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TECHNOLOGY TRANSFER AND OTHER
PUBLIC POLICY IMPLICATIONS OF
MULTI-NATIONAL ARRANGEMENTS
FOR THE PRODUCTION OF
COMMERCIAL AIRFRAMES

by AARON J. GELLMAN with JEFFREY P. PRICE

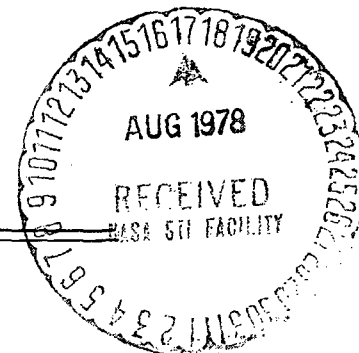
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16. Abstract A study to examine the question of technology transfer through international arrangements for production of commercial transport aircraft. The objectives were: to determine the likelihood of such transfer under various representative conditions; to develop an understanding of the economic motivations for, and effects of, joint venture arrangements; and to assess the relevant public policy implications. The report focuses primarily, though not exclusively, on multi-national consortia with U.S. participation because they generate the full range of pertinent public policy issues (including especially technology transfer), and also because of recognized trends toward such arrangements. The work involved an extensive search and analysis of existing literature to identify the key issues, and in-person interviews with executives of U.S. and European commercial airframe producers. Distinctions are drawn among product-embodied, process, and management technologies in terms of their relative possibilities of transfer and the significance of such transfer. Also included are the study contractor's observations on related issues such as the implications of U.S. antitrust policy with respect to the formation of consortia and the competitive viability of the U.S. aircraft manufacturing industry.					
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Chapter 1

SUMMARY

Introduction

A study has been conducted by Gellman Research Associates, Inc. (GRA) at the request of the National Aeronautics and Space Administration, Office of Aeronautics and Space Technology, to examine the question of technology transfer through international arrangements for production of commercial transport aircraft. The objectives were: to determine the likelihood of such transfer under various representative conditions; to develop an understanding of the economic motivations for, and effects of, joint venture arrangements; and to assess the relevant public policy implications. As the study progressed, several of the non-technological aspects appeared to warrant increased emphasis, both because of their bearing on the technology transfer question and because they raise valid public policy issues in their own right. The study results and the contractor's observations on the findings are presented in this report.

There have been significant changes in the commercial aircraft manufacturing industry in the last several decades, producing an environment in which the level of industry costs has spiralled. In meaningful degree, this grows out of the situation where initial investment (or threshold) project costs are rising and threaten to become prohibitively high. In addition, the express intention of

other nations to expand their respective shares of the free-world market for commercial transport aircraft--a market in which the U.S. has been overwhelmingly predominant--has introduced great uncertainty into all manufacturers' assessments of precisely what and where the market for any proposed U.S. commercial aircraft will be. Consequently, U.S. airframe producers may be unable to develop new generations of commercial air transport unless the structure of the industry is modified so as to accommodate these pressures while maintaining their individual competitive viability. Any modification of an industry's structure which addresses problems of these sorts is a "rationalization."

The Subcommittee on Aviation and Transportation R&D of the Committee on Science and Technology of the U.S. House of Representatives called for U.S. public policy to be such as to ensure the maintenance of "our worldwide commercial leadership in air transportation."¹ Rationalization of the U.S. commercial airframe industry, in order to protect that commercial leadership, can be achieved through several means, among which are consortia² and alternative "cooperative arrangements." A number of alternative cooperative arrangements are listed in Exhibit 1-1. This report examines these cooperative arrangements and the

¹U.S. Congress, House, Subcommittee on Aviation and Transportation R&D, The Future of Aviation, 94th Cong., 2d Sess., 1976.

²A thorough definition and description of consortia is contained in the Appendix.

Exhibit 1-1

TYPICAL "COOPERATIVE ARRANGEMENTS" FOR THE
PRODUCTION OF CIVIL TRANSPORT AIRFRAMES

	<u>Example(s)</u>
Multi-National Consortium without U.S. Participation	Concorde*; A-300B
Multi-National Consortium with U.S. Participation	None at present.**
Multi-National Prime-Subcontractor Arrangement with Formal Risk Sharing	F-28
Multi-National Prime-Subcontractor Arrangement without Formal Risk Sharing	DC-9; DC-10
Multi-National Co-Production	F-27; BAC 1-11; VFW 614
All-U.S. Airframe Consortium	None
All-U.S. Prime-Subcontractor Arrangement with Formal Risk Sharing	L-1011; B-747
All-U.S. Prime-Subcontractor Arrangement without Formal Risk Sharing	B-707; B-727

* Included co-production of aircraft.

** The CFM-56 aircraft engine is being developed by a consortium comprised of General Electric (U.S.) and SNECMA (France).

implications of such mechanisms for U.S. interests. The report focuses primarily, though not exclusively, on multi-national consortia with U.S. participation because they generate the full range of public policy issues attending rationalization (including especially technology transfer), and also because they may emerge as the most acceptable alternative cooperative arrangement given the basic conditions of supply and demand facing this industry.

Methodology

The work program underlying this study involved, first, an extensive search and analysis of existing literature to identify the key issues to be addressed in determining the public policy implications of the formation of consortia for production of transport aircraft.³

Then, in-person interviews were conducted with executives of a large proportion of U.S. and European commercial airframe producers. Those interviewed ranged from senior corporate officers to high-level division engineering, planning, and financial executives. Each meeting was conducted with the understanding that the names of the cooperating firms, but not of the specific persons interviewed, would be disclosed.⁴ The firms interviewed were:

³A bibliography is appended to this report.

⁴For this reason, most undocumented statements made in this report are actually buttressed by information or opinions supplied by the persons interviewed.

- ° The Boeing Company,
- ° McDonnell Douglas Corporation,
- ° Lockheed Aircraft Corporation,
- ° Fokker-VFW International B.V.,
- ° Societe Nationale Industrielle Aerospatiale (Aerospatiale),
- ° British Aerospace Corporation,
- ° Airbus Industrie.

In addition, there were interviews with U.S. Government officials in several agencies.

The final step in the research program was to codify and analyze the information gathered and to determine the public policy implications of consortia of various sorts.

Conclusions

The formation and operation of consortia permit individual commercial airframe manufacturers to reduce the financial resources required below what would be needed if the firm were to undertake a particular project alone. (This is not to say that the total initial investment required or subsequent unit production costs are lowest in a consortium setting, however.)

Multi-national consortia which include U.S. firms could help preserve U.S. access to free-world commercial airframe markets but would also increase non-U.S. firms' participation in the U.S. market.

The operation of consortia incorporating both foreign and U.S. manufacturers raises myriad issues, some with public policy

implications. One such set of implications concerns the possibility that technology may be transferred in the course of a consortium's development and operation. There are three types of technology that would be subject to transfer:

- 1) airframe product-embodied technology,
- 2) manufacturer process technology, and
- 3) management technology or technique.

Product-embodied technology is fast-moving and tends to lose significance as a competitive factor shortly after it is ready for incorporation in an aircraft development venture. The interviews conducted in this study indicated that product-embodied technology at the present time is considered to be at an essentially equivalent level of sophistication in the developed nations of the free world. For these reasons, the possible transfer of such technology via the consortium route is not a serious public policy concern. If research advances were to result in significant disparities in this area in the future, both private and public policies and programs would require reassessment.

Process and management technologies are more likely to differ among companies, and are more durable; their transfer would be more significant in terms of subsequent competition. U.S. process technology has been acknowledged to be superior by foreign competitors; furthermore, it is demonstrably transferable. U.S. commercial airframe manufacturers attribute their free-world market predominance largely to management technique; however, manufacturers

in other nations have apparently not yet recognized the value of U.S. management technique and certainly do not see it as a major source of the continuing U.S. competitive edge in commercial transport airframes.

Transfer of process and management technology can be promoted or minimized in a multi-national consortium. The extent of technology transfer is a function of the division of responsibilities among participants, the duration of the consortium project(s), and the organization and structure of the consortium.

Although it appears that the U.S. Government can have only limited control over transfer of process and management technology once a consortium is established, it is probable that any unique technology that Government would seek to protect on national security or other grounds (such as balance of payments) would be the same technology which U.S. entrepreneurs would also wish to protect for its competitive value.

Another set of public policy implications related to multi-national consortia with U.S. participation concerns the view of authorities of the Antitrust Division of the U.S. Department of Justice with regard to cooperative ventures as a means of achieving rationalization of the commercial aircraft manufacturing industry. The Justice Department is not presently receptive to the idea that rationalization of the industry may be a necessary precondition to its long-term competitive viability. Unless antitrust policy and instrumentalities are modified to provide the

industry with guidelines sufficiently substantial to be relied upon or challenged, as appropriate, they will remain significant barriers to the formation of both domestic and multi-national consortia.

Additional public policy implications generated by consortia affect such areas as employment, competition in transport aircraft markets, balance of payments, technological preeminence, and market predominance. The extent to which the U.S. intends to maintain its dominant position in the commercial airframe field is central to determining the detrimental results of transferring U.S. production process technology and management technique to foreign airframe (or components) manufacturers. The establishment of clear U.S. Government goals with regard to the level of predominance to be realized by the U.S. in the free-world commercial airframe market, however, requires extensive understanding of both the economic and competitive characteristics of the commercial airframe market. Assuming that government policy does include the maintenance of a dominant U.S. position, direct government intervention may be required to rationalize the commercial aircraft manufacturing industry if consortia and/or other cooperative arrangements are not implemented by the industry itself. Cooperative arrangements, however, appear to be a more efficient means of rationalization than direct government intervention. All-U.S. consortia in particular may be capable of generating net effects which are substantially positive in terms of the overall interests of the United States.

Chapter 2

MOTIVES FOR AIRFRAME MANUFACTURERS TO PARTICIPATE IN CONSORTIA

While there is a wide range of "cooperative arrangements" possible for the production of civil transport airframes,¹ the discussion that follows largely centers around consortia. Primarily, this is because the full panoply of issues a firm faces when considering a "cooperative arrangement" is found in the context of the consortium.

There are two major groups of incentives for domestic airframe manufacturers to participate in consortia. The first set of motives is rooted in the problems associated with amassing the tremendous financial, physical, and intellectual resources necessary to undertake such a large and risky business venture as the design, development, production, and marketing of a commercial transport aircraft. The second group of incentives is more subjective; it consists of concerns about the viability of U.S.-built transports in important foreign markets (as well as the viability of foreign-built transports in U.S. markets). By reviewing the relevant motives for airframe manufacturers to participate in consortia, the implications of these intercorporate arrangements can be more fully appreciated.

Economic Incentives

The production of modern commercial aircraft requires great aggregations of capital goods, skilled labor, aerospace engineers and designers, and an expensive inventory of production tools.

¹See Exhibit 1-1, page 3.

The industry's production function is consequently highly intensive in both intellectual and physical capital. Even so, compared to many other industries, the manufacturing of commercial airframes seems unexceptional but for the substantial risks which attend investments in civil transport aircraft development and construction. There is also a number of distinct but interrelated factors associated with production and risk in this industry. Such factors often act as economic incentives for domestic airframe manufacturers to consider participating in consortia. This is because such arrangements tend to spread costs and risks while minimizing the maximum loss which can be experienced by any one participant.

High Initial Investment

To produce a commercial airframe, the manufacturer must assemble a critical mass of resources consisting of fixed assets and technological research and development. The technological investment includes time and materials devoted to research, design, development, and perhaps prototype development, all of which are steps in the lengthy process of innovation. Depending partly upon how radical the technological advances are, these investments can range from several million to more than one billion dollars for subsonic transports.²

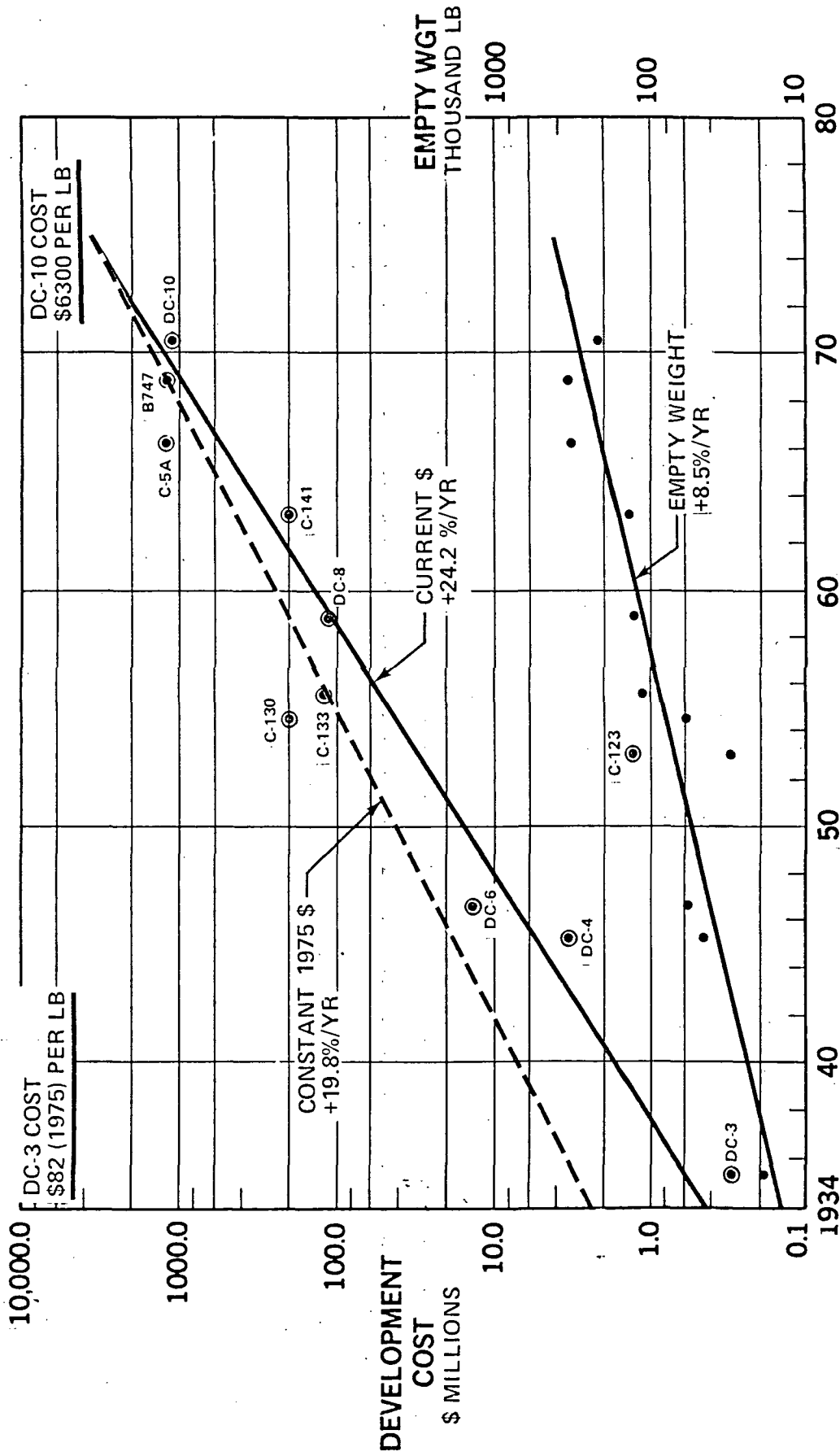
²Shields Model Roland, Inc., The Boeing Company: A Strategy for Continued Market Dominance (New York: SMR, 1976), pp. 27-29; Hartman L. Butler, Jr., George J. Podrasky, and J. Devon Allen, "The Aerospace Industry Re-Revisited: Commercial Aircraft," Financial Analysts Journal 33 (September/October 1977): 56.

In addition to this front-end investment,³ the manufacturer must assemble capital comprised of tools, a production-line building, a production line, a comprehensive marketing effort, and working capital. These resources are amassed prior to production of the aircraft. Consequently, long before the first aircraft is delivered, hundreds of millions of dollars will have been committed by an airframe manufacturer involved in a major new development program.

The magnitude of these resources and the problems inherent in predicting their size are shown in Exhibits 2-1 and 2-2 taken from material provided by McDonnell Douglas. The precipitous climb in development costs beginning with the DC-3 in the mid-1920s and continuing through to the delivery of the DC-10 is shown in Exhibit 2-1. Costs are increasing faster than empty weight of aircraft; the price per pound of empty weight climbed from \$82 in the case of the DC-3 to \$6,300 for the DC-10 (measured in 1975 constant dollars). As Exhibit 2-2 shows, the launching cost of the DC-10 was the equivalent of 155 percent of the equity value of McDonnell Douglas Aircraft Co., in contrast with the relatively smaller commitment required to launch

³For accounting purposes, Boeing did not capitalize these expenditures, while McDonnell Douglas and Lockheed did capitalize most of them and amortize them over a "block" of production output, say, 300 aircraft. However, Financial Accounting Standards Board Statement No. 2, issued in October 1974, provides that all research and development costs must be expensed when incurred. Other costs can be spread over a block; Boeing, McDonnell Douglas, and Lockheed each allocate on a unit cost basis the block's estimated cumulative production costs and tooling costs when computing an aircraft's cost of sales. Lockheed, McDonnell Douglas, and Boeing each employ this technique. See Butler, Podrasky, Allen, p. 60; also refer to Note 2 in Lockheed Aircraft Corp., 1976 Annual Report (Burbank: Lockheed, 1977), p. 17.

TRANSPORT AIRCRAFT DEVELOPMENT COST TRENDS



SOURCE: DOD-NASA-DOT STUDY "RADCAP" AUGUST 1972

Source: McDonnell Douglas Corporation, Douglas Aircraft Company, Office of Planning.

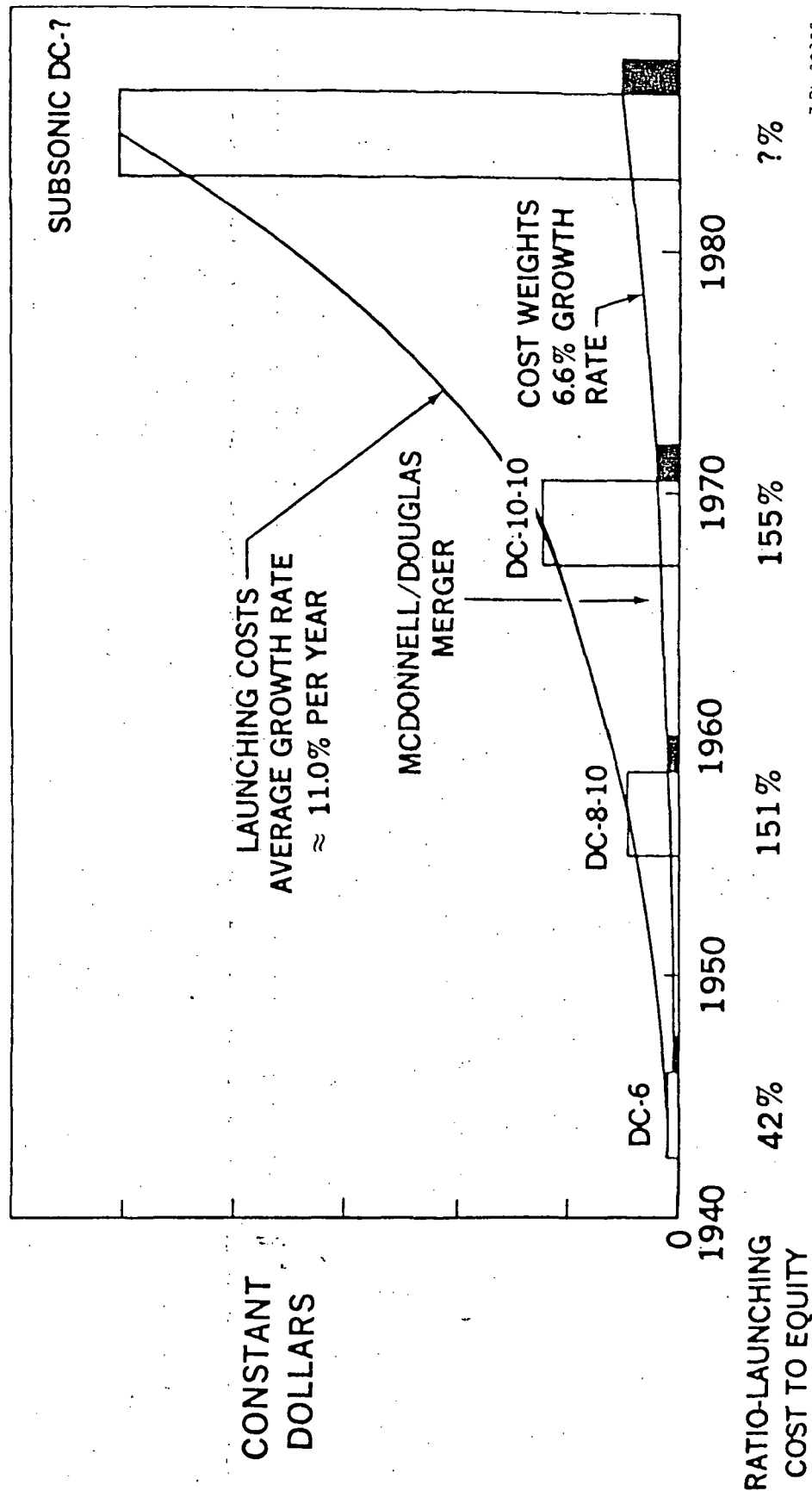
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Exhibit 2-2

NEW LARGE COMMERCIAL TRANSPORT AIRCRAFT

LAUNCHING COST

ONE MODEL — AIRFRAME ONLY — CONSTANT DOLLARS



Source: McDonnell Douglas Corporation, Douglas Aircraft Company, Office of Planning.

7-PL-30305

the DC-6 (42 percent of Douglas equity). The cost of development (including inflation) is, according to Douglas, likely to grow at approximately 11 percent annually, a rate that could exceed the growth in the firm's equity base.⁴ This implies that in the future the fixed cost of airframe development will become an increasingly heavy burden for individual aircraft manufacturers to bear.

The critical mass of the above-enumerated resources is the threshold investment required of an airframe producer that wishes to continue its participation in the industry, since it is not possible to reduce proportionately the quantity of resources needed to produce fewer aircraft. The lumpiness of investment is characteristic of the production of aircraft. A company that manufactures aircraft can mitigate the lumpiness problem by assuming responsibilities for only a subset of all the tasks in the process of manufacture. Other producers can bear responsibilities for the other tasks of manufacture. This ability to parcel out tasks--in order to avoid the lumpiness problem--is a strong incentive over time for a number of corporate entities to participate jointly in the development and production process--perhaps through a consortium.

At the present time, despite recent improvements in its financial condition, Lockheed in particular would seem to be heavily constrained in its ability to finance the initial investment required for major airframe development. As of the end of fiscal 1976, its net worth was only

⁴See Exhibit 2-2.

\$167 million.⁵ Furthermore, the profitability of its commercial aircraft division is questionable. Despite its technical capabilities, Lockheed is effectively foreclosed from development of a new aircraft (significantly different from its existing L-1011). This company, especially, feels the pressures to seek out coventurers--whether other airframe companies, unrelated companies, customers, banks, or governments--to aid it in keeping its product line competitive.

Though not as weak as Lockheed, Boeing and McDonnell Douglas feel similar pressures to help lower the price of entry into a new airframe program. Their net worths at the end of 1976 were \$1,092 million⁶ and \$945 million⁷ respectively. Considering the billion or more dollars required to launch a major project such as the B-7X7,⁸ even Boeing would have to be willing to bet the equivalent of the value of the whole company. Although the overall McDonnell Douglas net worth is great, it is not in the best position to launch a major new program because the Douglas division's own profitability⁹ is not

⁵Comptroller General of the United States, Report to the Congress by the Comptroller General of the United States: Implementation of Emergency Loan Guarantee Act (Washington: General Accounting Office, April 25, 1977), p. 12.

⁶Boeing Company, Annual Report 1976 (Seattle: Boeing, March 7, 1977).

⁷McDonnell Douglas Corp., 1976 Annual Report (St. Louis: McDonnell Douglas, December 31, 1976).

⁸Shields Model Roland, The Boeing Company, pp. 27-29.

⁹National Aeronautics and Space Administration, Ames Research Center, The Economics of Air Transport Manufacturing, Volume I: Industry Analysis, by Donald W. Kyle and others of SYSTAN, Inc. (Los Altos: SYSTAN, 1974), p. 19; Butler, Podrasky, and Allen, "The Aerospace Industry Re-Visited," pp. 62, 55.

particularly strong nor is the overall company's balance sheet as solid as Boeing's.

Financing and Risk--Risk is one of the key variables in the financing equation. One type of risk is exhibited by the example of a proposed short-range, twin derivative of the DC-10, a project with initial launch cost probably equal to about half that of the B-7X7. In this case, McDonnell Douglas is understandably concerned about whether such a derivative can attract sufficient demand to permit capital recovery in light of the fact that an existing aircraft, the A-300B, already addresses much the same market. A major risk is that a proposed aircraft may not succeed because another aircraft already serves a market which Douglas can enter only several years hence. (Boeing encountered this same problem in the mid-1960s when it chose to launch the B-737 program even though Douglas' DC-9 had a headstart.)

While the DC-10 derivative program exhibits one type of risk, there are many others. For example, a significant capital shortage may face the airline industry; financing may be difficult to obtain for many airlines in need of new aircraft because they are heavily leveraged and they have volatile profit records. Without subscribing fully to the implications of the table, it is interesting to note that in Exhibit 2-3, of the "big four" trunk carriers only United is shown to have investment capacity sufficient to meet its needs. The chart indicates that American, TWA, and Eastern will have a shortfall in

Exhibit 2-3

SUMMARY OF INVESTMENT CAPACITY VERSUS NEEDS

1976-1990

(\$ Billion)

Rank	Company	Investment Capacity*	Investment Needs	Surplus or (Shortfall)	Surplus or (Shortfall) as a % of Investment Capacity
1	Northwest	\$10.5	\$4.8	\$5.7	54.3%
2	Delta	14.3	7.4	6.9	48.3
3	Braniff	4.8	3.0	1.8	37.5
4	United	18.4	11.9	6.5	35.3
5	National	3.9	2.6	1.3	33.3
6	Western	3.6	3.2	0.4	11.1
7	Continental	3.1	2.9	0.2	6.5
8	American	7.9	9.4	(1.5)	(19.0)
9	Pan American	4.9	6.9	(2.0)	(40.8)
10	TWA	6.0	9.2	(3.2)	(53.3)
11	Eastern	4.6	8.1	(3.5)	(76.1)
	TOTAL	\$82.0	\$69.4	\$12.6	15.4%

* Estimates for investment capacity to finance flight and ground equipment requirements for U.S. trunk carriers through 1990 are based on maintenance by carriers of their existing market shares in a simulation that was developed by Shield Model Roland, a New York investment firm. While the group as a whole can meet projected requirements, some carriers will have excess investment capacity and some too little, the study estimates.

Source: William H. Gregory, "Airline Reequipment Financing Studied," Aviation Week & Space Technology, 107 (July 11, 1977): 26-29.

investment capacity totaling \$8.2 billion. The magnitude of this capital insufficiency is dramatically apparent since the total assets of the three companies in 1976, collectively, were only \$4.82 billion.¹⁰

Beyond this purely financial problem and the risk to manufacturers that it implies, the U.S. airline industry is currently facing the prospect of economic regulatory reform which has introduced much uncertainty¹¹ concerning future competition between air carriers. From the standpoint of any individual airline, regulatory reform introduces uncertainty because the company does not know by whom or how its markets may be intruded upon. In other words, demand for air service may remain strong, but each carrier's share is by no means dependable. Therefore, from the perspective of an airframe manufacturer, the picture is clouded as to who the customers will be and what aircraft they will require.

For different reasons, uncertainty concerning future airline demand for aircraft also exists on a worldwide basis. Nationalism and protectionism have emerged as important factors in the flight equipment investment decisions of European flag carriers. Depending upon the resolution of such issues, some of these major historical customers could become uncertain sales prospects for U.S. aircraft companies in general. Risks of the sort outlined above tend to make "cooperative

¹⁰E.F. Hutton & Co., "Airline Financial and Operating Statistics," June 1977.

¹¹The word "uncertainty" refers to possibilities which are not susceptible to the probabilistic approaches used in risk analysis.

ventures" more appealing than would otherwise be the case and multinational arrangements may be the most attractive response of all for commercial airframe producers.

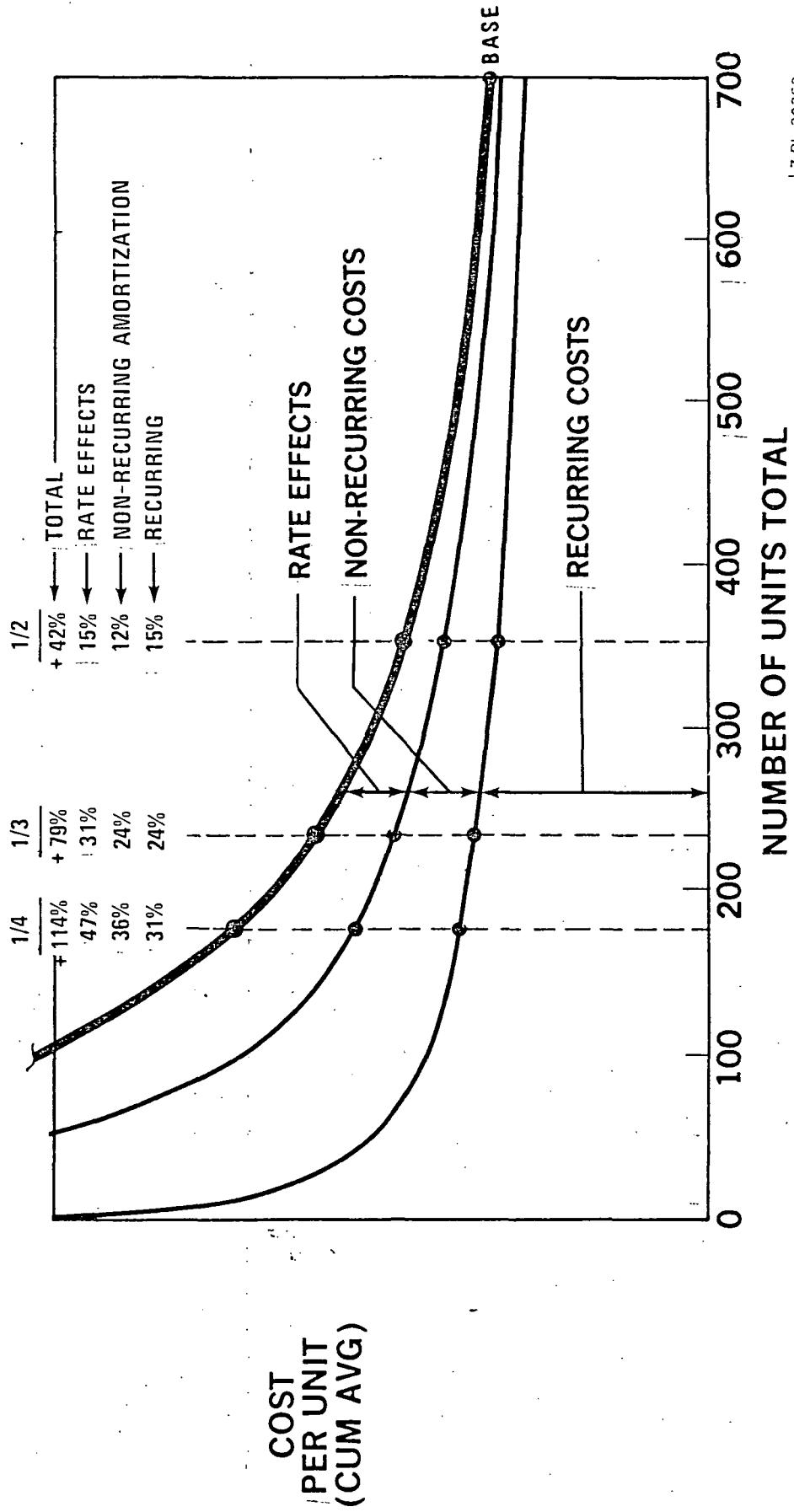
Principal Economic Incentives to Form Consortia

With front-end costs so high and risks and uncertainty so great, it can increasingly be expected that only one entity can profitably produce a given "class" of aircraft. In this connection, Exhibit 2-4, developed by McDonnell Douglas, is especially instructive. The data underscored the per-aircraft cost penalties incurred by producing 350, 233, or 175 instead of 700 aircraft. The chart suggests that two competitors would have to sell a total of at least 1,400 similar aircraft with comparable production cost characteristics in order to reduce average unit cost to a level experienced by a single manufacturer selling 700 aircraft. In any case, if the market for such aircraft is below 700, the average unit cost will be higher than a minimum. While it is far from clear that average unit costs and unit prices have been (or will be) closely and continually correlated with one another, where there is effective competition in the market, prices should be lower when costs are lower. This suggests the desirability of formulating and administering public policy so that suitably low unit costs of production are achievable for products such as transport aircraft,¹² where

¹²With reference to Exhibit 2-4, no inference should be drawn that 700 aircraft or any other level of production represents the most efficient output for transport aircraft manufacture. It is interesting to note, however, that only two commercial jet aircraft production runs have yet exceeded 700--the B-727 and B-707--and the DC-9 may well be the last to do so. The B-727 series appears likely to prove the only commercial aircraft program in this century to exceed 1,000 units, which has already been achieved.

MARKET SIZE IMPORTANCE AIRCRAFT PRODUCTION COSTS

AVERAGE UNIT COST PENALTIES
FOR REDUCED SALES



Source: McDonnell Douglas Corporation, Douglas Aircraft Company, Office of Planning.

7-PL-30358

their use is vested with public need.

Oligopolistic Industry Structure--The aircraft industry is an "oligopoly," a condition which exists "...where there are few sellers who sell differentiated (rather than identical) products."¹³ Another discussion of oligopoly indicates that the aircraft industry is appropriately characterized as such because only a few producers vie to sell their products, which are differentiable, but their products are competitive with each other and "...each [seller] believes his economic fortunes are perceptibly influenced by the market actions of other individual firms."¹⁴ If the actions of one competitor did not directly depend upon or influence the reaction of another competitor, then this industry would be characterized as "monopolistically competitive."

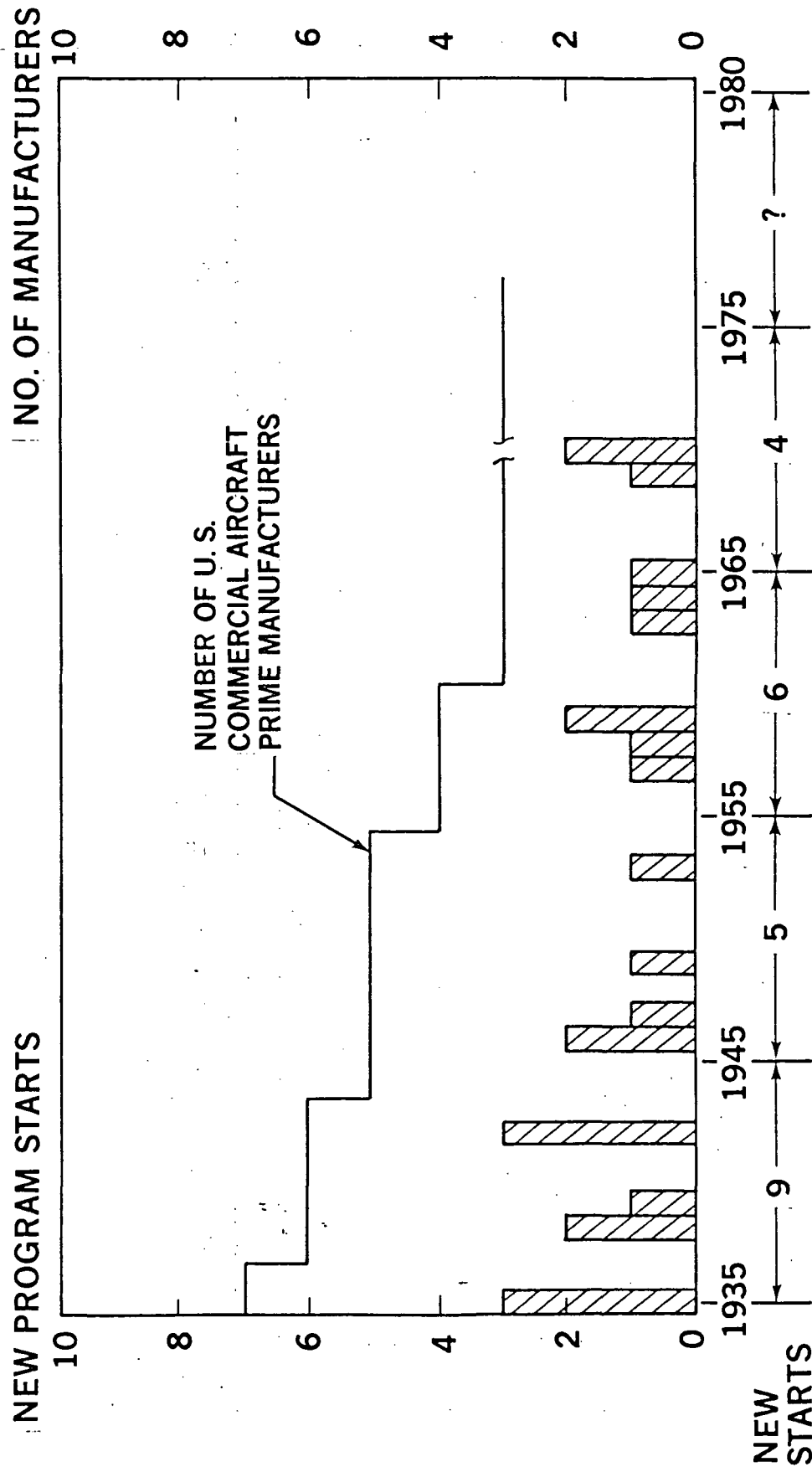
Competition is a powerful regulating force in the aircraft industry. Even though most aircraft are quite distinguishable from all others, they are partial substitutes for each other; that is, cross-elasticities of demand have usually been significant. This has remained the case despite increasing concentration of the industry both in the U.S. and abroad. Exhibit 2-5 relates the number of domestic U.S. aircraft manufacturers to new program starts and shows the increase in concentration. Fewer programs have been launched as the number of manufacturers decline, but two of the remaining manufacturers continue to

¹³Paul A. Samuelson, Economics, 8th ed. (New York: McGraw-Hill, 1970), p. 466.

¹⁴F. M. Scherer, Industrial Market Structure and Economic Performance (Chicago: Rand McNally, 1970), p. 10.

COMPETITION IN THE U. S. COMMERCIAL TRANSPORT INDUSTRY

NEW PROGRAM STARTS
(DOES NOT INCLUDE DERIVATIVE AIRCRAFT)



5-PL-30575A

sell at least two commercial airframes. But the key to the existence of effective competition¹⁵ is not the number of competitors or even the rate at which they introduce new products; rather, it is whether the remaining few competitors have been unable to act as monopolists, whose behavior is often reflected in pricing policy in such markets.

As noted previously, the decrease in the number of airframe manufacturers over the past four decades is a natural result of the acceleration in the capital or threshold investment associated with producing more modern aircraft. But it is equally important to point out that effective competition usually results when two or more aircraft are partial substitutes for one another. For example, the B-727 is a partial substitute for the DC-9, as the DC-10 is for the B-747. It also seems that for some airlines, a combination of DC-10s and B-727s can be a substitute for a fleet of A-300s, a conclusion reached in 1977 by Western Air Lines. This form of competition is usually both desirable and beneficial. Near perfect substitutes, however, can create difficulties where threshold costs are high. This can be illustrated through the DC-10 and L-1011 where competition often described as destructive leads to a situation where one or both of the aircraft will fail to earn any profits for their producers.

In sum, as long as the demand for several specific aircraft types is somewhat cross-elastic, each producer has a powerful incentive to

¹⁵"Effective competition" is used here to mean competition sufficient to limit monopoly behavior.

produce its own "entry" in an efficient manner and to offer it at an attractive price. Failure to do so can only cause other aircraft to be more successful in capturing airline business. It follows that this industry is most likely in the long run to operate competitively and stably when each supplier offers a product which is clearly differentiable from all others. The Europeans appear to reflect this concept as their commercial aircraft firms have come to specialize in medium-range and short-range aircraft (e.g., A-300B, F-28, and BAC 1-11). There seems to be recognition that destructive competition is avoided so long as the aircraft offered are not functionally too close to one another. Producers are not thereby guaranteed a profit on their respective programs,¹⁶ but they at least expect to be spared the financially debilitating consequences of "excessive" competition.

Exhibit 2-6 shows a variety of aircraft aligned by carrying capacity (expressed in terms of body size) and by range. This table, among other things, points out the present crowding of proposals in "medium body," short-to-medium range aircraft; these aircraft all accommodate between 180 and 250 passengers. Certainly, if all or most of the aircraft in each of the relevant "cells" of Exhibit 2-6 are offered, competition between them will be keen and perhaps destructive. It is "inter-cell" competition that is more healthy and is more likely to emerge when each manufacturer produces a differentiable aircraft.

¹⁶ Profits are realizable provided that sufficient demand for the product exists and that the manufacturer's process is efficient.

Exhibit 2-6

AIRCRAFT BY RANGE AND SIZE

	Narrow Body	Medium Body	Wide Body
Short Haul	DC-9** B-737** BAC 111**	B-7N7* Mercure 200* DC-10-Twin* BAC X-11*	A-300B** B-747SR**
Medium Haul	B-727-200**	B-7X7* DC-X-200* A-300B-10* A-200*	DC-10-10** L-1011** A-300B**
Long Haul	B-707** DC-8*** Concorde**	B-7X7*	B-747** DC-10-30/40** L-1011-500*
Super Long Haul (part of Long Haul)	DC-8-62, 63***		B-747SP**

Source: Shields Model Roland, Inc., The Boeing Company: A Strategy for Continued Market Dominance, report done for Boeing (New York: SMR, 1976), p. 14. (Modified and expanded by GRA.)

Legend: *proposed
 **currently available
 ***no longer in production

The commercial airframe business increasingly requires that each manufacturer produce or participate in the production of an aircraft which can turn a profit for its manufacturer. At the same time, this aircraft should have its own niche in the market,¹⁷ but nonetheless be faced by other aircraft which can do effectively and efficiently some of the jobs it can. In this way, profits can be earned from each aircraft program while at the same time society avoids the problems associated with more or less strict monopoly.

Non-Economic Reasons for Forming Consortia

This chapter has previously identified the most powerful economic pressures which can lead otherwise competitive airframe producers to form consortia for the development, manufacture, and sale of new transport aircraft. But there are other factors as well. Those which motivate European airframe firms are especially relevant and it is interesting to contrast their attitudes toward cooperative arrangements with U.S. companies to their view of ventures where only European enterprises are involved.

European Objectives

The goals of European airframe producers are different from the long-term objectives of U.S. companies because the formers' collective share of the world market is relatively small and because their value systems are often different.

¹⁷For a detailed discussion, refer to John E. Steiner, "The Timing of Technology for Commercial Transport Aircraft," Astronautics & Aeronautics (October 1977), pp. 44-46.

British Aerospace Corporation, Aerospatiale, and several other European firms are nationalized. The nationalized companies often are not profit-maximizing enterprises in the same sense as their U.S. counterparts. Nationalized corporations become direct instruments of national policies (such as by maintaining relatively stable employment, even in the face of gyrations in orders).

In contrast, private-sector enterprises, such as the U.S. aircraft producers (and Fokker-VFW in Europe),¹⁸ are not routinely used as instruments of national social policy. Consequently, the decisionmaking response of a private-sector firm and a nationalized firm, confronted with the same issue, may very well be different. Again, the nationalized enterprise's usual preoccupation with such goals as employment maximization influences their motivations for consortium participation, and at the same time, conditions U.S. firms' attitudes towards such undertakings if it requires their being in league with public enterprises.

National and regional pride is another significant factor governing aerospace industry goals in Europe and elsewhere. French pride, especially, is considered to be a force which motivates European (or French) equality with other--i.e., U.S.--aerospace manufacturers. As a result, the French view of all-European consortia is understandably

¹⁸Dutch and German firms are in the private sector, although their governments play active roles by supplying some risk capital.

different from their attitude toward amalgamations with non-European partners, especially if such ventures were to include U.S. firms, regardless of the basis.

Both European public officials and industry executives continually stress the importance of maintaining independent national or regional capability to conduct a comprehensive aircraft research, development, production, and marketing program. In general, an obviously subordinate role, such as one where European responsibilities would consist solely of partial manufacture of an aircraft, is not accepted happily. In support of their position, Europeans often point out that it is important to maintain an all-around aircraft capability for military purposes.

Individual Motives for Airframe Manufacturers to Participate in Consortia

Exhibit 2-7 is a matrix which displays the most significant motives for individual manufacturers to participate in consortia. It is based upon a program of interviews carried out in the U.S. and Europe supported by a supplementary literature analysis. The interview results are tabulated to reflect the different motive patterns of the several firms depending on whether or not U.S. firms were assumed to be included as participants.

Considering first the responses to the possibility of consortia with U.S. participation, it is of significance that the "vision" of a consortium arrangement held by U.S. firms contrasts quite sharply with

Exhibit 2-7

AIRFRAME MANUFACTURER MULTI-NATIONAL CONSORTIUM MOTIVES MATRIX

	WITH U.S. PARTICIPATION						WITHOUT U.S. PARTICIPATION					
	Douglas	Lockheed	Boeing	British Aerospace	Aerospatiale	Fokker-VFW	Airbus Industrie	British Aerospace	Aerospatiale	Fokker-VFW		
Enhancement of Financial Resources	1	1	S	5	4	2	N.A.	4	4	3		
Penetration of New Markets	N.A.	N.A.	N.A.	1	1	1	1	3	3	2		
Preservation of Market Access	2	2	1	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.		
Employment: Maintenance of High or Growing Levels	No	No	No	2	2	N.M.	S	1	1	S		
Technology Transfer--Product Embodied	No	No	No	S	No	S	S	No	No	No		
Technology Transfer--Production Process	No	No	No	5	No	No	S	No	No	No		
Technology Transfer--Management Techniques	No	No	No	N.M.	N.M.	N.M.	N.M.	N.M.	N.M.	N.M.		
Acquisition of Marketing Skills and/or Support	No	No	No	S	S	No	2	No	No	No		
Risk-Sharing--Financial	S	S	S	S	N.M.	S	N.M.	S	S	S		
Risk-Sharing--Technological	N.M.	S	N.M.	N.M.	N.M.	N.M.	N.M.	S	S	S		
Pride: Maintenance of Regional or National Full-Spectrum Aircraft Development-Production-Marketing Capability	N.A.	N.A.	N.A.	3	3	3	3	2	2	1		
Maintenance of Ability to Address Simultaneously Market for Different Type Aircraft	N.M.	N.M.	2	N.M.	N.M.	N.M.	N.A.	N.M.	N.M.	N.M.		
Retention of Measure of Control of Supply-Side of the Transport Aircraft Market	S	No	No	S	S	N.M.	N.A.	S	S	S		
Acquire Marketing Skills from Other Consortium Participants	N.M.	N.M.	N.M.	4	S	S	S	N.M.	N.M.	N.M.		
Enhance Military Capability	N.A.	N.A.	N.A.	S	S	N.M.	N.A.	S	S	No		

KEY: Numbers (1, 2, etc.): Ranking of motive (where determinable)

S: Subsidiary (unranked) motive

No: Specifically denied as a motive

NA: Not applicable

NM: Not mentioned in interview or literature

that of potential European partners, even though there are some differences within each group. For example, two of the three U.S. commercial airframe producers (Lockheed and McDonnell Douglas) see the enhancement of their respective financial resources as being the most attractive motive for them to participate in any multi-national consortium. In contrast, none of the European firms ranks this motive very high. For them, where a U.S.-European consortium was the issue, the clear primary motive was market penetration. They are aware of the size of the U.S. market (even if it is presently declining as a proportion of the total world market), and they are also sensitive to the fact that American manufacturers have achieved great success selling aircraft both at home and abroad. So it is not entirely surprising to find that market expansion dominates their thinking about consortia with U.S. manufacturers participating.

But the responses reflected in Exhibit 2-7 do not tell the whole story either, especially for the U.S. firms. For example, in the recent past, especially since June 1977, when the French took a hard line against an order for Boeing 737 aircraft, the preservation of market access for U.S. firms has become increasingly important. Both Lockheed and McDonnell Douglas indicated that this motive was strengthening--but their primary motive remained enhancement of their own financial resources through such arrangements as multi-national consortia.

In contrast, preservation of market access was by far the strongest motive for Boeing, with financial leverage being decidedly subsidiary

as is explained by Boeing's present strong profit performance and balance sheet condition. In a sense, however, Boeing's view of consortia as a means of the firm's participating simultaneously in more than one aircraft development and production project implies a desire to enhance its financial resources. Boeing indicates it will not again attempt simultaneous, multiple projects on its own as a matter of policy because of its unhappy experience in the 1960s with several contemporaneous civil transport development programs. In any event, Boeing appears dedicated to going forward with one major program on its own, perhaps employing some appropriate "cooperative arrangement" to pursue any other attractive new aircraft opportunity that is perceived to be available. Given Boeing's long-standing predominant position in the world market for civil transport aircraft, and given their previous history, this strategy seems entirely rational.¹⁹

It may appear at first that Boeing's position as reflected in Exhibit 2-7 is at variance with the immediately preceding discussion. Such is not the case. The table reflects the manufacturers' views with respect to a consortium arrangement for a single next project. In extended conversation with Boeing executives, it became clear that the

¹⁹The interviews with the U.S. firms underscore the fact that positions can change over time. Certainly Boeing's view of its capabilities and objectives has shifted, as has the comparative importance for Douglas or Lockheed of various motives for considering the consortium as a means to an end.

firm did not then see a consortium as either a necessary or attractive alternative for a first new aircraft project, but that if a consortium were employed for such a project, it would certainly be for market access reasons. For a second contemporaneous project, however, a consortium arrangement becomes a real candidate for Boeing primarily as a financial resource enhancement device, although market access preservation probably again enters the calculus as well.

With regard to the U.S. commercial airframe producers, it should also be noted that uniformly they expressed the view that they would not be motivated to join a multi-national consortium for the benefits to be derived through any sort of transfer of technology into either the consortium or into their own organizations. This is consistent with their attitude that they are preeminent in the world where product-embodied technology, process technology, and management techniques are concerned and therefore have nothing to gain in these areas from a "technology-transferring" sort of arrangement with enterprises in other countries. Similarly, each U.S. firm feels that it could not benefit from any marketing skills or after-sales support techniques or programs of non-U.S. aircraft manufacturers and therefore would not consider this as a motive for participating in a multi-national consortium either. With regard to technology transfer, marketing skills, and product support, it is important to note that the attitudes of the several European firms contrast more or less sharply with that of their U.S. counterparts. The former at least acknowledged that the latter have skills or intellectual capital in some of these areas, the

transfer of which would benefit either themselves or a consortium to which they were a party, or both.²⁰

The motives of the several constituents of the European air-frame industry are distinguishable by their ownership characteristics--nationalized industry (e.g., British Aerospace and Aérospatiale) contrasted against essentially private business (e.g., Fokker-VFW), or mixed enterprise (e.g., Airbus Industrie). Significantly, however, regardless of ownership, every European firm has the same top-ranking motive for seeking a consortium with U.S. participation: more effective penetration of the U.S. market. Beyond this single point of agreement, the Europeans diverge. Because the nationalized firms emphasize employment levels and stability, they regard a consortium as a better way to attain this goal than independent programs. In contrast, privately-owned Fokker-VFW did not cite employment as an objective while Airbus Industrie mentioned it only obliquely. Similarly, each enterprise denied that the maintenance of the labor force was a motive for considering consortium participation.

From the European standpoint, a consortium is a device that would permit Europe to maintain a full spectrum of capabilities in the commercial aircraft field. Some admit this is perhaps not a wholly rational view, but national (and regional) pride is a powerful force in the formation of consortia with or without U.S. participation.

²⁰It is of some interest to note that three of the four European firms interviewed appear to feel that there is at least the possibility of the transfer of some product-embodied technology from U.S. sources through a consortium, even though U.S. firms and Aérospatiale were strong in expressing the attitude that product-embodied technology differences were at a most minimal as between U.S. and European firms. The author was persuaded that the latter view reflects reality currently but that the situation may not last (see below pages 45-46).

Regarding technology transfer, with but one exception the Europeans either explicitly denied that it was a motive or treated it as a distinctly subsidiary issue. The exception was British Aerospace, whose executives explicitly recognized that American air-frame manufacturers--especially Boeing--are capable of producing aircraft far more efficiently when the production runs are comparatively large--i.e., in excess of, say, 200 or 300 aircraft. British Aerospace believes that through a "proper" consortium arrangement with Boeing, for example, it would learn a good deal about how the U.S. firm manages to achieve such a result. Otherwise, Europeans, with a few exceptions, maintain that technology transfer in all its guises is unimportant as a motive to form consortia with or without U.S. participation. (The next chapter explores this factor more thoroughly.)

It is also interesting to note that reasons for forming an all-European consortium differ among the various firms. Once again, for British Aerospace and Aerospatiale, the two nationalized companies, employment is clearly the prime objective, while for Fokker-VFW, it is subsidiary. The private-sector firm is motivated principally by desire to maintain in the European community a full spectrum of production capabilities and enjoy some of the benefits of participation in sales across a wider geographical market such as a consortium can achieve.

Summary of Reasons for Forming Consortia

In sum, consortia and similar cooperative efforts are mechanisms created to respond to logical, strategic, and economic motivations of each commercial aircraft producer, though the motivations are often different for each. The U.S. companies are strongly pressured by the sheer magnitude of financing required to launch a new airframe project, and they can still participate in what appears to be an attractive market at an acceptably low threshold cost through consortia with other firms.²¹ U.S. airframe producers also are understandably apprehensive of the growing specter of protectionism in foreign countries which may severely restrict their traditional access to the free-world markets.

On the other hand, aircraft manufacturers in other nations look favorably on consortia with U.S. participation as wedges into the still-large U.S. airline market. To a lesser extent, they wish to acquire marketing skills from successful U.S. partners. Usually such firms will not be satisfied with simple cooperative efforts. They must participate on a proprietary basis. Consequently, a consortium arrangement is often preferred.

²¹It is important to note that a consortium arrangement does not imply that either the total launching investment or average unit production costs will be lower than if an efficient individual firm pursued the same project. In fact, the opposite is almost certain to be the case, according to the results of the interview program.

Chapter 3

U.S. TECHNOLOGICAL ADVANTAGE

U.S. dominance of the free-world commercial aircraft market rests significantly more on a technological base than on any other. U.S. companies may not necessarily produce aircraft which exhibit "better" aerodynamics or structure features than their competitors are capable of incorporating, but they have been more successful in implementing and integrating technological advances into products which are timely and appropriate to the market. In other words, the U.S. comparative advantage may be found not in the technology of its airframes, but in the efficiency and effectiveness with which aircraft are designed, produced, and marketed. This distinction is best understood if one recognizes the difference between the three basic types of "technology" relevant to the airframe industry.

First, there is product-embodied technology. Such technology is manifest through the aircraft supplied by manufacturers. Literally each element of the aircraft embodies technology, some more advanced than others--e.g., innovative airfoils, drag-reduction techniques, high-lift leading-edge devices, light-weight composite materials, advanced control systems.

Process technology refers to the combination of means by which an airframe is produced--the resources and procedures used to build the aircraft. Again the technology can range from relatively crude to highly sophisticated, from production on a simple press break to heavy

extrusion presses and chemical milling and bonding. The state of process technology is partially reflected in the inventory of tools, dies, machines, fabrication and assembly plants, and testing facilities employed.

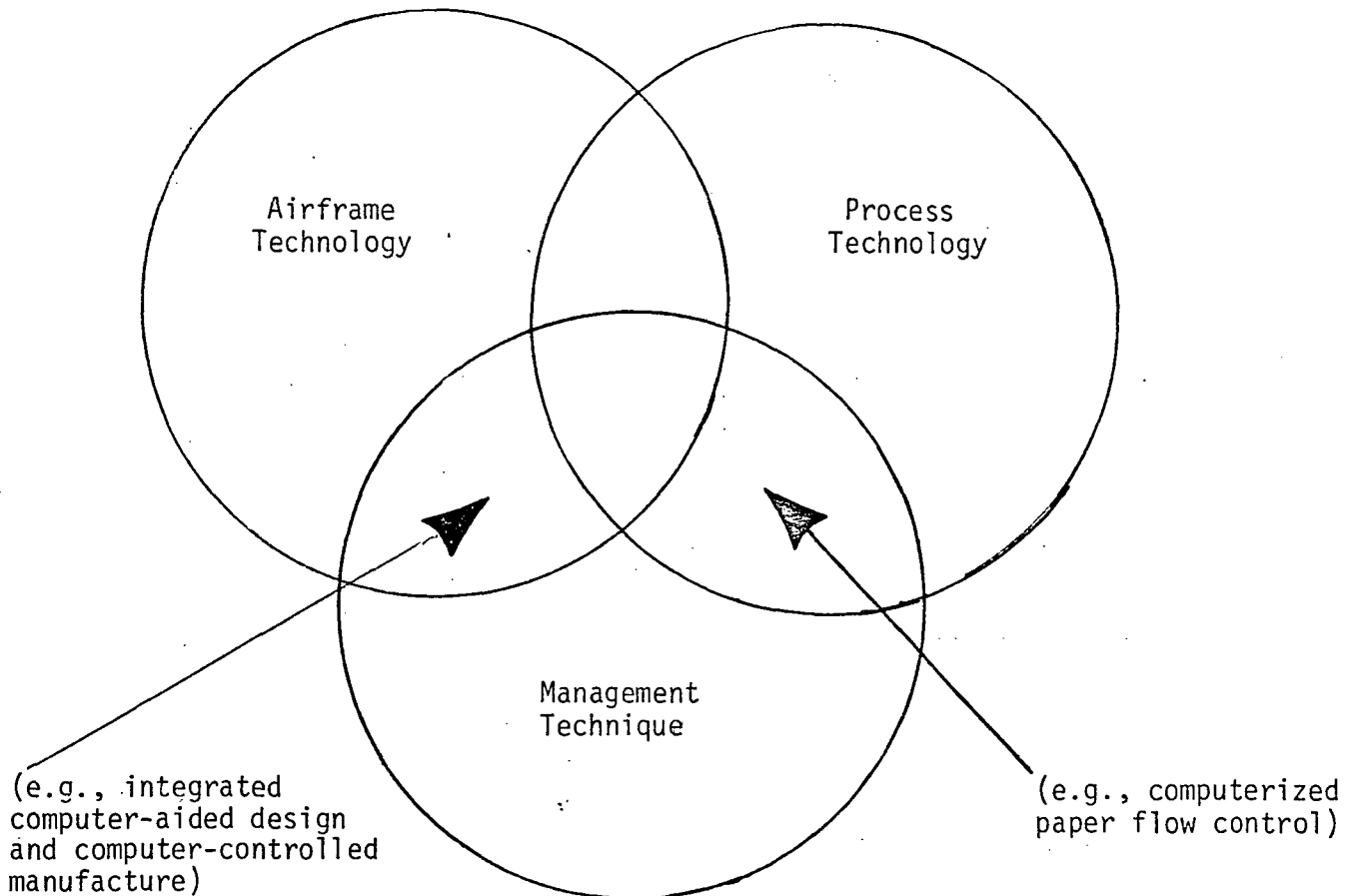
Management technology or technique is the third "class" of technology inevitably associated with airframe design and production. Probably because little hardware is evident, it is often referred to as "soft" technology. Management technique primarily reflects the skills, procedures, and organization an enterprise brings to the tasks of assembling, allocating, and controlling its physical and human capital. While such technology may be characterized as "soft," increasingly it is backed up by computers which are used with greater imagination and skill by some managers than by others.

Not every element of technology can be assigned clearly or solely to one of the three categories. Many represent a blend of at least two of these classes of technology. For example, the use of computers to manage paper flows accompanying the assembly of an airframe represents a combination of process technology and management technique. Computer-aided design coupled with computer-controlled production machine tools exemplifies the linking of all three categories of technology. Exhibit 3-1 illustrates how technology can overlap two or three of the categories.

The remainder of this chapter examines key elements of technology and focuses principally on those responsible for the U.S. comparative

Exhibit 3-1

OVERLAP OF TYPES OF TECHNOLOGIES



advantage in commercial aircraft. Perhaps most important, it identifies those technologies which are critical to the maintenance of this position by the U.S.

Product-Embodied Technology

Technology embodied in the airframes supplied is the most visible of the three types. More significant, it is the fastest moving sort of technology and much of it tends to become obsolete quickly. Indeed, within the period of time it takes to develop or obtain and apply many elements of such technology, it may very well have been surpassed by subsequent technological advances elsewhere. At present, Americans and Europeans generally agree that their respective airframe technologies are essentially equivalent. John E. Steiner, Vice President, Corporate Product Development of the Boeing Company, recently supported this point by stating: "The fact that we have done relatively little for some years has placed us in a position where we, as a nation, have no significant advantage in technology over foreign competitors."¹ Alan Buley² and Henri Ziegler³ concur that Europe is on a par with the U.S. in product-embodied airframe technology. Buley

¹The Boeing Company, Testimony to National Transportation Policy Study Commission (Seattle: The Boeing Company, August 10, 1977), p. 5.

²Alan R. Buley, President, Fokker-VFW International, "The Civil Market: A U.S. European's View," speech presented at Financial Times Conference "World Aerospace 1977" (Paris, May 31, 1977).

³Henri A. Ziegler, former Chairman, Airbus Industrie, "International Cooperation in Aerospace Projects: Cooperation Between European Industries and Between Europe and the United States," AIAA 1975 Aircraft Systems and Technology Meeting, AIAA paper no. 75-1051 (New York: American Institute of Aeronautics and Astronautics, 1975).

holds that the U.S. is probably more adept at exploiting technological possibilities successfully, but that where basic research is concerned, there is no significant difference. The European-produced A-300B aircraft, generally acknowledged to be equivalent to the most advanced subsonic commercial aircraft available today, supports his contention. When the requisite design and engineering resources are marshaled to do so, Europeans can produce a high-quality product. This parity with regard to product-embodied technology partially explains the general U.S. view that the sharing of product-embodied technology would not often be injurious to the competitive position of the transferor.

Process Technology

It is clear that process technology is highly prized by all engaged in the construction of commercial airframes. Most Europeans interviewed conceded, often enviously, that U.S. firms have superior process technology (and higher productivity⁴). Usually, they attributed this advantage to the fact that American managements assume substantial risk and gear up their production processes for large-scale programs. Perhaps growing out of their experience with transport aircraft programs, buttressed by a stress on labor-intensive approaches to production, Europeans appear unwilling to tool for similarly high

⁴J. M. Ramsden, "Britain's International Aerospace Industry," Flight International 112 (October 29, 1977): 1257.

rates and volume of output. As a result, unit costs for transport airframes are usually higher in other countries compared with the U.S.⁵

Although a military program, the case of the Lockheed F-104 aircraft illustrates several points about process as distinct from product. The U.S. Government owned the design and production drawings for this airframe and made them available to several western nations and Japan. However, the drawings alone were not sufficient; Lockheed's production know-how was necessary to make possible relatively efficient and reliable production. Thus, Lockheed came to license the production process rather than the airframe. Through these arrangements significant amounts of process technology were transferred and many licensees learned a great deal about how to organize inputs for a more efficient and larger production program. Certainly the F-104 program is a milestone in the history of many European and Japanese aerospace companies because it improved their ability to "mass produce" aircraft and aircraft components. Among the implications of these co-production arrangements are, first, that

⁵Referring to a military program, however, one privately owned European aerospace manufacturer asserts that it can produce aircraft at least as inexpensively as U.S. firms. It cited a program in which similar aircraft were produced by both a U.S. company and itself. The European company, with a lower rate of production, claimed to have produced them at a lower unit cost than the American firm. They felt its process was better than the American one. Whether there was any way this might have been true was not verified.

process technology is transferable and, second, that such technology can in the long run be far more valuable to the transferee than product-embodied airframe technology.⁶

It seems that the United States has worthwhile commercial airframe process technology advantages. Many of these advantages stem simply from the way in which manufacturing processes are organized. Overall organization of assembly plants is, in the opinion of at least one prominent aircraft manufacturing executive, the principal reason that Europeans have generally been unable to compete effectively. Machines, machine tools, and equipment, in addition to the ways in which they are combined, are valuable proprietary assets. Also, production techniques (e.g., "dry" joining methods and laser metal cutting) and the integration of sophisticated cost control systems (e.g., "management information systems") have aided in achieving and holding the advantages. Not surprisingly, U.S. airframe producers seem reluctant to part with such advantages unless adequately compensated. It is possible that no price would be high enough to cause a U.S. firm to transfer its best process technology or production management techniques where commercial aircraft are concerned. This may or may not be sufficient reason to doubt that a full and true "partnership" (i.e., consortium) between a major U.S. commercial aircraft producer and one or more foreign concerns will become a reality, at least in the foreseeable future.

⁶The F-104 example relates to a co-production rather than a consortium arrangement. This illustrates that a consortium is not a sine qua non of technology transfer; other arrangements--such as co-production--can serve as transfer mechanisms. Nonetheless, the consortium is thought to be the more "powerful" conduit for effecting such transfers, if only because the transferor has an equity interest in the transferee unlike the usual co-production situation, especially where military programs are concerned.

Management Technology

In the opinion of many U.S. aerospace executives, management "technology" or technique, above all others, is the main reason for the long-standing and largely unchallenged predominance by U.S. firms of the free-world commercial aircraft market. Furthermore, such executives point out that competitive enterprises outside the U.S. do not reflect this view of the situation. Certainly, this is borne out by the interviews GRA conducted in Europe, where the motive for consortium participation with a U.S. firm which was most closely related to management technology was expressed as the acquisition of the U.S. firm's marketing skills.

Undoubtedly, U.S. managerial resources in the aircraft field are generally superior to those found in other nations where aircraft are built. It is very difficult to pinpoint the reasons this should be so. In part, such superiority may derive from the long view generally taken in the U.S. with respect to project and investment decisions and from a keen sense of corporate responsibility. Concerning the latter, U.S. aircraft producers are keenly aware that they are in business to earn money for their stockholders. Thus, they are usually cost conscious and are willing to trim their work forces if sales decline. Long-term profit-maximization (in individual corporate terms rather than in national ones) also leads to stress on such aspects as marketing and after-sales product support.

Certainly stress in these areas, and others, has been more or less forced (or made necessary) by several external factors impinging upon

the U.S. aircraft producers. First, the native American market has always dominated the scene; U.S. firms in the aggregate have justifiably and optimistically planned to capture the great bulk of that market. At the same time, the U.S. market is characterized by substantial competition on both sides. That is, in their home market the airlines are highly competitive and there are no corporate ties whatsoever between air carriers and aircraft suppliers, in contrast to the situation in many other parts of the world. Also, there is intense competition between the several U.S. aircraft producers themselves; each recognizes the importance of long-term happy customer relationships to their own financial viability. It follows that the U.S. firms have earned a worldwide reputation for reliably delivering aircraft meeting performance guarantees as a result of their respective managerial techniques and philosophies which have contributed mightily to their individual and collective success.⁷

In the actual design and production of aircraft, U.S. management "technology" superiority is manifest from the earliest stages of the design process, where computers aid the exploitation of the

⁷The view is often expressed that U.S. commercial airframe producers owe a great deal of their success in civil programs to military support of one kind or another. While such "support" is present in some degree if only because some civil aircraft are adapted to military use, the effectiveness and value to the aircraft producers of military support would seem minimal, especially with regard to the launching costs which loom so large in transport aircraft programs. In fact, the military establishment has contributed little, if anything (even indirectly), to the threshold investment required for any U.S. civil jet passenger transport aircraft of U.S. manufacture that has been offered in the market to the present.

scientific and technical information data base, to actual production where, for example, the routine handling of purchase orders is highly automated and closely monitored. In fact, the management of paper-work has a great impact on the efficiency of the entire manufacturing process; Boeing, among others, feels that it has developed a process which has differentiated it favorably from all its competitors.

Finally, the U.S. advantage in management techniques is augmented materially by the mobility of the American aerospace workforce with respect both to location and firm. While the inevitable cycles in the continuum from conception, to design, to engineering, to production of transport aircraft occur as new projects start up while others continue and still others phase out, the locational flexibility of the labor force has contributed to the efficiency with which the U.S. airframe industry as a whole has been able to respond to new challenges and to innovate.

Relevant Technology

All three categories of technology are of significance to the U.S. position in the world market for commercial aircraft. This is true, even for product-embodied technology, despite the general agreement that at present there are few, if any, substantial differences in this respect between the transport aircraft of various major countries and companies. The reason is that product-embodied technology

is relatively fast moving and, while its transfer between firms and nations, however accomplished, currently poses little competitive threat, it remains important that a nation and its airframe industry not fall behind in generating technological possibilities lest it also fall behind competitive firms and nations and find it difficult, if not impossible, to catch up. For the U.S., this would seem especially important given the anticipated continued growth of both domestic and international markets for transport aircraft, the great balance of payments benefits derived from the U.S. aircraft industry, and the perishability of those benefits in a world where other nations have a demonstrated capability to keep up with the "state-of-the-art" as reflected in product-embodied airframe technology.

Process technology and management technique may be slower to change than product-embodied technology, but they clearly underlie the past and present market dominance of the U.S. commercial aircraft producers. If the Government seeks to influence the degree of worldwide dominance by the U.S. commercial airframe industry, these two categories of technology must be included in the scope of public policy formation and execution, especially where international transfers of such technology are involved.⁸ Happily, the interests of the U.S.

⁸The Task Force on Export of U.S. Technology, chaired by J. Fred Bucy, carefully addressed this same topic and reached a similar conclusion. See Defense Research and Engineering, Office of the Director, Task Force on Export of U.S. Technology, An Analysis of Export Control of U.S. Technology--A DOD Perspective (Washington, February 4, 1976). This report is also known as the "Bucy report."

Government and of the U.S. aerospace companies are consonant.

The latter seem to recognize that their competitiveness stems critically from their enlightened and efficient process and management technologies; they do not appear likely to yield their proprietary experience and knowledge simply to serve the ends of international cooperation. A U.S. airframe manufacturer, if it should consider joining a multi-national consortium, probably would not agree to part with any significant quantum of such valuable technological knowledge and experience.

Still, it behooves the Government to understand the technology transfer implications of all cooperative arrangements between commercial airframe producers. Only by acquiring an appreciation of the relationship between the structure and form of consortia (and other arrangements) and the transfer of technology can government establish sound public policies and monitor the extent to which they are being carried out.

Chapter 4

CONDITIONS CONDUCTIVE TO TECHNOLOGY TRANSFER

Since U.S. supremacy in the commercial aircraft field is largely based on the technological superiority of U.S. manufacturers, it is important to determine the conditions under which technology transfers are most likely to take place in a consortium setting.¹

The "technological endowment" of individual consortium members and the members' ability to absorb technology set limits on the extent to which technology is transferable. But limits may also be established at the outset of a consortium by members placing certain areas of technology outside the range of their contribution. Such limitations may come about because of an internal policy of the withholding consortium participant or as a result of externally imposed constraints. In support of the former is the generally held position of the U.S. commercial airframe producers that they simply will not "teach" others how to manage an aircraft design and manufacturing program because they uniformly feel that to do so would be to jeopardize seriously the competitive position they have so long enjoyed. (Still, it is difficult to predict what a U.S. firm might actually do if caught in a consortium where the difference between success and failure--i.e.,

¹For detailed discussion of the nature of consortia, see the Appendix, "Some Characteristics of Cooperative Ventures."

profit and loss--rested in its transferring management and technology know-how to the consortium.)²

Each U.S. airframe executive interviewed also expressed some doubts about sharing every element of manufacturing process technology with consortium partners, also for competitive reasons. All noted the possibilities of externally imposed constraints on technology transfer as might be imposed by government. The case of CFM International, an aircraft engine consortium between General Electric (G.E.) and SNECMA of France, was cited frequently. In this arrangement, the Department of Defense required that the core

²It should be pointed out once more that there are differences between military programs (e.g., the F-104) and civil ones. First, the former typically are co-production arrangements, not consortia. As such, the U.S. firm does not often have a profit motivation on both sides of the technology (or technique) transfer. Second, the nature of the relationship between transferor and transferee in military programs is usually quite different from that where a civil transport aircraft project is approached through a consortium. In the former situation, the co-production arrangement usually restricts the transferee's rights to sell aircraft to a finite and limited geographical market. In such situations, the aggregated customers for the output--one or more allied governments--also explicitly agree to limit (or totally throttle) competition with the specific military product being co-produced. Third, given the nature and purpose of military programs as contrasted with civil, it is reasonable that a conventionally-calculated profit yardstick is more difficult to devise and apply to the former. Put another way, governments purchasing military hardware often help "front-end" the project and accept the principle that unit prices must be such as to provide the producer(s) with a reasonable rate of return on their investment in the program. Rarely, if ever, is such an arrangement made by governments where civil programs are concerned.

Finally, it seems quite logical to assume that given the preceding characteristics of military co-production projects, transferors of technique or technology will not be very forthcoming with proprietary information (such as related to managerial techniques), especially if they anticipate such transfer will haunt them subsequently in competitive markets such as those for civil transport aircraft. Moreover, given the nature of military programs, it is less likely that the "success" or "failure" of a co-production program will turn upon the transfer of technology beyond that just sufficient to build and operate the aircraft.

of the CFM-56 engine be provided to the consortium intact by G.E. so as to minimize transfer of the technology which it embodies. This example pertains to both design and product-embodied technologies and establishes a modern U.S. precedent for external controls on technology transfer through multi-national consortia in aviation. (It remains to be seen if SNECMA will, in fact, acquire the technology anyway, given the nature of the project and, if so, whether it matters, given the fast-moving character of such technology. In any case, the outcome will be instructive and bears watching.)

On the receiving end, if technology in any category is to be transferred effectively through consortium participation (or otherwise), a precondition is recognition that such technology is of value to the receiver. But the interviews, as reflected in Exhibit 2-7, indicated that where most of the large European aircraft manufacturers are concerned, there is little appreciation of the actual role that technology has played in placing U.S. producers in a premier position in the market, particularly with respect to process technology and managerial technique.

It would be prudent, however, to assume that potential foreign commercial airframe consortium members will increasingly recognize the value and importance of process and management technology. It is possible that these more subtle transfers of technology might be achieved in favor of foreign airframe producers through the use of consultants or by hiring away personnel from U.S. firms, but the requisite knowledge and experience has a substantial critical mass and it would take not a few

people to represent the minimum required. It does not seem likely, therefore, that this would be a very promising policy for non-U.S. aircraft companies to pursue. So it is probable that such technology will be transferred from the U.S., if at all, through a multi-national consortium or similar cooperative arrangement where the U.S. Government can probably effect some measure of control on such transfer, or at least on the conditions precedent to the establishment of the arrangement. How effective such controls or conditions would be is not at all clear.

History records that the Government has intervened in such matters before. Several years ago, negotiations were terminated between a U.S. airframe manufacturer and a nationalized enterprise behind the Iron Curtain when the former was constrained by the U.S. Government in what it could contribute to the project. Specifically, the U.S. firm seemed prepared to provide airframe design drawings along with some special tooling for production of the aircraft. However, it was not willing to contribute specialized manufacturing equipment. Even if it had been willing to do so, the Government served notice it would not permit it to establish a complete co-production facility. In other words, the U.S. firm's contribution was to be limited by the Government to airframe technology and a limited component of process technology.

Still another facet of this abortive project is interesting: A U.S. supplier of wheels, brakes, and tires was willing to sell these products to the foreign enterprise but absolutely refused to license production. The position was based on the U.S. firm's perception that its primary competitive advantage was its ability to produce high-quality products at a relatively low cost, employing manufacturing techniques that had changed but little over the years. It was feared that transfer of the process technology (rather than sale of the products) would threaten, or even destroy, its competitive position in world markets, especially if it came under the control of a foreign entity with political objectives that might outweigh economic ones (causing predatory pricing policies which could not be stopped).

In any case, it appears that the technology transfer process in a consortium arrangement is most profoundly influenced by three factors:

- Division of responsibilities among consortium participants,
- Duration of the joint enterprise,
- Organizational structure.

Division of Responsibilities

Responsibilities within a consortium effort can be allocated in any pattern as can be observed by contrasting the Concorde and A-300 projects. In the former, the responsibilities and risks were divided as equally as possible between the two parties, British Aircraft Corp. and Aerospatiale. An early basic and unusual decision to have full co-production of the Concorde facilitated the equal distribution of investment and responsibilities. In the case of Airbus Industrie and its A-300 aircraft, neither risk nor

responsibilities are equally distributed (except to the extent that Aerospatiale and Deutsche Airbus are "equals" which is misleading since the latter actually is made up of several individual German aerospace firms). With the A-300 project, risk-bearing and value-added contribution are highly correlated and range from 4.2 percent for CASA (Spain) to 47.9 percent each for Aerospatiale and Deutsche Airbus.

In Concorde, technology transfer is said to have been complete as far as the "partners" were concerned. There were no artificial barriers erected to impede information flows. The contrast with the A-300 project seems quite sharp. In part, this reflects the disparity of participation; perhaps more, however, it is because the division of responsibilities between the parties is far more clear-cut and defined as must be the case where the "partners" are not equal and where co-production is not a characteristic of the consortium. In the A-300 consortium, the "need-to-know" of other consortium members is often very restricted, being generally limited to the interface technology required for the assembly of the final aircraft product. Although the divisions of responsibilities among the A-300 consortium members have not been made specifically for the purpose of preventing technology transfer, it appears that in the Airbus type of consortium the transfer of technology (and technique) between the parties is likely to be minimal, especially in the first years of the consortium enterprise.

As reflected in the interviews, the degree of closeness and parity in a cooperative effort related to commercial airframe production is the most important determinant of technology transfer and absorption. As long as responsibilities are allocated discretely between the partners, the transfer of technological knowledge and insights passing between them is minimized.

Duration of the Enterprise

The expected life of a consortium is of some importance with respect to the transfer of technology. Short-lived ventures are less likely to be the agencies of significant technology transfer than consortia founded on the expectation of long-term existence and viability. Clearly the time over which people interact plays a significant role in the amount and "quality" of technology transfer that takes place.

It is worth noting, however, that a consortium without a finite life--perhaps a consortium without a mandate dependent on a specific mission--may come to act independently of its constituent "partners" and thus may ultimately lead to the erection of barriers to technology transfer between the consortium and those "partners." Therefore, with respect to duration, technology transfer and diffusion are probably maximized in consortia where only a specific long-term mission is being pursued with substantial intellectual interactions all along the way between personnel drawn from the "partners." (Transfer is probably

further facilitated if these personnel are rotated frequently between the consortium and parent.)

Organizational Structure

Each cooperative venture must have a structure which defines ownership, management, and decisionmaking authority. The structure will influence the transfer of technological possibilities and know-how. In part, this is because technology transfer is significantly a function of the nature and extent of the interactions between people. Therefore, to the degree the organizational structure of the enterprise influences such personnel interactions, it will also influence the amount, character, and efficiency with which technology is transferred both within the corporate enterprise and between it and the firms which established it.

Management structure in a commercial aircraft consortium can be quite complex--e.g., the Airbus Industrie consortia. As the size and complexity of a consortium's management increase, so do the amounts of personal interaction. Especially where executives are drawn from various consortium partners, the likelihood of the transfer of technology is increased.³ Such transfer is accelerated if there is a programmed rotation of such personnel at relatively frequent intervals.

³The Bucy report, in effect, confirms this finding by declaring that "The more active the relationship [of cooperating partners], the more effective the transfer mechanism." Defense Research and Engineering, p. 4.

Moreover, if a consortium is established pursuant to a major innovative long-term project such as Airbus Industrie, in time it may well assume an identity of its own and become the principal technology transferee rather than a conduit for the passage of technological intelligence between consortium partners.

For other reasons, a cooperative arrangement organized on the basis of contractual obligations (e.g., Fokker F-28), rather than as a separate corporate entity (e.g., Airbus Industrie), may be less likely to catalyze the transfer of technology other than of the product-embodied (e.g., airframe) variety--the least "dangerous" form of technology. That is, in the former case, the only technology transferred is that conveyed through the contractual arrangement (such as a sub-contract to produce wings) as contrasted with the latter where there is day-to-day interaction between personnel with a wide variety of skills and backgrounds drawn from an assortment of consortium members.

In another variant, a consortium might be organized in such a way that each "partner" contributes capital but only a limited number of such "partners"--perhaps only one--dominates the decisionmaking process. In such consortia, control of the enterprise may well rest with the consortium participant responsible for conceptualizing and assembling the final aircraft product. This is especially true where such a "partner" has made a disproportionately large capital and risk commitment to the effort. In any case, technology is likely to be passed

between consortium "partners" only to the extent that they must interact in the production of the final product. It follows that cooperative arrangements are most likely to result in technology transfers between the "partners" where there is approximate parity of commitment, resources, and general management responsibility where the consortium is concerned.

In sum, the structure of the organization of a cooperative venture in the aircraft field can very well influence the quantity and character of the technology which is transferred, as well as timing. Nevertheless, further research is required to determine with greater precision just how important a role in technology transfer is played by the organizational structure of cooperative endeavors.

Implications

What sort of consortium, then, is most likely to generate minimal technology transfer? The key variable would likely be the extent of the division of defined responsibilities between each participant. Each would have to perform a specialized task (or tasks) requiring minimum amounts of technological communication with the other participants. This factor was illustrated in one interview in which the A-300 program was discussed; it was said that the only thing Aerospatiale knows about the wing technology is the first few centimeters--the knowledge required to effect the wing-fuselage junction in assembly. Apparently none of the consortium participants knows the intimate details of the wing's technology or, more important, the process and management technologies used to manufacture it.

The management structure of the minimum-transfer consortium would be decentralized with respect to development and production, but not necessarily marketing. It would help thwart transfers if the consortium had a short time horizon and the relationships between the parties were determined more through bilateral contracts than through a formal, quasi-independent organization. It is highly probable, however, that many prospective consortium members--especially those seeking approximately equal sharing by all parties--would balk at such an organization, not necessarily on grounds of lessened technology transfer probabilities but because the arrangement is not consistent with large financial commitments being made in the context of a technologically complex product.

A consortium enterprise maximizing technology transfer would be one in which the division of responsibilities was broad and somewhat overlapping. For example, consortium-member team efforts would characterize the program. A jointly designed and operated production facility would enhance technology transfer. General management structure would be centralized and participant executives would move between the consortium and the partners' organizations with moderate frequency. The anticipated duration would be considerable, such as the life cycle of one aircraft-type program which implies a decade or more.

Consortia can be established in such a way as either to maximize or minimize the transfer of process technology and management technique as well as product-embodied technology. But no consortium to date appears to have been formed in such a way as to catalyze significantly

technology transfer of any kind. Before determining the propriety of a particular consortium from a public policy standpoint, it is important to ascertain not only whether or not it appears likely to result in the transfer of technology but also whether or not such transfer would be inimical to the national interest. Such an evaluation should take into account the three conditions which must be met if the transfer of technology is to be harmful:

- Actual foreign adoption of uniquely U.S. product-embodied technology, process, or management techniques,
- Translation of the transferred technology into a significantly improved competitive position for a non-U.S. firm,
- A determination that the net effect of such increased foreign competition is detrimental for the U.S. interest in some sense.

The third condition is the most critical. Determination of the net effect of increased foreign competition in the commercial airframe field is complex. The next chapter examines many of the critical tradeoffs involved in such a determination.

Chapter 5

PUBLIC POLICY IMPLICATIONS

The creation or expansion of the scope of consortia for the production of commercial airframes is one of the more likely means of achieving rationalization¹ in the aircraft industry. This holds for the U.S. and elsewhere. In Europe, the trend towards consortia appears well established with the Concorde project and, more recently, the A-300 (Airbus Industrie), both of which are multi-national ventures.

The present chapter is concerned with the public policy issues and implications of the multi-national commercial airframe consortium. In order to consider these implications in some detail, however, it is necessary to look at consortia more generally. Therefore, as necessary, this chapter will consider (a) multi-national airframe consortia with U.S. participation, (b) multi-national consortia without U.S. participation, and (c) all-U.S. consortia. The U.S. public policy issues which will be addressed in some measure include:

- ° Technology Transfer,
- ° Employment,
- ° Balance-of-Payments,
- ° Military Capability,

¹"Rationalization" is defined as "the organization of a business or industry upon an orderly system, to avoid waste, to simplify procedure, to co-ordinate various parts, etc."; Webster's New International Dictionary, 2nd ed. (unabridged), 1961.

- Foreign Relations,
- Market Access for U.S. Firms,
- Access to U.S. Markets by Non-U.S. Firms,
- Competition in Transport Aircraft Markets.

Government Interest

The government has a vital interest in the commercial airframe industry for several reasons. First, the industry has for some time been the second largest contributor to the credit side of the U.S. balance-of-trade account.² Second, the industry's work force and capital investments are valuable national defense assets. Third, airframe industry performance and behavior is ultimately reflected in the character and efficiency of the air transport network of the U.S. and of much of the rest of the world.

In part, the government's interest is manifest by its involvement in the industry through:

- Sponsorship and financing of research, development, and testing of new techniques and technologies;
- Application of antitrust policies and laws;
- Military use of same or similar airframe for routine and/or emergency lift.
- Participation in special financing arrangements;
- Civil Aeronautics Board regulation and promotion of airlines;
- Federal Aviation Administration certification of aircraft airworthiness, promotion of safety, and maintenance of the airport-airways system;

²Steiner, "The Eighteen Months that Matter," p. 24.

◦ Controls over exports of certain aerospace technologies.

Certainly, then, government is concerned with the financial condition and long-term viability of the airframe producers. Since the cost structure of the industry continues to change in fundamental ways (as discussed in the initial part of Chapter 2 above), and because this gives rise to the need for industry rationalization which, in time, carries with it myriad implications for public policy, the concept of economic rationalization is appropriately considered at this point.

Rationalization of the Commercial Airframe Industry

The Concept

Any change in the structure of an industry can reflect the process of rationalization, though this need not be the case. Structural changes usually are manifest through changes in any or all of the following:

- Number of firms in an industry,
- Relationships between such firms,
- Sizes of firms,
- Rates of change in firm size,
- Character of firms (e.g., extent and rate of integration, both horizontal and vertical).

Rationalization typically occurs in response to changing basic conditions of supply (such as cost structure) or demand (such as being shut out of a significant part of the market by non-economic forces--e.g., politics). Some rationalization is often required, at least over the

economic long run. Even though rationalization generally promotes a more stable and profitable configuration for an industry,³ this in and of itself should not be grounds for suspecting that it also runs counter to the public interest. In part, the antitrust laws were developed to deal with those changes in the structure of an industry which appear to undermine the public interest.

Most often, the need for industrial rationalization can be traced to a changing structure of costs, usually related to technological change in an industry, sometimes itself accelerated by changing relative prices of labor and capital. This situation seems to obtain in the commercial airframe industry, both in the U.S. and elsewhere. With regard to costs in this industry, it is clear that threshold and fixed costs continue to rise. (See Exhibits 2-1, 2-2, and 2-4.) This change in the industry's cost structure is one cause of the dwindling number of airframe manufacturers worldwide; with such changes in the production function, the size of the market has simply not been large enough to support the number of aircraft suppliers of earlier years. Thus, firms such as General Dynamics dropped out of the market as prime contractors and others have merged or have been nationalized, or both. The trend towards capital intensity in aircraft manufacturing appears to be continuing today.

³Profits are not guaranteed, however, as inefficiency, poor managerial decisions, assumption of excessive risks, or general economic conditions can cause a producer to suffer a loss.

Mechanisms of Rationalization

In the commercial transport airframe industry, rationalization requires a move towards an industry structure in which each manufacturer produces aircraft with unique payload/range capabilities and operating cost characteristics.⁴ Each aircraft type would have a defined place in the spectrum of transport aircraft offered, although, at the margins, it would compete with other aircraft, each of which would display different payload/range capabilities and costs. Such a market structure would remain oligopolistic as at present; also, it would promote efficient production and reasonable pricing to the extent that effective competition were present.

Rationalization of this industry can be accomplished through one or a combination of the following mechanisms:

- Consortia;
- Withdrawal from the commercial transport market (e.g., Glenn L. Martin, Convair, and Canadair);
- Bankruptcy;
- Horizontal merger (e.g., consolidation of McDonnell and Douglas, and of all independent British firms into British Aerospace);
- Vertical merger (such as would be exemplified by a consolidation of, say, Northrop and Boeing, or Douglas and Rohr);
- Conglomerate merger (as would be illustrated by an amalgamation of, say, Fokker-VFW and Bayer, or of Lockheed and Textron);

⁴See Chapter 2 above, pages 9 through 35.

- Prime-subcontractor relationship (as manifest in the Fokker F-28 and Douglas DC-10 programs, among others, where sometime primes serve as subcontractors to other airframe manufacturers);
- Licensing (e.g., British Aerospace's licensing of the Rumanian state aircraft manufacturer for the co-production of the BAC 111-475);⁵
- Public ownership (e.g., Aerospatiale and British Aerospace, owned by the French and British governments, respectively);
- Government subsidization of existing enterprises, direct or indirect;
- Other public-sector assistance to existing enterprises (e.g., the Emergency Loan Guarantee to Lockheed).

While this discussion is largely concerned with consortia, much of what will be discussed with respect to the public policy implications will apply (in varying degrees) to other means of rationalizing the airframe industry.

Clearly, the government's great interest in the commercial airframe industry requires that it play some role in any substantial rationalization. The extent of government involvement will depend, first, on how the government perceives the effects of rationalization on the public interest. Next, from the array of possible governmental actions or programs, some will be chosen and some eschewed, depending on what is needed to protect or to advance the public interest in the specific situation. The mechanisms may be industry-specific (such as some of those appearing in the list just above), or they may be more

⁵"Britain's International Aerospace Industry: Commercial," Flight International 112 (October 29, 1977): 1266.

general but nonetheless applicable to certain sorts of airframe rationalization situations. Tax policy, tax rulings and antitrust posture are examples of the latter sort of mechanism available to government.

"Pre-eminence," "Predominance," and U.S. Public Policy

The 1976 report of the Subcommittee on Aviation and Transportation R&D of the Committee on Science and Technology of the U.S. House of Representatives (the "Milford Subcommittee") entitled The Future of Aviation recommended that:

National policy must clearly declare that maintenance of the United States' pre-eminence in aeronautics is absolutely vital to the national interest.⁶

The report also calls upon U.S. public policy to be such as to ensure maintenance of "our worldwide commercial leadership" in air transportation. Thus, it can be concluded that the Subcommittee is urging upon the Congress (and upon the public) the policies and steps necessary to guarantee U.S. pre-eminence in the field of aviation to support its predominance in the market for commercial transport aircraft.

Neither the report nor the hearings on which it was based ascribe any precise meaning to "pre-eminence." According to the dictionary, "pre-eminence" refers to "excellence...distinction above others in quality." "Predominance" is meant to convey superiority in "strength... position " and "exceeding in number." In the present context, then,

⁶U.S. Congress, House, Subcommittee on Aviation and Transportation R&D, The Future of Aviation, 94th Cong., 2nd sess., 1976, Vol. I, p. 1.

"preeminence" is characterized by superiority in knowledge and intellectual capital; "predominance" is more concerned with the marketplace, specifically as in the production and sale of a substantial majority of the world's transport aircraft. The Milford Subcommittee Report plainly wishes to assure that the United States remains both preeminent and predominant where commercial transport aircraft are concerned.⁷

In high technology fields, preeminence often supports predominance, though this need not be the case. The British, for example, consider themselves preeminent in the large aircraft turbine engine field;⁸ they clearly are not predominant in this area. In any event, it is reasonable to suggest that a public policy "requiring" that the United States maintain its preeminence in the field of aviation may not be enough to ensure long-term U.S. predominance in the market. The reverse is also true, at least in the short run.

In aviation it is probable that continued technological leadership (in process technology and management technique as well as in product-embodied technology)--i.e., preeminence--is a necessary condition for long-term predominance in the free world aviation market. It follows, then, that continued U.S. preeminence in aviation generally, and in the transport aircraft field in particular, reflects sound public policy.

⁷While the Subcommittee report does not mention predominance per se, pages 1 through 8 of Vol. 1, for example, clearly point to the desirability of maintaining a leadership position in the market place. On page 6, for example, the Subcommittee says: "In the past, the American aircraft industry has maintained world 'preeminence' because of superior technology, better manufacturing processes, extensive marketing and servicing organizations and extremely reliable equipment, all of which have combined to produce superior aircraft at lower prices. Retention of these factors is necessary to insure U.S. dominance." (emphasis added) Ibid., p. 6.

⁸This report makes no judgment as to the accuracy of this perception.

This issue is not quite as simple where market predominance is concerned. The U.S. is not nearly as much the master of its fate in the marketplace as it is in the maintenance and expansion of its stock of intellectual capital in aviation science and technology. The U.S. is facing increasing competition for its present market share--approximately 85 percent⁹--in the commercial transport field. Consequently, rationalization of the airframe industry is not merely a domestic issue but is one which encompasses at least the entire free world as far as the U.S. policymakers are concerned. Powerful forces are threatening the current level of U.S. market predominance. The U.S. Government clearly does not possess the power to establish directly and unilaterally the free world market share of U.S. firms, but it does have the ability to help maintain an environment in which U.S. firms have the best chance to perform in a manner consistent with the public interest.

To what extent, then, should the U.S., as a matter of public policy, seek continued predominance in the world market for transport aircraft as measured by some finite substantial percentage established by an appropriate public process? Establishing a clear position on this issue is important because such a policy will influence, if not determine, policy in other areas such as rationalization, antitrust, technology transfer, employment, and balance-of payments. There are implications in this issue for the consortium concept as well. For example, because of the changing function of the commercial airframe industry, consortia may well be a promising and important means of achieving rationalization in support of continued U.S. market predominance. On the other hand, if the share

⁹U.S. Congress, The Future of Aviation, Vol., p. 9.

of the market to be enjoyed by U.S. commercial airframe producers as a whole is to be something less than it has been in the past, this would heighten the need for U.S.-industry rationalization and may require earlier consideration of the consortium alternative than would otherwise be the case.

The link between preeminence in the field of aviation and consortia is substantially less direct and critical than is the link between market predominance and consortia under a scenario as now seems to be unfolding in the free world. Preeminence can generally be assured with relatively modest investments of public resources if there are no other means. But preeminence, in any case, is recognized by the Milford Subcommittee as a desirable attribute for the United States to maintain, even if the United States' commercial airframe industry is characterized by fewer suppliers than at present, by consortia, or by any other post-rationalization configuration. Predominance, on the other hand, may not be so easily maintained (even, at, say, the 70 or 75 percent level) if necessary industry rationalization is thwarted because such rationalization is not seen to be required to support U.S. market participation on the higher level. It follows, then, that if preeminence and predominance are to be explicit goals of U.S. public policy, as the Milford Subcommittee urges, it will be necessary for all those involved in public policy formulation and execution to maintain currency with both supply-side and demand-side conditions in the commercial airframe field throughout the world.

Moreover, such policies and policy administration must reflect the realities of the future rather than conditions of the past.

None of the foregoing, however, is meant to suggest that it is clear that the future best interests of the United States are served by policies, programs, and practices which lead to continuation or expansion of the current U.S. share of the market for commercial transport aircraft. There are arguments that suggest that the U.S. would be prudent to accept a lower share in this market. It is not possible to resolve such issues in the present analysis; it is possible only to point out that those responsible for enunciating and administering U.S. policy should be aware that "predominance" of the market at a lower level than the present approximate 85 percent might prove to be in the best long-run interests of the United States, even though such a reduction in U.S. market participation might lead to the formation of consortia, both in the U.S. and abroad, as part of an overall rationalization process.

No matter how the market predominance issue is resolved, one of the central factors which will profoundly influence the structure of the U.S. airframe industry is antitrust policy and practice in the United States.

Antitrust Barriers to Consortia

Among the most significant barriers to the formation of consortia as a means of rationalizing and strengthening the U.S. airframe industry are those related to antitrust policy. The type of joint ventures considered in this study have few precedents; therefore, it

is difficult to predict the degree to which they would comply with antitrust policy and law as they have developed. There are two major criteria, however, by which the anticompetitive effects of joint ventures in general are judged.

First is the concept of "potential competitors." If it can be shown that, in the absence of a joint venture, the participants would have competed with one another independently, then the joint venture or consortium is considered to be anticompetitive and probably illegal under antitrust law.

A second criterion applied to joint ventures concerns the notion of a de facto merger. Although the agreement which forms the basis for the consortium may limit both its term and its activities, the limited cooperation inherent in the consortium can provide an ideal starting point for cooperation (or collusive behavior) in other areas. The consortium, as laid out by the specific terms of the agreement which governs it, may not be illegal in itself. However, if it provides the opportunity for illegal cooperation, it may not be acceptable. In its extreme form, cooperation between consortium partners may lead to what is, in fact, a merger. That such a merger is a de facto result of a consortium would not exempt it from antitrust law.

A firm contemplating a potentially unacceptable course may seek to take advantage of the Business Review Procedure of the Department of Justice. Under this procedure "the Department may issue a statement of enforcement intention with respect to a specific pending transaction."¹⁰

¹⁰United States Department of Justice, Antitrust Division, Anti-trust Guide for International Operations, revised (Washington, D.C.: GPO, March 1, 1977), p. 1.

Participation by a firm in this procedure requires that it make full disclosure about the contemplated activity. A positive opinion by the Justice Department, however, does not grant a permanent exemption from prosecution. "Even under this procedure the Department always reserves the right to institute civil proceedings if it subsequently wishes to test the legality of the practices concerned."¹¹ In addition, a statement that it does not intend to prosecute may be withdrawn if it develops that there has been less than full disclosure or if deception has been practiced by the firm in its request for the Department's opinion.¹²

Thus, with regard to the formation of airframe consortia, anti-trust considerations could have a restraining effect at three stages. First, legal counsel to the prospective participants in a consortium could find that such involvement would be illegal through an analysis of decisions in similar cases, by examining such Justice Department publications as the Antitrust Guide for International Operations, or by having informal conversations with Justice Department personnel. Second, such firms might receive a negative opinion under the Business Review Procedure. Finally, if they proceeded with the consortium, the Justice Department could investigate and, perhaps, litigate.

Under current policy and procedure, the Justice Department's attitude towards specific consortia to produce commercial airframes will not be known until either: (a) potential participants file under the

¹¹ A.D. Neale, The Antitrust Laws of the U.S.A.: A Study of Competition Enforced by Law, 2nd ed. (Cambridge, England: Cambridge University Press, 1970), p. 382.

¹² Ibid., pp. 382-383.

Business Review Procedure (in which case the answer, if positive, would not necessarily be final), or (b) action is brought against such a consortium. In either case, months--even years--of delay are involved, which in itself could be a powerful discouraging factor when and if cooperative arrangements in the nature of consortia are a response to production or market conditions. It is not entirely clear that either a high degree of such uncertainty or such great delays are necessary to the administration of the antitrust laws--especially if arrangements such as consortia in this field are in the public interest, as seems increasingly likely given the changing cost structure of air-frame production. The industry problems would be eased greatly if the Justice Department were to find the means for making known its general views of such matters so they can be challenged or relied upon, as appropriate, even in advance of an actual proposed venture. At the very least, considerable relief might be afforded if Justice were to consider strengthening the language incorporated in the "product" of the Business Review Procedure, perhaps with the "no-action letter" of the Internal Revenue Service serving as a model.

Although it has yet to be tested in the court, the Department of Justice holds that its jurisdiction is not diminished when a multinational consortium involving U.S. enterprise is the issue rather than an all-U.S. arrangement of similar character. This was emphasized by the then-Assistant Attorney General for Antitrust, Thomas E. Kauper, in testimony before the House Subcommittee on Aviation and Transportation Research and Development, when he said that, "in terms of the

antitrust laws, the fact that a participant in a joint venture happens to be a foreign firm usually has no inherent significance."¹³ The important consideration for the Justice Department is the effect of a consortium on competition in domestic markets; the inclusion of a foreign participant implies no special consideration, either positive or negative, according to the Department of Justice.

The competitive impact of any proposed cooperative arrangement will be gauged by the Department of Justice primarily by its treatment of the technology transfer issue and by the extent to which market competition in the U.S. between commercial airframe producers is foreclosed.

Transfer of Technology--Technology transfer is directly affected by antitrust law primarily through patents and licensing agreements. Any or all three categories of technology considered in this report (design, process, and management technique) might be the subjects of such agreements. Nevertheless, a provision pertaining to the transfer of managerial techniques would likely prove difficult to move against in an antitrust context because the law has generally not viewed such ephemeral factors as impermissible instrumentalities of monopolization. (Indeed, superiority of management is often a successful defense against antitrust charges.)

Arrangements which transfer technology in a consortium setting are ancillary to its main purpose. Most antitrust cases dealing with patents or licensing refer to situations in which the patent or license is central to the questioned activity. However, general principles applicable in these instances may also be relevant to consortia.

¹³ U.S. Congress, The Future of Aviation, p. 540.

In essence, a patent is a grant of a monopoly, one which is defined by a specific technology or method of production. A license to use patented information also carries with it a degree of monopoly power typically assigned within a geographic region. The trade-off in public policy which antitrust law addresses in the area of patents is between encouraging innovation (by allowing innovators to derive economic benefits from their activities), and making sure that there is sufficient access to technological information to promote competition.

The specific manner in which each consortium handles the transfer of technology from one partner to another will vary. (Some alternatives are discussed in the attached Appendix.) In general, the reasoning the Justice Department can be expected to employ with regard to this issue is indicated by one of Mr. Kauper's statements before the Subcommittee in the "Future of Aviation" hearings. He pointed out that "as joint activities move away from the voluntary, open exchange of information toward agreements which directly affect the rights, properties, or competitive actions of competitors, anti-trust problems are more likely to arise."¹⁴ This does not provide much to base plans on, however, given the very general nature of the observation.

Market Competition--Of greatest interest to the antitrust authorities would be the influence of consortia (or other cooperative arrangements) on market competition.

¹⁴ Ibid., p. 538.

Whether or not the anti-competitive effects of the formation of an airframe consortium would be unacceptable depends upon the definition of the "relevant market." Such a definition involves two interdependent issues: delineation of the product through which the "relevant market" is defined and determination as to what firms could reasonably be expected to compete in such a market absent the arrangement in question. With respect to the latter issue, the Justice Department would make a judgment as to what firms have both sufficient resources and the desire to develop and produce a new airframe for the "relevant market."

As for the issue of product definition, as noted in Chapter 2, important considerations include range and capacity (payload) relationships. If a consortium were formed to produce an airframe with certain payload-range characteristics, a determination would be made as to what degree other existing or planned airframes could be viewed as substitutes by airlines. A total market dominance would be said to exist if a single enterprise were to produce a jet aircraft with a payload/range combination sufficiently differentiated that no other could be considered a substitute. Such total market dominance ("100 percent concentration at the one-firm level") is not a likely occurrence but a very high degree of concentration is likely. In fact, however, a high degree of concentration (but not 100 percent) does not preclude there being effective competition in the marketplace; one example, among many others is the U.S. automobile industry.

The importance of market definition cannot be over estimated where the public policy (i.e., anti-competitive) effects of consortia

are to be gauged. For example, in an entirely hypothetical example, assume that the L-1011 and DC-10 in at least some versions are defined as serving the same "relevant market," as seems reasonable given their payload-range characteristics, and their capital and operating costs. Further assume that these two firms form a consortium to develop a single new aircraft which is both larger and longer ranging than either the L-1011 or the DC-10. In such an instance, concern would surely be expressed as to whether this consortium's very existence would reduce competition between the two firms in the DC-10/L-1011 context. Is the new consortium aircraft in the same "relevant market" as the present tri-jets and, if so, will the consortium arrangement tend to suppress competition between the partners (as couched in terms of the DC-10 and L-1011) or to enhance competition by affording customers another choice in the market?

Linked to market definition in any attempt to ascertain a consortium's influence on market competition is a determination of the events that would occur were the consortium not to be formed. Using the same example as before, the issue would turn on what expectations the government had as to the independent actions of Douglas and Lockheed without the joint venture. Would they each have proceeded with a similar new aircraft? Would one of them have done so? If the answer to either question were "yes," the Justice Department might look with disfavor on the consortium. But if the answer to both were "no," the consortium might be welcomed not only as providing additional choices in the market, but also as providing a new competitive foil

for aircraft produced by others (such as Boeing and its B-747SP, or the product of a foreign firm). Exhibit 5-1 spells out the most likely alternative "scenarios" through which either a multi-national consortium with U.S. participation or an all-U.S. airframe consortium might come into being. The exhibit also summarizes the anticipated possible competitive effects accompanying each case. It is extremely important to note the extent to which the competitive effects are uncertain and hinge upon judgment about future events taking place or not. Even if time and other resources are devoted to reducing the uncertainties, the competitive effects remain largely indeterminate ex ante where airframe consortia are concerned, especially in the long-run where it counts most. What seems clear is that given the nature of the commercial airframe production process at present and in the foreseeable future, consortia--multi-national or otherwise--have at least as great a likelihood of enhancing competition as thwarting it.

Implications of Antitrust Policies--Given the economic character of the commercial airframe industry, it is entirely possible that at some point in the future no present independent U.S. firms would be both willing and able to respond to demand for a next generation of commercial transport aircraft. If such were the case, antitrust policy might well present a significant barrier to the introduction of new technology. Moreover, if non-U.S. aircraft producers were already in this market, there might well be less competition with U.S. representation in the market thus restricted. In any event, the legal requirements for "proving"

Exhibit 5-1

COMPETITIVE AND U.S. PARTICIPATION EFFECTS OF REPRESENTATIVE
SCENARIOS FOR CONSORTIUM INTRODUCTION INTO A DEFINED MARKET
FOR TRANSPORT AIRCRAFT

<u>Initial Condition</u>		<u>Subsequent Entrant</u>	<u>Competitive and U.S. Market Participation Effects</u>
Case I:	One U.S. Producer	Multi-national consortium including a different U.S. firm.	Competition enhanced in world markets including U.S. in short-run. Long-run depends on whether two or more individual consortium members would have entered independently. If U.S. consortium member is already extended and could only participate in this market through this consortium, the effect is an increase in competition and perhaps a greater net U.S. share of this market in the long-run.
Case II:	One U.S./Foreign Producer	Multi-national consortium with U.S. participation.	Same as Case I.
Case III:	No Producers (i.e. a new class of aircraft)	Multi-national consortium with U.S. participation.	Short-run and long-run effects on competition depend on whether the consortium members alone or in other arrangements would have competed individually. Independent behavior of U.S. firm, absent the consortium, would determine implication for U.S. market participation.
Case IV:	One Foreign Producer (can be a consortium)	All-U.S. consortium, including at least two of the three "primes."*	Same as Case I.
Case V:	No Producers	All-U.S. consortium including at least two of the three "primes."	Same as Case III.
Case VI:	No Producers	All-U.S. consortium, including at least two of the three "primes," each of which is already committed to launching another project.	If the resources of each firm are already substantially stretched and each could only enter the market with a consortium, then the effect is an increase in competition and probably in long-run U.S. participation.
Case VII:	No Producers	Multi-national consortium with U.S. participation where the U.S. firm is already committed to launching another transport project in another market.	If the resources of the U.S. firm are already substantially committed and it could only participate in this market through this consortium, the effect would be to increase competition. The implications for U.S. participation in this market will depend upon behavior of other U.S. firms and the U.S. firm's role in the consortium

*Boeing, McDonnell-Douglas, Lockheed

that a consortium with a considerable degree of monopoly power is the only viable market participant may be sufficient to prevent a sound economic case from being translated into a sound legal one.

The comments by the Justice Department on the application by Eastern Air Lines for authority to discuss design features of new aircraft with other carriers provides insight concerning the Antitrust Division's attitude toward the rationalization of the airframe industry. Underlying a significant portion of Eastern's argument is the notion that the market will no longer support competition between two new aircraft that are near-perfect substitutes. Eastern fears "the spectre of a repeat of current wasteful duplication of wide-body aircraft types."¹⁵ For the most part, Justice disregards this argument. The Antitrust Division instead is concerned that as a result of Eastern's proposal "competitive new aircraft types, such as the three models of the wide-body jets, could not be developed."¹⁶ This implies the Department is not presently receptive to the suggestion that there may be need for airframe industry rationalization without which effective market competition may be reduced in the long term even if not in the near future.

¹⁵U.S. Civil Aeronautics Board, Comments of Eastern Air Lines, Inc.: The Nature of the Circumstances that Prompted Eastern to Request Discussion Authority, Application of Eastern Air Lines for Discussion Authority, Docket 29439 (Washington, D.C., September 24, 1976), p. 3.

¹⁶U.S. Civil Aeronautics Board, Comments of the United States Department of Justice, Application of Eastern Air Lines for Discussion Authority, Docket 29439 (Washington, D.C., October 8, 1976), p. 6.

Certain areas of the economy, such as organized labor, public utilities, some regulated transport carriers and agriculture, enjoy some degree of legislative immunity from antitrust prosecution.¹⁷ Although the airframe business does not approach the size of these components of U.S. industry, an important public policy question appears to be whether any industry displaying comparable cost characteristics should also be treated with special antitrust consideration on the grounds that in the production of a particular type of aircraft, over the relevant range of output, the manufacturers now exhibit a fundamental attribute of natural monopoly--i.e., a single firm can produce the given airframe at ever-lower cost as it moves further down the long-run average cost curve.¹⁸ The point is that antitrust policy which serves the nation's interests will be sensitive to such conditions and reflect an understanding of the situation sufficiently early to avoid setting the stage for reduced market competition and all that would follow in terms of aircraft prices, adverse U.S. balance-of-payments effects, etc.

Technology Transfer

The Export Administration Act states that:

Rules and regulations under this subsection may provide for denial of any request or application for authority to export articles, materials, or supplies, including technical data or any other information, from the United

¹⁷The immunities of these and other sectors are described in A.D. Neale, The Antitrust Laws of the U.S.A., pp. 5-9.

¹⁸See Exhibit 5-1 and Chapter 2.

States, its territories and possessions, to any nation or combination of nations threatening the national security of the United States if the President determines that their export would prove detrimental to the national security of the United States.¹⁹

This Act, along with the Arms Export Control Act, addresses the need to prevent technology of possible military significance from becoming available to potential adversaries.

Any U.S. firm which seeks to participate in a multi-national consortium must obtain a license from the Office of Export Administration of the Department of Commerce. These licenses are granted pursuant to the Export Administration Act. In dealing with application for licenses, the Office consults the Inter-Agency Operating Committee on which sit representatives of the Departments of Commerce, State, Defense, and Energy, and the CIA. In matters pertaining to aviation, NASA and the FAA are also consulted.

As long as a U.S. participant in a multi-national airframe consortium does not propose to use or contribute military-oriented technology, a consortium project of this nature should have little difficulty receiving Commerce approval. Approval by the Committee of arrangements involving only non-Communist venturers is seldom denied, even though some constraints on technology transfer may be imposed where military technology is perceived to be a part of the transaction.

¹⁹U.S. Congress, Senate and House, An Act to Amend the Export Administration Act of 1969: Export Administration Amendments of 1977, 95th Cong., P.L. 95-52 (Washington, D.C.: GPO, June 22, 1977), p. 91.

The case of CFM International, previously discussed, illustrates this latter point.

In any event, the requirement for an "export license" indicates that significant safeguards against the transfer of technology with military importance already exist.

Technology transfer is only a public policy concern--apart from antitrust issues--if the consortia in which U.S. firms participate are multi-national. In such a case, national security considerations historically have been of greatest concern to policymakers and, as just discussed, the current review and licensing process at least provides a safeguard mechanism. In contrast, however, there has been only modest concern for the long-run commercial significance of international transfers of technology. Such concern is manifest primarily through constraints such as those placed upon "hot section" technology transfer in the U.S./French CFM-56 consortium and, more generally, in the "for early domestic distribution" (FEDD) approach taken with respect to certain data and information developed by or for the government.

As elaborated in Chapters 3 and 4, it seems that the transfer of commercial airframe technology (i.e., "product-embodied technology") through consortium arrangements is not an important public policy issue: first, the United States does not have a clear advantage in this area; second, any advantage which a foreign firm might gain from such a transfer would be short-lived; and third, U.S. firms participating in such consortia would be as likely to receive technology as to transfer it. The conclusion is not the same for production process technology and for management technique, however. Still, the U.S. would be

harmful by the transfer of these types of technology only if (1) the foreign recipients were willing and able to exploit them; (2) by making use of them, they were able to improve their competitiveness with U.S. industry; and (3) if such increased competitiveness on the part of foreign firms were considered, on balance, to be harmful to the U.S.

In assessing the effect on the U.S. of policies which would enable overseas airframe manufacturers to increase their share of the market, it is necessary to examine some of the factors which might balance the losses which the U.S. airframe industry would suffer. The first of these relates to the promotion of domestic political stability among U.S. allies in Europe and/or Japan. The strengthening of national economies through expansion of the European or Japanese airframe industry would contribute to political stability because economic factors, especially employment, have proved to be important determinants of such stability. It is doubtful, however, whether this alone is a sufficient reason to promote technology transfer in the transport aircraft field, especially if it might subsequently undermine a U.S. firm's competitive position.

A second possible result of promoting international airframe technology transfer to U.S. allies is to enhance (or maintain) their capacity to produce sophisticated military equipment. While a stronger European (or Japanese) airframe industry would be better able to accomplish this task, it would appear that a more effective approach would involve joint or co-production of military aircraft as is the case with the F-104, the F-16, and other aerospace products.

Third, in view of growing nationalism, especially in Europe, there is an emerging tendency for governments of nations with major air-

frame manufacturing capability to demand that preference be given to native equipment by national airlines. Any U.S. policy which results in the maintenance or increasing of the predominant market share of U.S. commercial aircraft manufacturers might well cause explicit and strong (and probably economically irrational) retaliation from the offended countries. To bar U.S. participation in multi-national airframe consortia could well be viewed in this light, probably to the detriment of all concerned.²⁰

Given a policy decision to permit U.S. participation in multi-national consortia, it may be feasible for the public sector to apply partial controls over the flows of technology between partners. In Chapter 4, factors influencing the transfer of technology were listed. It is possible for government to regulate some of the characteristics of a consortium in an attempt to discourage flows of technology. For example, the government may be able to exert limited controls over such attributes of consortium as its duration, ownership structure, and the division of responsibilities²¹ within the enterprise. At the same time, government probably cannot effectively bound or dictate the internal management organization; nor can it practically constrain the internal mechanics of such arrangements and functions, transfer pricing agreements

²⁰One example of what can happen in such circumstances is provided by the French Government's reversing a decision by Air France to acquire Boeing 737 aircraft to replace the Caravelle. The Concorde situation was assumed to be the reason at the time.

²¹Different kinds of responsibilities exist: managerial, financial, and tasks. It is feasible for an outside entity to monitor and influence the delegation of tasks assigned to and carried out by each consortium member.

(see Appendix) joint development teams, and the planning of the assembly process. At best, then, government can have only limited influence over the transfer of technology in multi-national consortia. Moreover, a government's influence in this regard is greatest prior to the actual formation of a consortium, declining rapidly as the consortium begins to function.

In the event government seeks to regulate or control technology transfer in a consortium setting, additional public policy issues will arise: What agency of government is in the best position to regulate technology transfer? Should the same agency that seeks to influence (or regulate) industry structure also be responsible for controlling technology transfer? By what means, if any, can the transfer of soft technology (e.g., management technique) be regulated? Should military considerations be incorporated into regulatory policy? How are production processes to be protected if machine tools must be transferred in order to make possible the manufacture or assembly of airframes and components? How is a variable price to be determined for technology transferred in a multi-national consortium environment?

Employment

Employment in the U.S. aircraft industry (including airframe, engines and engine parts, and other components and equipment) has shown a fairly steady decline since the peak year of 1968. In 1976,

however, 485,000 persons still worked in these areas.²² Although the figures do not separate commercial from military equipment, they give a reliable picture of the magnitude of employment in the fields likely to be directly affected by the financial condition and prospects of the airframe industry.

The formation of an airframe consortium involving only domestic participants as a means of rationalizing, and thereby strengthening the airframe industry, would appear to lead to a lower level of employment than would be possible if there were several competing independent firms. However, if rationalization is required to preserve the economic viability of the industry, then absent such rationalization (through consortia, mergers, etc.) there would be even fewer opportunities for employment in the long run. Similar reasoning can be applied to the case of U.S. participation in multi-national consortia. Although it might be argued that some employment would be lost to foreign countries, if such participation serves to strengthen and expand the domestic industry, the net future employment picture might well be improved. Such would be the probable result of the case where a U.S. airframe manufacturer saw the market as requiring two differentiable aircraft types, was unwilling to tackle more than one on its own, but was prepared to join other firms in a consortium to manufacture the second.

²² Aerospace Industries Association of America, Economic Data Center, Aerospace Facts and Figures 1977/78 (New York: Aviation Week & Space Technology, McGraw-Hill, 1977); p. 122.

In any arrangement where U.S. participation leads to a strengthening of foreign commercial airframe capabilities, the cost might include some foregone long-run domestic employment. Ultimately, however, the amount and composition of domestic employment in the aircraft manufacturing field will depend on the character and extent of the activities performed in the U.S., whether under consortium agreements or not. Consortia do not automatically imply a reduction or an increase in domestic aerospace employment opportunities, either short- or long-run. Each case must be examined in detail and with the requisite analytical skills to reach a conclusion in this regard.

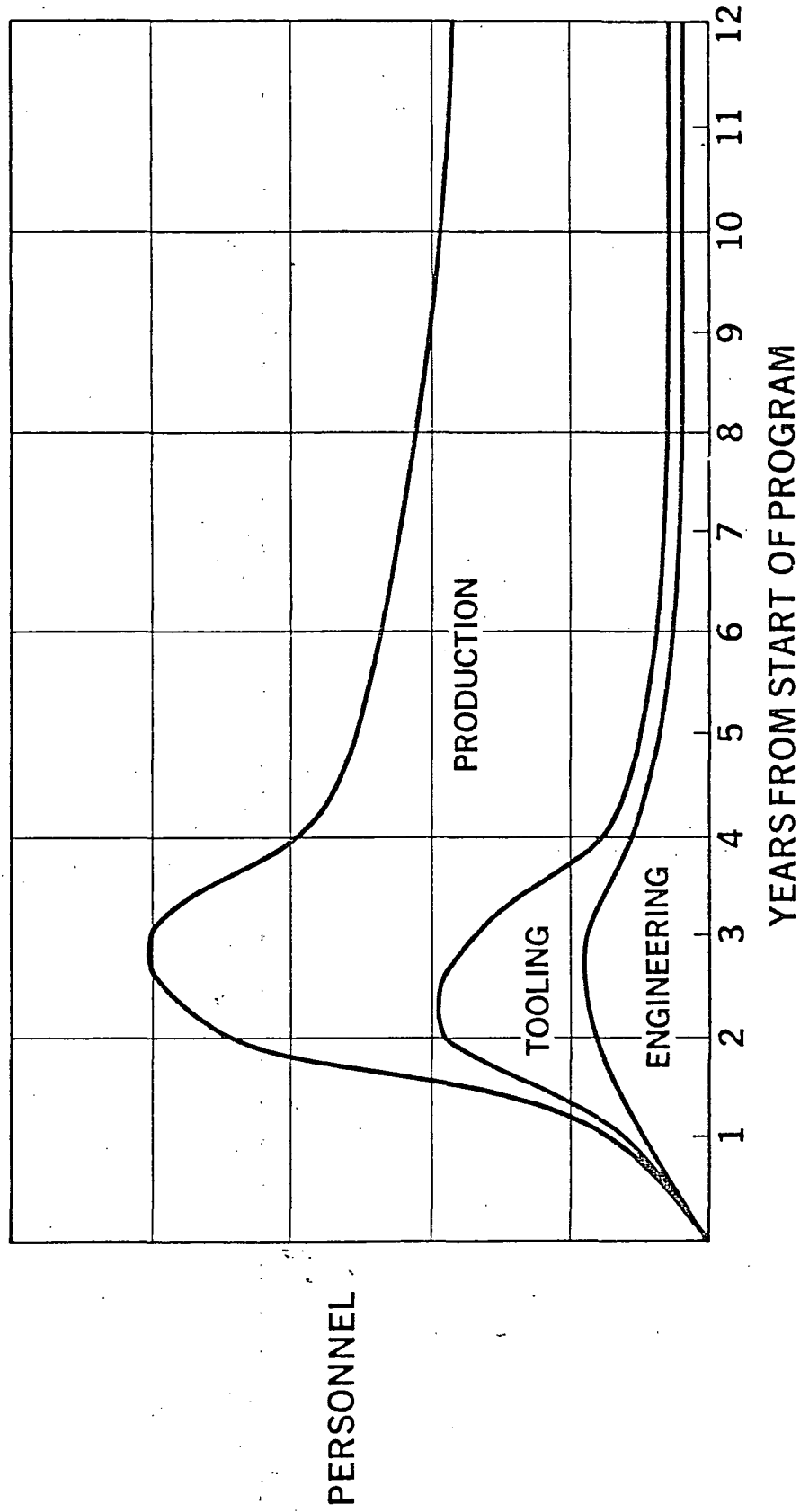
One especially sensitive employment problem that arises in connection with the formation of consortia (and the use of other means of rationalization) concerns the timing of the demand for specific skills in the cycle of design, development, and production. Exhibit 5-2 illustrates the time pattern of labor demand for the engineering, tooling, and production phases of an aircraft program. It also implies that different skills are required in different stages of the activity. In the past in the U.S., the presence in the market of several manufacturers, their typically being at different points in the cycle at the same time, and the high mobility of the workforce have combined to keep the overall industry's peaks and valleys of demand for special skills at far more tolerable levels than would otherwise have been the case. The establishment of consortia cannot but exacerbate the cyclical demand for skills of various sorts if their formation reduces the number of transport aircraft projects as seems certain. This final result may well be unavoidable anyway in an industry undergoing economic rationalization.

DOUGLAS AIRCRAFT COMPANY

TYPICAL TRANSPORT AIRCRAFT PROGRAM

MANUFACTURERS LABOR PATTERNS

(STACKED DATA)



7-PL-30357

Source: McDonnell Douglas Corporation, Douglas Aircraft Company, Office of Planning.

Balance of Payments

Aerospace products make up a significant proportion of United States exports. In 1975, the last year in which the United States had a favorable balance of payments, the positive balance in aerospace products was equivalent to 73.2 percent of the total U.S. surplus.²³ In the narrower context of civilian transport aircraft, exports in 1976 had a value of approximately \$2.5 billion.²⁴ This figure can be compared to a value of approximately \$115 million for all aircraft, new and used, which were imported during the same year.²⁵ Should major changes in the levels of U.S. exports and imports follow formation of multi-national airframe consortia it would clearly have a significant impact on the U.S. balance of payments. Once more, to determine the precise effects requires detailed analysis of a specific scenario leading to creation of multi-national consortia and the conduct of the commercial aircraft industry thereafter.

In order to appreciate the effect of participation in a multi-national consortia on the U.S. balance of payments, the accounting procedure that would be applied to these cooperative ventures must be understood. The fundamental principle is to assign a dollar value to any good or service that crosses an international boundary, at the time of the crossing. Thus, in a consortium agreement, components manufactured in the U.S. would be assigned a dollar value as an export as they crossed into another country. Technological know-how that was supplied from one country to another would also be ascribed a dollar value.

²³ Ibid., p. 107.

²⁴ Ibid., p. 111.

²⁵ Ibid., p. 109.

If an aircraft assembled in another country were purchased by a U.S. firm, it would be considered an import by the U.S., while if it were purchased by a firm of a nation other than the U.S., its final sale would not be included in domestic balance of payments accounting at all, except through the net income that a U.S. firm, as a member of a consortium, might realize from its sale.

The above accounting practice is designed to arrive at the net value of U.S. exports and imports that result from participation in a consortium. In practice, then, an aircraft manufactured in France using certain U.S. components and know-how which is sold to a U.S. air carrier would involve a net import for the United States, but the value of the U.S. components that were first exported would be subtracted from the price of the total aircraft that was imported.

Two other types of consortia should be considered. First, the multi-national consortium without U.S. participation may or may not influence the balance-of-trade through sales it realizes in the U.S. But if it is at all active, it can be expected to reduce the sales enjoyed by U.S. aircraft firms and hurt the U.S. payments position. Airbus Industrie is a case in point, of course, even though its product, the A-300, incorporates U.S.-supplied General Electric engines and other components.

The all-U.S. consortium probably would have positive benefits for the U.S. trade position, both in the short- and long-terms. This is especially true if it were a response to consortia established outside the U.S. with modest or no U.S. participation. Were the all-U.S. joint

enterprise viewed as a predatory act by foreign buyers, some retaliation might be forthcoming but the net effect would likely remain positive.

Direct Government Intervention

Some form of direct government intervention would be indicated to rationalize the airframe industry if consortia were not given government sanction. Current government involvement in the industry is clearly insufficient to effect rationalization; consequently, the possible forms of direct government intervention discussed in this chapter should be compared to the alternative of consortia rather than to current government policy.

Direct government intervention could manifest itself in various ways, including programs to transfer risk from the private to the public sector, direct sponsorship of aircraft development projects, subsidization or restructuring of ailing firms, or nationalization of all parts of the airframe industry.

Risk transfer or risk sharing could be assumed by the government through:

- ° Outright grants,
- ° R&D contracts or loans,
- ° Support for specific tasks in the process of innovation (e.g., prototyping, product testing, and international marketing),
- ° Indemnification for losses experienced as a result of lower-than expected sales,

- Government ownership and bailment of assets (e.g., production buildings, tooling, and prototypes),
- Quasi-public banks to provide low-interest financing for aircraft development,
- Subsidies to cover interest expenses,
- Guarantee of debt,
- Purchase of special issues of equities,
- Tax credits.

Another possible means of direct intervention would be government sponsorship of specific projects--a policy common in Europe. Governments have increasingly taken the position that, with respect to the transport field, certain new vehicles are so important to the public interest that it is worthwhile to underwrite projects to "see" such innovations, at least through the construction of a prototype,²⁶ or even further.

Of course, the most radical means of government intervention is nationalization. All or part of the airframe industry might be affected in what some might see as the ultimate rationalization. After all, this has happened in such nations as France, Britain, and Canada. Such an alternative might be seen as necessary to ensure continued viability in the U.S. commercial airframe industry, especially if one or another or the more promising alternatives (such as consortia) are treated as out-of-bounds.

²⁶ It is interesting to note that programs to develop taxicab, railroad, and electricity-generating equipment prototypes are currently being sponsored by the U.S. Government.

Direct intervention raises a number of thorny problems which would have to be addressed. For instance, the security of government investments made pursuant to such intervention presents a complex policy issue. The government would have to determine its recourse in the event of failure on the part of a debtor to which it had provided funding. If the government were to demand senior liens--as it did in the case of Lockheed²⁷--it would likely neither bear any serious financial risks in the long run, nor would it encourage management to assume major risks for fear of the heavy penalties attendant upon failure. In such cases, however, the government could encourage firms to take relatively high risks through its willingness to take a lower-priority claimant status.

For a government-financed or backed assistance program to be functional, certain restrictions--e.g., liens, tests of financial viability, criteria limiting uses of funds--will obviously have to be incorporated into the program. Restrictions are intended to regulate the decisions of management, but it is apparent that in doing so, they would also inhibit management's freedom of action in a technological environment and a marketplace where financial success often requires timely, bold, risk-laden decisions. If the government planned to be selective in choosing projects for assistance programs, criteria would have to be established to determine the relative worth and priority of various projects. However,

²⁷ Comptroller General of the United States, Reports to the Congress by the Comptroller of the United States, Implementation of Emergency Loan Guarantee Act (Washington, D.C.: General Accounting Office, April 25, 1977), pp. 1, 3.

any government selectivity whatsoever could well lead to changes in intra-industry competition favoring particular firms over others.

Certainly, then, direct government intervention does not appear to be as efficient a means of rationalizing the airframe industry as the formation of consortia would be if the industry requires consolidation to ensure long-term economic and market viability.

Summary

The principal elements of the discussion of this chapter are summarized in Exhibit 5-3. This matrix relates several prominent means of achieving commercial airframe industry rationalization with major public policy issues. The matrix considers the intrarelationshiPs between sixteen public policy issues and six different types of cooperative arrangements. The latter are:

- ° Multi-national consortia with significant U.S. participation;
- ° Multi-national prime-subcontractor relationships with significant U.S. participation;
- ° Multi-national consortia without U.S. participation;
- ° Multi-national prime-subcontractor relationships without U.S. participation;
- ° All-United States consortia;
- ° All-United States prime-subcontractor relationships.

The matrix is coded so as to reflect positive and negative intrarelationshiPs (of varying "strengths") as well as indeterminacies, and those cases where there appear to be no interrelationships between the issue and the sort of cooperative arrangement hypothesized. In

all cases, the implications are reckoned in terms of the U.S. public interest which, among other things, is taken to favor both continued U.S. "predominance" and "preeminence" in commercial transport aircraft.

It is instructive to scan each row and column of Exhibit 5-3. The frequency of "I's" (indeterminate relationships) is striking. In many instances these indeterminacies can be converted into a more precise estimate of the interrelationship if substantial analysis is undertaken. The point to make at present, however, is that the interactions need to be understood far better before public policy positions are established with respect to cooperative arrangements for the production of transport aircraft. This applies especially to the consortia which are far more formal and highly structured than the typical prime-subcontractor relationships with which they are contrasted in Exhibit 5-3.

It is also important to note that Exhibit 5-3 buttresses the argument advanced through Exhibit 5-1 which traces the implications of cooperative arrangements in a different way. Taken together, these exhibits lead to several inescapable conclusions: First, the formation of consortia for the production and sale of transport aircraft, regardless of their location and whether or not U.S. firms participate, is a matter of considerable concern to the United States. Where a proposed arrangement is multi-national, the ability of the United States airframe industry to maintain market predominance at a very high level is jeopardized along with its ability to sustain high employment and to contribute to a favorable U.S. trade. On the other hand, if consortia or other mechanisms of rationalization are undertaken involving only U.S. firms, the negative

Exhibit 5-3

SUMMARY OF IMPLICATIONS FOR U.S. PUBLIC POLICY
FLOWING FROM PROSPECTIVE COOPERATIVE ARRANGEMENTS
FOR THE PRODUCTION OF TRANSPORT AIRFRAMES:
GRA'S PERCEPTIONS*

Types of Cooperative Arrangements Public Policy Issues	Multi-National with Significant U.S. Participation						Multi-National Without U.S. Participation						All-U.S.					
	Consortium			Prime-Sub.			Consortium			Prime-Sub.			Consortium			Prime-Sub.		
	S-T	L-T	I	S-T	L-T	I	S-T	L-T	I	S-T	L-T	I	S-T	L-T	I	S-T	L-T	I
(1) Maintenance of U.S. "Predominance" in Commercial Transport Aircraft	?N	I	I	I	I	?P	SN	SN	SN	SN	SN	SN	SP	?P	?P	?P	?P	?P
(2) Maintenance of U.S. "Pre-Eminence" in Commercial Transport Aircraft	WN	?N	I	I	I	I	I	I	I	I	I	I	WP	I	0	I	I	I
(3) Export of U.S. Product-Embodied Technology	WN	?N	WN	WN	WN	WN	--	--	--	--	--	--	--	--	--	--	--	--
(4) Export of U.S. Process Technology	WN	?N	I	I	I	I	--	--	--	--	--	--	--	--	--	--	--	--
(5) Export of U.S. Management Techniques	WN	SN	I	I	I	I	--	--	--	--	--	--	--	--	--	--	--	--
(6) Import of Foreign Product-Embodied Technology	?P	?P	WP	WP	WP	WP	WP	WP	WP	WP	WP	WP	--	--	--	--	--	--
(7) Import of Foreign Process Technology	?P	?P	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--
(8) Import of Foreign Management Techniques	0	I	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--
(9) Employment (US)	I	I	I	I	I	I	WN	?N	WN	WN	?N	?N	?P	?P	I	I	I	I
(10) Balance-of-Payments (US)	I	I	I	I	I	I	SN	?N	SN	SN	?N	?N	?P	?P	0	I	I	I
(11) Military Capability (US)	0	0	0	0	0	0	--	--	--	--	--	--	?P	?P	0	I	I	I
(12) Military Capability (Non-US)	WP	?P	?P	?P	?P	?P	?P	?P	WP	WP	?P	?P	?N	?N	0	0	0	0
(13) Foreign Relations	SP	I	?P	?P	?P	?P	0	I	0	I	0	I	I	?N	0	I	I	I
(14) Market Access (for US Firms)	WP	?P	WP	WP	WP	WP	?N	?N	?N	?N	?N	?N	I	I	0	0	0	0
(15) Access to U.S. Markets (Non-US Firms)	SN	SN	WN	WN	WN	I	?N	?N	WN	WN	?N	?N	?P	I	0	0	0	0
(16) Competition in Final Product (Aircraft) Markets	I	I	0	0	I	I	?P	?P	?P	?P	?P	?P	I	I	I	I	I	I

*Assumes a cooperative arrangement begun in 1977. Implications might well change in years to come, especially if cooperative ventures are widely undertaken in the intervening years.

N.B. The effect being summarized is that bearing upon the U.S. public interest. For example, it is suggested that if increased market access were provided one or more non-U.S. aircraft producers as a result of the establishment of a multinational consortium, the implications for U.S. public policy would be strongly negative in both the short-term and long-term.

Key	
SP	= Strong Positive
WP	= Weak Positive
SN	= Strong Negative
WN	= Weak Negative
I	= Indeterminate
?P	= Positive, Unknown Strength
?N	= Negative, Unknown Strength
0	= None Anticipated
--	= Not Applicable
S-T	= Short-Term
L-T	= Long-Term

impacts would seem to be small and may even be substantially positive on balance if both the conditions of supply in the airframe industry and the character of demand continue to change in the directions already manifest, as discussed above.

It is abundantly clear that governmental attitudes toward consortia, multi-national and otherwise, have substantial actual or potential impacts on a variety of public policy issues. The precise implications in any proposed or actual consortium arrangement for each of the public policy issues can only be determined once the specifics of the consortium are known as well as the details of the competitive and technological environments in which the consortia are projected to operate. Since there are many conditions under which the formation of consortia involving U.S. airframe producers generates net public benefits to the United States, it is critical not to rule out consortia as an alternative for rationalization in any general way; it also seems prudent to provide guidance to airframe manufacturers as to what the limits of permissibility are in the formation and operation of consortia, multi-national or all-U.S.

Chapter 6

FINDINGS AND RECOMMENDATIONS

The results of this work program, manifest in Chapters 2 through 5, lead to a number of findings and recommendations.

Findings

International arrangements for the cooperative development and production of commercial transport aircraft represent potential mechanisms for the transfer of technology. The technology susceptible to transfer falls into three general categories:

- Product-embodied technology,
- Process technology,
- Management technology or technique.

The degree to which technology is likely to be transferred through such arrangements as multi-national consortia depends upon several factors including--

- The proprietary or investment interest of the transferor in the transferee;
- The specific divisions of responsibilities between parties to the arrangements;
- The scope and duration of the venture;
- The organizational structure of the joint enterprise;
- The nature and extent of inter-personal professional relationships between individuals from the various partners assigned to the international effort.

In order to grasp the full range of implications flowing from the international transfer of technology through multinational cooperative arrangements, it is necessary to cast the analytical net broadly to include consideration of the economic character and trends in the airframe industry which require industry rationalization, the motives for manufacturers to participate in consortia, and a set of related public policy issues including:

- ° Technology transfer mechanisms and motives,
- ° Antitrust,
- ° Employment,
- ° Market access for U.S. firms,
- ° Access to U.S. Markets by non-U.S. firms,
- ° Balance of payments,
- ° Competition in transport aircraft markets,
- ° Foreign relations,
- ° Military capabilities.

Economic Character and Trends in the Airframe Industry

- ° There has been a precipitous climb in the development and threshold costs required to support commercial aircraft innovation from the mid-1930s to the present; these project "launching" costs continue to rise, often exceeding the net worth of the aircraft producers.

- The number of commercial transport airframe manufacturers has decreased in the past four decades, in part because of the sharp increase in the threshold investment associated with producing modern aircraft, and in part because of the increase in lift capacity represented by each aircraft. With such changes in the relevant production functions the market for aircraft has not been large enough to support the number of aircraft suppliers of earlier years.
- To maintain an efficient range of production (in terms of levels of output), an airframe manufacturer must capture a larger share of the free world market for transport aircraft in the 1970's than would have been the case in the 1950's or earlier.
- The changing cost structure of aircraft production, the express intentions of other nations to expand their share of the free world market, and changes in the regulatory environment necessitate the rationalization of the commercial airframe industry. Such rationalization would enable the commercial aircraft industry to accommodate changing conditions on both the supply and demand sides while remaining effectively competitive and economically viable in the long run.
- The means of rationalization employed in the airframe industry should promote an industry structure in which--
 - 1) each product has unique payload/range and operating cost characteristics, so as to have defined a place

in the spectrum of transport aircraft offered; and
2) at the margins, each product competes with other aircraft having somewhat different payload/range characteristics, so as to avoid any significant measure of monopoly. In this way, although producers are not guaranteed profit, they will be spared some of the consequences of destructive competition, while the maintenance of effective competition serves the ends of air carriers and of the public alike.

- ° The consortium represents one especially attractive method of rationalizing the structure of the airframe industry, both nationally and internationally, in order to spread costs and risks while minimizing the losses experienced by any one producer.

Motives for Participating in Consortia

- ° A principal motive for commercial airframe manufacturers to participate in consortia is to reduce the magnitude of financing required to launch a new airframe project by sharing risks, costs, and responsibilities with other firms.
- ° The mechanism of a consortium can be expected to reduce the resources required for the development, production and marketing of a transport aircraft below what would obtain if any individual participant were to undertake the project alone. However, the consortium device will probably increase markedly the total resources required for its project.

- From the European standpoint, consortia permit European nations as a whole to maintain a full spectrum of capabilities in the commercial airframe field. This view of consortia is, to a certain extent, a function of national and regional pride.
- The primary motive of U.S. firms for considering participation in multi-national consortia is the enhancement of their individual financial resources. The consortium mechanism might also provide a means for a U.S. firm to pursue contemporaneously more than one transport aircraft development project.
- Preservation of market access is a secondary, but perhaps at times important, motive for commercial airframe manufacturers to join multi-national consortia.
- In contrast, European firms do not rank the motive of enhancement of financial resources very high. The primary motive of European firms for seeking U.S. participation in consortia is more effective penetration of U.S. markets. This is true whether the European firm is nationalized, private, or of mixed ownership.
- For the most part, non-U.S. firms deny or treat as distinctly subsidiary any possible motivation of technology transfer in their desire for U.S. representation in a multi-national consortium. They do expect, however, that through a consortium with U.S. participation they might

acquire insight into the increased efficiency with which U.S. aircraft are produced when production runs are large.

Technology Transfer

- ° Three types of technology are central to airframe production and marketing:

- 1) product-embodied technology,
- 2) manufacture process technology,
- 3) management technology or technique.

Operation of a consortium might lead to the transfer of one or more of these types of technology.

- ° Product-embodied technology advances and becomes obsolete relatively quickly. Although continuing advancement through research is vital to national preeminence, it is generally agreed that commercial airframe technology is presently at an essentially equivalent level of sophistication, at least among major manufacturers in the non-communist world. Consequently, there appears to be little chance of injury to the U.S. competitive position in the commercial airframe field if product-embodied technology were shared through a multi-national consortium, with or without U.S. participation.
- ° The superior process technology of the U.S. airframe producers is acknowledged by competitors in other parts of the world. Most often this advantage is attributed to the large scale of U.S. aircraft manufacturing programs.

- ° The Concorde and the Lockheed F-104 programs, among others, demonstrate that process technology is transferable. Moreover, such technology can, in the long run, be more valuable to the transferee than product-embodied technology.
- ° Management technique has rarely, if ever, been transferred effectively through international cooperative arrangements in the aviation field. Nonetheless, management technology appears to be a primary reason for the consistent predominance by U.S. firms of the free-world commercial aircraft market.
- ° To the present, other nations do not generally recognize the importance of process technology and management technique to the maintenance of the U.S. predominant position in the airframe industry. There is no reason, however, to expect that their importance will continue to be overlooked in the future.
- ° It is probable that U.S. process and management technology, with regard to transport aircraft, would be transferred overseas only through U.S. participation in a multi-national consortia.
- ° Three conditions must be met for the transfer of U.S. technology to be inimical to U.S. national interests:
 - 1) foreign assimilation of U.S. production processes and management techniques;

- 2) translation of transferred technology into an improved competitive position for non-U.S. firms;
 - 3) determination that the net effect of such increased foreign competition will be detrimental to U.S. interests.
- ° The transfer of product-embodied technology through cooperative production arrangements is not a significant public policy issue. At present, such technology is considered approximately equivalent among the major transport airframe competitors; U.S. firms participating in multi-national consortia would be as likely to acquire as to provide such technology. In any case, the advantage which a foreign firm might gain from such a transfer would probably be short-lived.
 - ° It is in the mutual interest of the U.S. Government and the U.S. aerospace industry that unique commercial airframe process technology and management technique not be transferred through multi-national cooperative arrangements, including consortia.
 - ° Consortia can be established and operated in such a way as to either promote or thwart the transfer of technology.
 - ° At best, the Government can have only limited control over the transfer of technology in a multi-national consortia once the enterprise is established.
 - ° Technology transfer in a consortium is most affected by the division of responsibilities among consortium participants. There is a direct relationship between the breadth and overlap

of responsibilities and parity among consortium members and the extent of technology transfer between them.

- ° Technology transfer is affected to a lesser extent by the anticipated and actual duration of the consortium. Technology transfer and diffusion are probably maximized in consortia where a well-defined, long-term project is undertaken.
- ° The organizational structure of a consortium will also affect the extent and pace of technology transfer. As the size and complexity of a consortium's management increases, so does the amount of personal interaction. The likelihood of technology transfer is heightened where executives for the consortium project are drawn from consortium partners and where there is a programmed rotation of such personnel between the consortium enterprise and their own "parent" firm at relatively frequent intervals.
- ° The transfer of technology and technique enabling overseas firms to increase their world commercial airframe market share could serve U.S. interests by:
 - 1) promoting the domestic political stability of U.S. allies by strengthening national and regional economics;
 - 2) helping to enhance or maintain U.S. allies' capabilities to produce sophisticated military equipment; and
 - 3) minimizing retaliation from foreign countries which resent the overwhelming U.S. predominance of the free-world market for commercial transport aircraft.

However, these "benefits" must in each case be weighed

against the "costs" incurred by the U.S. in terms of the balance-of-payments, employment levels, etc.

Antitrust Policy

- ° Among the most significant barriers to the formation of both domestic and multi-national consortia is antitrust policy. The United States Department of Justice is not presently receptive to the suggestion that there may be a need for rationalization of the commercial airframe industry without which effective market competition may be reduced in the long run and U.S. interests may suffer materially in several ways.
- ° The only means currently available to a firm contemplating participation in any consortium to ascertain formally the acceptability of that consortium to the antitrust authorities is the Business Review Procedure of the Department of Justice. However, even a positive opinion by the Justice Department does not grant a permanent exemption from prosecution.
- ° The competitive impact of any proposed cooperative arrangement will be gauged by the Department of Justice primarily by:
 - 1) the extent to which market competition in the U.S. between commercial airframe producers would be foreclosed in both the short term and the long term, and

2) the way in which the arrangement proposes to treat the issue of technology transfer.

- ° The competitive effects of proposed airframe consortia are largely indeterminate ex ante, particularly in the long run. However, given the present and prospective nature of the commercial airframe production process, both multi-national and all-U.S. consortia have at least as great a likelihood of enhancing competition as of thwarting it.

Other Public Policy Issues

- ° Although technological preeminence supports market predominance, it is not necessarily a guarantee to market predominance, especially in the short run.
- ° Neither multi-national consortia with U.S. participation nor all-U.S. consortia automatically imply either a reduction or an increase in domestic aerospace employment opportunities, in either the short run or long run. Each case must be analyzed on its own merits.
- ° Competitive multi-national consortia can be expected to reduce direct sales by U.S. aircraft firms and to jeopardize the ability of the U.S. to maintain market predominance at a very high level. Especially where such a consortium operates without U.S. participation, U.S. employment levels, trade position, etc. will suffer.
- ° Under certain conditions, the formation of an all-U.S. consortium as a means of achieving necessary rationalization would have

positive effects on the U.S. trade position and on other U.S. interests, both in the short run and long run.

- ° As long as a U.S. participant in a multi-national consortium does not propose to use or contribute military-oriented technology, a consortium project should have little difficulty receiving approval from the Office of Export Administration of the U.S. Department of Commerce.
- ° Direct U.S. government intervention in the commercial transport airframe industry is likely to be required to effect rationalization if "strong" and timely cooperative or joint arrangements (e.g., mergers or consortia) are not implemented by the industry itself.
- ° Consortia appear to be a more desirable and efficient means of rationalization than direct government involvement.
- ° Where consortia or other mechanisms of rationalization are undertaken involving only U.S. firms, the effects in terms of overall U.S. interests are expected to be substantially positive if both the conditions of supply in the airframe industry and the level and character of demand for transport aircraft continue to change in the directions manifest in the past.

Recommendations

United States Pre- Transport Aircraft Market

- ° U.S. public policy must promote and facilitate continued U.S. technological preeminence and predominance¹ in the transport aircraft field in particular.
- ° The U.S. should establish a clear goal reflecting at least the minimum level of U.S. commercial airframe market participation to permit achievement of public policy objectives in employment and balance of payments.
- ° The broad spectrum of international interests of the U.S. must be taken into account in determining the level of commercial airframe market predominance by U.S. firms.
- ° In the event that multi-national cooperative ventures are formed with U.S. participation, a federal agency should be designated to monitor the potential for the transfer of valuable technological information, data, or materials. Active regulation would become necessary only when the U.S. member(s) does not appear adequately motivated to protect these assets.

Antitrust Policy and Procedure

- ° Antitrust policies must be reviewed frequently to assure that they do not impede the development of an efficient, competitive U.S. commercial airframe industry. In this connection, it is recommended that the Business Review Procedure (BRP) of the Antitrust Division of the United States Department

¹ See page 67 for definitions and discussion of "preeminence" and "predominance."

of Justice be reviewed for possible modification or replacement to provide this industry with reliable, timely guidance along lines parallel to the "no-action letter" employed by the Internal Revenue Service.

- ° High priority must be attached to the Justice Department's finding means to make clear at all times its position with regard to the formation and operation of consortia and alternative cooperative arrangements in the airframe manufacturing industry.
- ° A study should be undertaken to determine whether the airframe industry (or any other industry displaying similarly changing cost characteristics) should be granted a degree of immunity from antitrust prosecution approximating that granted labor, public utilities, and agricultural cooperatives, among others.
- ° It is strongly recommended that consortia not be ruled out in any general way as an alternative means for achieving rationalization in the commercial airframe industry.

Alternatives to Consortia

- ° If consortia or other rationalization mechanisms are not permitted to operate, the government must be prepared to develop risk-mitigating devices and/or to provide direct resource support that will enable airframe manufacturers to launch new, competitive, commercial airframe programs.

- ° The U.S. should monitor on a continuing basis the economic and competitive state of the U.S. and world commercial airframe industry. This is necessary to ascertain:
 - 1) U.S. performance in terms of market participation;
 - 2) Sources and character of present and anticipated competition;
 - 3) The need for industry rationalization and the steps being taken abroad to meet such needs;
 - 4) Character of rationalization mechanisms to be applied in the U.S. and the timing of their application.

Role of NASA

- ° Because a reliable flow of new airframe technology is necessary to long-term U.S. competitiveness, and because the U.S. commercial airframe industry does not presently hold a clear competitive edge in product-embodied technology, and because the research necessary to develop and test such airframe-embodied innovations represents investments that the private sector generally cannot readily undertake, NASA research efforts supporting continued U.S. technological advancement should be expanded.
- ° NASA's programs in R&T should be geared to the retention of U.S. technological preeminence in the commercial airframe field.

- NASA's research and technology support for the U.S. commercial airframe industry should be re-examined to determine whether significant research efforts should be directed to manufacturing process technology and management technique because of the importance of these factors in the maintenance of the U.S. airframe industry's comparative advantage.

Appendix

SOME CHARACTERISTICS OF COOPERATIVE VENTURES

Terms such as "consortium" or "joint venture" have long been used to describe a wide variety of cooperative business ventures. However, not all of these types of ventures are likely to exist in the airframe industry. This appendix describes those types of ventures, primarily consortia, which are relevant to this study. The descriptions will be considered applicable to both domestic ventures and to those which combine U.S. firms with enterprises of other nations.

Traditionally, firms have formed cooperative relationships for a variety of reasons, primarily the desire to gain entrance to a new market or to spread the risks of an uncertain venture. In addition, economies of scale derived from combining capital and/or technological resources may make development of a new product feasible for a firm which does not possess, by itself, sufficient resources. Finally, market forces may exist which make it impossible for more than one supplier to survive in a given market.

Consortia--Major Joint Development Projects

Definition

The concept of a consortium is difficult to define precisely because the term is used to refer to cooperative ventures which have as

their primary characteristics two different qualities. The definition in this appendix treats these two qualities as two conditions, either of which is sufficient to denote a consortium. Although the dictionary definition of a consortium requires that it be international,¹ the two conditions given below can be applied just as well to exclusively domestic ventures.

Balance of Authority--No single firm can be in the position to dictate all decisions. Thus, if there are only two firms, each must have roughly 50 percent of decisionmaking power, implying that both firms must agree to any decision. The Concorde project, governed by a treaty between the French and British governments, operates on this principle.² If there are more than two firms, no single member can unilaterally implement a decision binding the whole consortium, although an alliance between a firm with a large share and one with a smaller share could have control. An example of this type of arrangement is the European Airbus project in which the Germans, represented by Deutsche Airbus (itself a consortium), and the French, represented by Aerospatiale, each have only 47.9 percent of the decisionmaking authority. The balance is held by CASA, a Spanish Company.³

¹Webster's New Collegiate Dictionary, Collegiate Series 8 ed. (1975), s.v. "consortium."

²John Davis, The Concorde Affair: From Drawing Board to Actuality (Chicago: Henry Regnery Co., 1969), pp. 78-80.

³Basic Organisation Airbus Project, fact sheet prepared by Fokker-VFW International b.v. Amsterdam [1977].

Risk Sharing--The other sufficient condition for the existence of a consortium is a sharing of risk, as opposed to a strictly buy-sell (prime-subcontractor) relationship, between the parties to the effort. A participant in a consortium must actually risk capital, thereby having an interest in the success of the venture beyond that of a supplier of components at a fixed price.

Therefore, in order to qualify as a consortium, a joint venture may exhibit only a balance of authority (with no risk sharing), only risk sharing (with no balance of authority), or both qualities concurrently. The basic principle is that a consortium's members work together towards a common goal, although shares and decisionmaking power may differ.

Other arrangements in which one firm is clearly subordinate (for example, subcontracting, partially or wholly owned foreign subsidiaries with the primary role of marketing agents, or licensing agreements) are also observed in the airframe industry. They will be touched upon later in this appendix, but they are beyond this strict definition of a consortium.

Issues to be Resolved

Consortia must resolve certain key issues (listed in Exhibit A-1) in order to function. Such ventures can be differentiated according to the decisions which they make and the institutional arrangements which they employ in settling these issues. The following are descriptions of the issues and some of the options available to potential consortium participants.

Exhibit A-1

ISSUES TO BE RESOLVED BY A CONSORTIUM

Goal (Nature of the Product)

Control

Duration

Legal Entity

Management Structure

Technology-Sharing Arrangements

Financial Arrangements

Transfer Prices

Goal--Every consortium in the business sector is formed with the goal of producing a certain product, the nature of which is the first issue which must be resolved. In the airframe industry, the product might be limited to only one phase of the business such as sales, development, basic research, or production. Most commonly, it is a complete aircraft which is the product of all of the above steps.

Control--A second issue is the degree of control which can be exercised by any one firm. As the definition indicates, in some consortia no single firm has a controlling share of authority. But consortia in which risk is shared, with one firm having control, are also possible.

The issue of control is especially important in consortia which include both privately and publicly owned firms. Public enterprises are generally more concerned with maximizing employment than with maintaining long-run profitability. In addition, because they are more concerned with stability, nationalized companies are less likely than private firms to vary their output in response to changes in market demand. There is also the possibility that decisions of a publicly owned firm will lack consistency over a period of time due to changes in the political regime.

Duration--The participants in a consortium must decide on the expected duration of the enterprise. If the purpose of the consortium is to develop and produce a specific airplane, it is possible that the enterprise's life could be limited to the length of time during which the production line is operating, or during which the aircraft would be in service. However, the length of time required to provide services

until the last of a model (or variation) has been retired might prove to be quite long. In addition, the benefits derived from cooperating on one aircraft might be maintained through continued cooperation on subsequent aircraft. Thus, although the originally anticipated duration of a consortium may be limited, the possibilities for indefinite co-operation seem significant.⁴

Legal Entity--A fourth issue which must be resolved is the exact nature of the legal entity to be formed. There are two common types, with infinite variations.

The first is a jointly owned subsidiary, separate from but controlled by the parent firms, with the amount of control over the subsidiary reflecting the degree of each parent firm's participation in the consortium. Airbus Industrie (which produces the A-300) is an example of this kind of arrangement, although complicated by the involvement of governments. The Airbus project is based on a "Framework Agreement" between the governments of France, Germany, Spain, and the Netherlands. As such, it has an "Inter-governmental Committee" which provides governmental input to management.⁵ But the "main contractor for the whole program" is Airbus Industrie, a separate company structured as a "Government d'Interet Economique (G.I.E.) which is a particular company structure, unique to French law."⁶

⁴A consortium of indefinite duration, however, would still be distinct from a merger as long as it did not involve the complete consolidation of two firms. In the aerospace industry, a merger would mean joint effort on many projects besides commercial transports. It would also require that the two firms be indistinguishable financially.

⁵Basic Organisation Airbus Project.

⁶N.W. Boorer, Some Observations of European Collaborative Projects, provided by the author, p. 4.

As a separate company, Airbus Industrie "signs the contracts with its suppliers...and...the sales agreements with the airlines."⁷ It is important to note that such a jointly owned subsidiary, because it has its own structure and authority, could very well develop a kind of independent momentum, making collaboration on subsequent projects through the subsidiary a logical consequence.

A second type of legal entity involves a legally binding agreement between the partners without the formation of a separate company. Such a contract or treaty is usually sufficiently detailed to make clear the division of effort among the partners. The Concorde project is based on a set of such agreements, governed by a treaty between the British and French governments. The treaty makes reference to other agreements between the British and French companies which actually perform work on the aircraft.⁸ However, there is no separate corporate entity comparable to Airbus Industrie.

Management Structure--The resolution of the issue of how a consortium will be managed necessarily depends upon which legal form the consortium takes. A jointly owned subsidiary has its own set of managers, borrowed from the parent companies and/or hired from outside. Although the final hiring and policy authority should rest with the parents (in the agreed-upon proportions), such an organization could develop a certain level of autonomy (depending on the proportion of managers hired from outside the parent firms).

⁷ Ibid., p. 4.

⁸ John Costello and Terry Hughes, The Concorde Conspiracy: The International Race for the SST (New York: Charles Scribner's Sons, 1976), pp. 51, 286-87.

A consortium based entirely on a contractual agreement requires a joint managing committee to oversee the application of the agreement in day-to-day operations. The members of this joint committee might be chosen from the participants in the consortium in proportion to the relative contribution of each partner. In cases in which the consortium rests upon an agreement between governments, there are likely to be at least two levels of committees, the top level being made up of government officials and considering broad policy questions, with a second-level committee for day-to-day operations as described above. The Concorde project is run by a series of such committees.⁹ Even projects which lead to the formation of a subsidiary, if they are based on inter-government agreements (especially if they include nationalized firms) can have a government-level committee with broad policy oversight authority. The "Inter-governmental Committee," overseeing Airbus Industrie, is an example.¹⁰

⁹Boorer, Some Observations of European Collaborative Projects, p. 3.

¹⁰No matter which management structure is implemented, participants in a consortium face a certain level of costs associated with coordination and consultation between them. These "transactions costs" are not likely to appear directly on the books of either partner. Nevertheless, time and effort are expended to maintain coordination between participants that would not have to be spent in a single-firm venture.

The level of transactions costs in a consortium is likely to be related to two factors. The first is the autonomy of the legal entity's management structure. On an *a priori* basis, one would expect these costs to be less significant for subsidiaries than for managing committees because the degree of direct input from the parent companies would be smaller. The second factor is the degree to which profit maximization, rather than political objectives, is important to management. The introduction of politics into a consortium can lead to disagreement over points having more to do with public policy or national pride than with profitability.

Technology Sharing--Partners in a consortium for the development of a technological product such as an airframe must decide how to share the technological contributions of each. Specific arrangements are necessary in order to regulate or to prevent the use of the technological development of one company by its partners, turned competitors, after the termination of the consortium, or on projects which are separate from the consortium. Without such protection, the incentive to contribute technology may be small.

For technology that has already been developed by one of the participants, there are three options for disseminating it to the others:

- ° Patented technology can be licensed to other partners, perhaps for a nominal royalty. Such a license might specify that for the life of the patent, the licensee use the technology in question only as part of the jointly produced airframe. In cases of multi-national consortia, such licenses should be made enforceable under the laws of the licensee's country, and the countries in which aircraft using the technology might be sold.
- ° Know-how which is not patented might be shared without a formal licensing agreement, although the terms of its transfer could be set down in the agreement governing the consortium.
- ° A third possibility is the provision by one partner of certain components, intact, keeping the technology to itself. Such an arrangement can be a necessary condition for participation

in an international consortium if the technology is considered to have national security value by the participant's government.

A consortium is also likely to generate new technology. The arrangement for patenting it depends on the nature of the consortium. Consortia that include no jointly owned company can specify development tasks in the governing contract. This contract can also include a provision for cross-licensing of new technology. Such a provision states that newly patented developments of any partner are automatically to be licensed to the others. It provides the same protection for post-consortium use of the technology by the partner which developed it as licensing of present technology.

If the consortium sets up a semi-autonomous operating unit, technological developments made by it are difficult to attribute to any particular partner. In such a case, a patent can be taken out in the name of the unit. The technology is thereby protected for the duration of the consortium (unless the consortium exceeds the patent's time limit). If the partners want to use the technology in other areas, they can be licensed by their subsidiary.

Financial Arrangements--The resolution of what financial arrangements are to support the consortium depends heavily upon its exact nature. Any agreement, however, should cover certain areas. For example, capital is required for development and production. If the consortium is of the jointly owned subsidiary type, each partner provides a portion

of its capitalization, although the subsidiary can also raise funds through the sale of its own obligations. Where no such company exists, each partner generally must provide the necessary capital to back its own contribution to development or to production.

A governing agreement must also specify the division of liabilities among the partners. Again, with a semi-autonomous operating unit, the task is simpler, as the operating unit--a subsidiary itself--is liable; and the partners may be affected only in their capacity as owners.

The profits earned by a consortium have to be distributed, as well as the proceeds from liquidation once its task is completed. The most obvious division is according to levels of capital contributions. However, transfer prices are, in essence, a device that allocates profit, as well.

Projects which are conducted at the inter-government level (such as Airbus and Concorde) actually resemble government programs more than business ventures. As such, governments supply large amounts of funding for the projects, which are constrained more by political than by economic considerations.

Transfer Prices--A final issue for a consortium to resolve is the arrangement(s) specifying the prices at which goods and services are transferred between members or between the consortium (as a distinct entity) and one of its members. Transfer prices can be (1) strictly on a cost-reimbursement basis, (2) negotiated on the basis of marginal costs, or (3) arbitrarily prespecified charges. The transfer-pricing mechanism and

the basis upon which these prices are computed play an important role in the attitude of each individual consortium member with respect to its obligation to the overall enterprise. For example, if one of the members experiences a substantial unforeseen cost in the process of development of an airframe component, its ability to pass some of these excesses through the consortium is largely a function of the transfer-pricing arrangement. Thus, its response to unforeseen costs (e.g., halt production) can be influenced by its ability to pass some of these costs through to its partners.

Other Types of Cooperative Ventures

Joint ventures in which one firm dominates decisionmaking and in which there is no sharing of risk are also possible for the airframe industry. Examples of such arrangements are licensing, subcontracting, and the acquisition of foreign marketing subsidiaries. Licensing or subcontracting may be used in what is known as a production offset agreement, in which a certain amount of production work is performed in the country to which an aircraft is exported. These types of agreements are most prevalent in the area of military aircraft (the F-16 sales to Europe are an example). However, with the increasing specter of protectionism in the aviation industry, production offsets are becoming more important determinants in aircraft purchase decisions.

An interesting hybrid combination of several of the above categories has been proposed recently by Boeing. The company wants British Aerospace

Corporation to "take over the design leadership and production of a stretched version of its successful 737 civil airliner."¹¹

Boeing would act as a subcontractor by providing the cockpit and fuselage, while the British would provide the wing and be in charge of overall development and assembly.¹² The plan, although containing elements of a prime sub-relationship, appears to be essentially an enhanced production offset agreement. "Boeing is seriously concerned about the growing resentment in Europe over its dominance of the civil jet market,"¹³ and may, therefore, be offering the Europeans a chance to develop a derivative aircraft as a means of counteracting such resentment.

¹¹"Boeing Wants to Build 737's in Britain," The Economist (August 13-19, 1977), p. 73.

¹²Ibid., p. 73

¹³Ibid., p. 74.

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