to about 35 percent prior to delivery, when the balance is due. *

However, because aircraft manufacturers compete with each other on the terms of customer financing, which are negotiated separately with each customer, advance payments are a somewhat unreliable source of funds that is usually under pressure to be reduced. Also, manufacturers may in some cases finance commercial aircraft purchases, thereby drawing out the period over which they will receive payment and increasing their needs for cash. At the end of 1981, Boeing, McDonnell Douglas, and Lockheed together reported having over $6 billion in advance and progress payments, an aggregate increase of about $165 million over end-of-1980 levels.

"'Completed Contract Method of Tax Accounting in Aerospace Industry, " a memorandum prepared by John S. Nolan, attorney for the Aerospace Industries Association of America, Inc.

*Personal communication with Wolfgang Demisch, aerospace industry analyst, Morgan Stanley & Co., Inc.

FINANCIAL CAPACITY

The above discussion of sources of funds suggests that, excluding debt and deferred taxes (an uncertain source vulnerable to policy changes), the three firms which have been dominant in commercial air transport manufacture have been able to garner together up to about $2.5 billion in new funds in a year (about $1 billion from net income plus about $1 billion in net increases in advance and progress payments, plus under $0.5 billion in depreciation charges, based on 1980 figures). Adding in debt and other sources could at least double this aggregate figure. However, there are several reasons why a single commercial aircraft manufacturer would have difficulty affording the $6 billion to $11 billion or higher investment required over a period of several years for an advanced air transport program. These reasons are reviewed below.

First, the 1980 figures cited above reflect a relatively good year for commercial air transport manufacturers. Because finances in this industry are relatively volatile, neither total nor source-specific figures for 1980 or any other year can be viewed as reliable indicators of financial capacity in any future year or period. Indeed, 1981 figures for net income, net increases in advance and progress payments, and depreciation for the three companies total $1.02 billion, or less than half of the 1980 total.

Second, the funds amassed by aerospace firms support a variety of projects. Therefore, the total amount of funds generated by a given manufacturer overstates the amount available for a commercial air transport project. Moreover, funds from certain sources may be restricted in their application. For example, advance and progress payments for Government aerospace projects—the major component of advance and progress payment funds—should not be considered a source of funds available for commercial air transport development.

Third, the firms that are today involved in commercial air transport production differ substantially in financial strength and fund raising capacity. For example, during 1981 Boeing generated $825 million from net income, net increases in advance and progress payments, and depreciation charges, compared with $545 million generated by McDonnell Douglas and $355 million by Lockheed. Industry analysts generally accept that Boeing is financially the strongest of the three.

Finally, even the most financially sound of existing aerospace firms might well have difficulty raising enough debt to support an advanced air transport project for two reasons. First, applying substantial amounts of leverage to a single aerospace firm would entail very high and probably unacceptable financial risks for lenders. Second, a $6 billion to $11 billion or greater investment is so high relative to the net worth of any one aerospace firm (indicated by stockholders' equity), which ranged from over $0.1 billion for Lockheed to about $2.7 billion for Boeing in 1981, that it would appear to put the viability of a single commercial aircraft manufacturer at a totally unacceptable risk. * That is, it appears to be beyond the capability of a single commercial aircraft manufacturer at this time to bear the risk of financial loss associated with an advanced air transport program requiring an investment of $6 billion to $11 billion or more.

* Stockholders equity equals the par value of common stock plus capital in excess of par value plus retained and net earnings less dividends and treasury stock purchases

Chapter 5

PROGRAM ALTERNATIVES

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As long as a large market for advanced air transports exists there are incentives for industry to develop them and private lenders and investors to finance them. Whether or not private parties can produce advanced air transports on their own, the Government may be interested in the management and financing of advanced air transport projects. The U.S. Government has demonstrated an ongoing concern with the structure and operations of the aerospace industry and with the development of aerospace technology.

Two important questions of potential interest to Congress regarding advanced air transport projects are: Given the existence of a market for advanced subsonic transports (ASUBTs) and, in particular, advanced supersonic transports (ASTs), could such projects be undertaken privately, and how? If the Federal Government were to take an active interest in AST and ASUBT projects, what further management and financing alternatives would exist?

The principal alternatives for implementing advanced air transport projects include: 1) conventional programs headed by a single manufacturer and supported by several subcontractor firms; 2) cooperative projects, such as a joint venture by American firms or by American and foreign firms; and 3) projects assisted by the Government, with direct or indirect financial support (and possibly technical support or guidance). This chapter will examine these alternatives, focusing on cooperative and Government-assisted alternatives because they represent departures from customary commercial air transport programs.

SINGLE MANUFACTURER

Implementation of a commercial air transport project by a single U.S. aircraft manufacturer supported by several subcontractor firms has been the norm. This approach has persisted in recent decades, with variations, despite substantial increases in aircraft production costs and instances of financial distress among aerospace firms. With sufficient resources, the single-manufacturer project can be the most efficient alternative because centralized management enables the greatest realization of economies of scale and other economies related to the division of labor among plants, firms, and geographic areas. * However, the industry may prefer an alternative approach if anticipated costs and risks are so high relative to individual manufacturers' net worth that advanced air transport projects could jeopardize the financial viability of single manufacturers—even the most financially hardy—undertaking them. Whether this would be the case cannot be determined at this time.

● Whether costs are minimized depends in part on the relationships between manufacturer and subcontractors. For example, some financial analysts believe that Boeing has ***lower*** costs than its competitors because of better relations with subcontractors. See the Standard and Poor's "Aerospace Industry Survey: Basic Analysis" prepared by Robert Spremulli, Apr. 3, 1980,

JOINT VENTURE

An obvious alternative to the traditional program headed by a single firm is a joint venture. A joint venture is a means of formally pooling resources (financial, technical, and physical) and liabilities among participating firms. It can also be a means of securing the use of patents held by one or more participants. On the other hand, joint ventures can entail additional costs for the project. For example, if venture arrangements require that work be allocated equally (e. g., by number of hours or jobs, number of units produced, or value of product) among partners, the division of labor and the operations at any one facility may not be the most efficient. Work on a shared project may also proceed inefficiently because of differing labor conditions and work rules among partners, which may also influence how work is allocated among partners and facilities. Differing labor conditions and work rules frequently affect the activities and costs of international joint ventures, especially those that involve European aerospace firms.

Joint ventures could be established by U.S. aircraft manufacturers with other manufacturers, subcontractors, or other firms to do advanced air transport R&D or production or both. It is likely that joint ventures for advanced air transport projects would be oriented toward production for three reasons: 1) much basic advanced air transport research and development (R&D) has been (and will have been) done, 2) specific R&D is both relatively expensive and wedded to specific product concepts, and 3) production offers greater expected returns on investment than R&D. Consequently, such ventures would probably conduct only those R&D activities necessary to assure technical success of the project, although sharing the risks involved in that R&D would be a major motivation for undertaking the joint venture.

Aside from the possibility of conflicts and additional costs arising from the sharing of responsibilities, the advantages and disadvantages of joint ventures depend on whether they contain only American firms or American and foreign firms together. Major concerns regarding the composition of joint ventures pertain to national security, financing and sales, and U.S. antitrust laws. These are discussed below.

Arguments favoring U. S.-U. S. joint ventures over U. S .-foreign ones center on concerns about national security and international leadership. One argument is that international cooperative ventures should be discouraged for advanced technology projects because they may transfer technology with military applications that has been developed by Americans to foreigners. A similar argument is that international cooperative ventures may cede potential American leadership in important technologies.

The merit of these concerns depends on the state of foreign efforts in this area, and the ease with which relevant technologies can be adopted by rivals. Foreign firms have demonstrated strength in aviation technologies with both civil and military applications, strength that has been growing over the years. Consequently, the United States may have less of a technological edge in aviation projects than in the past. Nevertheless, it may be possible to reduce or eliminate opportunity for transfer of sensitive technologies by structuring a joint venture such that work in sensitive technologies originating in the United States is confined to American firms, while other work is allocated to foreign partners.

The principal appeal of joint ventures between American and foreign firms is the prospect of easier financing and larger markets than U. S.-U. S. joint ventures would expect to face. It may be easier to finance an international than a domestic joint venture because foreign participants offer greater access to foreign capital and, in particular, foreign Government funds, Several major foreign aerospace firms are owned or backed by foreign Governments (e.g., France, Great Britain, Italy, West Germany, and Japan). These governments also frequently own, support, or otherwise control local airlines, too. Consequently, a venture with foreign firms can also secure sales to foreign airlines. * Both the Concorde and the Airbus programs provide examples of foreign government support for airplane development, production, and purchases. Assurance of both foreign and domestic airline purchases would raise the expected profitability of advanced air transport projects, which could in turn facilitate external financing for American firms in the United States, if necessary.

*Aerospace joint ventures are common among European firms because they lack the large, relatively homogeneous home market U.S. manufacturers have. Joint ventures have made aircraft ventures involving only foreign firms viable by essentially guaranteeing customers in the countries of participating companies. They have also helped to spread financial losses among companies and supportive governments, Formal access to foreign customers may be more important for an ASUBT than an AST because the special productivity and performance advantages of the AST may be sufficient to create adequate market interest. Also, regardless of production arrangements, foreign customer interest may be easier to secure for an AST than an ASUBT, inasmuch as rival programs may be much less likely.

Another advantage of international joint ventures is that such a venture may entail fewer legal or political risks to U.S. firms than a domestic one. This is because an international joint venture may be less likely to violate U.S. antitrust laws, inasmuch as foreign participants are relatively small factors in the U.S. aircraft market.

Whether or not a joint venture violates U.S. antitrust laws is a function of its design and the circumstances under which it is established. Although each potential or actual joint venture must be evaluated as a unique entity, it is possible to characterize broad considerations affecting the legality of a joint venture. Three principal considerations are: 1) whether the joint venture would limit existing or potential competition in the industry (in particular, whether independent efforts by the participants or others could and would otherwise take place); 2) whether venture arrangements impose collateral restrictions on competition; and 3) whether the venture is designed to deny competitor firms access to participation or products (especially innovations) and thereby restrain competition.

Antitrust problems are more likely (though not assured) where the market is concentrated and/or where many or all firms in a particular field seek to work together. On the other hand, if an industry leader is or will be developing the product in question, a venture among other firms may be acceptable if without it no alternatives to the product of the industry leader would be available.

Research and production joint ventures inspire different legal concerns and responses, in part because research, per se, is not market activity and also because research may help to enlarge markets through development of new products. By contrast, a joint venture to produce specific products is like a merger. The key question in either case is whether the loss of potential competition implied by a joint venture is at least balanced by the enhancement of the market provided by the products created.

The answer is found by evaluating the nature of the product, the risks involved in producing it, the likelihood of entry by participants or other firms into the relevant market, the existence of technical barriers to the formation of alternative joint ventures, and other factors. Unless the joint venture is found to have as primary or collateral purpose the fixing of prices, market shares, or market territories (which are per se violations of antitrust law), the legality of a joint venture will be judged by a “rule of reason” standard.

Note that the inability of a firm to finance a project internally is not, by itself, an acceptable justification under antitrust laws for a joint venture as long as outside financing is available (without creating a major financial burden on the firm). Also, the nationality of participants is irrelevant under antitrust laws. All foreign participants (actual or potential) in U.S. markets are subject to U.S. antitrust laws. Questions of international relations, foreign trade, national security, and international competitiveness do not enter into determinations of compliance with antitrust laws, although they may affect enforcement practice, which can vary with the policies of the Executive.

The key antitrust concerns for an advanced air transport joint venture include: 1) market definition: is the relevant market ASTs, ASUBTs, commercial air transports, or something else? 2) the ability of individual manufacturers to sponsor advanced air transport projects independently (with subcontractor support); and 3) the acceptability of particular combinations of firms and particular venture arrangements under antitrust laws.

FEDERAL GOVERNMENT INVOLVEMENT

The Federal Government may choose to sponsor or assist in the development of advanced air transports. Possible arguments that can be made for Government involvement in such projects are reviewed below.

First, Government involvement may be justified if it can be concluded that extreme risk aversion prevents private capital markets from funding advanced air transport projects. Through sponsorship or financial assistance the Federal Government could share project costs and risks and could provide an additional incentive to private parties to provide funding at reasonable costs.

Historically, the U.S. Government has assisted in the financing of risky projects to aid classes of borrowers regarded as poor risks (e.g., small business and minority credit programs), to facilitate very costly projects in the public sector (e.g., subway and sewer construction financing), and to facilitate high-cost/high-risk projects that bear on national security (e. g., shipbuilding and development of the merchant marine). In all of these cases, unusually high financial barriers have prevented private parties (or local governments) from obtaining sufficient capital from private sources for activities that further such broad social goals as equal economic opportunity, national security, and the raising of standards of living among communities.

In the past, Federal support for aeronautical R&D that may have commercial applications, like other R&D, has been accepted in part because innovation is regarded as beneficial to society. It is not clear, however, whether explicit Federal support for advanced air transports can be justified on grounds of broad societal value. Since advanced air transports would benefit directly only those citizens who can afford to fly (and perhaps, of those, only citizens who can afford premium fares), whether Federal aid is appropriate may depend on the perceived societal value of public investments in specific aviation technologies and in the aerospace industry. In this as in other cases, whether a project merits financial aid from the Government is a matter of political as much as economic analysis.

A second argument for Federal involvement is that accelerating development of an advanced air transport might sustain American leadership in relevant technologies, enhance the international competitiveness of American industry, and increase U.S. aerospace exports. Exports of aerospace products are an important factor in the U.S. balance of trade. While the total U.S. balance of trade has been negative since 1976, aerospace trade has had a large positive balance, helping to offset negative balances in other sectors (see table lo).

Note that transport aircraft dominate aerospace trade because of their high unit values (see table 11). Recently, growth in aerospace imports has increased, while growth in aerospace exports has decreased. These trends could contribute to future worsening of the total balance of trade. Government support for advanced air transports, which would have significant export potential, would be one alternative for promoting U.S. aerospace exports as well as U.S. technological leadership. *

There are examples of Government intervention to accelerate technology deployment and influence related economic activity, but they are less common than those of Government intervention in response to unusual financial circumstances. One example is the Tennessee Valley Authority (TVA), which was established to provide for efficient power generation, flood control, river navigation, and agricultural improvement, as well as stimulation of area economic development. The formation of TVA *secured* Federal Government control over the timing, form, and responsibility for projects under its jurisdiction.

Another example is COMSAT, a corporation that was established to transfer communications satellite technology developed with Federal funds to private industry. Among the goals for COMSAT were U.S. technological leadership and avoidance of private monopoly in satellite communications. Although COMSAT deals with aerospace technologies, it is not necessarily an appropriate model for Federal involvement in ad-

*Similar arguments were advanced in favor of the U.S. SST.

Table 10.—Total and Aerospace Balance of Trade

Year	Total U.S. trade balance[a]	Aerospace Trade balance	Exports	Imports	Aerospace trade balance as percent of U.S. total
1960 . . . ,	$ 5,369	$ 1,665	$ 1.726	$ 61	31.0%
1961 . . . ,	6,096	1,501	1,653	152	24.6
1962	4,180	1,795	1,923	128	42.9
1963.	6,061	1,532	1,627	95	25.3
1964.	7,555	1,518	1,608	90	20.1
1965.	5,875	1,459	1,618	159	24,8
1966. . . .	4,524	1,370	1,673	303	30.3
1967.	4,409	1,961	2,248	287	44,5
1968	1,133	2,661	2,994	333	234,9
1969 . .	1,599	2,831	3,138	307	177,0
1970..	2,834	3,097	3,405	308	109,3
1971... :::	-2,024[b]	3,830	4,203	373	c
1972. .....,,	-6,351	3,230	3,795	565	
1973, . .	1,222	4,360	5.142	782	356.8
1974... ..	-2.996	6.350	7.095	745	r
1975	9,630	7,045	7,792	747	73,2
1976	-7,786	7,267	7,843	576	
1977 ,	-28,970	6,850	7,581	731	c
1978..	-31,786	9,058	10,001	943	c
1979 : :	-27.250	10,123	11.747	1,624	c
1980	–27,340	11,952	15,506	3,554	
1981	–30,051	13,134	17,634	4,500	c

[a]Exports Imports
[b]First negative U.S balance of trade since 1888
[c]Not applicable

SOURCE Aerospace Industries Association using Bureau of the Census data

vanced air transport technologies. This is so primarily because a large market for the technologies and related services promoted by COMSAT was established before the corporation was formed, while the market for advanced air transports, especially ASTs, is expected to be much less certain. Because of the anticipated market, the Government was able to structure COMSAT to operate without recourse to Federal funds, while Federal financial support may be necessary to launch advanced air transport projects.

Note that Government has typically intervened to accelerate the deployment of technology to benefit the Nation without creating marketable civilian products such as advanced air transports. A major exception was the U.S. Supersonic Transport (SST) project (1963-71), which had as its goals the advancement of air travel and aviation technology, and the enhancement of U.S. technological leadership, prestige, and foreign trade. Although there were several factors behind the cancellation of the SST project, the experience underscores the political and economic risks of Government involvement in highly complex, narrowly defined, and expensive commercial projects,

In particular, the SST experience suggests that the political acceptability of a commercial project supported by the Federal Government may hinge on specific attributes of the final product, such as fuel consumption, environmental impacts, and accessibility to all socioeconomic groups. The SST experience also suggests that insofar as Government support for the production of specific commercial products is controversial, Government involvement in either nonspecific R&D or marketing activities (e.g., through provision of seed money) may be more acceptable, at least because the financial commitment is less.

Finally, Government involvement in advanced air transport development might protect the

Table 11 .—Exports of Civil Aircraft

	1976-	1977	1978	1979	1980	1981
Total number of aircraft	4,283	4,368	4,399	5.115	4,434	3,826
Helicopters, under 2,200 lbs.	201	233	243	294	335	268
Helicopters, over 2,200 lbs.	114	88	125	165	190	185
Single-engine aircraft	2,374	2.664	2,640	2,821	2,172	1,800
Multi-engine aircraft, under 4,400 lbs. . .	228	273	455	645	546	371
Multi-engine aircraft, 4,400-10,000 tbs.	612	525	339	360	432	426
Multi-engine aircraft, 10,000-33,000 lbs. .	4	7	37	52	28	20
Passenger aircraft, over 33,000 lbs..			99	172	215	236
Cargo aircraft, over 33,000 tbs.		101	3	13	8	7
Other aircraft, over 33.000 lbs. .	5 8		9	15	14	12
Other aircraft, Including balloons, gliders and kites ., ...	NA	NA	NA	NA	NA	NA
Used or rebuilt aircraft	592	477	449	578	494	501
Total value (millions of dollars)	$3,211	$2,747	$3,625	$6,177	$8,256	P8,613
Helicopters, under 2,200 lbs. . . .	28	38	42	61	82	71
Helicopters, over 2,200 lbs.	85	68	114	146	217	275
Single-engine aircraft ...	74	93	103	124	114	105
Multi-engine aircraft, under 4,400 lbs. . . .	17	27	62	94	88	72
Multi-engine aircraft, 4,400-10,000 lbs. ., .,	269	262	240	306	454	526
Multi-engine aircraft, 10,000-33,000 lbs	2	6	91	126	83	87
Passenger aircraft, over 33,000 lbs. ...			2,111	4,128	5,511	6,087
Cargo aircraft, over 33.000 lbs.	2,468	1,936	142	322	480	363
Other aircraft, over 33,000 lbs.			305	548	736	730
Other aircraft, Including balloons, gilders and kites	4	4	27	11	5	62
Used or rebuilt aircraft .	264	313	388	311	486	235

NA: Not available
NOTE Data prior to 1978 may not be strictly comparable to data for subsequent years due to revision of the export schedule effective in 1978

SOURCE Aerospace Industries Association using Bureau of the Census data

aerospace industry from the instability of the commercial aircraft market. The Government has historically sheltered other industries considered essential to the public interest, including railroads (most notably by creating Amtrak and Conrail); such financial industries as banking, stockbrokering, and commodities trading (through a variety of Government-sponsored corporations’); and others.

Commercial aviation projects, although not themselves objects of policy concern, affect the structure and financial health of the aerospace industry, the allocation of its resources, and the ability of firms to meet military aerospace needs. The Government has already aided Lockheed in recent years (like other aerospace firms earlier) when it foundered on a commercial project, in order to preserve technological knowhow and product competition vital to defense needs. Also, during the 1970’s, the Civil Aeronautics Board and some industry analysts promoted legislation to coordinate U.S. commercial aircraft program selection and timing as a means of abating financial pressures and risks in aircraft manufacture.

The Government could choose to become involved in advanced air transport projects in advance both as a prophylactic measure and because an AST or ASUBT project may provide practical experience with technologies applicable to defense

*Such corporations include the Federal Deposit Insurance Corporation, the Securities Investors Protection Corporation, and the Commodity Futures Trading Corporation.

products. However, the public interest in technologies with military applications may be less ambiguously served by explicitly underwriting the development of such technologies for defense applications. Also, justifying Government involvement in advanced air transport projects as a means to promote the stability of the aerospace industry would likely raise questions about other Government activities that influence the industry, including those that affect its international competitiveness. Other activities may be better alternatives for Government investment in supporting the industry.

CONCLUSION

As the above discussion suggests, advanced air transport projects could be undertaken with either private or public funding or both. If desired, Government involvement could range from financial aid to establishment of a special organization, such as a Government-sponsored corporation. Financial aid alone, which could be provided to individual companies or to joint ventures, can be delivered in a variety of forms (e.g., loans, loan guarantees, grants, special tax incentives). It is, in general, a more limited means of Government involvement than creation of a Government-sponsored organization.

A Government-sponsored organization, which could provide a greater level of Government involvement, could take several forms. As the contrast between TVA and COMSAT illustrates, the form of a Government-sponsored organization would depend on the level of Government funding and participation desired (although a Government-sponsored corporation would have to conform to provisions of the Government Corporation Control Act of 1945).

Whether, and in what form, the Federal Government would support an advanced air transport program would depend on how policy priorities are perceived, how advanced air transport projects compare with other candidates for the limited Federal assistance dollar, and the extent to which Congress and the Executive choose to bear the risks.

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