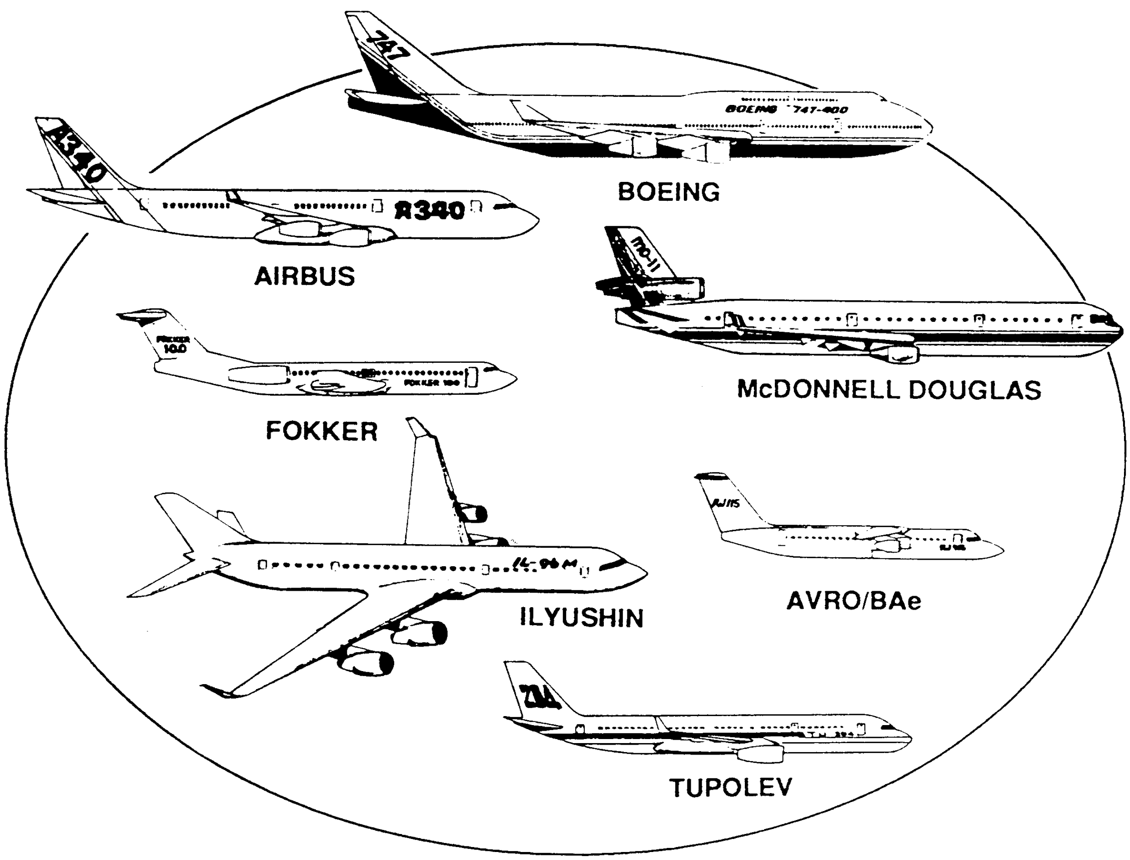
Global Competitiveness of U.S. Advanced-Technology Manufacturing Industries: Large Civil Aircraft

Investigation No. 332-332

Publication 2667 **August 1993**

U.S. International Trade Commission



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PREFACE

On June 11, 1992, the United States International Trade Commission received a request[1] from the Senate Committee on Finance to conduct a series of three investigations under section 332(g) of the Tariff Act of 1930 on the global competitiveness of U.S. advanced-technology manufacturing industries. These three studies, on the cellular communications, aircraft, and computer industries, are part of a series begun in 1990 at the request of the Finance Committee. In response to the request of June 11, 1992, the Commission instituted investigation No. 332-332, Global Competitiveness of Advanced-Technology Manufacturing Industries: Large Civil Aircraft, on September 2, 1992.

The Committee noted that the global competitiveness of key U.S. industries continues to be of concern and interest to the U.S. Congress, and requested that the Commission study include factors found relevant to the global competitiveness of the industry, including, but not limited to: (1) government policies; (2) regulatory and trade impediments; (3) research and development financing and expenditures; (4) issues of competition in civil aircraft from the Airbus consortium; and (5) the proposed acquisition of U.S. aerospace technologies and manufacturers by foreign interests.

Copies of the notice of investigation were posted at the Office of the Secretary, U.S. International Trade Commission, Washington, DC 20436, and the notice was published in the *Federal Register* (vol. 57, No. 178) on September 14, 1992.[2] Public hearings were held in conjunction with this investigation on April 15, 1993.[3]

The sources consulted in the preparation of this report include domestic and foreign manufacturers, industry associations, airline officials, research establishment officials, and appropriate government officials. Questionnaires were completed by purchasers based in the top three global markets. Testimony at the public hearing and written submissions provided pertinent information on competition in the large civil aircraft (LCA) industry. Staff also completed a rigorous examination of existing literature on competitiveness in general and on competitiveness in the global LCA industry.

[1] See app. A.
[2] See app. B.
[3] See app. C.

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EXECUTIVE SUMMARY

This study is the second of three assessments of the global competitiveness of selected U.S. advanced-technology manufacturing industries requested by the Senate Committee on Finance on June 11, 1992. The other studies assess the cellular communications and computer industries. The cellular communications report was submitted to the Senate Finance Committee on June 11, 1993; the computer report is scheduled to be submitted to the Senate Finance Committee on December 7, 1993. These three studies are part of an ongoing series of competitive assessments begun in 1990.

For the current study, the Commission has been requested to examine factors relevant to the competitiveness of the global large civil aircraft (LCA) industry,[1] including, but not limited to: (1) government policies; (2) regulatory and trade impediments; (3) research and development (R&D) financing and expenditures; (4) issues of competition in civil aircraft from the Airbus consortium; and (5) the proposed acquisition of U.S. aerospace technologies and manufacturers by foreign interests.

The analysis presented in this study focuses primarily on the LCA-manufacturing industries in the United States and Western Europe. It also includes some discussion of Russia's LCA industry, which is beginning to produce aircraft for export. Although Japan is not a producer of LCA, it is examined in the context of its aeronautical R&D.

The global LCA industry comprises manufacturers of civil passenger aircraft with 100 seats and over, and cargo aircraft of over 33,000 pounds. The industry includes three major producers and two minor producers in the United States and Western Europe, as well as two major producers in Russia. Two of the major Western producers are U.S. companies, The Boeing Co. and McDonnell Douglas Corp. The third major Western producer is Airbus Industrie, G.I.E., a consortium of four West European producers.[2]

Boeing, McDonnell Douglas, and Airbus have typically accounted for 90 percent of global deliveries of LCA outside the Commonwealth of Independent States. The remaining two Western producers—NV Koninklijke Nederlandse Vliegtuigfabriek Fokker of the Netherlands (recently acquired by Daimler-Benz of Germany) and Avro International Aerospace, Inc. (a joint venture between British Aerospace plc of the United Kingdom and Taiwan Aerospace Corp.)—compete only in the lower range (under 120 seats) of the LCA market, and are minor players in the global LCA industry. The two major Russian LCA producers—Ilyushin and Tupolev—have a long history of LCA design and production for their domestic and other nonmarket economies, and are beginning to produce LCA for export.

The approach of this study is to identify factors internal and external to the firm that determine the competitiveness of the U.S. LCA industry in the global market. Internal factors include such items as firm strategy and private-sector-funded R&D. External factors include market and macroeconomic variables such as exchange rates and price of fuel, as well as government policies affecting the LCA industry.

Industry and Market Conditions

- During the period 1988-92, U.S. LCA manufacturers' share of global orders, deliveries, and backlog for LCA fluctuated downward. The global market for LCA grew

[1] The study does not include an analysis of aircraft of under 100 seats, military aircraft, or LCA components suppliers.

[2] Airbus was established as a "groupement d'intérêt économique" (G.I.E.) under French law in 1970.

significantly to 1,141 units during 1987-88, and fluctuated downward to 438 units during 1992. The U.S. share of global market orders (measured by units) declined from 81 percent in 1988 to just over 64 percent in 1992. U.S. LCA manufacturers accounted for 73 percent of global unit deliveries, and 64 percent of backlog in 1992. Competition from Airbus was largely responsible for the decline in the U.S. share of orders; Airbus orders, deliveries, and backlog rose commensurately with the U.S. decrease.

- Boeing's estimated commercial aircraft revenues increased from $21.3 billion in 1990 to $22.9 billion in 1991 and $24.2 billion in 1992. Total firm backlog declined from $97.9 billion in 1991 to $87.9 billion in 1992. Employment[3] in Boeing Commercial Airplane Group, Boeing's LCA division, increased from 57,000 in 1988 to 84,000 in 1992.

- McDonnell Douglas' commercial aircraft revenues initially increased from $3.9 billion in 1990 to $6.8 billion in 1991 and then declined $6.6 billion in 1992. Total firm backlog decreased from $30.4 billion in 1991 to $24.1 billion in 1992. Total employment of Douglas Aircraft Co.,[4] the LCA division of McDonnell Douglas, dropped from 38,400 in 1988 to 30,400 in 1992.

- In 1992, the principal markets for LCA were the United States, Western Europe, and the Asia-Pacific region, accounting for nearly 92 percent of the world fleet. U.S. LCA manufacturers accounted for a total of 84 percent of the world LCA fleet: 93 percent of the U.S. fleet, 75 percent of the West European fleet, and 74 percent of the Asia-Pacific fleet.

- The world's airlines are estimated to have lost over $11 billion on international scheduled services during 1990-92. The poor financial condition of the airline industry has increased the incidence of aircraft leasing, the purchase of used aircraft, and the deferral of orders and options for new LCA.

- An increasing proportion of U.S. sales of aircraft equipment will be in markets outside the United States. U.S. LCA manufacturers should focus their efforts on emerging markets, while maintaining a high level of participation in established markets. Joint manufacturing agreements often provide market access; U.S. LCA companies have entered into such agreements in Europe and the Far East for that purpose.

- The airline industry is moving toward global alliances that may yield "megacarriers". Megacarriers would have considerable leverage in negotiations with the major LCA manufacturers.

Determinants of Competitiveness in the Global LCA Industry

- Factors that affect competitiveness in the global LCA industry include government policies; private- and public-sector-funded R&D; firm strategy; commonality (incorporation of common parts and/or systems across a manufacturer's LCA product line); length of time in the industry, because of such benefits as orders based on commonality, cost efficiency, labor productivity, and market credibility; airline profitability; ability to raise capital; and exchange rates.

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[3] Employment data exclude Wichita, KS facility.
[4] Includes personnel on the military C-17 program.

Competition in the Global LCA Industry

Government policies

- Although many legal requirements and government policies affect the competitiveness of the LCA industry, only a few, such as government direct and indirect support, have a significant effect on the competitiveness of U.S. and foreign LCA producers.

Western Europe

- Direct support from West European governments to Airbus programs has reduced Airbus LCA R&D, manufacturing, and marketing costs. From the late 1960s through 1989, the British, French, and German Governments reportedly allocated some $13.5 billion in direct support for Airbus activities to British Aerospace, Aérospatiale, and the Daimler-Benz subsidiary Deutsche Airbus. A total of $8.2 billion had been disbursed through 1989.

- Commission staff have verified that the above figures comprising launch aid disbursed and launch aid to be disbursed are credible. The figures were derived from government budgets in the countries concerned and legislative and administrative reports associated with legislation allocating the funds.

- The Airbus partner companies depend more on military sales for revenue than does Boeing, though not to the same extent as does McDonnell Douglas. A high reliance on military sales may lead to an accelerated aircraft design and production capability, which in turn may enable companies to develop skills more rapidly than if they had not had military programs.

United States

- The U.S. Government has authorized direct support for the U.S. LCA industry on two occasions. The United States guaranteed loans to facilitate the merger of McDonnell Aircraft Corp. and Douglas Aircraft Co. in the late 1960s. It also guaranteed loans to assure the solvency of Lockheed in the early 1970s.

- Indirect support[5] for the U.S. LCA industry allegedly is provided through U.S. Department of Defense R&D and military contracts, and National Aeronautics and Space Administration (NASA) R&D. U.S. policy has not been designed to guarantee success in the commercial operations of U.S. LCA manufacturers; however, R&D support and large backlogs of military contracts may have enabled U.S. producers to minimize their risk, and develop their aeronautical R&D and manufacturing infrastructure.

Bilateral Agreement on Support

- The agreement between the United States and the European Community signed in July 1992 (1992 agreement) concerning application of the 1979 General Agreement on Tariffs and Trade (GATT) Agreement on Trade in Civil Aircraft eliminates future direct government support for the production of LCA (e.g., production subsidies). However, it "grandfathers" existing government support programs, with some reservations, and permits direct development support (e.g., development subsidies) within certain limitations and

[5] The U.S. Government and the European Commission are currently negotiating the definitions to be used in determining what constitutes indirect support, and the methodology to be applied in determining the amount of such aid provided to U.S. LCA manufacturers and Airbus.

requirements. The 1992 agreement also requires parties to ensure that indirect government support does not confer unfair advantages on domestic manufacturers or lead to distortions in international trade in LCA, and places specific limits on indirect support relative to annual commercial sales of the LCA industry and individual firms.

Corporate structure

- As a G.I.E., Airbus is not required to report financial results to the public. Moreover, while the partner companies are subject to taxation, the G.I.E. is not liable to pay taxes on its profits unless it so elects. U.S. manufacturers are subject to tax requirements and disclosure standards imposed by the Securities and Exchange Commission.

- A G.I.E. is able to assemble financial resources that individual corporations cannot, because it can draw on the resources of its member companies. This structure also enables the entity to spread out among its member companies the financial risks associated with the high cost of R&D, manufacturing, and marketing a new product.

- Airbus member companies need not share information about their costs with the other members, the shareholders of Airbus, and thus are subject to less oversight and control by shareholders than their U.S. counterparts. The members' dual role of owner and subcontractor, however, contains an inherent tension that may make it difficult for each partner to identify its own best interest, let alone that of Airbus as a whole. In contrast, U.S. manufacturers, through their accountability to many shareholders that are not its manufacturing partners, may have more of a need to make decisions on the basis of cost.

Research and development

- U.S. capability in aeronautical R&D will remain strong in the foreseeable future. However, U.S. expertise will be challenged increasingly by Airbus and Western Europe's aeronautical research institutions. Funding for overall aerospace R&D by U.S. public- and private-sector R&D organizations is higher than in Western Europe, and is likely to ensure U.S. leadership, particularly in such key areas as computational fluid dynamics (CFD) proficiency and application.

- Almost all U.S. private-sector-funded LCA R&D is consumed by new programs or by projects to improve existing products. U.S. private-sector aeronautical R&D tends to be near-term proprietary R&D, which can guarantee a short-term economic return to justify the expenditures. The U.S. private sector tends to underinvest in long-term generic R&D projects that have limited ability to capture a sufficient rate of return in the short term.

- National laboratories and government-sponsored R&D in Western Europe tend to be more product-oriented. These laboratories and government research organizations work more closely with the LCA manufacturers than is the case in the United States.

- The U.S. overall aerospace industry ranked eighth among all U.S. industrial sectors in R&D expenditures as a percentage of sales, at 3.8 percent in 1991. In contrast, Western Europe's private-sector aerospace R&D expenditures historically have amounted to more than 15 percent of sales, placing aerospace third behind the electrical engineering and electronics and the chemical industries as Europe's leading investor in R&D.

- The EC Commission has reported that aerospace is the only industry that receives more than 50 percent of its R&D funding from government sources. At the time the EC made this comment, however, the level of government-funded aerospace R&D in Western Europe was declining despite rising production.

- Private- and public-sector aeronautical R&D spending in the United States exceeds slightly that of Western Europe. NASA's aeronautical R&D budget totaled $512 million in 1991 compared with $445 million for the four West European national laboratories (ONERA, DLR, DRA, and NLR). The U.S. Government increased its spending in aeronautical R&D in 1992, and further increases are expected during the mid-1990s. In 1992, NASA's aeronautical R&D expenditures rose to $555.4 million (not including expenditures for staffing) and is scheduled to increase to $716.8 million in FY 1993 and to $877.2 million in FY 1994. NASA officials expect funding at the West European laboratories to remain relatively flat as a result of declines in public funding of LCA R&D.

- In the private sector, Boeing and McDonnell Douglas spent $1.8 billion on R&D compared with $1.6 billion for the major Airbus partners in 1991. R&D expenditures by Boeing and McDonnell Douglas increased to $2.4 billion in 1992, while those of Aérospatiale, British Aerospace, and Deutsche Aerospace rose to $1.9 billion.

- U.S. leadership in CFD rests principally on access to sophisticated computers, such as supercomputers; however, access to supercomputers, by itself, does not guarantee supremacy in CFD. For example, very sophisticated algorithms for solving CFD problems have been developed by Russian researchers, but their limited access to computing facilities has hampered their research efforts in this area. In contrast, Japanese firms with access to supercomputers have not achieved significant CFD developments. The U.S. lead in this area will increasingly erode as West European and Russian aircraft manufacturers gain increased access to supercomputers and other sophisticated computers.

- Wind tunnel tests increasingly are being replaced by CFD modeling; however, wind tunnels remain essential facilities for the development of aircraft. Western Europe has made significant investments in modern wind tunnel facilities for aerodynamic testing. Currently, U.S. wind tunnels are not on par with those in Western Europe. The United States has only recently begun a wind tunnel restoration program. Congress authorized $300 million in 1988 for NASA to revitalize 6 of its 41 wind tunnels; however, most of the wind tunnels at NASA Ames Research Center currently are closed or awaiting closure for repair.

- In recent years, Airbus has applied NASA research more extensively than have U.S. manufacturers. Airbus has drawn on NASA's work in aerodynamics research for wing technology, as well as research on and application of new materials (e.g., composites) in primary structures such as the vertical fin and control surfaces.

Regulatory and trade policies

- Competitiveness in the global LCA industry is influenced minimally by regulatory restrictions, such as U.S. antitrust laws, the Foreign Corrupt Practices Act, aircraft certification requirements, and export controls.

Competitive Position of the U.S. LCA Industry

- It is likely that the growth in demand anticipated with the end of the worldwide recession and the need for fleet replacements will have somewhat conflicting impacts on the performance of the U.S. industry. Although U.S. orders should recover and grow, this growth will probably not keep pace with growth in global demand. This scenario would provide room for growth in market shares accounted for by Airbus and by such potential new entrants as Russian firms.

CHAPTER 1: Introduction

Scope of the Study

The global large civil aircraft (LCA) industry comprises manufacturers of civil aircraft with over 100 seats, in the case of passenger aircraft, or over 33,000 pounds, in the case of cargo aircraft. It includes three major and two minor producers in the West, as well as two major producers in Russia. Two of the major Western producers are from the United States—The Boeing Co. and McDonnell Douglas Corp. The third major Western producer is Airbus Industrie, G.I.E., a consortium of four West European producers—Aérospatiale of France, Deutsche Aerospace Airbus GmbH of Germany, British Aerospace Airbus Ltd. of the United Kingdom, and Construcciones Aeronáuticas S.A. of Spain—established as a groupement d'intérêt économique (G.I.E.) under French law.

The remaining two Western producers—NV Koninklijke Nederlandse Vliegtuigfabriek Fokker of the Netherlands (recently acquired by Daimler-Benz of Germany) and Avro International Aerospace, Inc. (a joint venture between British Aerospace plc of the United Kingdom and Taiwan Aerospace Corp.)—compete only in the lower range (under 120 seats) of the LCA market, and thus are minor players in the global LCA industry. The two major Russian producers—Ilyushin and Tupolev—have a long history of LCA design and production for their domestic and other nonmarket economies, and are beginning to produce for export.

Currently, the principal markets for LCA are the United States, Western Europe, and the Asia-Pacific region. These regions account for nearly 92 percent of the world LCA fleet.

Aircraft production in the United States affects nearly 80 percent of the economy. According to one study, for every additional dollar of shipments of aircraft, the output of the economy increases by an estimated $2.30, and for every $1 billion (in constant 1977 dollars) of shipments, nearly 35,000 jobs are created.[1]

U.S. producers' market dominance of the global fleet is under increasing pressure from Airbus. U.S. LCA manufacturers are concerned with Airbus methods of developing its aircraft and bringing them to market, specifically issues relating to government subsidies.

This report covers a 15- to 25-year time period in order to capture more accurately the overall trends and long-term effects of two events that have shaped the current competitive environment in the global LCA industry: the creation of Airbus in 1970, and the deregulation of the U.S. airline industry in 1978.

Approach of the Study

The approach of this study is to identify factors internal and external to the firm that determine the competitiveness of the U.S. LCA industry in the global market. For example, some of the internal factors examined are firm strategy and private-sector-funded research and development (R&D). External factors include market and macroeconomic variables such as exchange rates and price of fuel, as well as government policies affecting the LCA industry. The indicator employed to measure the competitiveness of the U.S. LCA industry is its global market share.

Data-Gathering Efforts

Many sources of information were consulted in the preparation of this report. Among these were personal and telephone interviews with domestic and foreign LCA and engine manufacturers; industry associations; and airline, research establishment, and domestic and foreign government officials. Interviews

[1] John W. Fischer, et al, *Airbus Industrie: An Economic and Trade Perspective* (Washington, DC: Congressional Research Service, Feb. 20, 1992), summary page.

and plant visits were conducted in the United States, France, Germany, the Netherlands, Belgium, the United Kingdom, and Russia. To develop information on the market for LCA, questionnaires were completed by purchasers based in the top three global markets.[2] A public hearing was held on April 15, 1993; testimony from this hearing and posthearing statements provided pertinent information on competitiveness in the LCA industry. A rigorous examination of the literature on the competitiveness of the global LCA industry was conducted that included studies of government policies and R&D issues. Literature on competitiveness in general also was examined to provide a context for investigating the LCA industry.

Competitiveness Defined[3]

International competitiveness has become a subject of great concern in the United States; it has been intensely scrutinized in the press and studied by many different public and private organizations. These analyses have examined competitiveness on three different levels: the nation, the industry, and the firm.

The definition of national competitiveness from President Reagan's Commission on Industrial Competitiveness is as follows:

> *Competitiveness is the degree to which a nation can, under free and fair market conditions, produce goods and services that meet the test of international markets while simultaneously maintaining or expanding the real incomes of its citizens.*[4]

A similar version by the Competitiveness Policy Council states—

> *America's economic competitiveness—defined as our ability to produce goods and services that meet the test of international markets while our citizens earn a standard of living that is both rising and sustainable over the long run.*[5]

Industry- and firm-level competitiveness often are defined as the ability to sustain market position profitably in a competitive environment as products and production processes evolve. Theodore Schlie has proposed a simplified definition:

> *Competitiveness is the ability to get customers to purchase your products or services over competing alternatives on a sustainable basis.*[6]

Success at these less aggregate levels can be measured by trade balances and market shares, or in terms of profits, shipments, real income per employee, and employment. Under the above definition, firms in more than one country can be competitive at the same time in an industry.[7]

The determinants of industrial competitiveness according to Guenther's survey of the literature on industrial policy consists of four primary factors: cost structure; the quality of output and inputs, especially labor; exchange rates; and government policies that affect industry performance and structure.[8] These determinants can be divided usefully into internal factors, over which the firm has some control, and external factors, which are beyond the firm's influence. For example, a firm's organization of production to capture the beneficial effects of learning can significantly reduce labor and material costs. In contrast, the market rate of interest also affects costs, but is largely beyond the firm's control. In addition, many aspects of government policy are viewed as factors external to an industry that affect its structure and performance, and therefore its competitiveness.[9]

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[2] In 1992, the U.S., West European, and Asia-Pacific markets accounted for nearly 92 percent of world passengers carried.

[3] A review of literature on competitiveness issues generally and on competitiveness in the global LCA industry is presented in appendix D.

[4] Commission on Industrial Competitiveness, *Global Competition—The New Reality* (Washington, DC: Jan. 1985), vol. I, p. 6.

[5] Competitiveness Policy Council, "Building A Competitive America," *First Annual Report to the President and Congress* (Washington, DC: Mar. 1992), p. 1.

[6] Theodore W. Schlie, *Analysis of Studies of the International Competitiveness of Specific Sectors of U.S. Industry*, draft prepared for Competitiveness Policy Council (Bethlehem, PA: Jan. 26, 1993), p. 8.

[7] Gary L. Guenther, *Industrial Competitiveness: Definitions, Measures, and Key Determinants* (Washington, DC: Congressional Research Service, Feb. 3, 1986), p. 5.

[8] Ibid.

[9] Richard R. Nelson, "Government Stimulus of Technical Progress: Lessons From American History," in *Government and Technical Progress: A Cross-Industry Analysis* (New York: Pergamon Press, 1982), pp. 451-482.

This study assesses the competitiveness of the LCA industry. An important consideration in this assessment is the radical change that has occurred in the dynamic conditions of this competition. One view of the dynamic dimension of the competitive history of the LCA industry is offered by Artemis March:

> *Americans enjoyed a virtual monopoly in commercial aviation from the end of World War II into the 1980s. This situation was based upon the active exploitation of a unique constellation of historical-political factors by pilot/managers who loved flying. ....But this particular constellation of factors has gone forever, and with it the American monopoly. .....Boeing and Douglas now face serious foreign competition in a dramatically changed environment that has reduced their technology edge, shifted customer relationships away from engineering toward finance, and accelerated the globalization of both production and marketing.*[10]

A major force that significantly changed the competitive situation for the LCA industry was deregulation of the U.S. airline industry. In March's view, this development essentially replaced technology with cost as the primary factor in choosing aircraft. While this situation has had many positive economic effects on LCA manufacturers through increased efficiency and sales, according to March it has adversely affected the entire industry:

> *...[the] demand pull for technology has been diminished, the decline of airline engineering accelerated, progress payments from launch customers dried up, close customer relationships and service weakened by leasing intermediaries, and safety compromised by lessened maintenance and continued use of aging aircraft and engines.*[11]

The LCA industry has had to adjust to these changing conditions with a revised approach to competition. That is, instead of the old approach focused largely on promoting technological features and product support in the sale of an aircraft, LCA manufacturers now promote a total package of features, ranging from creative financing to personal involvement by high government officials. In addition, manufacturers participate in international joint ventures to facilitate the flow of technology and gain leadership in critical technology. There also is greater emphasis on the cost side of production and technology. Thus, any potential advantages of new and more sophisticated equipment are weighed against airlines' incentives to continue using older aircraft that may be less efficient, but are already depreciated or available at very low prices.[12] In other words, "the 1978 deregulation of the domestic airline industry has fundamentally shifted the primary axis of competition for both airlines and manufacturers from performance to price."[13]

In contrast, the Council on Competitiveness as well as the Aerospace Industries Association of America, Inc. consider competition in the LCA industry to be driven largely by technological competition.[14] According to these sources, success in the marketplace will depend primarily on technological advancement.

The relative importance of price and technology often determines competitiveness in high-tech industries: that is, whether the competitive confrontation will be won on the basis of price or by improved performance through technological advances.[15] A recent analysis of the LCA industry notes—

> *Since the launch of a new aircraft always involves substantial risk, and since the cost advantages of staying with a proven model are enormous, there is an understandable incentive for the incumbent producer to postpone innovation. In other words, the industry's economics give rise to an inherent*

[10] Artemis March, *The U.S. Commercial Aircraft Industry and its Foreign Competitors* (Cambridge, MA: MIT Commission on Industrial Productivity, 1989), p. 1. March does not place much emphasis on the importance of cost structure in the early period of U.S. LCA manufacture.

[11] Ibid., p. 5; and George Eberstadt, "Government Support of the Large Commercial Aircraft Industries of Japan, Europe, and the United States," contractor document for Office of Technology Assessment, *Competing Economies: America, Europe, and the Pacific Rim* (Washington, DC: Congress of the United States, 1991), pp. 195-210.

[12] Ibid., pp. 5-6.

[13] Ibid., p. 30.

[14] Council on Competitiveness, "A Competitive Profile of the Aerospace Industry," research paper for *Gaining New Ground: Technology Priorities for America's Future* (Washington, DC: Mar. 1991), p. 14; and Virginia Lopez and David Vadas, *The U.S. Aerospace Industry in the 1990s: A Global Perspective* (Washington, DC: The Aerospace Research Center, Aerospace Industries Association of America, Inc., Sept. 1991), pp. 11-13.

[15] Schlie, p. 2.

> *tension between static production efficiency and dynamic efficiencies, and between the welfare of the producer and that of its customers.*[16]

Lower costs and prices obtained through production efficiencies may be more than offset by the introduction of a new aircraft enhanced by new technology. If several players are involved, especially new entrants, the situation can be very dynamic.

While the definition of competitiveness in the LCA industry is the same as the generic definition at the national level, distinctive measures need be used. As mentioned earlier, recommended measures are real net income or profits per employee. Lacking data on these measures, researchers frequently choose to analyze market share. With respect to this study, because the necessary data on recommended measures are not available for either the U.S. industry or its West European competition, the selected measure of the competitiveness of the U.S. industry is its global market share, which is defined as the U.S. industry's orders as a share of the global market for LCA.

Organization of the Study

Chapter 2 reviews the structure of the industry in the United States, Western Europe, and the Commonwealth of Independent States. Specific topics discussed include market share, risk-sharing arrangements, regional strengths, types and extent of foreign participation of principal producers and suppliers, and technology transfer.

[16] Laura D. Tyson and Pei-Hsiung Chin, "Industrial Policy and Trade Management in the Commercial Aircraft Industry," ch. in *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Washington, DC: Institute for International Economics, 1992), p. 156.

Chapter 3 describes the market for LCA, in terms of both major national/regional markets and principal purchasers. The interaction between purchasers and suppliers is examined, with particular attention to the contract process. Trends in the global civil air transport industry also are presented in such areas as deregulation, airline profitability, and globalization.

Chapter 4 describes and evaluates the various factors that determine competitiveness in the global LCA industry, including factors internal to the firm, such as corporate structure and firm strategy, and external factors, including market and macroeconomic factors and government policies. Two prominent factors, government policies and R&D, are discussed in greater detail in chapters 5 and 6, respectively. These internal and external determinants serve as a framework for the statistical analysis conducted in appendix H.

Chapter 5 examines country-specific policies, including company structure; support programs; antitrust, tax, export assistance (including export financing and risk assumption), and procurement policies; and regulatory and certification requirements.

Chapter 6 provides an overview and comparison of R&D funding, expenditures, and infrastructure capabilities in the major LCA-producing countries.[17] LCA R&D in Japan also is examined.

Chapter 7 presents the principal findings of this study, discussing the present competitive position of the U.S. LCA manufacturers, the major competitive differences between the U.S. and West European LCA industries, and the future competitive position of the U.S. LCA manufacturers.

[17] App. G contains a glossary that defines technical terms used in chapter 6 and throughout the report.

CHAPTER 2:
Structure of the Global Large Civil Aircraft Industry

United States

Historical Development of the U.S. Large Civil Aircraft Industry

This section first provides an overview of the historical development of the U.S. large civil aircraft (LCA) industry. The section then examines U.S. technology transfer and risk-sharing agreements. Finally, this section reviews the strengths of the U.S. LCA industry.

Principal Manufacturers Post-1945

During 1945-60, five U.S. manufacturers—The Boeing Co., Consolidated Vultee (later, the Convair division of General Dynamics), Douglas Aircraft Co. (Douglas), Lockheed Aircraft Co., and the Glenn L. Martin Aircraft Co., built the majority of large civil transport aircraft used in global airline service. During this period, Douglas, known for the range of its product line, and Lockheed, famous for the speed of its products, were the most profitable large civil transport producers. Boeing, which built aircraft primarily for the military until the mid-1950s, did not equal the commercial success of Douglas and Lockheed.

Since 1945, major advances in aircraft engine technology allowed airframe manufacturers to offer the turbopropeller[1] and subsequently the turbofan engine.[2] These engines increased the speed and passenger appeal of aircraft, two important factors for the world's airlines. In addition, developments in the field of aeronautics, such as the design of the swept wing, contributed to higher-performance aircraft and allowed airframe manufacturers to take full advantage of the potential of the turbofan engine.

Significant U.S. Aircraft Programs[3]

The Jet Age

In 1952, Boeing launched its model 367-80, the first jet-powered transport built in the United States. After the first flight in July 1954, a modified version secured an immediate order from the U.S. Air Force. This version subsequently evolved into Boeing's model 707, which was first introduced into service by

[1] A turbojet engine uses a gas turbine to produce thrust that moves the aircraft. A turbopropeller engine is a turbojet engine with a gearbox and a propeller attached; it relies on the propeller to impart motion to the aircraft. A turbofan engine consists of a turbojet with an enclosed fan attached to the front of the engine, which is larger in diameter than the engine itself.

[2] Laura D. Tyson and Pei-Hsiung Chin, "Industrial Policy and Trade Management in the Commercial Aircraft Industry," ch. in *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Washington, DC: Institute for International Economics, 1992) pp. 177, 183. Tyson, in citing Mowery and Rosenberg ("The Commercial Aircraft Industry," ch. in Richard Nelson, ed., *Government and Technical Progress: A Cross-Industry Analysis* (New York: Pergamon Press, 1982), p. 141), indicates that air travel during 1938-78 was heavily controlled by the U.S. Government. Therefore, airlines competed on the basis of state-of-the-art aircraft as an important marketing strategy. If one carrier used a comparatively newer-type aircraft, its competitors perceived themselves to be at a disadvantage.

[3] Information for this section was derived in part from John E. Steiner, "How Decisions Are Made: Major Considerations for Aircraft Programs," speech delivered before International Council of the Aeronautical Sciences, American Institute of Aeronautics and Astronautics, Aircraft Systems and Technology Meeting, Seattle, WA, Aug. 24, 1982, pp. 18-20.

Pan American Airways in October 1958. Douglas, which had previously underestimated the popularity of jet engine technology, delivered its first jet aircraft, the DC-8, in 1959. Primarily because of its early investment in new engine technology, Boeing continued to increase its share of U.S. deliveries of LCA during 1959-64.[4]

Jumbo Jets

The first U.S. jumbo jets were envisioned during the global market expansion of the early 1960s, and included Boeing's model 747, Douglas' model DC-10, and Lockheed's model L-1011. Boeing's objective was to design a "super plane" that would have a high level of performance and low seat-mile costs. The airplane was intended to be oversized at its introduction, in order to become a "market fit" (i.e., address the size of the projected passenger/cargo market) about 4 years after introduction. The risks were great; for example, airplane design, factory construction, and the development of the new Pratt & Whitney JT9D engine had to proceed concurrently to meet delivery schedules. The 747 was first placed in service on January 21, 1970.

The DC-10 and L-1011, delivered initially in 1971-72, competed directly with each other, but did not compete directly with the 747.[5] The DC-10 and L-1011 were technically acceptable and had similar range capabilities; however, both were targeted at a market niche that failed to develop.[6]

Supersonic Transports

During the early 1960s, the U.S. Government held a competition among Boeing, Convair, Lockheed, and North American (a U.S. producer of military aircraft) to select a supersonic transport (SST) design for development.[7] On December 31, 1966, the U.S. Government announced that Boeing's design, the swing-wing 2707-200, had won the competition.[8] However, funding for the aircraft eventually was denied by the U.S. Senate, and the program was officially cancelled on May 19, 1971.[9] Research done by the U.S. industry for the SST program led to the following spin-offs:

- Modern flight-deck technology
- Large-scale application of computers to aeronautical engineering problems;
- Titanium alloy developments and new structural concepts; and
- Augmented flight control systems having both military and civil applications (relaxed static stability-active controls).[10]

Structural Changes in the U.S. LCA Industry

Producers/Aircraft Programs

On April 28, 1967, Douglas, which was approaching bankruptcy in spite of its $2.3 billion

[4] The impact of new engine technology is reflected in U.S. LCA market share data for the late 1950s. Martin ceased production of large civil transport aircraft in 1955. During 1955-58, the market, in terms of deliveries of large civil transport aircraft, was dominated by piston-engined aircraft produced by Douglas, Lockheed, and Convair. In 1958, the top two producers were Douglas (59.8 percent) and Lockheed (14.6 percent). In 1959, Douglas' share dropped to 10.8 percent, and Lockheed's rose to 57.8, while Boeing, with no shipments of LCA during 1955-57, captured 30.1 percent of the market. Boeing proceeded to increase its share of deliveries through 1964; Lockheed stopped production of its turboprop Electra in 1962, while Convair, which had failed to deliver large civil transport aircraft in 1958 and 1959, stopped piston-engined production in 1960, and began shipping jet-powered LCA. Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2, 1992; and The Boeing Co., *Pedigree of Champions: Boeing Since 1916* (Seattle, WA: The Boeing Co., 1977), p. 57.

[5] The 747, which seats 350 passengers in mixed-class seating, had no competitors in its class. The DC-10 and L-1011 each accommodated 250-300 passengers in mixed-class seating.

[6] Steiner, p. 20. As a reflection of general market conditions, Boeing's 747 also did not sell well for several years after its introduction.

[7] Richard K. Schrader, *The Full Story of the Anglo-French SST: Concorde* (Missoula, MT: Pictoral Histories Publishing Co., 1989), p. 21.

[8] Ibid., p. 37. Projected costs of the U.S. SST increased from $1 billion to $4 billion. The aircraft proved too heavy to fly as intended, raised concerns about potential damage to the earth's ozone layer, and overran its projected costs. The development costs for the French-British SST, the Concorde, were calculated at $4.3 billion. Ian McIntyre, *Dogfight: The Transatlantic Battle over Airbus* (Westport, CT: Praeger Publishers, 1992), p. 32.

[9] Schrader, p. 37.

[10] Steiner, p. 17.

order backlog,[11] merged with the McDonnell Aircraft Corp., a large producer of military aircraft, to form the McDonnell Douglas Corp.[12] This merger was assisted by the U.S. Government's guarantee of $75 million in loans.[13] During 1971, Lockheed was confronted with the bankruptcy of Rolls-Royce, its sole engine supplier; financial difficulties due to its military C-5A transport aircraft program;[14] and aggressive competition from the Douglas DC-10. Its collapse was averted only by a Federal loan guarantee of $250 million and the rescue of Rolls-Royce by the British Government.[15] According to industry sources, these moves came too late for the success of the L-1011. Doubts in the airline industry as to the long-term solvency of both Lockheed and Rolls-Royce plagued the sales efforts of both. Lockheed stopped production of its wide-body L-1011 in 1985, leaving Boeing and McDonnell Douglas the only remaining U.S. manufacturers of jet-powered LCA.[16]

Current Conditions

During the period 1988-92, U.S. manufacturers' share of global orders, deliveries, and backlog for LCA fluctuated downward (see figures 2-1, 2-2, 2-3, and appendix H). The global market for LCA grew significantly during 1987-88, before falling in 1988-90 and rising slightly in 1991 (figure 2-1). The U.S. share of global market orders (measured by units) declined from 81 percent in 1988 to just over 64 percent in 1992. Competition from Airbus was largely responsible for the decline in U.S. market share of orders; Airbus' orders, deliveries, and backlog rose commensurately with the U.S. decrease.[17] Total sales for Boeing doubled during the 1988-92 period, from $12.2 billion to $24.7 billion,[18] while McDonnell Douglas revenues increased by 26 percent, from $13.8 billion to $17.4 billion.[19]

Total employment at Boeing Commercial Airplane Group grew from 57,000 to 84,000 during 1988-92,[20] whereas employment at Douglas Aircraft Co., the McDonnell Douglas division responsible for LCA and the C-17 military transport program, declined from 38,400 to 30,400 during the same period.[21] Boeing employment grew in preparation for the introduction of its newest version of its 747 and development of both a new 737 and the 777. Douglas employment declined as a result of lessened development and production needs for their MD-11 and through the effects of a difficult corporate reorganization, intended in part to increase its productivity.

In the near term, it is improbable that there will be any new U.S. manufacturers of LCA, largely because of—1) the formidable expense involved in the design, development, manufacture, and support of such aircraft;[22] 2) the current market conditions with existing manufacturers cutting capacity in response to actual and projected lack of profits of the airline industry; and 3) cutbacks in military spending. Industry sources also indicate that there are no potential entrants in the U.S. LCA engine or fuselage manufacturing market for similar reasons.

[11] David C. Mowery, *Alliance Politics and Economics: Multinational Joint Ventures in Commercial Aircraft* (Cambridge, MA: American Enterprise Institute, Bollinger Publishing Co., 1987), p. 39.

[12] Douglas Aircraft Co. became a division of McDonnell Douglas, responsible for civil and military transport aircraft.

[13] Virginia C. Lopez and David H. Vadas, *The U.S. Aerospace Industry in the 1990s: A Global Perspective* (Washington, DC: The Aerospace Research Center, Aerospace Industries Association of America, Inc., Sept. 1991), p. 51.

[14] McIntyre, p. 88.

[15] John Newhouse, *The Sporty Game* (New York: Alfred A. Knopf, 1982), p. 182.

[16] Convair did not move successfully into the jet aircraft market, ceasing deliveries in 1962. Lockheed continues to produce an LCA-version of its C-130 (Hercules) turboprop, known as the L-100.

[17] Statistical analysis in appendix H also indicates that the emergence of Airbus has had a significant impact on U.S. LCA market share.

[18] The Boeing Co., 1992 Annual Report, p. 51.

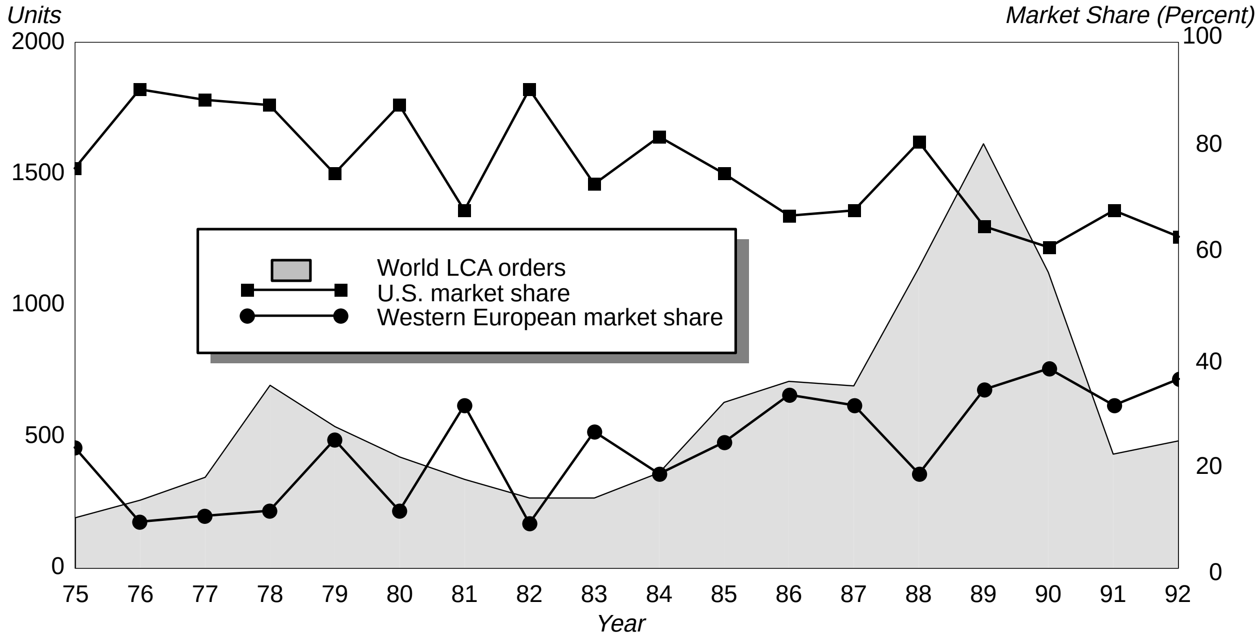
[19] McDonnell Douglas Corp., 1992 Annual Report, p. 52.

[20] Boeing officials, telephone interviews by USITC staff, Jan. 1993. Boeing announced potential staff layoffs of up to 28,000 in February 1993, due to market conditions.

[21] McDonnell Douglas officials, telephone interview by USITC staff, June 1993. McDonnell Douglas announced the possibility of substantial reductions in workforce due to the current recession.

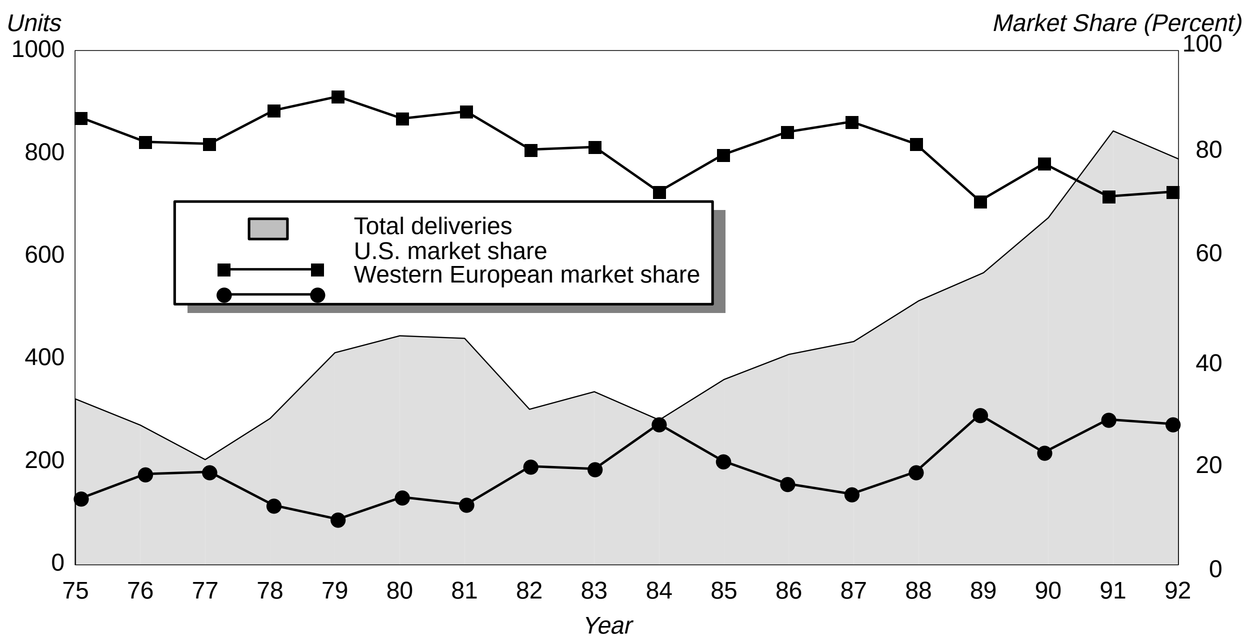
[22] In the 1930s, it cost Douglas roughly $3 million to produce the DC-3; the DC-8, introduced in 1958, cost about $112 million (R. Miller and D. Sawers, *The Technical Development of Modern Aviation* (London: Routledge & Kegan Paul, 1968), p. 267, as cited in Mowery, *Alliance*, p. 34). The Boeing 747, delivered in the early 1970s, has been estimated to have cost over $1 billion.

Figure 2-1
Global LCA orders, 1975-92: U.S. and West European market share



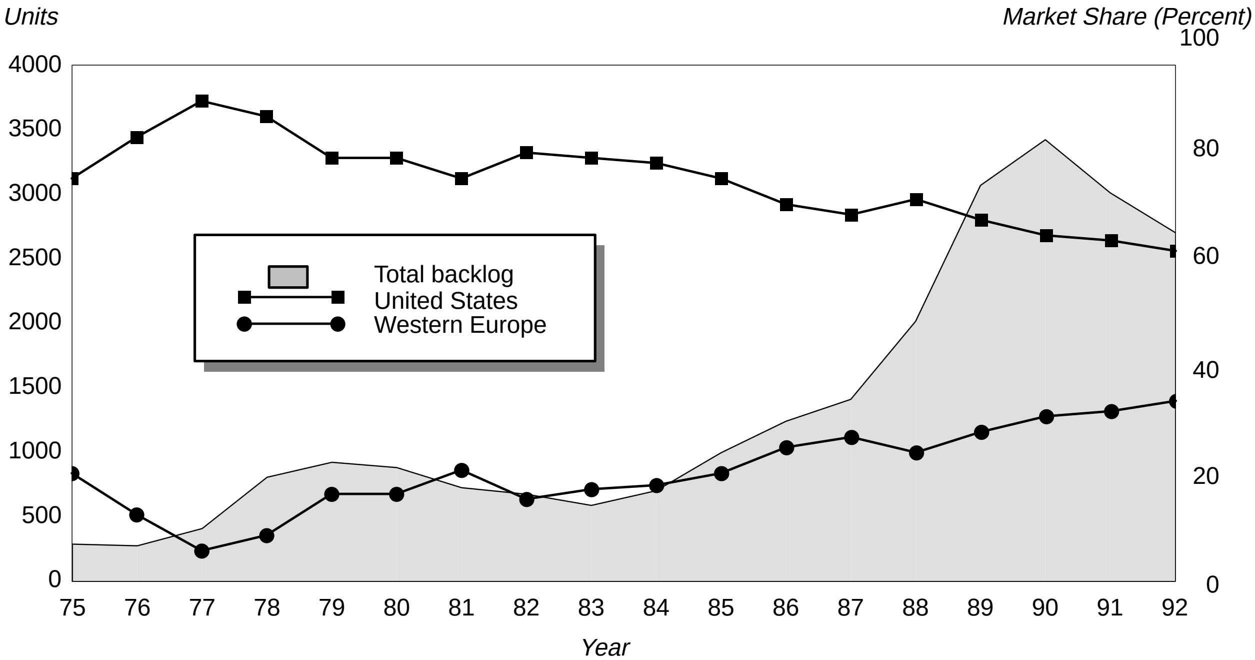
Source: Commission of the European Communities; and Boeing Commercial Airplane Group. Manufacturers include Aérospatiale, Airbus, Boeing, British Aerospace, Dassault-Bréguet, Fokker, Lockheed, and McDonnell Douglas.

Figure 2-2
Global LCA deliveries, 1975-92: U.S. and West European market share



Source: Commission of the European Communities; and Boeing Commercial Airplane Group. Manufacturers include Aérospatiale, Airbus, Boeing, British Aerospace, Dassault-Bréguet, Fokker, Lockheed, and McDonnell Douglas.

Figure 2-3
Global LCA backlog, 1975-92: U.S. and West European market share



Source: Boeing Commercial Airplane Group. Manufacturers include Aérospatiale, Airbus, Boeing, British Aerospace, Dassault-Bréguet, Fokker, Lockheed, and McDonnell Douglas.

Suppliers of Primary Aircraft Subcomponents

Fuselage/parts manufacturers

Global LCA manufacturers are more properly described as airframe assemblers, given the extent of subcontractor involvement. Thousands of subcontractors fabricate up to 60-70 percent or more of the value of the airframes (not including engines) for U.S. manufacturers. In some cases, only one or two suppliers have the expertise to provide certain components, for example, for products such as large titanium forgings[23] or for turbine-blade casings in the case of engines. With most other, less-specialized components, vendors compete for sales based on price, delivery, and quality. To sell aircraft in many countries, LCA manufacturers must offer offset agreements that give a share of production to parts-manufacturing firms in those countries.[24] Offsets have reduced the business of some U.S. suppliers, and may have longer-term negative effects because of foreign business development based on learning gained from technology transfer.[25]

Engine manufacturers

The success of an LCA program is heavily dependent on the success of the propulsion system; moreover, the engine represents the single highest-value part of an aircraft. Engine selection is critical, and can be more complex than decisions made on the airframe itself, because three parties are involved (the LCA manufacturer, the customer, and

[22]—*Continued*
More recently, the bid by British Aerospace for 26 percent of the development and production activity and costs of the Airbus A320, a 150-seat aircraft, was estimated to be $900 million, implying an overall cost for the A320 of over $3 billion. See Arthur Reed, "Airbus A320 Launched with British Loan to BAe," *Air Transport World,* Apr. 1984, pp. 17-18. Cost estimates for producing an ultra-high-capacity aircraft range up to $10 billion.

[23] These forgings form the banjo housing of the "middle", i.e., vertical-stabilizer-mounted, engine of McDonnell Douglas' model MD-11.

[24] U.S. and West European industry sources, interviews by USITC staff, Sept.-Nov. 1992.

[25] Artemis March, *The U.S. Commercial Aircraft Industry and its Foreign Competitors* (Cambridge, MA: MIT Commission on Industrial Productivity, 1989), p. 10.

the engine manufacturer) and because engines take longer to develop than airframes.[26]

The Pratt & Whitney Division of United Technologies (Pratt & Whitney) and General Electric (GE) are the two major U.S. producers of LCA engines. Pratt & Whitney and GE aircraft jet engines powered 58 and 12 percent, respectively, of world LCA as of December 31, 1992.[27]

Historically, an LCA manufacturer chose one engine company for its airframe for the launch of a new program. All original Boeing 707s and 737-100/200s and Douglas DC-9/MD-80s were powered by Pratt & Whitney engines. With the advent of Boeing's 747 (1970), and later its 757/767 models (1983/1982), airlines could choose among Pratt & Whitney, GE, and Rolls-Royce engines, thereby introducing a new element in the purchase decision. Competition among engine makers for market share on specific aircraft has allowed airlines to demand price and financing concessions from both the LCA manufacturers and the engine makers. This also provides an advantage to the LCA manufacturer, as it can shift some of the burden of concessions to the engine maker.

Type and Extent of U.S. Technology Transfer and Risk-Sharing Agreements

Background to Technologies Underlying the LCA Manufacturing Industry[28]

A primary reason for the rapid technological progress of the U.S. LCA industry has been its ability to draw on and benefit from innovations in other high-technology industries.[29] For example, high-speed supercomputers accurately model aircraft airflows without the aid of wind tunnels. This process, known as computational fluid dynamics,[30] illustrates how airflows impact the aircraft at various angles, and under differing conditions of temperature and air density. Supercomputers can now perform these complex equations in several days, a significant advance over slower computers.

Computers also have been incorporated significantly in LCA cockpits[31] as integrators of information. With the increased usage of flat-panel displays that project the image of an electromechanical gauge, several displays either can be transferred individually to various panels or superimposed on one panel at the pilot's discretion. In addition, computers have aided in the development of Full-Authority Digital Engine Control (FADEC) systems. FADEC allows for improved monitoring and adjusting of engine operating parameters, such as fuel flow and speed. This enhanced control of aircraft engines has led to a decrease in both fuel consumption and maintenance demands.

Composite materials increasingly are used in LCA fuselages. The primary advantages of composites include their high strength/low weight correlation; disadvantages include the initial price and problematic diagnosis of damaged parts. While their strength would lend themselves to primary aircraft structures (large sections of the wing/fuselage/landing gear), the inherent problems have not been overcome. To date, composites have been used in LCA floors, flat sections of wings, landing gear doors, and on aircraft engine nacelles.[32]

Technology Transfer Agreements Between U.S. Companies and Foreign Firms

Since U.S. firms generally have been recognized as the technological leaders in the aerospace industry, technology has tended to flow from U.S. to foreign

[26] Steiner, p. 22.

[27] Boeing Commercial Airplane Group, *World Jet Airplane Inventory, Year-End 1992* (Seattle, WA: The Boeing Co., Mar. 1993), p. 22. Market share percentages do not include the participation of Pratt & Whitney or GE in cooperative manufacturing programs with international partners. If cooperative programs were included, their market shares would be 53 and 27 percent, respectively.

[28] See chapter 6 for further discussion of current technologies.

[29] Mowery, *Alliance,* p. 32.

[30] See app. G.

[31] Computers are also an integral part of "fly-by-wire" and "fly-by-light" systems used currently on Airbus A320 LCA. Two advantages made possible by fly-by-wire technology include decreased weight in the aircraft through deletion of some/all of the hydraulic flight control systems/plumbing, and the creation of a computerized record of operation, which can be accessed by ground support crews either on the ground or while the aircraft is in flight.

[32] Aircraft engine nacelles direct airflow into and around the engine.

firms.[33] U.S. firms indicate that they can best maintain their position of leadership by staying ahead on yet newer technologies than the ones they have shared. Technology transfer has occurred primarily with military aircraft programs; little has occurred in the LCA industry. The U.S. Government has placed limitations on the transfer of technology in several areas, including airfoils, carbon-carbon composites, and other high-temperature components, very-high-speed integrated circuitry, and source codes for the digital flight control computer.[34] Technology that has been transferred is typically in the area of production technologies, and not in the areas of design, development, and marketing.[35]

One of the most publicized examples regarding the issue of aerospace technology transfer involved the General Dynamics/Mitsubishi Heavy Industries[36] agreement of January 1989 to develop and produce Japan's Fighter Support Experimental (FS-X) aircraft. This agreement, foreshadowed by a memorandum of understanding (MOU) in November 1988 between the U.S. and Japanese Governments, detailed the specific terms of workshare and technology flows that would occur between the two companies. The aircraft would be based on the General Dynamics F-16C,[37] which had been designed originally in the 1970s. Proponents of the deal argued that it would not transfer technology to Japan any more than do existing programs with NATO allies such as Norway, the Netherlands, and Belgium. Opponents of the deal feared the outcome of U.S. assistance in area of aircraft systems integration to a country that purportedly intended to become an LCA manufacturer.

Although the agreement calls for codevelopment, it does not represent a true risk-sharing effort because Japan alone will support the development costs, and the Japanese Government will provide a guaranteed market for the finished product. In return for the transfer of airframe technology, General Dynamics will receive all new technologies emerging from the project, although limitations will be placed on its receipt of information concerning phased-array radar, inertial navigation, and electronics warfare and fire control computer technology.[38]

Role of Risk Sharing in the Development of LCA

Airframe Manufacturers

Risk sharing in LCA programs has increased recently for several reasons. Risk sharing can satisfy offset requirements unrelated to LCA in the purchasing country, diminish the initial investment (capital and personnel) required of the LCA manufacturer,[39] facilitate export sales financing,[40] and it may aid in sales of aircraft to the risk-sharing nation.[41] Every LCA airframe and engine manufacturer is involved in multinational joint ventures and expects, to some degree, to conduct all or most of its future programs in a risk-sharing

[33] However, the U.S. industry is not perceived to be the leader in the incorporation of advanced technology in LCA. Compiled from responses to USITC airline questionnaire, Feb. 1993.

[34] John D. Morrocco, "Revised FSX Pact Eases Trade, Technology Concerns," *Aviation Week & Space Technology,* May 8, 1989, p. 16, as cited in Lopez and Vadas, p. 21, footnote 10.

[35] Mowery, *Alliance,* p. 54.

[36] General Dynamics produces military fighter aircraft and fuselage panels for LCA; it does not produce LCA.

[37] General Dynamics sold its F-16 production facilities to Lockheed Corp. in 1993.

[38] Lopez and Vadas, p. 21. A more detailed discussion of the issues involved is found in—Hearings before the Subcommittee on Investigations and Oversight and the Subcommittee on International Scientific Cooperation and the Subcommittee on Transportation, Aviation and Materials of the Committee on Science, Space, and Technology, U.S. House of Representatives, Apr. 6 and May 11, 1989, No. 62. Also, see "FSX Fighter Agreement with Japan," CRS Issue Brief, Richard F. Grimmett, Congressional Research Service, updated Mar. 20, 1989, and Memorandum to the Committee from Jack Moffett, Congressional Research Service, Apr. 3, 1989.

[39] For example, during January 1993, the four partners of Airbus and Boeing agreed to carry out a feasibility study on developing a 600+ seat aircraft. Airbus Industrie, G.I.E. is not a party to the agreement. Development costs could reach $10 billion for this program.

[40] Lopez and Vadas, p. 26.

[41] Mowery, *Alliance,* p. 69. For example, Boeing has established significant relationships with Japanese parts makers; according to Boeing, All Nippon Airways is currently the largest global operator of Boeing 767s, and Japan Airlines is the world's largest operator of its 747s. Boeing officials, interview by USITC staff, Seattle, WA, Sept. 14, 1992.

manner. Foreign partners can gain engineering, manufacturing, and management expertise, and share in potential profits. Typically, U.S. partners do not believe that such partnerships transfer important technology that affects their competitive edge.[42] Further, U.S. export laws stringently control the export of sensitive technologies that are important to U.S. national security.[43]

The Boeing Co.

In the mid-1960s, Boeing subcontracted about 70 percent of the value of the early production of the 747 program to both U.S. and foreign sources, while a number of other subcontractors contributed funds to support nonrecurring costs for the first 200 aircraft produced.[44] In 1978, Aeritalia (an Italian parts manufacturer) and the Japanese Commercial Transport Development Corp. (JCTDC, the forerunner of the Japanese Aircraft Development Co. [JADC])[45] signed an MOU with Boeing as risk-sharing subcontractors to produce the wing flap system and fuselage panels for the 767 program.[46] Aeritalia and JCTDC each assumed the costs of development and production tooling for 15 percent of the total value of the aircraft for the first 500 aircraft.[47] These two foreign subcontractors received up to 50-percent funding[48] from their respective governments for the development costs of their components.[49] According to Boeing, Japanese subcontractors were considered for the 767 program only after U.S. companies had been approached and were either unable or unwilling to risk the investment.[50] In addition, JADC agreed to pay Boeing a $143 million royalty as an acknowledgement of Boeing's design experience and its global sales and support network.[51] Some industry officials indicate that Boeing subsequently was able to finance development of the 757 on its own because of the extent of commonality with the 767 program.

Boeing signed another risk-sharing MOU with Saab-Scania of Sweden, Shorts Brothers of Northern Ireland, and JADC during March 1986, for work on the 7J7.[52] Saab-Scania and Shorts are to be

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[42] GE and Pratt & Whitney have structured their foreign partnerships to maintain control of the "hot section" of their engines initially developed for the U.S. military, sharing only the interfaces rather than interior designs. March, p. 10.

[43] Foreign direct investment (FDI) in the U.S. aircraft and engine manufacturing sectors rose from $459 million in 1986 to approximately $831 million in 1990, or 81 percent. The level of FDI in these sectors is modest when compared with that in other U.S. industries. For example, in 1990, FDI in the automobile industry amounted to $2.7 billion; in construction and mining equipment to $4.4 billion; and in the household audio and video equipment industry to $6.2 billion. David Vadas, "Foreign Direct Investment in the U.S. Aerospace/Defense Market," The Aerospace Research Center, Aerospace Industries Association of America, Inc., Oct. 1992, p. 6.

[44] This trend toward subcontracting is part of Boeing's efforts to avoid the huge buildup of manpower that marked the late 1960s and subsequently resulted in massive layoffs. Richard G. O'Lone, "Boeing Cools on Cooperative Programs," *Aviation Week & Space Technology,* June 6, 1977, pp. 48-49 as quoted in Mowery, *Alliance,* p. 68.

[45] Primary members of both groups include Mitsubishi Heavy Industries, Kawasaki Heavy Industries, and Fuji Heavy Industries.

[46] Boeing's 767 program relies more heavily on foreign subcontractors, primarily Italy's Aeritalia (now, Alenia) and Japan's Japanese Commercial Aircraft Companies (JCAC), than did the 747 program. Mowery, *Alliance,* pp. 68, 70.

[47] Mowery, *Alliance,* p. 70.

[48] Foreign manufacturers often receive working capital for the production of LCA from their governments. The Japanese Government provides a share (usually 50 percent) of development money to its aviation companies as long as they are working as a consortium. Akihiko Takao, "Japan's Aerospace Industry: Government Policy and Support," *Interavia,* Sept. 1986, as cited in March, p. 18.

[49] For the Japanese partners, government funding took the form of loans (about $73 million), repayable out of profits from production of the aircraft. Mowery, *Alliance,* p. 70.

[50] U.S. General Accounting Office (GAO), *U.S.-Military Co-production Agreements Assist Japan in Developing Its Civil Aircraft Industry* (Washington, DC: GAO, 1982), note, p. 16 as cited in Mowery, *Alliance,* p. 69, footnote 5. In Japan, the Ministry of International Trade and Industry has supported Japan's major aerospace companies since these industries utilize high-technology inputs, link with other R&D-intensive industries, and manufacture high value-added products.

[51] Mowery, *Alliance,* p. 71.

[52] The 7J7 program is a joint venture originally established in 1984 between Boeing and Japan Aircraft Development Corp. to develop a medium capacity (150-seat) aircraft. In 1986, this agreement was expanded to include additional partners, and in 1991, it was renewed. However, the 7J7 program has not been developed to prototype stage because

risk-sharing associates, responsible for 5 percent of the development program. JADC is to be responsible for providing approximately 25 percent of the equity needed. This agreement could represent an important advancement for JADC over its agreement on the 767, where it was in the lesser position of a subcontractor.

In May 1991, Boeing signed an agreement with the members of JADC, allowed them to become participating partners in the design, manufacture, and testing of portions of the 777 airframe structure. The Japan Aircraft Manufacturing Co. and Shin Meiwa Industry Co. will act as prime subcontractors. JADC member companies will be responsible for 20 percent of the 777 airframe structure, including the majority of the fuselage panels and doors, the wing center section, the wing-to-body fairing, and wing spars and ribs.[53]

Boeing is also involved with projects in Taiwan and Russia. Taiwan's Industrial Technology Research Institute (ITRI) will invest $2-3 million to establish a new aerospace quality assurance test facility, and Boeing will advise ITRI on the procedures necessary to meet international certification standards.[54] ITRI envisions the facility as the core of its future Center for Aviation and Space Technology.[55] In addition, Boeing is involved in a joint venture with Russia's Central Aero-Hydrodynamics Institute to explore areas of aeronautics that may be mutually beneficial (see chapter 6 for further discussion). In addition, Boeing currently has two agreements with Deutsche Aerospace concerning an SST; one of these agreements includes McDonnell Douglas as a partner.

McDonnell Douglas Corp.

In 1981, McDonnell Douglas entered into a joint venture with NV Koninklijke Nederlandse Vliegtuigfabriek Fokker (Fokker) of the Netherlands for the development of an aircraft initially known as the MDF100.[56] In May 1982, Fokker withdrew from the arrangement because it was involved heavily in developing two of its own programs. However, during the development phase of the MDF100, McDonnell Douglas discovered the potential of the DC-9 wing, which with larger engines allowed the aircraft to be stretched to accommodate up to 150 seats.

Fokker's financial obligations for the MDF100 launch costs amounted to $1 billion, almost 70 percent of which came from public funds.[57] As with JADC government funds, Fokker was obligated to repay the monies as royalty on each aircraft sold before achieving a profit, and as a fixed share of total program profits after that point. Although the amount of technology transfer between Fokker and McDonnell Douglas was significant in the joint-development work on the wing applied to the Fokker 100, neither partner had planned to maximize the transfer of technology as in the case of the aforementioned Boeing-JADC agreement.[58]

McDonnell Douglas entered into a licensing arrangement[59] with the People's Republic of China (China). McDonnell Douglas signed an MOU with Shanghai Aviation Industrial Corp. on April 12, 1985,

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[52]—*Continued*
the market conditions it sought to address (anticipated high jet fuel prices) have not materialized.

[53] For the 777 program, about 260 Japanese personnel were working at Boeing in Seattle in 1991. The Japanese engineers (about 190) are learning to use Boeing's computer systems for the development of 777 subsystems. In 1992, Boeing established satellite communication links with its Japanese partner companies for computer data transmission concerned with the development of 777 subsystems. U.S. General Accounting Office, *Technology Transfer: Japanese Firms Involved in F-15 Coproduction and Civil Aircraft Programs* (GAO/NSIAD-92-178, June 1992), pp. 19-20. The installation of workstations in Japan was estimated to cost about $1.2 billion, with Japanese firms contributing 20-30 percent of the cost and Boeing funding the remainder. "Linked Systems," *Aviation Week & Space Technology*, Nov. 4, 1991, p. 15.

[54] "Boeing Expands Taiwanese Links," *Flight International*, July 15-21, 1992, p. 10.

[55] "Boeing to Build Quality Assurance Lab for Taiwan in Move Toward Closer Ties," *Aviation Week & Space Technology*, July 13, 1992, p. 33.

[56] Mowery, *Alliance,* p. 77.

[57] Nearly $700 million of this total was to be obtained from public funds: $326 million in credits and $367 million in guaranteed loans. "Industry Observer," *Aviation Week & Space Technology,* Sept. 21, 1981, p. 15 as cited in Mowery, *Alliance,* p. 78.

[58] Mowery, *Alliance,* p. 78.

[59] Licensing involves the transfer of know-how, patents, or trademarks from one company to another in return for a licensing fee or royalty. Licensing in this industry is most prevalent when a firm possesses a range of technological skills useful in a foreign market, the technology transfer costs are reasonable, the opportunity costs do not outweigh the benefits of licensing, and host-country licensing requirements are considered reasonable. Lopez and Vadas, p. 21, footnote 7.

for the assembly in China of 25 out of 26 MD-82s ordered by China. China ordered another 10 aircraft in April 1990, and an additional 20 in July 1992.[60] McDonnell Douglas recently signed an agreement with China for the production under license of 20 MD-80 and 20 MD-90 series aircraft, the so-called Trunkliner program, designed to provide China with a standardized air-transport fleet of up to 170 aircraft.[61]

Proposed Alliance with Taiwan

During the last 2 years, McDonnell Douglas' LCA division, Douglas Aircraft Co., has approached numerous foreign firms in hopes of gaining a strategic and/or financial linkup, initially to launch its MD-12 aircraft.[62] In November 1991, Douglas signed an MOU with Taiwan Aerospace Co. (TAC)[63] for the formation of a company provisionally called Douglas Global. The MOU proposed that Douglas sell up to a 40-percent share of its LCA company to TAC in return for up to $2 billion. McDonnell Douglas hoped to gain both increased market access to the Asian market and an infusion of cash with this deal. Opponents of the linkup were wary of the Taiwan Government's financial stake in TAC, and the possibility of transfer of U.S. technology and the loss of U.S. jobs.[64]

On May 18, 1992, TAC submitted a revised proposal that did not include an equity infusion for Douglas. This proposal committed TAC to build parts for the MD-12 and to form a new leasing company that would be one of the launch customers for the MD-12. It called for the leasing company to place firm orders for up to 20 MD-12s if McDonnell Douglas could secure an airline launch order for 30 aircraft. The orders were to be backed with letters of credit for up to $2.5 billion from the state-owned Bank of Taiwan, against which McDonnell Douglas could borrow the estimated $4.5 billion needed to fund the development of the MD-12. In return, McDonnell Douglas would award offset contracts to TAC to manufacture the MD-12 wing and fuselage at a new $1 billion production center in Taiwan. TAC also offered to take convertible debentures in McDonnell Douglas, which could be exchanged for an equity stake after perhaps 2 years.[65] At present, McDonnell Douglas is not actively considering the proposal.[66]

Suppliers

General Electric

In 1974, GE and Société Nationale d'Etude et de Construction de Moteurs d'Aviation (SNECMA)[67] of France formed the joint engine manufacturing company CFM International, Inc. (CFM). CFM produces aircraft engines for both the Boeing 737 and Airbus A320.[68] As of December 31, 1992, CFM engines were on 15 percent of global LCA,[69] and on over 50 percent of aircraft having 100-200 seats.[70] GE is teamed with SNECMA, Motoren- und Turbinen-Union (MTU) of Germany, and Japanese manufacturers on its GE-90 program to produce an engine that will first appear on the Boeing 777.

[60] *Jane's All the World's Aircraft, 1992-93* (London: Jane's Information Group Ltd., 1992), p. 411.

[61] Bruce A. Smith, "Commercial Strategy for Douglas," *Aviation Week & Space Technology,* Feb. 22, 1993, p. 25.

[62] The MD-12 is designed to be a long-range, high-capacity (400-600 seat) LCA. Its current four-engine configuration was announced in April 1992.

[63] TAC was established on September 27, 1991 as a foundation for Taiwan's civil aircraft industry. The Taiwan Government holds 29 percent of TAC's equity, providing start-up capital of $200-250 million. The Taiwan Government is able to increase its holding up to a maximum of 45 percent under TAC's charter. TAC will endeavor to develop Taiwan's capability in the production of aircraft, engines, avionics, and materials.

[64] "Taiwan Aerospace Waffling on Taking Stake in MD-12," *Aviation Week & Space Technology*, May 25, 1992, p. 26.

[65] "Taiwan Aerospace Seeks MD-12 Rethink," *Flight International,* May 27-June 2, 1992, p. 5.

[66] McDonnell Douglas Corp. official, telephone interview by USITC staff, July 26, 1993.

[67] SNECMA is wholly-owned by the Government of France.

[68] GE is responsible for design integration, the core engine (derived from the F101 turbofan developed for the U.S. military), and the main engine controls. SNECMA is responsible for the low-pressure system, gearbox, accessory integration, and engine installation. *Jane's*, p. 638; and SNECMA officials, interview by USITC staff, Paris, Nov. 5, 1992.

[69] Boeing, *World Jet Airplane Inventory,* p. 22.

[70] Ibid., p. 22; SNECMA officials, interview by USITC staff, Paris, Nov. 5, 1992.

Pratt & Whitney

Pratt & Whitney is a member of International Aero Engines, Inc. (IAE), a consortium of global aircraft engine producers. Pratt & Whitney and Rolls-Royce each have a 30-percent equity in IAE, while Japanese Aero Engines Corp.[71] has 19.9 percent, MTU 12.1 percent, and Fiat of Italy 8 percent. The IAE V2500-series engine, currently available on the Airbus A320 and A340, has captured a 35-percent share of all A320 deliveries;[72] it will be offered on the McDonnell Douglas MD-90 when that aircraft is certificated. Each non-U.S. member of IAE used public funds to develop this engine.[73] Pratt & Whitney also has an agreement with MTU and the Russian Ministry of Civil Aviation to develop and coproduce engines for two Russian passenger aircraft.

Relationship of U.S. LCA Industry to Military Aircraft Industry

During the 1960s and 1970s, U.S. LCA producers manufactured modified versions of their civil aircraft for the U.S. military. For example, Boeing reconfigured its model 707 airframe in the late 1970s by incorporating sophisticated radar and communications systems to create the U.S. Air Force's E-3, or Airborne Warning and Command System (AWACS).[74] Similarly, McDonnell Douglas converted its DC-10 LCA into a combination cargo carrier and tanker, the KC-10, for the Air Force in the late 1970s. For the U.S. military, these modified LCA proved to be economical alternatives to the purchase of an aircraft specifically designed for their needs. For the U.S. manufacturers, the military adaptation of these aircraft provided for an extended production run. The European Community (EC) has claimed that work performed by U.S. LCA producers on the U.S. military's heavy lift requirement in the late 1960s, which eventually produced Lockheed's C-5 Galaxy, enabled Boeing, Lockheed, and McDonnell Douglas to gain expertise necessary for the development of their wide-body aircraft.[75] As discussed in chapter 5, the relationship of the military to global LCA manufacturers is being explored by the U.S. Government and the European Commission in the context of defining indirect subsidies under the 1992 U.S.-EC bilateral agreement that limits direct and indirect subsidies.

Strengths of the U.S. LCA Industry

The U.S. LCA industry includes all phases of production, from suppliers of small components, to major subassembly producers, to the final LCA manufacturers. Boeing and McDonnell Douglas assemble the entire aircraft, whereas individual Airbus Industrie partners concentrate only on major sections, with final assembly primarily done by one partner. In addition, the U.S. companies have faster and more streamlined decision-making capabilities regarding product lines than does a less integrated firm such as Airbus.

Because U.S. manufacturers have been supplying the LCA market longer than Airbus, they benefit from the advantages associated with incumbency and dynamic economies of scale, including increased productivity and decreased unit costs. Since 1975, the U.S. global market share of LCA orders, deliveries, and backlog has never dropped below 60 percent (see figures 2-1, 2-2, and 2-3).

As indicated in chapter 6, the U.S. aerospace research and development (R&D) infrastructure and funding is extensive. This infrastructure and funding principally has been geared toward the U.S. Government's aerospace R&D needs. One component of aerospace R&D is aeronautical R&D, or research conducted on aircraft. Since R&D on basic aeronautical (vs. aerospace) concepts can be common to both military and civil aircraft, it is likely that historically, some of the funds spent on aerospace R&D also assisted U.S. LCA producers in civilian programs. Although the amount of this assistance is speculative, nonetheless it has benefited the U.S. civil aircraft industry.

71 Japanese Aero Engines Corp. is a consortium of Ishikawajima-Harima Heavy Industries, Kawasaki Heavy Industries, and Mitsubishi Heavy Industries.

72 SNECMA officials, interview by USITC staff, Paris, Nov. 5, 1992.

73 Mowery, *Alliance,* pp. 93-94.

74 Boeing also used this airframe for its model E-6A TACAMO, which had a 75-percent commonality with the AWACS, for the U.S. Navy. Boeing's 767 is currently being considered as the replacement airframe for this mission, as the 707 production line was officially closed in 1992.

75 Arnold & Porter, *U.S. Government Support of the U.S. Commercial Aircraft Industry*, prepared for the Commission of the European Communities (Washington, DC: Nov. 1991), pp. 19-32.

Western Europe

This section reviews the historical development of the West European LCA industry and the relationship of military manufacturers to LCA manufacturers. It then discusses the strengths of the West European LCA industry.

Historical Development of the West European LCA Industry

Principal Manufacturers Post-1945

After 1945, the West European LCA industry comprised principally British and French manufacturers, including Bristol, de Havilland, Hawker, Saunders Roe, and Vickers of the United Kingdom, and Nord Aviation, Sud-Est Aviation, and Bréguet of France. Western Europe was the pioneer of jet transports. The Comet 1, powered by jet engines and developed by de Havilland Aircraft Co., first flew on September 25, 1945. However, it suffered from an unknown structural flaw, later diagnosed as metal fatigue.[76] Although sold through the mid-1960s, it was never able to capitalize on its first mover advantages (see chapter 4). The world's airlines preferred to buy the nearly twice as large, faster (by about 40 mph) Boeing and Douglas jet transports offered in the late 1950s.[77]

France developed the first narrow-body twin-jet aircraft in the world, Sud Aviation's 64-seat, 485-mph Caravelle. The Caravelle went into commercial service on April 26, 1959. Although popular with West European airlines, it met with limited success in the United States because of the lack of adequate after-sales support from both the airframe manufacturer and Rolls-Royce, the engine manufacturer.[78] During this period, West European firms did not have the commercial success in the global market that was warranted by their technological sophistication, allowing U.S. firms to capitalize on both first-mover advantage and the size of their home market.

Principal Cooperative Programs

Concorde

During the early 1960s, in response to the success of U.S. firms in the global marketplace, the Governments of the United Kingdom and France were determined to establish a successful West European aircraft program. The British and French groups decided to codevelop an SST, which became known as the Concorde.[79] The costs for such a program were recognized to exceed substantially those of any previous civil aircraft program. Primary contractors were Sud Aviation and SNECMA of France, and the British Aircraft Company (BAC) and Bristol Siddeley Engines of the United Kingdom. The program officially was launched in 1963 to produce a long-range, 100-seat, Mach 2 airliner,[80] with an order of six aircraft from Pan American World Airways. West European interest in the project heightened with the announcement of the U.S. Government's interest in developing a U.S. SST program, and the discovery that the Soviet Union also was working on an SST.[81]

The Concorde made its first flight on March 2, 1969; it had no competitors when the U.S. Government cancelled the U.S. SST program in 1971. However, two problems depressed future orders for the Concorde—(1) the limited segment of the U.S. market it was allowed to serve; and (2) the poor financial state of the airlines at the time of its introduction.[82] U.S. environmental concerns greatly reduced the number of cities the Concorde could serve; this limited access restricted the Concorde to a market that was too small to provide adequate financial returns for the airlines. The Concorde also was available shortly after most major world airlines

[76] Comet's metal fatigue was brought on by the cycle of pressurization and depressurization as the aircraft climbed to and descended from its cruising altitude of 30,000 feet, higher than the altitude flown by LCA of the period. Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2, 1992.

[77] Schrader, p. 12. Vickers, the other principal British jet-powered LCA manufacturer, produced its VC-10, a long-range aircraft with four Rolls-Royce turbofan engines attached at the rear of the fuselage; 54 were delivered during 1964-70.

[78] Newhouse, p. 123. United Airlines was the only U.S. carrier to operate Caravelles, purchasing a fleet of 20. Airlines that did not buy the aircraft also

[78]—*Continued*
noted the lack of desire on the part of the airframe manufacturer to custom-build interiors for them, and the cost of maintaining the Rolls-Royce engines.

[79] Steiner, p. 17.

[80] Mach 2 is twice the speed of sound, or 1,350 nautical mph.

[81] Newhouse, p. 124.

[82] Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2, 1992.

had borrowed heavily to purchase wide-body aircraft for the projected passenger market.[83] The Concorde became a financial disaster for its manufacturers, with a production run totaling 16 aircraft.[84]

Airbus Industrie, G.I.E.

In 1964, the British Government oversaw the formation of the Plowden Commission, which was charged with explaining the competitive problems of the British civil aircraft industry. The Commission issued a report in December 1965, finding that the United Kingdom's limited industrial base and relatively small domestic market for aircraft, in contrast with the broader U.S. industrial base and comparatively huge domestic market, had hindered the development of the British industry.[85] The Commission observed that the cost of building an airplane was 10 to 20 percent lower in the United States than in the United Kingdom because longer production runs allowed U.S. companies to absorb "learning costs" more rapidly.[86] The report also stated that the U.S. industry was three times more productive than the British industry, which was also found to be less productive than the French industry.

By 1966, the Governments of France, Germany, and the United Kingdom had fostered discussions among their leading aerospace companies, having decided that they would not permit their airframe manufacturing industries to cease operation in the face of increasingly popular U.S. designs. Work on a West European LCA competitor for U.S. LCA had begun independently in each country. In the United Kingdom, Hawker Siddeley Aviation and BAC began separate studies. Both Bréguet and Nord in France also began work on preliminary plans to produce an LCA, and German companies ATB Siebelwerke, Bölkow, Dornier, Flugzeug-union Süd, HFB, Messerschmitt, and VFW formed Studiengruppe Airbus to collaborate on an LCA design.[87] The discussions led to the formation of a cooperative organization, to be Airbus Industrie, G.I.E. The United Kingdom and France were each to have a 37.5-percent share, and Germany a 25-percent share. The organization began plans to produce an LCA; Rolls-Royce was to be the engine of choice,[88] in return for French-owned Aérospatiale's[89] leadership in the design of the aircraft. However, when Rolls-Royce decided to supply the engine for Lockheed's L-1011, it relinquished its position on the proposed aircraft, having reached its own funding and staffing limitations. In 1969, the United Kingdom withdrew from the consortium. Hawker Siddeley Aircraft, then a private firm, continued to participate in the organization as a risk-sharing subcontractor responsible for the design and fabrication of the wing for the new aircraft, to be called the A300. The Governments of Spain and the Netherlands together contributed over 10 percent of the development costs for the A300. In addition, Belairbus of Belgium and VFW-Fokker, a German subsidiary of Fokker-VFW of the Netherlands, participated as prime subcontractors, but not as risk-sharing partners.[90]

On December 18, 1970, Airbus Industrie, G.I.E. formally began operations, with Aérospatiale of France and Deutsche Airbus (a cooperative venture

[83] The projected rise in passenger travel failed to materialize; subsequently, airlines suffered from overcapacity.

[84] "The Concorde program was terminated as the market could not substantiate its economics." Steiner, p. 17.

[85] "Report of the Committee of Inquiry into the Aircraft Industry," (London: Her Majesty's Stationery Office, December 1965), p. 3., as cited by Newhouse, p. 124.

[86] Newhouse, p. 124.

[87] Bill Gunston, *Airbus* (London: Osprey Publishing Ltd., 1988), pp. 13-14.

[88] The British Government acquired a 75-percent share in the all-new RB 207 engine, with Germany and France each accounting for 12.5 percent.

[89] Aérospatiale was formed through the merger of Nord Aviation, Sud-Est Aviation, and SEREB on January 1, 1970. *Jane's,* p. 58. It is currently being considered for privatization. William Drozdiak, "France to Sell Its Control in 21 Key Firms," *Washington Post,* May 27, 1993, p. A-1. However, officials of Aérospatiale and the French Transport Ministry have indicated that privatization is not likely to occur until 1995 or 1996 because of the company's current debt situation and the continuing weaknesses in economic conditions throughout the world.

[90] On December 18, 1970, the Dutch Government took a 6.6-percent shareholding in the A300B program, cutting the French and German shares from 50 to 46.7 percent each. Belairbus is a consortium composed of the Belgium Government (one-third), the Walloon (Flemish) development authority (one-third), and an industrial group comprising SONACA (formerly Avions Fairey), FN (Fabrique Nationale Herstal) and Asco, and engineering company (one-third). Gunston, pp. 29, 92.

between Messerschmitt-Bölkow-Blohm (MBB)[91] and VFW-Fokker) as the major partners. Airbus was headquartered in Paris, with design responsibilities in Toulouse, France. Construcciones Aeronáuticas S.A. (CASA) of Spain joined on December 23, 1971. British Aerospace plc (BAe)[92] eventually became a partner on January 1, 1979, at which time the ownership was split as follows: 37.9 percent Aérospatiale and Deutsche Airbus; 20 percent BAe; and 4.2 percent CASA.

Airbus' A300 design was influenced by events in the United States. As discussed earlier, during the late 1960s, U.S. manufacturers introduced jumbo jets, which were intended to be long-range commercial transports seating 250-350 passengers. Airbus had initially decided to produce a short-range, wide-body, twin-engine 300-seat aircraft. However, with the announcement of the U.S. jumbo jets, the Airbus design was reduced to approximately 250 seats to avoid direct competition with U.S. LCA.[93] The A300 program faced no similar twin-engine competitor, had the financial backing of many West European governments, and provided a base for West European aerospace industry expansion.

The A300 was followed in July 1978 by the launch of the A310,[94] a 218-seat aircraft capable of flying over 3,800 nautical miles (nm).[95] Each of these aircraft found market niches not addressed by Boeing or McDonnell Douglas. These products, however, have not generated large-scale demand. A total of 418 of these aircraft had been delivered as of December 31, 1992.[96]

The A320, a direct competitor to the Boeing 737 and the McDonnell Douglas MD-80 series, was launched in 1984. Its launch served to generate a 3-year increase in West European market share (orders) and a corresponding decrease in U.S. market share. The A320 flies over 2,800 nm with 150 passengers;[97] as of December 31, 1992, 362 of these aircraft had been delivered.[98] Four additional aircraft have been launched by Airbus, as of June 1993; the A319, A321, A330, and the A340. The A330/340 program was launched in June 1987 to produce two similar large-capacity, wide-body aircraft that would compete with McDonnell Douglas' MD-11 and extended-range models of Boeing's 767. The first deliveries of the A340 began in March 1993, with deliveries of the A330 scheduled during December 1993.[99] The A319 and A321 are smaller and larger variants of the A320. The A321 was launched in November 1989; it will transport 186 passengers 2,300 nm,[100] while the A319, launched June 1993 at the biennial Paris Air Show, will transport 124 passengers 2,000 nm.[101] It will be smaller than the A320, and compete with Boeing's 737-500, Avro's RJ115, and Fokker's F-100. The A319 is expected to enter service in mid-1996.[102]

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[91] During 1967, MBB joined a limited liability management company, Deutsche Airbus GmbH, along with five other German aerospace companies. MBB emerged in 1969 as the pre-eminent German firm of this group, which, along with several German states and the German Federal Government, proposed to participate in the Airbus consortium after the United Kingdom declined to participate. In 1989, MBB was sold to Daimler-Benz, along with other German Government holdings, and Deutsche Aerospace was formed. Part of the plan for privatization included a foreign exchange support scheme, later found by a General Agreement on Tariffs and Trade (GATT) panel to be contrary to GATT regulations (see chapter 5 for further discussion). McIntyre, p. 68.

[92] In 1977, British Aircraft Corp. (Holdings) Ltd., Hawker Siddeley Aviation Ltd., and Scottish Aviation Ltd. were nationalized to form BAe. BAe was privatized in 1981; however, the British Government held one "special" share to ensure that BAe would remain under British control. At present, BAe manufactures the majority of all Airbus aircraft wings.

[93] The emergence of the larger-sized planes (McDonnell Douglas' DC-10 and Lockheed's L-1011) caused the A300 to be scaled down by about 50 seats. Steiner, p. 27.

[94] The A310 uses the same fuselage cross-section as the A300; however, its engines and wing are dissimilar.

[95] *Jane's,* p. 92. Subsequent models are able to fly over 4,200 nm.

[96] Airbus Industrie of North America, Inc. officials, telephone interview by USITC staff, Feb. 1993.

[97] *Jane's,* p. 95.

[98] Commission of the European Communities, *The European Aerospace Industry: Trading Position and Figures, 1992* (Brussels: Commission of the European Communities, Mar. 1, 1992), p. 31.

[99] Airbus Industrie of North America, Inc. official, telephone interview by USITC staff, July 16, 1993.

[100] *Jane's,* p. 95.

[101] Airbus Industrie, *Product Line Review* (Blagnac, France: Airbus Industrie, Marketing Division, August 1992).

[102] Airbus Industrie of North America, Inc., *Insiders Report,* June 1993, front page.

At present, there are three West European manufacturers of LCA: Airbus, Avro International Aerospace, Ltd. (Avro),[103] and Fokker.[104] Avro and Fokker independently produce LCA under 120 seats, and also participate in Airbus programs. Together, they typically accounted for less than 10 percent of the global LCA market during 1980-91.[105]

Between 1952 and December 31, 1992, West European LCA manufacturers had delivered 18 percent, or 2,405 units, of all civil jet transport aircraft since 1952.[106] During 1984-92, Airbus captured 75 percent of all West European orders (1,496 out of 2,001) and 14 percent (415 out of 2,889 aircraft) of total U.S. orders.[107] Airbus took a significant share of the global market for narrow-body aircraft during 1985-92, largely because of the introduction of the A320. Orders (and deliveries) of Airbus aircraft increased greatly after 1983, from 10 (36) units in 1983 to over 135 (157) LCA in 1992.[108]

New West European producers of LCA likely would come from joint venture or merger efforts among the existing airframe manufacturers. Deutsche Aerospace's acquisition of a controlling interest in Fokker is such an example. Deutsche Aerospace likely will gain global marketing and support experience as a result of this move, while Fokker will receive a cash infusion. Deutsche Aerospace also had been negotiating with the ATR consortium, comprising Aérospatiale and Alenia (Italy), concerning the production of a series of jet transport aircraft. However, the merger with Fokker could offer an opportunity for ATR to become members of the new Deutsche Aerospace-Fokker entity.

Suppliers of Primary Aircraft Subcomponents

At present, Rolls-Royce and SNECMA (through the CFM joint venture)[109] are the sole West European suppliers of civil aircraft engines to the global LCA industry. Rolls-Royce produces a range of military and civil turbine engines, and has agreements with several world producers of aircraft engines, notably IAE and Bavarian Motor Werke (BMW) of Germany. Rolls-Royce engines powered 11 percent of the world LCA fleet as of December 31, 1992.[110]

The West European aircraft support industry (parts, subcomponents, engines, and fuselage manufacturers) has been rationalized, primarily in response to the needs of Airbus, but also because of cuts in military spending. New West European suppliers have supplanted the historical dependence of Airbus on U.S. suppliers in the areas of avionics and systems.[111] Several countries have developed specialties: for example, the United Kingdom in aircraft wings and systems assemblies, Spain in fuselage and tailplane assemblies, and Germany in aircraft systems and fuselage assemblies.[112]

Relationship of West European LCA Industry to Military Aircraft Industry

The three Airbus major partner companies rely more heavily on military sales for revenues than does Boeing but less than does McDonnell Douglas. In 1992, Boeing and McDonnell Douglas non-civil sales amounted to 18 and 56 percent, respectively, of total revenue.[113] In 1992, Aérospatiale space and defense sales amounted to 26 percent of total revenues,[114]

103 Avro was formed on January 19, 1993 through an agreement between BAe and TAC. Avro will assume production of the BAe 146 successor, which has evolved into the RJ-series of LCA.

104 Fokker was recently acquired by Daimler-Benz of Germany, parent of Deutsche Aerospace.

105 *The European Aerospace Industry,* p. 26.

106 West European LCA captured 21 percent (3,373 units) of total worldwide orders of 15,730 for the period 1947-91. Boeing, *World Jet Airplane Inventory*, p. 12-13.

107 Ibid., p. 12.

108 Ibid., p. 28.

109 See the discussion of General Electric under Suppliers in the section on Role of Risk-Sharing in the Development of LCA.

110 Boeing, *World Jet Airplane Inventory*, p. 22.

111 U.S. content in Airbus aircraft has decreased with each model, and ranges from approximately 30 percent on the A300 to about 10 percent on the A330. Renee Martin-Nagle, corporate counsel, posthearing submission on behalf of Airbus Industrie, G.I.E. and Airbus Industrie of North America, Inc., p. 2.

112 West European LCA, engine, and aerospace association officials, interviews by USITC staff, Nov. 2-13, 1992.

113 The Boeing Co., 1992 Annual Report; and McDonnell Douglas Corp., 1992 Annual Report.

114 Aérospatiale, 1992 Annual Report. Note: These figures do not capture Aérospatiale's military production in the areas of avionics and military aircraft upgrades.

whereas the BAe and DASA non-civil sales accounted for 40 and 21 percent, respectively, of total sales.[115] West European countries usually have one domestic source for military aircraft, which increases the bargaining power of the firms in negotiating contracts with their governments. This high reliance on military sales and limited domestic competition have led to an accelerated aircraft design and production capability, which in turn has enabled these companies to develop skills more rapidly than if they had not had military programs. Western Europe's military aircraft manufacturers also export a higher percentage of their production than do U.S. manufacturers, in part because of their relatively smaller domestic market.[116]

Strengths of the West European Industry

Airbus Product Strategy

The Airbus strategy emphasizes design commonalities among planes, and aggressive use of advanced technology, which is then applied to older models.[117] The financial and political participation of the West European governments in the West European LCA industry is also an enormous advantage relative to the situation of its competitors.[118]

Airbus has made commonality a cornerstone of its approach to both design and marketing; industry sources indicate that Airbus identified commonality as a strategic marketing issue sooner than did Boeing or McDonnell Douglas. However, in the pursuit of commonality, Airbus has had to weigh the benefits of commonality against the introduction of new technology on its aircraft.[119] For example, Airbus changed the cockpit layout from a three-person to a two-person design when it moved from the A300 to the A310, and then made the subsequent A300-600 cockpit identical to that of the A310, causing a period of adjustment and cost for operators of the older A300s.

Airbus Marketing Strategy

Airbus had to offer something distinct from U.S. competitors to overcome the enormous reluctance of airlines to incur the costs of switching to a new supplier with no track record.[120] Thus, it has offered advanced technology in aerodynamics, materials applications, and aircraft systems, such as its use of computers to assist both flight controls and to monitor aircraft service needs. Drawing on National Aeronautics and Space Administration (NASA) aerodynamics research, Airbus has made its wings (currently the fourth generation on the A330/340) less swept and more slender, thereby pushing out farther the point at which the airflow becomes supersonic. Airbus has been rather aggressive in its research and application of new materials (e.g., composites in primary structures such as the vertical fin and control surfaces), to reduce both weight and parts numbers. Airbus also has drawn on NASA work in this area, and has applied that work more extensively than have U.S. manufacturers.[121] Besides pioneering the wide-body twin with a forward-facing, two-person cockpit, Airbus has led in applying certain safety-oriented systems, such as an advanced automatic landing system (with U.S. Federal Aviation Administration-certified category III capability, which is the most demanding category of such systems), automatic windshear protection, and digital flight management, especially fly-by-wire[122] and sidestick

[115] British Aerospace, 1992 Annual Report; and Deutsche Aerospace, 1992 Annual Report. Note: DASA figures do not capture its participation in military aircraft production, and include expenditures on some civil radio and environmental monitoring systems.

[116] Office of Technology Assessment, *Competing Economies: America, Europe, and the Pacific Rim* (Washington, DC: Congress of the United States, 1991), p. 357.

[117] March, p. 8.

[118] "Affordability has different meanings to differing political or societal structures. Nowhere is this more aptly demonstrated than by the European value judgments in the decisions that initially funded the Airbus development and then provided the 'staying power' to sustain Airbus through its first six years with less than 30 orders booked and only 13 deliveries." Steiner, p. 27.

[119] March, p. 35.

[120] Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2, 1992.

[121] March, p. 35.

[122] Fly-by-wire refers to the use of computer-actuated electronic servo motors in place of hydraulic actuators used in moving an aircraft's control surfaces. This technology decreases weight in the aircraft through deletion of some/all of the hydraulic flight control systems/plumbing, and can create a computerized record of operation, which can be accessed by ground support crews either on the ground or while the aircraft is in flight. Fly-by-wire was first installed on the Concorde. *Countdown,* no. 32 (Blagnac, France: Airbus Industrie Product Marketing), p. 4.

control. Digital flight management and windshear protection together inhibit the ability of the aircraft to go outside its flight envelope (overspeeding, excessive pitch attitudes, stalling), as well as making it easier to fly the aircraft to its limits.[123]

Government Direct Support

Airbus partner governments have supplied loans and grants for both nonrecurring product development costs and recurring production costs.[124] Repayment of these low-cost loans is contingent on a revenue stream from the program.[125] The tremendous risks and outflows prior to the break-even point are borne primarily by West European governments, rather than by private industry (see chapters 5 and 6 for further discussion).[126]

Commonwealth of Independent States[127]

This section provides an overview of the historical development of the Commonwealth of Independent States (CIS) LCA industry, reviews structural changes in the industry, and briefly examines the role of risk sharing in the development of CIS LCA manufacturers and suppliers.

Historical Development of the CIS LCA Industry

Russian aircraft have been designed and developed differently from Western-made aircraft. Prior to the recent economic reforms of the region, Aeroflot, the official Soviet air carrier, would submit a request for a new aircraft type to the Soviet Ministry of Civil Aviation, and the Ministry would decide whether such an aircraft was needed. If so, the Ministry would request designs from Soviet design bureaus to meet the proposed mission. A design bureau was typically composed of a Central Design Bureau (TsKB) in Moscow and experimental design bureaus (OKBs) throughout the republics.[128] The TsKBs of each design bureau performed feasibility studies, determined the type of aircraft necessary, and investigated the new technologies (e.g., structures, engines, and avionics) that would be needed. They also specified what standardized componentry was to be used by the OKB on the aircraft. A design was chosen from among those submitted by the various TsKBs to the Ministry; it was then reviewed by the Central Aero-Hydrodynamics Institute (TsAGI)[129] for airframe strength and aerodynamic efficiency. Once TsAGI gave its preliminary approval, a prototype was developed and tested for airworthiness in flight and on the ground by both TsAGI and the TsKB. When these tests were completed and approved by the Ministry of Civil Aviation, TsAGI, and Aeroflot, the TsKB sent the design to its OKB. The OKB performed the detailed design and development of the aircraft, interpreted specifications for a new aircraft, and produced prototypes that conformed to the TsKB's specifications.

After the prototype was accepted by Aeroflot and TsAGI, the design bureau would authorize one of several serial production facilities[130] to build the aircraft in large numbers. Serial production facilities are in Ulyanovsk, Samara, Kazan, Saratov, and Voronezh in Russia; Tashkent in Uzbekistan; and Kharkov and Kiev in Ukraine. These factories were built primarily in the 1930s; the exception is the facility in Ulyanovsk, which began production in 1977. The facilities had no legal tie to any of the design bureaus; each bureau had its preferred facility, but placed work at several of the sites at the

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[123] March, p. 35.

[124] Gellman Research Associates, Inc. for the U.S. Department of Commerce, *An Economic and Financial Review of Airbus Industrie* (Jenkintown, PA: Sept. 4, 1990), p. 2-5.

[125] Ibid., p. 2-6.

[126] BAe, for instance, sought $725 million from the British Government to design and develop a new common wing for the A330/340. These monies will fund some of the flight testing and most of the wing tooling as well. David A. Brown, "British Aerospace Seeks to Produce A330/340 Wing," *Aviation Week & Space Technology,* Feb. 10, 1986, pp. 49-50, as cited by March, p. 18.

[127] Information for this section was derived primarily from USITC staff interviews with Russian designers and test facility officials, Moscow, Nov. 16-20, 1992.

[128] The TsKB performed many of the functions of a Western company's advanced design department. Design bureaus are located predominantly in Moscow.

[129] See chapter 6 for further discussion.

[130] Serial production facilities are manufacturing complexes that produce validated aircraft designs for both civil and military use.

direction of the Ministry. Over time, however, certain facilities became linked with certain bureaus, for example, Ilyushin with facilities in Voronezh, and Tupolev with those in Ulyanovsk.

The former Soviet Government provided funds for the entire development and production process, and told the production facilities the annual quantity (typically, 10 to 20 LCA) they were required to produce and the level of revenue over costs they could expect. A typical contract between Aeroflot and the production facilities involved the payment of 85 percent of the value of the aircraft on delivery to Aeroflot, with the remaining 15 percent paid over an agreed-upon time after the aircraft had been placed in service. This type of contract differs from that offered by Western LCA manufacturers, who typically require 100 percent of the agreed-upon price by delivery.

Structural Changes in the CIS LCA Industry

Changes in the political and economic system of the former Soviet Union have affected significantly the CIS LCA industry. Whereas formerly the industry was guaranteed a certain level of revenues from sales to Aeroflot, the design bureaus and the serial production facilities now must compete with Western aircraft for these sales. Therefore, revenues are no longer ensured by the government. The design bureaus have been affected significantly, because the only "products" they sell are the design and development of the aircraft. The serial production facilities, in contrast, sell the aircraft they produce directly to the customer, and are not obligated to pay the design bureaus a fee per aircraft. However, both the design bureaus and the serial production facilities are realizing the importance of mutual partnership, and are moving in that direction.

Principal CIS LCA producers include Ilyushin, Tupolev, and Yakovlev in Russia, and Antonov in Ukraine. Ilyushin, Tupolev, and Yakovlev have supplied the majority of LCA in the region comprising the former Soviet bloc, and continue to be the major sources of LCA for the CIS. Other sales of Russian LCA have occurred in Iraq, Libya, Syria, and Cuba. All CIS design bureaus have designed and developed both military and civil aircraft. During 1970-92, combined estimated LCA deliveries of Ilyushin and Tupolev peaked at 90 units in 1979-80 (figure 2-4).[131]

Producers

The Ilyushin Design Bureau (the Aviatsionnyi Kompleks Imeni S.V. Ilyushina), founded in 1933, produced designs that led to the production of about 60,000 aircraft through early 1992.[132] Current products[133] developed by Ilyushin include the IL-78MD, a cargo aircraft; the IL-86, a medium-range transport seating up to 259 passengers; the IL-96-300, successor to the IL-86 (a 235-300 seat long-range aircraft); and the IL-96M, a stretched version of the 96-300, which incorporates Pratt & Whitney engines and Collins (U.S.) avionics. On June 16, 1993, Pratt & Whitney announced that the Dutch aircraft leasing company Partnairs ordered 10 IL-96Ms (5 firm, 5 option), which represents the first order of the aircraft.[134]

The Ilyushin Design Bureau and the serial production facility at Voronezh have formed the Ilyushin Aircraft Association. The Association provides the participants a chance to interact and discuss matters of mutual benefit and concern. Should the participants decide to form a company, the firm would likely consist of the design bureau and facilities at Voronezh and Tashkent, with the possibility of including up to six other facilities.[135]

The Tupolev Design Bureau, founded in 1929, designed the Tu-154 (a medium- to long-range aircraft with 154-180 seats) and its successor, the Tu-204, with 190-214 seats. The Tu-204 is equipped with either Russian (Perm/Soloviev PS-90AT) or Western (Rolls-Royce) engines, the first non-Western aircraft to use Western engines. Tupolev also is developing the Tu-334, an 86-102 seat, medium-range airliner, to replace the Tu-134.

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[131] Deliveries data are not available for Yakovlev.

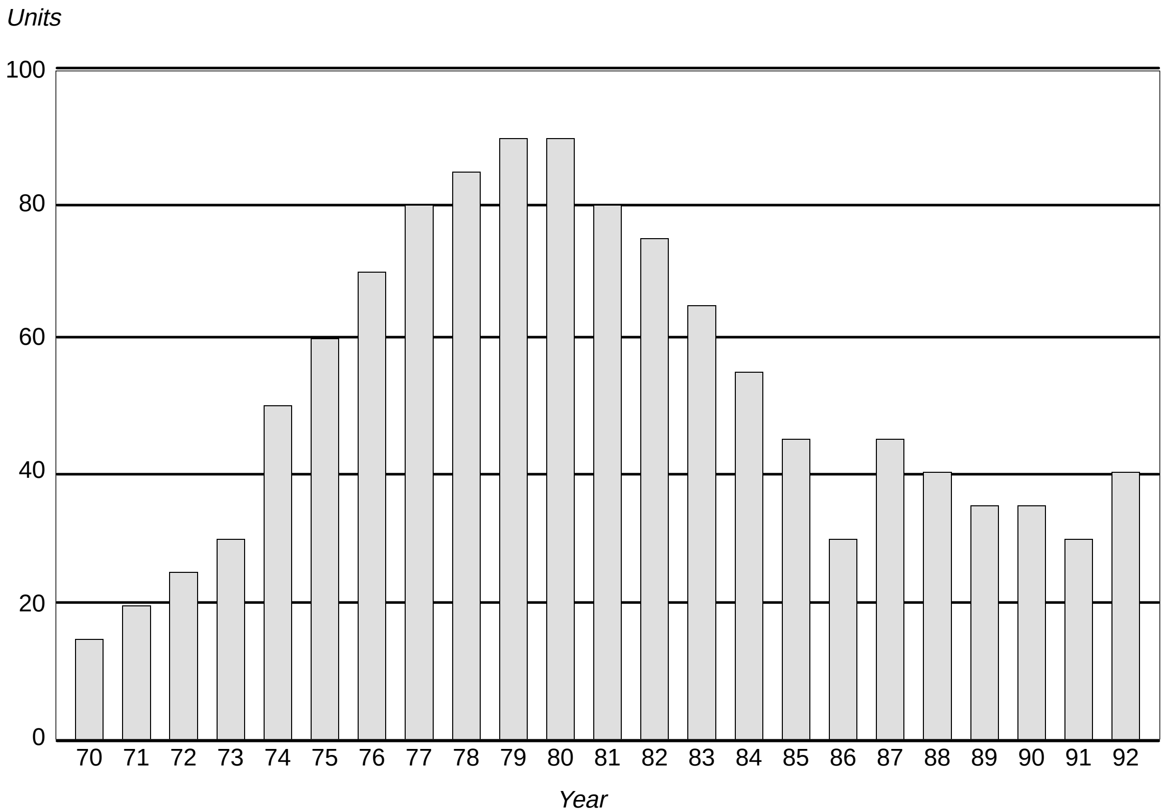
[132] Ilyushin Design Bureau officials, interviews by USITC staff, Moscow, Nov. 16-20, 1992; and *Jane's,* p. 199.

[133] Current products of Airbus, Boeing, and McDonnell Douglas are presented in chapter 3, fig. 3-1.

[134] "The Jumboski Option," *The Economist,* June 19, 1993, p. 72.

[135] Ilyushin Design Bureau officials, interview by USITC staff, Nov. 17, 1992.

Figure 2-4
Russian LCA deliveries, 1970-92



Source: U.S. Government estimates. Aircraft delivered include Ilyushin IL-62, IL-86, and IL-96; Tupolev Tu-154, and Tu-204.

During 1992, Tupolev and the serial production facility in Ulyanovsk formed Aviastar,[136] a joint venture designed to act as a coordinating body between the two to produce, market, and support the Tupolev Tu-204 aircraft. However, the overall strategy of this venture is unclear, as Tupolev also plans to sell this aircraft separately from, and in competition with, Aviastar. Aviastar has announced that it has launch orders for up to 15 Tu-204s from 3 airlines in the CIS;[137] deliveries of these aircraft are scheduled to begin in mid-1994. Both Aviastar and Tupolev see a potential Western market of up to 250 aircraft, which will be developed partly through pricing the aircraft at 30 percent below that of the somewhat comparable Boeing 757, due to the projected lower cost of manufacturing inputs.[138]

Heretofore, CIS aircraft have not been sold in any quantity to market economies, as they have not been certificated to Western standards.[139] Other problems with CIS aircraft include a lack of ground support equipment (tools and airport terminal facilities), parts and technical support, and reliability. Tupolev is

[136] Antonov of Ukraine may also become a partner in this alliance. Currently, Antonov's civil production is limited to a cargo transport, the AN-124, and the largest aircraft in the world, the AN-225. *Jane's*, p. 280.

[137] Ian Verchere, "Rolls-Powered Tu-204 Jet Gets Orders from CIS," *Commercial Aviation News,* Feb. 15-21, 1993, front page.

[138] The Tu-204 will carry the same number of passengers over a shorter range than Boeing's 757. "Russian Tupolev Tu-204 Featured in Clearance Sale Outside of CIS," *Commercial Aviation News,* Feb. 15-21, 1993, p. 28.

[139] The U.S. Federal Aviation Administration is examining Russian airworthiness standards, testing procedures, and methods of production, with the goal of offering reciprocal recognition of certificates for airworthiness. This would then allow Russian aircraft certification to be recognized throughout the world.

using Western engines and avionics to overcome the global mistrust of Russian engines, and to counteract the general perception of the unreliability of Russian LCA. Through this initiative, Tupolev is taking advantage of the Western airline infrastructure in terms of the knowledge and tools needed for Western engines and avionics. Ilyushin has followed this lead with its IL-96M.

In addition to Ilyushin and Tupolev, three other CIS LCA producers have announced plans to develop LCA. In 1991, Antonov announced it was studying the development of a 150-180 seat medium-range LCA (model AN-180) and a 200-220 seat wide-body LCA (model AN-218).[140] The Beriev Design Bureau in Tagenrog, which has manufactured a large amphibian aircraft for military uses, is considering the production of a passenger and/or cargo version of this aircraft. In its civil form, it would seat 105 passengers and have a range of 2,160 nm.[141] Yakovlev developed the Yak-42, a 120-seat short- to medium-range LCA, in production since the mid-1970s. Since 1990, Yakovlev has announced design studies for two LCA: the Yak-42M (short- to medium-range, narrow-body, 168 passengers, to be called the Yak-242), and the Yak-46 (turbofan and/or propfan version of the Yak-42M).[142] A stretched version of the Yak-42, targeted at high-density, short-haul airline routes, was shown at the Paris Air Show in June 1993. The aircraft, designated the Yak-142, incorporated U.S. avionics from Bendix/King, a division of Allied-Signal, Inc.[143]

Suppliers of Primary Aircraft Subcomponents

Industry sources are unable to identify the number of primary Russian aircraft subcomponent producers. However, Russian LCA producers indicate that, except for the engines and avionics, each design bureau and its associated serial production facilities manufacture all the parts necessary for the complete aircraft.[144] According to Russian LCA officials, there are no Western vendors producing parts for Russian aircraft, although some of the production facilities that fabricate subassemblies and/or systems are outside Russia, principally in Ukraine (Antonov).[145]

140 *Jane's,* pp. 286-287.

141 Ibid., p. 196.

142 Ibid., p. 259.

143 "Paris '93," *Aviation International News,* July 1, 1993, p. 22; and Allied-Signal Inc., news release, June 10, 1993.

144 Russian LCA officials, interviews by USITC staff, Nov. 16-20, 1992.

Role of Risk Sharing in the Development of CIS LCA

Airframe Manufacturers

The British Russian Aviation Co. (Bravia) was formed in April 1992, as a joint stock company among Tupolev Design Bureau, Aviastar Joint Stock Co., and the British investment bank Robert Fleming.[146] The goal of this organization is to certify and market the Tu-204. The Robert Fleming Bank has established the Fleming Russia Investment Corp. (FRIC), which will assist in aircraft certification. FRIC will also offer a special-purpose leasing structure in conjunction with some of the leading world lessors, which include Guinness Peat Aviation Group plc of Shannon, Ireland; International Lease Finance Corp. of Los Angeles, CA; and Ansett Worldwide of Redfern, Australia. FRIC will acquire aircraft from Bravia and act as a lessor, offering airlines the right to purchase the aircraft at the discretion of the airlines.[147]

Suppliers

Boeing, McDonnell Douglas, and Airbus have all considered purchasing parts such as small titanium fabrications from Russia. However, the timing of Russia's liberalized policies of reform coincided with a worldwide depression in the LCA market. Therefore, with capacity in the United States and Western Europe currently in excess of demand, there is less incentive for the three major Western LCA producers to establish a relationship with Russian producers.

145 Western companies have supplied both Ilyushin and Tupolev with engines and avionics for their newest aircraft, the IL-96M and Tu-204, production versions of which have not been delivered as of yet.

146 Aviaexport, the former Soviet government agency charged with aircraft export activities, has become a partner in Bravia. "Aviaexport Joins Bravia for Global Tu-204 Sales," *Aviation Week & Space Technology,* July 12, 1993, p. 34.

147 "Russian Tupolev Tu-204 Featured," *Commercial Aviation News,* Feb. 15-21, 1993, p. 28.

CHAPTER 3: Structure of the Global Large Civil Aircraft Market

This chapter describes the principal regional large civil aircraft (LCA) markets and purchasers, reviews LCA marketing and the purchase process, and examines trends in the global airline industry during 1978-93 that have affected LCA demand.

Description of the Principal Regional Markets and Purchasers

In 1992, three major world[1] regions—the United States, Europe, and the Asia-Pacific—accounted for nearly 92 percent of world passengers carried, 91 percent of world revenue-passenger-kilometers[2] (RPKs), and 90 percent of freight-ton-kilometers[3] (FTKs);[4] they also accounted for 90 percent of the world airline fleet in operation.[5] The world fleet consisted of approximately 9,985 aircraft at the end of 1992.[6] Approximately 84 percent of that fleet was of U.S. manufacture, and just over 9 percent was of Airbus manufacture.[7] Principal purchasers of LCA include passenger airlines, freight carriers, and leasing companies.

The U.S. Market

The United States is the largest single market for air transportation services and for LCA in the world (table 3-1). In 1992, U.S. airlines flew 44 percent of world passengers[8] and owned/operated approximately 4,349 jet aircraft, or nearly 44 percent of the world fleet.[9] The three largest U.S. carriers by LCA fleet size in 1992 were American Airlines, Inc., with 676 aircraft; Delta Airlines, Inc., with 561; and United Airlines, with 539. USAir was fourth, with 487, while Northwest Airlines, Inc. was fifth-largest, with 372. Only 7 percent of the fleet of U.S. major and national[10] airlines was of non-U.S. manufacture at the end of 1992.[11]

The European Market

The European market is the second-largest market for air transport services and for LCA (table 3-1). In 1992, European airlines flew approximately 31 percent of world passengers[12] and owned/operated 2,408 jet aircraft, or 24 percent of the world fleet.[13]

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[1] In this section, unless otherwise stated, world data exclude the Commonwealth of Independent States (CIS).

[2] One revenue passenger transported 1 kilometer in revenue service. According to *Air Transport World,* RPKs are computed using the sum of the products of revenue aircraft kilometers flown on each interairport flight, multiplied by the number of revenue passengers carried on that flight.

[3] According to *Air Transport World*, an FTK is one ton (2,205 lb) of freight transported 1 kilometer. *Air Transport World* calculates FTKs by multiplying the aircraft kilometers flown on each interairport flight by the number of tons carried on that flight.

[4] Data from "World Airline Report," *Air Transport World,* June 1993, pp. 70-82.

[5] Ibid.

[6] Boeing Commercial Airplane Group, *World Jet Airplane Inventory, Year-End 1992* (Seattle, WA: The Boeing Co., Mar. 1993), p. 77.

[7] Ibid.

[8] "World Airline Report," June 1993, p. 53.

[9] Boeing, pp. 62-64.

[10] Major carriers are those that earn $1 billion or more per year, while national carriers earn between $100 million and $1 billion. A third category, regionals, are those airlines that earn less than $100 million annually.

[11] Boeing, pp. 66-70.

[12] "World Airline Report," June 1993, p. 53.

[13] Boeing, pp. 66-70.

Table 3-1
Percentage distribution of world market for air services and LCA, by regions, 1983-1992

	1983	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*
	Revenue-passenger-kilometers									
U.S.	39	40	40	42	41	39	39	39	41	40
Europe	35	35	34	34	33	34	34	34	32	32
Asia-Pacific	14	15	14	15	17	17	16	17	17	19
All other	11	11	12	09	09	10	11	10	10	09
Total	100	100	100	100	100	100	100	100	100	100
	Freight-ton-kilometers									
U.S.	24	19	27	39	32	31	31	32	32	32
Europe	53	43	38	32	34	35	34	31	34	32
Asia-Pacific	08	23	21	20	24	24	25	25	25	26
All other	15	15	14	09	10	10	10	12	09	10
Total	100	100	100	100	100	100	100	100	100	100
	Fleet size[1]									
U.S.	59	42	41	42	43	43	44	48	47	51
Europe	[2]19	40	42	39	38	36	37	31	31	26
Asia-Pacific	11	08	09	10	10	11	09	10	11	13
All other	12	09	08	09	09	10	10	11	11	10
Total	100	100	100	100	100	100	100	100	100	100
	Passengers									
U.S.	43	43	44	45	46	43	42	42	44	44
Europe	33	32	33	32	32	33	34	34	31	31
Asia-Pacific	13	14	11	14	13	14	14	15	17	17
All other	11	10	12	09	09	10	10	09	08	08
Total	100	100	100	100	100	100	100	100	100	100

[1] Historical fleet figures provided by *Air Transport World* are slightly greater than fleet figures provided by Boeing. Boeing figures exclude all non-jet aircraft.
[2] The 1983 European fleet data do not include Aeroflot.

Source: "World Airline Report," *Air Transport World*, 1984-1993.

The largest passenger carriers in Europe by LCA fleet size in 1992 were British Airways plc, with 249 aircraft; Lufthansa German Airlines, with 231; and Air France, with 143. The next largest were Iberia Airlines of Spain, with 112, and Scandinavian Airlines System, with 109. At year-end 1992, 26 percent of the European fleet was of non-U.S. manufacture; 15 percent consisted of Airbus products.[14] Of the total European airline fleet, 49 percent is of Boeing manufacture; 25 percent of European owned/operated aircraft are McDonnell Douglas products.[15]

The Asia-Pacific Market

The Asia-Pacific market, while less than 20 percent of the world market for passenger services, is growing quickly, and is approximately one-fourth of the world market for freight (table 3-1). In 1992, the airlines of the fast-expanding Asia-Pacific market flew approximately 17 percent of world passengers[16] and owned/operated 1,447 jet aircraft, or nearly 15 percent

[14] Ibid. The remainder of the European fleet was sourced from other West European manufacturers, many of whom are no longer in existence. The other two active West European manufacturers are Avro International Aerospace, Inc., (Avro) of the United Kingdom and NV Koninklijke Nederlandse Vliegtuigfabriek Fokker (Fokker) of the Netherlands.

[15] Ibid.

[16] "World Airline Report," June 1993, p. 53.

of the world fleet.[17] The largest passenger carriers in the Asia-Pacific region by LCA fleet size in 1992 were Japan Airlines, with 109 aircraft; All Nippon Airways Co., Ltd., with 108; and Korean Air, with 85. Just over 59 percent of the aircraft in the Asia-Pacific fleet was made by Boeing, approximately 12 percent was built by McDonnell Douglas, and 3 percent was of other U.S. manufacture.[18] At year-end 1992, 373 aircraft, or nearly 26 percent of the aircraft of the region, were of non-U.S. manufacture; 16 percent were Airbus products.[19]

Other Regional Markets

Other regional markets include Canada, the Middle East, Africa, and Latin America and the Caribbean (see table 3-1 for a combined market total). These markets combined comprise less than 10 percent of the world total for airline services (both passenger and freight),[20] and approximately 17 percent (1,728 aircraft) of the world LCA fleet.[21] At year-end 1992, 11 percent (189) of these aircraft were Airbus products, 5 percent were of other European manufacture, and 84 percent were U.S.-produced.[22]

Two potentially large markets for both passengers and freight, closed until recently to private commercial activity, are the Commonwealth of Independent States (CIS) and the People's Republic of China (China). With sufficient income expansion, both of these markets have enormous untapped traffic potential. The CIS market sustained the largest air carrier in the world, Aeroflot, until its breakup in 1992. The CIS market is unique among the potentially large emerging markets in that it has its own LCA supplier base. China, also with great traffic potential, is currently developing its aerospace production skills with joint venture arrangements (see chapter 2); prior to recent purchases of Western aircraft, most of the fleet in China was Russian made.[23]

[17] Boeing, pp. 74-75.

[18] Ibid.

[19] Ibid.

[20] "World Airline Report," June 1993, p. 53.

[21] Boeing, pp. 62-77.

[22] Ibid.

[23] "World Airline Report," June 1992, p. 179.

Specialty Markets

Other than by region, LCA markets may also be distinguished by specialty, such as the passenger, freight, and leasing markets (see discussion of leasing later in this chapter). In 1992, the airlines of the world owned 933 freight aircraft, with approximately 66 percent, or 619 aircraft, owned by U.S. airlines.[24] Of these 619 aircraft, 618 were U.S.-produced aircraft as of year-end 1992. Of the total world freight aircraft fleet, 61 percent were produced by Boeing, 35 percent by McDonnell Douglas and other U.S. firms, and approximately 3 percent were produced by various European firms.[25] Much of the global market for freight carriage is provided for by passenger airlines, which carry substantial amounts of cargo on regularly scheduled passenger flights and which own much of the world freight aircraft fleet. Only 2 of the world's top 10 freight carriers are freight-only (table 3-2).[26]

Marketing and the Purchase Process

The Decision to Purchase an Aircraft

Airlines purchase aircraft that will improve their economic position; that is, an aircraft should produce a positive cash flow for the airline over its useful life. The key to selling a specific aircraft is to demonstrate that it is the most operationally cost-competitive of the available aircraft that could fulfill the carrier's stated mission (passenger, cargo, or both) in light of interrelated economic factors, such as load factors, competition, projected demand, and route structure.[27] For the airline to remain financially sound, acquisition and operating costs must be outweighed by the revenues generated from flying the aircraft. Many factors determine costs and revenue. For example, acquisition costs are a function of the cash outlay, including the financing and any special benefits, training, or other contract terms. Operating costs are a function of the maintenance and repair costs of

[24] Boeing, p. 21.

[25] Ibid.

[26] Lufthansa has announced that within the next few months, it will spin off its cargo operations into a $2 billion new company, which will then rank as the world's largest specialized air cargo carrier.

[27] West European airline executive, interview by USITC staff, Dec. 1992.

Table 3-2
Ten largest freight carriers, by freight-ton-km, 1992

Airline company	*Freight-ton-km (mil)*
Federal Express (freight-only)	6,152
Lufthansa	4,400
Air France/Air Inter/UTA	3,972
Japan Airlines	3,229
United Parcel Service (freight-only)	3,133
Korean Air	2,828
Northwest Airlines	2,705
British Airways	2,653
KLM	2,407
Aeroflot	2,350

Source: "World Airline Report," *Air Transport World*, June 1993, p. 56.

the aircraft, crew costs, fuel costs, the relative efficiency of the aircraft, and any advantages and disadvantages of commonality[28] with respect to the rest of the fleet. Revenues are influenced by the general state of the economy, and the airline's ability to maximize the economic potential of the aircraft through route application and accurate passenger/cargo forecasting.

Because of the increasingly competitive environment for both LCA manufacturers and airlines, the business of marketing aircraft is changing dramatically. For LCA manufacturers, successful marketing is based on product differentiation. This may involve a difference in the purchase price, financing, or incentives,[29] or a perceived difference in the character of the aircraft. For example, the aircraft may be more technologically advanced, more flexible in terms of passenger configuration, or it may be more flexible in that the aircraft can be used economically on different routes.[30] An airline must consider all these factors to obtain the most value for its capital expenditure.

[28] Airlines prefer to maintain fleet commonality. A fleet composed of a single manufacturer's aircraft or a fleet of aircraft with little variation among models (type variation) decreases operating costs in several ways, including crew, maintenance, and parts costs. See chapter 4 for a discussion of commonality.

[29] An example of an incentive is an offset agreement, whereby the LCA manufacturer agrees to purchase parts (subcontract) from a supplier in the customer's country.

[30] Flexibility can be an important selling factor, particularly in times of economic uncertainty, when passenger demand is highly variable. If an aircraft can be operated profitably on different types of routes, it can be used more readily by an airline when route structure or passenger demand changes.

Airlines typically conduct a series of evaluations as to the specific aircraft type and model required, along the following lines:[31]

- The mission of the aircraft is identified, reflecting the application (route); operating costs (seat-mile economics); and integration into the existing fleet: for example, whether the aircraft is a straight replacement for an existing one, or a niche purchase to fill a specific need.
- Conversations are held with the various LCA manufacturers to discuss overall carrier requirements and to identify the products that best match those requirements. The specifications for the aircraft to be purchased are defined by both the purchaser and the manufacturers. Performance data on the contending aircraft designs are provided by the manufacturers and evaluated by the airline's engineering department.
- The airline issues invitations to bid. The bids should include delivery dates and aircraft specifications. Subsequently, noncontenders among the airframe manufacturers are eliminated, based on a detailed economic analysis that compares the performance of various aircraft with the purchaser's requirements.
- The airline develops a new fleet plan (implementation of the new aircraft relative to the remainder of the fleet) based on each contending manufacturer's proposal, incorporating elements such as delivery, seats, and routes. The airline also constructs an economic model, with a review of operating costs discounted back to present value.

[31] West European airline executive, interview by USITC staff, Dec. 1992.

- Based on the resulting data, the airline recommends to its board which aircraft to acquire. At the same time, "boiler plate" (basic) negotiations are conducted between the airline and the chosen manufacturer. At this time, the major points of negotiation are relative to price, and center on additional technical concerns and operating economics. The airline also evaluates possible engines at this time.

Contending manufacturers typically perform cost-benefit analyses incorporating factors such as likely deployment (including the utilization rate), passenger/cargo demand and yield, operating costs (such as fuel, maintenance, cockpit and cabin crew), and capital costs. After the decision to acquire a new aircraft has been made, the airline generally conducts its own cost-benefit analysis in more detail than those of the manufacturers, often with fleet planning as the focal point for the analysis. Given the airline's access to actual operating data, its internal analysis generally is more accurate than those of the manufacturers and can be tailored to specific deployments.[32] In general, an airline that has had a long-term relationship with an LCA manufacturer typically finds that LCA manufacturer's performance and cost projections most reliable among manufacturer's projections.[33] Therefore, while the economics of purchasing an aircraft are paramount, historical links with a manufacturer are an important factor.

One of the most difficult decisions for an airline is to buy the first aircraft of a new program from a particular manufacturer, thereby becoming the launch customer. Nearly as difficult is an airline's decision to make its first purchase from a different manufacturer. An individual airline typically has limited input into proposals for entirely new types of aircraft, given that manufacturers must balance the competing needs of a large number of airlines. Influence on the design for any aircraft is proportional to the size of the potential order; however, the launch customer may exert a disproportionate amount of influence because of its status. As a targeted customer, or preferably as a committed purchaser, an airline can voice objections or suggest enhancements to existing designs. There is some opportunity for airline participation in the basic definition of the aircraft (size and capability), operating characteristics (payload/range and airport compatibility), and the detailed design of the basic aircraft. There is most opportunity for participation when it comes to customer specifications. Although U.S. airlines state that Boeing and McDonnell Douglas can be approached more easily than Airbus or Fokker,[34] only Boeing and Airbus are perceived to have the financial capability to create an entirely new type of LCA. Fokker and McDonnell Douglas are perceived as currently being limited to derivative designs because of a lack of capital.[35]

Aircraft Types and Cost-Effectiveness on Various Routes

Each airline, depending on its route structure and passenger and cargo demand, needs different mixes of aircraft types to operate profitably. Cargo aircraft generally have the same airframes as those discussed below for passenger aircraft; however, their interior configurations differ.

Passenger aircraft fall primarily into categories delineated by range and number of seats. Each aircraft has its own set of performance characteristics that identify how efficiently it operates in its particular range/capacity category (figure 3-1). Although aircraft may be grouped by range and capacity capabilities, no two aircraft overlap exactly. Short-range aircraft (1,000-3,000 miles), with passenger capacity of approximately 100 to 200 seats, are popular in a hub-and-spoke system where greater flight frequencies are demanded, and/or where flight distances and passenger demand are limited. Greater flight frequencies using smaller aircraft are used to establish or increase an airline's market share. As a carrier's market share increases, larger aircraft become more economical because cost-per-seat-mile is lower on larger aircraft as a result of the ability to carry more passengers on an individual flight.[36]

The group of medium-range aircraft (3,500-5,500 miles) has a greater range of passenger capacity; the number of seats may vary from approximately 200 to 400. Such aircraft can be used economically on both shorter and longer range flights because of their flexible seating capacity and optimum fuel-burn efficiency.

[32] Compiled from responses to USITC airline questionnaire, Feb. 1993.

[33] West European airline executive, interview by USITC staff, Dec. 1992.

[34] Questionnaire responses did not indicate an opinion regarding British Aerospace (Avro).

[35] Compiled from responses to USITC airline questionnaire, Feb. 1993.

[36] West European airline executive, interview by USITC staff, Nov. 1992.

The long-range (6,000+ miles) category of aircraft also includes a wide variety of seat capacities, from just under 200 to over 400. Typically, these aircraft are used over great distances; however, Japanese carriers buy 747s for short routes because of high passenger demand for air travel on these routes.[37] ANA, one of the largest Japanese carriers, has determined that short-term service expansion is possible only with the introduction of larger aircraft because of constraints in obtaining new landing slots.[38]

Aircraft also can be differentiated by whether they are narrow- or wide-body aircraft. Wide-body aircraft are increasingly popular because of their increased payload relative to fuel burn. Increases in traffic, coupled with the desire to cut or maintain costs, have made aircraft that can carry more passengers while burning a comparable amount of fuel much more important to established airlines. Airport congestion also has spurred the use of larger aircraft with fewer frequencies. Therefore, the same number of passengers can be moved with fewer flights.

Other Selling Factors

Always important as a sales factor, direct operating costs of an aircraft have become even more important because of airlines' difficulty in predicting increasingly variable passenger revenues. For this reason, aircraft efficiency and good seat-mile economics have gained importance as selling factors. However, the unpredictability of direct operating costs and revenues has complicated the interaction and relative importance of various sales factors such as commonality, after-sales support, technological advances, and jet fuel prices (see chapter 4).

Increases in operating costs have a negative and somewhat cumulative effect on LCA demand. For example, rising fuel prices (fuel can account for up to 20-30 percent of operating costs) tend to reduce airline profitability and thus the airlines' ability to buy newer, different, and more fuel-efficient aircraft, unless higher costs can be passed on to passengers.[39] If an airline must continue to operate older, less fuel-efficient aircraft, profitability may further decline.

Outfitting costs do not vary enough to influence supplier choice. It is also normal practice to permit the alteration of outfitting specifications prior to delivery. The closer to the delivery date, the more difficult it is to change such specifications. Reportedly, product support is also a "given" in choosing among manufacturers. Although not all manufacturers are equal in this respect, all are regarded as at least adequate. Parts availability is also not an issue, only the price and commonality of parts.[40]

The Contract, Including Incentives and Financing

Sales agreements contain a number of important elements, any one of which may be considered an incentive if the terms are sufficiently favorable. The sales agreement stipulates separate prices for the airframe, engines, airline-specified equipment (also known as buyer-furnished equipment, such as interior furnishings), and avionics offered by the LCA manufacturer beyond the basic package.[41] Training and spares are included in the sales agreement, as are aircraft performance and warranty guarantees. The contract also specifies the financing terms, including progress payment schedules and delivery dates.[42] Although the volume of the purchase affects the purchase price (and consequently the financing), launch customer status (the first purchaser of a new aircraft) and market forces such as supply and demand of aircraft also are important.[43]

In past years, air carriers usually would take options (to lock in at a particular price and delivery date) on additional aircraft when making a purchase, without evaluating each exercised option to the same extent as the original purchase. Since there is currently less incentive for carriers to take options in light of the economic uncertainties in the industry, airlines increasingly solicit new bids to satisfy fleet needs, rather than exercising options as in the past.[44]

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[37] A typical short inter-Japan flight may carry 500 to 600 passengers on a 747 over only several hundred miles. Such high-density domestic aircraft have a narrower seat width and shorter seat pitch.

[38] "Overseas, under pressure," *Airline Business,* Sept. 1992, p. 85.

[39] Compiled from responses to USITC airline questionnaire, Feb. 1993.

[40] Ibid.

[41] Gellman Research Associates, Inc. for the U.S. Department of Commerce, *An Economic and Financial Review of Airbus Industrie* (Jenkintown, PA: Sept. 4, 1990), p. A-5.

[42] Ibid.

[43] West European airline executive, interview by USITC staff, Dec. 1992.

[44] Today, options are an advantage primarily to the manufacturers, enabling them to gauge more accurately demand and therefore production rates.

Industry sources report that in recent years, many airlines have attempted to reduce financial obligations by rescheduling deliveries or by canceling orders for new aircraft altogether.

The order size and the market position of the carrier remain perhaps the most significant determinants of the manufacturers' pricing of aircraft. Order size is important, because building significant quantities of like-configured aircraft reduces manufacturing costs and ongoing support required. The market position and strength of the carrier affects its negotiating or bargaining position. The availability of financing is an important sales factor, although financing from manufacturers is most often available when demand is low. Boeing and Airbus are best able to offer financing because of their financial strength.[45] According to several large airlines, no manufacturer consistently offers contract terms that are better than its competitors.[46] Although larger airlines may use manufacturer financing on occasion, the most common methods of financing are long-term leveraged leases (with a variety of domestic and foreign sources) or third-party financing.

An important part of the contract, and price component, are buyer incentives. Buyer incentives include innovative financing deals whereby the manufacturer makes price concessions, offers financing, accepts buy-backs and trade-ins, and/or arranges deals with a country to purchase that country's products. Historically, offsets have been a persuasive marketing tool, especially in developing countries. However, signatories to the recent U.S.-European Community (EC) bilateral aircraft agreement have agreed to try to avoid certain offset or countertrade arrangements in the future.[47] Incentives that include offsets, countertrade arrangements, or other inducements are discussed later in this report.

During the 1980s, airlines turned to equity financing because it was difficult to find lenders. In general, airlines may debt-finance up to 80 percent of the value of a purchase, thereby requiring the liquidity for a minimum down payment of 20 percent of their order.[48] Most large airlines, depending on their investment rating, can go to commercial banks for financing. However, because of the lack of stability in the airline industry and the resulting reduced cash flow, traditional financing markets for aircraft are no longer as reliable as they once were, and finding new sources of aircraft financing is becoming important to even the most creditworthy carriers.[49] Decreased airline profitability also has resulted in a shift from buyer-financed to seller-financed aircraft. As a result, the LCA manufacturer that can offer better financing terms has a competitive advantage whenever financing is difficult to obtain because of high capital costs.[50]

The U.S. Export-Import Bank (Eximbank) has been called upon during the current economic climate to provide loan guarantees for a variety of financing proposals. Consequently, Eximbank has developed a set of aircraft transaction guidelines: the Aircraft Matrix.[51] Although these guidelines are more restrictive than those embodied in the Large Aircraft Sector Understanding (LASU) (see chapter 5), Eximbank nevertheless has demonstrated a certain degree of flexibility in providing loan guarantees. A number of innovative banking institutions have put together capital market financing packages using Eximbank guarantees. These packages have provided borrowers with low-cost fixed-rate loans from investors.[52]

In addition, financing may become more difficult as lenders determine that they would have difficulty placing the aircraft should they have to take possession.[53] The financial problems in the airline industry have prompted deferrals and cancellations in orders and deliveries of new aircraft. This in turn has affected the value of new aircraft. As the value of nearly new aircraft declines, financing may be granted only on the basis of the adjusted price rather than the invoice price.[54]

Representatives of some of the largest airlines maintain that LCA demand is not a function of the availability of financing; rather, they suggest that the availability of financing is a function of the demand

[45] Compiled from responses to USITC airline questionnaire, Feb. 1993.

[46] Ibid.

[47] The agreement does not appear to include clear definitions of the activities involved or provisions for enforcement. See chapter 5 for more detail; see also appendix F.

[48] U.S. LCA manufacturer financial officer, interview by USITC staff, Sept. 1992.

[49] Compiled from responses to USITC airline questionnaire, Feb. 1993.

[50] Artemis March, *The U.S. Commercial Aircraft Industry and Its Foreign Competitors* (Cambridge, MA: MIT Commission on Industrial Productivity, 1989), pp. 68-69.

[51] U.S. Eximbank (Editorial by Bankers Trust), *Airfinance Journal*, No. 149, Apr. 1993, p. 28.

[52] Ibid.

[53] "Tangled: A Survey of the Airline Industry," *The Economist,* June 12, 1993, p. 22.

[54] *Aircraft Value Newsletter,* Jan. 11, 1993, p. 1.

for air transport services and thus for LCA.[55] While creative financing arrangements provide alternatives to marginally profitable carriers, they do not appear to affect overall demand for LCA. Conventional lease arrangements also serve to increase airline flexibility and smooth out LCA demand fluctuations across carriers and over time, but it is unlikely that they have a significant effect on overall, or net, demand.

Some airline representatives maintain that if the free market is allowed to function with respect to airline operations (i.e., bankrupt carriers are allowed to fail, and capacity restrictions such as slots are removed), demand for aircraft and investment in new LCA will mirror the expected return on investment.[56] Financing alone should not affect the demand for LCA; capital generally is made available when airlines can provide an adequate return on investment. New sources of funding therefore are unlikely to affect the net long-term demand for LCA to any significant degree.[57]

Leasing

Certainty and timing flexibility regarding disposal of the aircraft, and the projected value of the aircraft to the airline over time are deciding factors in the decision to lease or purchase. In addition, because the availability of financing is part of the deal or package, the decision to lease or purchase is generally inseparable from other financial considerations of acquisition. Some of the benefits of leasing are as follows: (1) liabilities may not appear on the airline's balance sheet; (2) large capital expenditures are minimized; (3) fleet flexibility is increased; (4) the risk of technological obsolescence is mitigated;[58] and (5) airlines moderate their own risks, passing more risk back to the lessor and indirectly back to the manufacturer.

Many types of leases are available, including dry leases, which involve the aircraft alone; wet leases, which include crew and other services; and leases that are part of innovative financing deals. The most common types of leasing agreements currently in use are financing, or full-payment, leases; operating leases; option leases; and "walk-away" leases.

Financing leases are typically long-term (10 to 12 years) and provide the option to purchase the aircraft at fair market value at the expiration of the lease. While these leases are typically the most economical in the long run, they have fallen somewhat out of favor because of their relatively long length and the volatility of the U.S. marketplace.

Operating leases run 5 to 10 years, but require the surrender of the aircraft upon expiration. Although the asset is typically surrendered at a time when its book value and useful life are still considerable, these leases have increased in popularity because they give the airlines increased flexibility in managing their fleets. Such leases allow airlines to make financial commitments on a shorter term basis.

Option leases provide airlines with even greater flexibility because they begin as an operating lease, but can be converted into a financing lease at the airline's discretion. The airline thus can tailor the lease to respond to its changing financial situation.

A walk-away lease is normally structured as a long-term (18-24 years) lease. It differs in that the lessee is given the right to terminate the lease ("walk away") before the end of the lease term without having to pay the high fees associated with early lease termination.[59] The effect of a walk-away lease is to provide the lessee a lease rate reflecting the full economic benefits of a long-term tax lease, along with even greater flexibility than could be obtained under a short-term operating lease.[60] This lease may give the aircraft customer the option to terminate the lease on very short notice (as little as 30 days) with a minimal penalty.[61] These leases have been helpful to airlines because the aircraft do not have to be recorded on the airlines' balance sheets under these terms. U.S. aircraft manufacturers say that such leases have allowed Airbus to make sales that otherwise might have gone to U.S. firms, but U.S. airlines have stated that a ban on such leases would reduce their flexibility

[55] Compiled from responses to USITC airline questionnaire, Feb. 1993.

[56] Ibid.

[57] Ibid.

[58] March, p. 41.

[59] John F. Hayden, vice president, Washington DC office, posthearing submission on behalf of The Boeing Co., p. 1. According to Airbus, the exercise of early termination rights precipitates significant early termination fees; higher standards for the condition of the aircraft at the time of return; and occasionally the requirement that aircraft be returned in lots, rather than individually. In such cases, early termination provisions would be costly to both the manufacturer and the airline. Renee Martin-Nagle, corporate counsel, posthearing submission on behalf of Airbus Industrie, G.I.E. and Airbus Industrie of North America, Inc., p. 2.

[60] Hayden, p. 1.

[61] March, p. 70.

and their negotiating leverage with all aircraft manufacturers. It is believed that to date, aircraft transactions involving walk-away leases have been confined to airline customers in the highly price-competitive U.S. market.[62]

Walk-away leasing arrangements were employed by Boeing, McDonnell Douglas, and Airbus in the 1980s to promote the sales of the 767, MD-80, and A300-600, respectively. McDonnell Douglas offered a walk-away lease to American Airlines (20 aircraft) and TWA (15 aircraft) on MD-80 aircraft. McDonnell Douglas eventually sold 1,100 MD-80s, of which 260 were ordered by American alone. Likewise, the Airbus 1987 walk-away lease offer to American (19 aircraft), which consequently became the launch customer for the A300-600, was critical to gaining market credibility for this model. Airbus subsequently received worldwide orders for 200 additional aircraft. In 1987, Boeing offered walk-away lease terms to American for twelve 767-300ERs in an unsuccessful attempt to block Airbus from closing the A300-600 lease deal cited above.[63]

Recently, walk-away leases have come under close scrutiny as a sales tool. Boeing and several engine manufacturers have complained that deals incorporating such leases put them at a competitive disadvantage. According to Boeing, these leases make little commercial sense, given the substantial level of risk of lease termination assumed by the manufacturer. The lessor must assume, with respect to the leased aircraft, both the credit risk and the business risk of the lessee.[64] Airbus has stated that early termination provisions are costly to both the airline and the lessor because the lessor then must remarket the aircraft on short notice.[65] Boeing also has stated that the corporate structure of the Airbus consortium (see chapter 4) obscures the liability implicit in walk-away leases to the detriment of companies such as Boeing, which must carry such aircraft on its balance sheets.[66]

Airbus also used walk-away leases in its 1992 deals with Delta Airlines for nine A310-300s, and with United Airlines for 50 firm orders for A320s and an option on 50 more.[67] Airbus asserts that it has never initiated an offer of a walk-away lease as a sales incentive; rather, the airlines have been the first to raise it as an issue in sales negotiations. Aircraft engine manufacturers also have offered walk-away

[62] In fact, Airbus contends that the use of walk-away leases is limited to the U.S. market because of U.S. accounting rules that permit companies to keep less-than-one-year contingent liabilities off their profit and loss statements.Because these leases allow for cancellation on less than a year's notice, the airline can postpone including the cost of the lease on its balance sheet. Airbus' walk-away leases have provided for termination notice ranging from 30 days in one case to 11 months in another.

[63] "Walk-Away Leases: Brilliant or Albatross?" *Commercial Aviation Report,* May 1, 1993, pp. 10-11.

[64] The lessee generally elects to terminate a lease during difficult economic times, when there may be an excess of aircraft. It is then likely that the aircraft will be sold at a "fire sale" price, stored until demand returns, or leased at a highly discounted rate. In any case, costs to the lessor are likely to be prohibitive. Hayden, p. 1.

[65] Martin-Nagle, p. 2.

[66] John F. Hayden, vice president, Washington DC office, The Boeing Co., testimony before the U.S. International Trade Commission, Apr. 15, 1993. In its posthearing submission, Boeing stated that a lessor would normally account for an aircraft on a walkaway lease as a capital asset (at the company's cost, rather than the sales price), just as though the aircraft had never been "sold." For tax purposes, the aircraft would be depreciated over 7 years, and over 20 years for financial accounting purposes. Rental income on the aircraft would be booked when received. (Hayden, posthearing submission, p. 2.) As the return on capital for such leases is significantly less to the manufacturer than selling the aircraft without a walk-away lease, this situation is viewed as less-than-desirable. According to Boeing, should an aircraft company have a number of such leases on its books at any one time, it would almost certainly affect the company's credit rating and ability to raise money. Boeing also maintains that walk-away lease arrangements do not affect Airbus in such a way, because Airbus does not depend on commercial credit to the same extent. Boeing official, telephone interview by USITC staff, July 22, 1993.

[67] Delta insisted on revised lease terms permitting walk-aways on 18 A310-200s/300s and a number of Boeing 727-200s in the Pan Am fleet before acquiring the assets. *Commercial Aviation Report,* May 1, 1993, p. 10. Airbus officials have described their walk-away lease arrangements as follows: Airbus itself enters into a "head" or primary lease with a bank or other entity that pays Airbus for the aircraft. Airbus then enters into a sublease with the airline. The sublease contains the walk-away provisions. Ideally, the airline will not exercise the walk-away option and pay the full amount for the aircraft. However, if the airline does exercise its option, Airbus remains liable to the bank under the head lease for the balance of the payments.

leases in support of their own commercial interests in aircraft sales.[68]

The negative consequences of walk-away leases for LCA manufacturers became apparent when American recently threatened to return twenty-five A300s to lessors, and Delta announced that it was returning eighteen A310s to lessors.[69] In an effort to induce American to maintain its leases, Airbus offered maintenance guarantees termed "customer support," and also reportedly offered pricing guarantees for future orders, 20-year maintenance cost guarantees, and additional incentives, all of which amounted to an allegedly substantial total package.[70] Thus, regardless of the fact that walk-away leases can lead to significant long-term benefits for a manufacturer (such as follow-on sales), they can represent a substantial financial risk that LCA producers are usually reluctant to incur.

A number of alternatives to supplier-originated[71] lease financing currently exist in international markets. Since the early 1980s, the most popular has been the Japanese Leveraged Lease (JLL), applicable to all equipment that has a depreciable life.[72] The Japanese National Trade Administration guidelines for JLLs call for an equity investment by Japanese investors of at least 20 percent of the purchase price of the aircraft. The remainder of the purchase price (debt portion) is typically provided by a syndicate of Japanese and/or foreign banks. The lessor acts as an intermediary between the equity suppliers and debt holders and is permitted to depreciate 100 percent of the asset cost for tax purposes. A portion of this benefit is passed on to the lessee in the form of lowered lease rental payments.[73]

Although JLLs have accounted for as much as 60 percent (1990) of the total share of worldwide aviation financing, projections suggest that JLLs will supply no more than 20 percent in the near term.[74] In Japan, equity for aircraft leases has become increasingly scarce over the last 2 to 3 years, and such equity is usually available only for the most creditworthy air carriers. Reasons for this decline include lower levels of Japanese corporate profits and the resulting reduction in potential tax benefits to equity investors, and the depressed state of the Japanese stock and real estate markets, which has reduced the level of funding available from Japanese banks.[75]

The percentage of leased aircraft is comparable for U.S. airlines and those of the rest of the world.[76] However, some large U.S. airlines, with fleets of several hundred LCA, lease as much as 50 percent of their fleets.[77] Industry sources indicate that, since most U.S. airlines are comparatively cash-poor at present, it makes economic sense for them to conserve their capital and lease aircraft.

While leasing offers airlines many advantages, there are also some negative aspects: (1) airlines are not able to take advantage of various tax breaks and asset depreciation;[78] (2) airlines are unable to derive any benefit from aircraft salvage values (unless the airline is able to purchase the aircraft as a condition of the lease); and (3) by introducing a middleman into the acquisition process, leasing may inflate LCA prices over time as compared with outright LCA

[68] "Walk-Away Leases," pp. 10-11. General Electric Co. (nine aircraft), International Aero Engines (two aircraft), and Pratt & Whitney (five aircraft) have become participants in various walk-away lease deals, despite the fact that they have expressed their displeasure with such leases.

[69] *Commercial Aviation Report,* May 1, 1993, p. 11.

[70] Ibid.

[71] The term "supplier-originated" refers to the LCA manufacturer.

[72] As it specifically applies to wide-body aircraft (above 130 tons), the lease term (120 percent of the depreciable life) has been established at 12 years. The lease term for narrow-body aircraft (15 to 130 tons) is 10 years.

[73] "Japanese Leveraged Lease," editorial by Sumitomo Bank, *Airfinance Journal,* (Apr. 1993,) No. 149, p. 24.

[74] Ibid.

[75] Ibid.

[76] This statement refers to operating leases. An attempt was made to exclude finance leases (which may often be a simple financial arrangement rather than a true lease-back) from this calculation. According to Boeing, just under 2,900 aircraft, or 28 percent of the global fleet, are currently leased to airlines worldwide under some sort of operating lease. Approximately 27 percent of the U.S. fleet is leased, and approximately 29 percent of the non-U.S. fleet is leased.

[77] "World Airline Report," June 1993, pp. 142-161.

[78] However, the lessor can pass along the benefits of these deductions in the form of lower lease payments. In fact, if the airline is operating at a loss or has a large loss to carry forward, it will not be in a position to benefit from these deductions, and leasing might be preferable.

purchases. However, given that many airlines may continue to find it difficult to raise sufficient capital for new or replacement aircraft purchases, various types of lease arrangements will continue to be a popular alternative.

Trends in the Global Airline Industry, 1978-93

Deregulation of the U.S. Airline Industry

In 1978, the U.S. Congress passed the Airline Deregulation Act (the act), which incrementally eliminated the control over the allocation of air routes among airlines and the regulation of airfares previously exercised by the Civil Aeronautics Board (CAB); deregulation was to be complete by December 31, 1985. The act was preceded by a period of "administrative deregulation," which began in 1975 with the opening of certain previously shielded markets to increased competition.[79]

Passage of the act introduced an era of "open skies" in which a freely competitive market was expected to result in a more efficient allocation of industry resources. Prior to 1978, Federal regulation placed constraints on the number of carriers that could operate in particular markets and capped airfares the carriers could charge, maintaining a certain amount of stability with regard to airline profits, ticket prices, and the level of airline competition.[80] The cost of this stability was borne by consumers through higher airfares and less affordable travel. Soon after deregulation, many carriers recognized that low fares on certain routes could be partially or fully offset by increasing the load factor (decreasing the number of vacant seats per flight) on each flight. The larger carriers began to adopt a route strategy employed to a limited extent by companies such as Delta and Eastern in the 1960s: the hub-and-spoke system. During the era of regulation, building a hub-and-spoke system was severely constrained by the lengthy and expensive process under which the CAB granted route authority. In the deregulated marketplace, however, carriers were free to establish their individual route systems. The hub-and-spoke system, which made possible greater flight frequencies, increased demand for narrow-body aircraft. The system also allowed the larger carriers to concentrate the flow of passengers toward a central point and thereby increase aircraft load factors, and service a greater number of city pairs without a corresponding increase in costs associated with point-to-point service.

Between 1978 and early 1984, the number of carriers (excluding commuter airlines that operate aircraft with fewer than 60 seats) that reported financial data to the U.S. Department of Transportation increased from 43 to 87. The rapid entry of new competitors contributed to lower passenger ticket prices, which in turn caused the number of domestic revenue passenger-miles flown annually to nearly double between 1976 and 1987, while conversely reducing air carrier revenues.[81] The 11 prederegulation trunk (major) carriers[82] shared in the growth of air traffic during this period, even though their overall market share declined from 94 to 77 percent between 1978 and 1985.

The competition that arose from deregulation eventually rationalized the number of U.S. air carriers. By 1990, fewer than one-third of the 148 new companies that had reported financial data to the Department of Transportation were still operating. Seven of the new entrants that had come to be classified as major or national carriers were still engaged in domestic passenger operations by December 1992. The number of new competitors that entered the industry annually fell from a high of 22 in 1979 to just 3 in 1988.[83] Following rationalization, the major carriers' share of the market was slightly

[79] John R. Meyer, Clinton V. Oster, Jr., Ivor P. Morgan, Benjamin A. Berman, and Diana L. Strassmann, *Airline Deregulation: The Early Experience* (Boston, MA: Auburn House Publishing Co., 1981), p. 44. In September 1975, the CAB granted new competitive route authority on nonstop flights between Des Moines and coastal points, and Omaha and coastal points. In November 1975, the board also granted competitive authority on nonstop service between Reno, NV, and Portland, OR.

[80] For example, prior to deregulation, the New York-Los Angeles market was serviced by three air carriers; since deregulation, this total has been as high as eight.

[81] Transportation Research Board, *Winds of Change: Domestic Air Transport Since Deregulation,* special report 230 (Washington, DC: National Research Council, 1991), p. 31.

[82] American, Delta, United, Eastern, Trans World, Western, Braniff, Continental, National, Pan Am, and Northwest.

[83] Transportation Research Board, p. 31.

higher than prederegulation levels. (Although on a city-pair basis, concentration was still lower than before deregulation.) However, the composition of the key players had changed significantly.[84]

The increased competition resulting from the "open skies" of the marketplace added an element of risk, and the industry's principal lenders responded by either restricting the availability of funds, increasing the interest rates charged, or decreasing the terms of loan agreements for new aircraft.[85] Air carriers began to hold onto their equipment longer[86] and to increase their acquisition of aircraft under leasing agreements to reduce the financial obligations inherent in purchasing LCA.

Profitability of U.S. Airlines[87]

The U.S. airline industry maintained a record of annual profitability during the period 1971-79 (figure 3-2). In fact, 1978 was a banner year for U.S. airlines, which posted $1.4 billion in total profits. However, industry profitability declined significantly to just under $200 million in 1979. This was followed by 3 consecutive years of losses totaling nearly $1.4 billion during 1980-82. This sustained decline in industry profitability was to a large extent the result of the fuel crisis of 1979 (and the resulting jump in jet fuel prices in 1980), the air traffic controllers' strike of 1982, the increased number of competitors in the marketplace, and the recession of the early 1980s.

In 1983, the U.S. industry rebounded and recorded a modest profit of $362 million, largely as the result of its very profitable international operations. The industry subsequently sustained 6 of the most profitable years in its history, during which time annual operating profits never fell below $1.2 billion. The all-time industry high of $3.4 billion was recorded in 1988. Total industry operating profits during 1983-89 totaled $12.8 billion, for an average annual profit of $1.8 billion for the 7-year period. Much of this profitability was the result of the sustained growth in revenue passenger-miles flown during the period. This growth was attributable, to a large extent, to the strength of the domestic economy and to reduced airfares in the very competitive deregulated marketplace.[88] In 1990, however, U.S. air carriers recorded their worst losses to date for a year-end total of $1.9 billion in operating losses. This was followed by a $1.7 billion loss in 1991[89] and a $2.3 billion loss in 1992.[90] This downturn was the result of a number of factors, the most important of which were a sharp drop in passenger traffic due to steep decline in worldwide economic activity; the Persian Gulf War and fear of terrorism; substantial increases in operating costs, including fuel costs; rising capital costs; and a significant level of overcapacity within the industry when air passenger traffic failed to grow as projected.

International routes were the hardest hit for U.S. and foreign carriers alike, causing many carriers to lose substantial amounts of money in the last 2 to 3 years. In total, International Air Transport Association (IATA) member airlines are estimated to have lost $4.8 billion on international scheduled services in 1992.[91] These airlines lost $2.7 billion and $4 billion in 1990 and 1991, respectively, raising the combined figure for the first 3 years of the decade to $11.5 billion.

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[84] Eastern, Braniff (reorganized for the fourth time as a large regional airline in July 1991), National (purchased by Pan Am in 1980), Western, and Pan Am were replaced by America West, Southwest, and USAir as major U.S. carriers.

[85] *The Competitive Status of the U.S. Civil Aviation Manufacturing Industry (A Study of the Influences of Technology in Determining International Industrial Competitive Advantage)* (Washington, DC: U.S. Civil Aviation Manufacturing Industry Panel, National Academy Press, 1984), pp. 37-42.

[86] Retaining older aircraft with significantly higher fuel consumption rates and maintenance requirements can add substantially to operating costs.

[87] Data in this section were taken from Aerospace Industries Association of America, Inc., *Aerospace Facts and Figures: 1992-1993* (Washington, DC: The Aerospace Research Center, Aerospace Industries Association of America, Inc., 1992), p. 80.

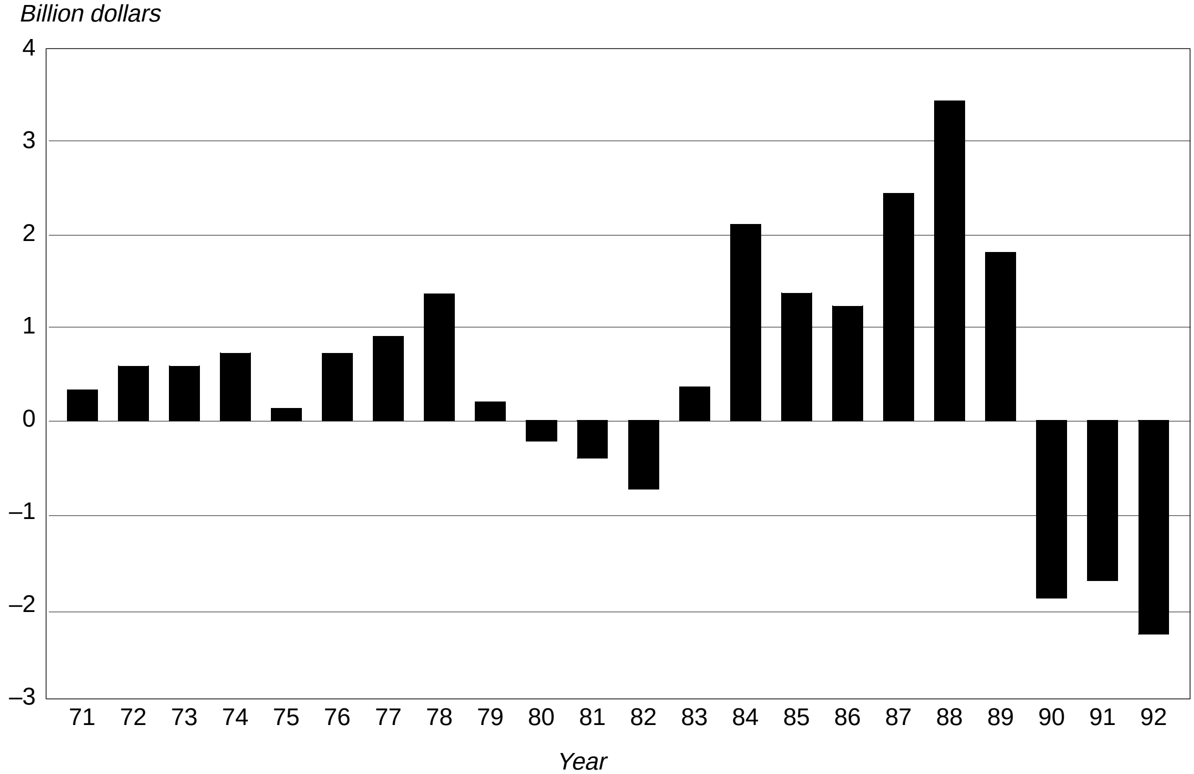
[88] Transportation Research Board, pp. 33-37.

[89] The International Civil Aviation Organization (ICAO), a specialized agency of the United Nations whose members comprise most of the world airlines, reported that 1991 passenger traffic figures showed the first decline since records were first kept in the 1940s.

[90] Federal Aviation Administration, Office of Airline Statistics official, interview by USITC staff, June 1992.

[91] Ian Goold, "Aerospace Apocalypse," *Flight International,* Apr. 28-May 4, 1993, p. 26. IATA is an association that represents most of the major world airlines for the purpose of promoting safe, regular, and economical air transport, and providing a platform for international cooperation among these air transport enterprises. Its membership currently

Figure 3-2
U.S. air carriers, operating/profit loss, 1971-92



Source: FAA, Office of Airline Statistics.

U.S. carriers also experienced increased competition in their domestic market, as costs continued to rise and revenues remained flat or declined. The decline in revenues was largely the result of intense ticket discounting, even during normally peak flying periods. In light of this, U.S. carriers sustained relatively more serious losses than their foreign competitors (figure 3-3).[92]

[92]—*Continued*
comprises approximately 215 air carriers worldwide, which account for an estimated 98-percent share of total world scheduled passenger miles flown. The only major world area not represented in the association's membership is China.

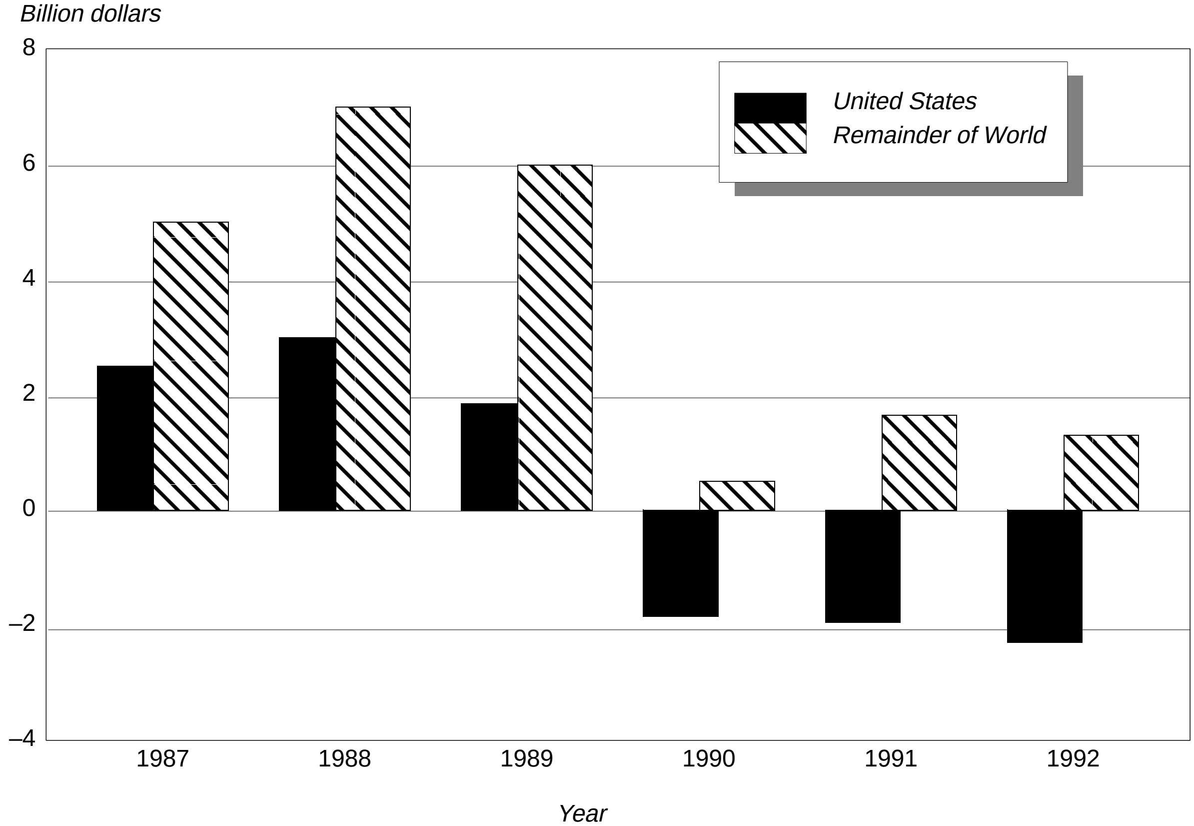
[92] On May 24, 1992, President Clinton signed legislation establishing a commission to recommend methods of reviving the airline industry. The National Commission to Ensure a Strong, Competitive Airline Industry will be required to report its findings by late August 1993. It will assess the impact on the airline industry of pricing policies, deregulation, bankruptcy laws, foreign investment, and government noise regulation.

The airlines (both freight and passenger carriers) that are the largest LCA purchasers in terms of fleet size are not necessarily the most profitable at present (table 3-3). The inability of many airlines to generate the profits necessary to invest in new aircraft has depressed demand for new LCA.

The current economic recession has depressed demand for air services, resulting in overcapacity, lowered airline profitability, and depressed demand for LCA. This has been exacerbated by the presence of Chapter 11 carriers in the market. If a bankrupt carrier fails and its assets are sold off, its entire fleet enters the LCA market at once, depressing prices for both old and new aircraft.[93] Carriers that do not fail but continue to operate under Chapter 11, contribute to overcapacity and lowered airline profits and thus depress demand for LCA.

[93] Anticipation of the event can depress prices of aircraft, even before the aircraft come on the market.

Figure 3-3
Airline operating profit: U.S. vs. remainder of world, 1987-92



Source: ICAO, ATW.

Table 3-3
Ten largest carriers, 1992

By Fleet Size	*By Operating Revenue*	*By Operating Profit*
American	American	Singapore
Delta	United	British Airways
United	Delta	Cathay Pacific
Federal Express	Air France	SAS Group
USAir	Lufthansa	Swissair
Aeroflot	Northwest	Federal Express
Northwest	Federal Express	Korean
Continental	British Airways	South African
British Airways	USAir	KLM
Air France	Continental	Southwest

Source: "World Airline Report," *Air Transport World*, June 1993, p. 56.

While a number of factors have contributed to overcapacity and declining profitability,[94] the rules governing bankruptcy of U.S. carriers may have contributed to the degree of unprofitability because of the large proportion of the market operating under Chapter 11 provisions.[95] Because of the disproportionate downward price pressure generated by these weak airlines that were not operating on a conventional profit-oriented basis,[96] intense price competition then could be sustained for a long enough period of time to damage even financially sound airlines.[97]

At present, only 2 carriers remain in Chapter 11. It may be that with a smaller proportion of the market in Chapter 11, and the rest of the industry driven by the need to make a profit, that the period of severe price wars has passed. If this is so, and profits rise,[98] demand for aircraft may begin to increase.

[94] According to one analyst, whatever the immediate cause of overcapacity, overcapacity in itself is not likely to be the cause of the current lack of profits, as load factors were actually lower in 1980 when industry profits were marginally higher. Perry Flint, "What's Wrong with the Airlines?," *Air Transport World,* May 1993, p. 59.

[95] The level of concentration in the airline industry also may have been a factor in the unprofitability of airlines.

[96] Carriers, as long as they remain in Chapter 11, are not required to make payments on pre-petition liabilities. Thus, they have lower cost curves than the industry as a whole, and can charge fares where marginal revenue is actually less than marginal costs. Bankrupt carriers must also generate any necessary cash from internal sources and therefore attempt to price at levels that will generate the most cash, but may not necessarily cover total costs. Flint, p. 62.

[97] Increased competitive pressures per se are not usually a primary cause of severe losses by nearly all participants in the market. While carriers always attempt to match the prices charged by competitors (Melvin Brenner, as found in Flint, p. 59.), prices that do not cover costs would normally not be sustainable.

[98] A number of analysts and companies predict an upswing in profits when the economy rebounds and demand outpaces capacity. Julian Maldutis, Salomon Brothers, and Richard Albrecht, Boeing, as found in Flint, p. 59.

Growth of Independent[99] Leasing Companies

As stated previously, the open environment created by the deregulation of the U.S. airline industry in 1978 brought a host of new entrants and increased competition. The need to lower costs in order to remain competitive, the recession of the early 1980s, the desire not to tie up scarce capital in LCA purchases, and the increased real cost of new aircraft, gave rise to the popularity of aircraft leasing during the 1980s. In 1986, for example, approximately one-third of the fleets of the major U.S. carriers was leased, compared with one-fifth in 1980. Between 1982 and 1984, in fact, one-half of all aircraft acquisitions were the result of lease agreements.[100]

While a variety of sources for aircraft leasing (e.g., JLL arrangements, insurance companies, and various investment groups) currently are available, independent leasing companies have been among the most visible and versatile lease suppliers. The major independent leasing companies in existence today are Guinness Peat Aviation Group plc (GPA), Shannon, Ireland; GE Capital Corporation (GECC),[101] Stamford, CT; Polaris Aircraft Leasing Finance Corp., a subsidiary of GECC, San Francisco, CA; and International Lease Finance Corp. (ILFC), Los Angeles, CA, a wholly-owned unit of U.S. insurer American International Group. Although a number of leasing companies initially concentrated on leasing used aircraft, as their operations grew, they began to place significant orders for new aircraft with Boeing, McDonnell Douglas, and Airbus. In spring 1993, GPA managed a fleet of approximately 419 aircraft, GECC had 292, Polaris had 262, and ILFC had approximately 194.

While some leasing companies are doing well from the standpoint of both profitability and growth, GPA has struggled to survive the current downturn in world aircraft business. This situation may be the result of the GPA placement of speculative orders and options for 308 aircraft totaling $16.8 billion in early 1989.[102] As a result, GPA found itself in a severely

[99] Independent refers to the fact that these companies are involved only in leasing aircraft; airlines and LCA manufacturers that lease aircraft are not included in this discussion.

[100] Transportation Research Board, p. 68.

[101] GECC is a division of General Electric Co.

[102] "Off Course: Troubles of a Lessor of Jet Airliners Touch Many Parts of Industry," *Wall Street Journal,* Dec. 17, 1992, p. A5.

extended financial position as a result of both its drastically increased capital costs and the worldwide economic downturn beginning in the early 1990s, which caused the market to fall drastically short of GPA market projections.[103]

GPA appears to have survived its current crisis.[104] Some industry observers feared that if it had not, the sudden dumping of so many additional aircraft into a market already faced with significant overcapacity could depress aircraft values to the point where the value of airline asset portfolios would decrease, possibly undermining the financial positions of the airlines with their creditors and depressing orders for new aircraft. However, it is likely that independent leasing companies will continue to provide a large portion of LCA, given the current financial situation of many large world air carriers.[105]

Globalization[106] of the Airline Industry

Globalization of the worldwide airline industry has proceeded at a much slower pace than that of LCA production. This has been due largely to the numerous restrictions placed by world governments on access to their domestic markets, as well as foreign ownership of domestic carriers. Most government restrictions are covered in bilateral agreements between nations. The regulatory policies that currently exist in the United States and most foreign markets also include cabotage restrictions[107] that preclude the expansion of air services or flights by a foreign carrier into the domestic market of another nation, except where such services or flights are incidental to an international flight, without government negotiation. By and large, these bilaterals have been implemented in the nationalistic interest of controlling access (i.e., air transport freedoms)[108] to home markets by constraining the extent to which foreign carriers can offer air transport services.[109]

In the EC, steps have been taken to ease progressively the barriers among member states and with the rest of the world. The initial steps to relax economic regulation in the EC took place in 1987, when the implementation of the First Liberalization Package for Air Traffic Services restricted the scope of the capacity-sharing arrangements that were in effect between airlines on most of the passenger routes within the member states. The Second Liberalization Package (1990) limited the power of individual member states to veto intra-EC passenger airfares and placed additional restrictions on airline capacity-sharing arrangements.

The Third Liberalization Package (mid-1992) places even more severe constraints on the ability of member states to regulate the fares and rates airlines charge, provides uniform standards for licensing air carriers within the EC, and further lifts restrictions (particularly cabotage) on access to air routes within

[103] Ibid. In response to its difficulties, in 1992 GPA reduced its firm aircraft orders to $5.5 billion from $11.9 billion earlier in the year, and took delivery of approximately $1.6 billion in new planes. The deferrals will have a significant impact on Boeing, whose outstanding orders from GPA represented approximately 10 percent of its total order backlog (146 out of 1,427) near year-end 1992. An even greater impact is expected on Airbus, as orders for 20 wide-body A340 and A330 models may be canceled altogether. McDonnell Douglas now is attempting to reschedule approximately $2 billion in orders (18 MD-11 tri-jets and nine smaller planes) with GPA.

[104] GPA and GE announced a proposed deal under which GE has the option of purchasing a controlling interest in GPA in return for a capital infusion. GPA and GE's Polaris unit combined will control a portfolio of nearly 1,000 LCA. "The Dangers of Overreach," *Airline Business,* June 1993, p. 7.

[105] Bron Rek and J.R. Wilson, "Mixed fortunes for leasing giants," *Interavia/Aerospace World,* Jan. 1993, p. 29.

[106] Globalization can be defined as the process by which individual air carriers expand the scope of their operations through international route structures, typically by entering into bilateral agreements with other carriers or governments, or by acquiring full or partial equity interests in other carriers.

[107] Cabotage restrictions prohibit nondomestic airlines from carrying passengers or cargo between two points within that country.

[108] The five freedoms of air transport were a byproduct of the Chicago Convention of 1944. They pertain to the right to (1) fly over another nation, (2) land in another nation without picking up or disembarking passengers, (3) disembark in another nation passengers that boarded in the carrier's home country, (4) carry passengers of another nation to the carrier's home country, and (5) carry passengers from one foreign country to another. Governments can choose to either grant or deny any of these freedoms, and thereby partially or fully restrict the access of carriers to their airspace.

[109] Mark Dunkerley, British Airways, remarks made at "Era of the Megas," Airline Business/SH&E Conference, Washington, DC, Nov. 6, 1992, p. 3.

the EC. The EC Commission also has proposed regulations to identify the types of activities among carriers that will be granted categorical exemptions from the anticompetitive provisions of the Treaty of Rome.[110] The EC Commission appears committed to the economic deregulation of the EC market as a necessary condition for achieving a unified air transport market, in spite of some industry opposition.[111] Many industry observers anticipate that the integration and deregulation of the EC air transport market will hasten the rationalization and consolidation of the European airline industry, creating an environment conducive to the creation of global alliances.

In contrast to the liberalization efforts in Western Europe and North America, carriers in Southeast Asia have been taking steps to block the anticipated expansion of U.S. and European carriers into the Far East. Concerned that their competitive advantage is being eroded, the six member airlines[112] of the Association of Southeast Asian Nations (ASEAN) have agreed to establish a cooperative arrangement to lower their costs, protect their regional markets, and increase their international profile and competitiveness.[113] Initially, cooperation is expected to take the form of commercial agreements to consolidate resources for purchasing, sales and marketing, and market strategy. In addition, a subcommittee headed by Thai International has been formed to secure the lowest available price for aviation fuel. Joint maintenance facilities also are tentatively planned for the lowest-wage-rate areas of the region to further reduce labor costs. In addition, nine carriers in southern Asia have proposed the formation of an Association of South Asian Airlines (ASAA).[114]

The apparent movement of the carriers of this region toward cooperation does not offer prospects for the liberalization of cross-border barriers to the free flow of air transport services. In fact, the effect of both ASEAN and ASAA developments likely will be to erect impediments to the introduction of competitive market forces into the region.[115]

With the current lack of domestic market growth, most major U.S. carriers are counting on international profitability and market expansion to increase market share and profits.[116] Following domestic consolidation, which has allowed carriers to cut costs, U.S. and foreign airlines have attempted to consolidate their international services through three principal means: acquisitions, joint marketing agreements, or internal growth.[117] Under U.S. law, however, a foreign firm cannot hold more than a 25-percent voting right stake in a U.S. airline.[118] A number of carriers have already made important strides in developing truly global airline operations.

The 1989 alliance between Northwest Airlines and KLM Royal Dutch Airlines may be the most complete marketing arrangement between two major carriers in existence today. The terms of the agreement include the payment by KLM of $400 million for a 20-percent stake and a 10.6-percent voting right in Northwest's parent, Wings Holdings. Northwest and KLM have

110 The Treaty of Rome, enacted on March 25, 1957, established a European customs union and required the elimination of all quantitative restrictions and other measures having an equivalent effect on trade among the European signatory member states. It envisioned a single internal European market and became the founding charter for the European Economic Community, which came into being on January 1, 1958.

111 For additional information, see U.S. International Trade Commission, *The Effects of Greater Economic Integration Within the European Community on the United States: Fourth Followup Report*, USITC publication 2501, Apr. 1992, pp. 9-3 through 9-5.

112 Singapore Airlines, Thai International, Garuda, Philippine Airlines, Malaysia Airlines, and Royal Brunei Airlines.

113 "Newsline (ASEAN bloc hardens)," *Airline Business,* Sept. 1992, p. 20.

114 Ibid. These carriers are Pakistan International, Air India, Indian Airlines, Air Lanka, Biman Bangladesh, Druk Air, Maldives Air Services, Royal Nepal Airlines, and Vayudoot Airlines.

115 Ibid.

116 "Ruffled feathers," *Airline Business*, Sept. 1992, p. 39.

117 Internal growth suggests that a company expand its operations internationally by acquiring or developing routes (either new or existing) through its own internal resources. The major hindrance to this approach is that its success is often heavily dependent on the availability of extensive first through fifth freedom air traffic rights.

118 H.R. 926, currently before the House of Representatives, would liberalize this restriction. Foreign investments in the U.S. airline industry above the current 25-percent threshold would be permitted as long as (1) the key officers and two-thirds of the airline's board of directors would still be U.S. citizens, (2) U.S. citizens would still control at least 51 percent of the airline's stock, and (3) the Secretary of Transportation finds that the investment would be in the public interest. *Federal Register,* Feb. 17, 1993, E344.

established joint venture flights on two routes,[119] and have increased efficiency by sharing maintenance facilities, ticket offices, and ground services. In January 1993, the Department of Transportation approved the closer integration of KLM and Northwest flight scheduling, pricing and sales activities, joint advertising campaigns, and negotiation of revenue-sharing agreements. In the future, the two airlines expect to consolidate fully pricing and commissions, and institute a joint service platform (a set of ground and flight service commitments made jointly by both companies to its customers). This consolidation of service may affect future LCA acquisitions if Northwest and KLM should also wish to standardize their equipment.[120]

In Western Europe, British Airways (BA) already has taken a number of steps to globalize its operations. By making a minority investment in Germany's Delta Air (subsequently renaming it Deutsche BA) in early 1992, and by proposing to purchase a minority interest in USAir and 49.9 percent of TAT European Airlines (a French regional carrier), BA could expand its operations substantially outside the United Kingdom. The investment in TAT, which is one of the few remaining independent French domestic carriers, would give BA access to one of Western Europe's more lucrative markets. Recently, BA also opened a gateway to the Australian market by closing a successful bid for 25 percent of the dominant regional carrier, Qantas.

The BA link with USAir involves both joint marketing and a substantial equity acquisition. The initial BA/USAir proposal involved the proposed exchange of $750 million in funds from BA for 21 percent of the voting equity and 44 percent of the economic interests of USAir. This proposal prompted strong protests from the "Big Three" U.S. airlines.[121] Consequently, on January 21, 1993, BA reduced its cash outlay proposal to $300 million to acquire preferred stock in USAir that constituted 19.9 percent and 24 percent of the USAir voting rights and equity, respectively. These levels are below the U.S. statutory restrictions of 25 and 49 percent that are currently in effect on foreign voting control and equity holding, respectively, in U.S. airlines. The new proposal also gives BA the option to purchase an additional $450 million of convertible preferred stock (for a total equity interest of 32.4 percent in USAir) in two installments, should restrictions on foreign ownership of U.S. air carriers be lifted. On March 15, 1993, the Department of Transportation conditionally approved the BA initial investment in USAir. However, it stated that it will not act on the subsequent two phases of an additional $200 million in 3 years and $250 million within 5 years unless Congress first alters laws governing foreign ownership in U.S. airlines.[122] Any change in the laws are viewed as likely to be challenged by the major U.S. air carriers, which already argue that no new authority should be granted to British carriers to operate in the U.S. market until the British Government eases its current air transport service restrictions on U.S. flag carriers.[123]

Air France has announced a number of cooperative agreements that would provide the company with linkages to Aeromexico and Vietnam Airlines. Similarly, Japan Airlines has a 5-percent stake in Air New Zealand, and All Nippon Airlines owns 9 percent of Austrian Airlines. The agreement among Delta, Singapore Airlines, and Swissair (which involves only minor exchanges of equity), although not resulting in a seamless integration of services of the respective carriers, may represent an example of future airline linkage trends, providing for cooperation across the three major regions for air services.

These linkages are viewed within the industry as suggesting the course world airlines will take over the next few years. As worldwide competition is allowed to proceed in a less restrained environment, the tendency toward global alliances may yield what many in the industry have called "megacarriers." The evolution of megacarriers likely would alter significantly the competitive environment for both airlines and LCA manufacturers worldwide. Megacarriers would have considerable purchasing power, and therefore influence, with the major world LCA manufacturers.

[119] Under this arrangement, essentially one-half of the plane is designated for Northwest passengers and the other half for KLM passengers. KLM operates the aircraft on both of these joint flights (Minneapolis to Amsterdam and Detroit to Amsterdam).

[120] Frits Njio, "KLM Pushes Ahead with Global Alliances," *Interavia/Aerospace World,* Feb. 1993, p. 39.

[121] American, Delta, and United.

[122] Mark B. Solomon, "DOT OKs First Phase of BA Deal With USAir," *Journal of Commerce,* Mar. 16, 1993, p. 1A.

[123] "USAir/BA Pact Faces New Fight," *Aviation Week & Space Technology*, Feb. 1, 1993, p. 29.

Privatization of European Airlines[124]

The European airline industry today is approximately 25-percent state owned, 21-percent privately owned, and 54-percent mixed (public and private) ownership. Only in the Africa-Middle East region is the percentage of government control among carriers higher (over 50 percent) than in Europe. This situation may change markedly in the future, however, as the opening of the European market under the Third Liberalization Package begins to bring increased competitive pressures to bear on the major European carriers.[125] Due to the size and scope of their operations, Air France, which is 100-percent government owned,[126] and Lufthansa, which is 51-percent government owned, are likely to be the most severely affected because they have been somewhat insulated from competitive market forces by assistance from their respective governments. In addition, the dissolution of the Soviet Union, with its concomitant relinquishing of controls on the Eastern bloc countries, has made the formerly state-run carriers in these countries the targets of extensive privatization efforts. Some of these carriers may need to either replace a portion of their aging fleets of predominantly Soviet-built aircraft and/or expand their fleets should they be able to secure the requisite infusion of capital following privatization. The competition for equipment sales to these carriers may help alleviate the problems of excess capacity currently being experienced by suppliers of Western aircraft. However, Russian LCA manufacturers are not expected to concede these traditional markets easily; consequently, competition for these sales likely will be intense.[127]

[124] Much of the information contained in this section was extracted from a paper entitled "The Multinational Airline—Is Airline Privatization a Positive-Sum Game?" authored by Uli Baur, vice president, Simat, Helliesen, & Eichner, Inc., and presented at a conference sponsored by *Airline Business* magazine in London, June 30-July 1, 1992.

[125] "First Aid, Last Time" (adapted from paper delivered at the Airline Business Conference, June 30-July 1, 1992), *Airline Business,* Sept. 1992, p. 69.

[126] William Drodziak, "France to Sell Its Control of 21 Key Firms," *Washington Post,* May 27, 1993, p. A-1. In a move to invigorate the sluggish French economy, the new French administration announced plans to allow private buyers to acquire 21 state-owned firms, including Air France, in fall 1993.

[127] *Aircraft Value Newsletter,* Nov. 2, 1992, p. 1.

Comparisons of privately- vs. publicly-held airlines generally demonstrate a significant advantage for private carriers in terms of employee productivity and airline efficiency. The prime example of government airline divestiture has been BA, which was privatized in 1987. In terms of profitability, BA has outperformed its two leading West European rivals, Air France and Lufthansa, since being divested. This was to some extent the result of productivity improvements (principally employee reductions) that were undertaken prior to privatization.[128]

The global air carrier industry has expressed concern with respect to West European airline privatization, indicating that government-funded privatization could be harmful to unsubsidized carriers. Privatization of government-owned airlines may have a negative impact on U.S. airlines' demand for aircraft as foreign governments, in the course of privatization, pay off the debt of privatized companies, thereby strengthening these companies' position in the marketplace to the disadvantage of U.S. carriers. However, with respect to future anticipated effects of foreign privatization efforts, the creation of new private airline entities is expected to stimulate competition and, in turn, increase air traffic.[129] Reduced government ownership of airlines also is expected to encourage aircraft purchases based solely on market criteria.

Shifting Importance of Regional Markets

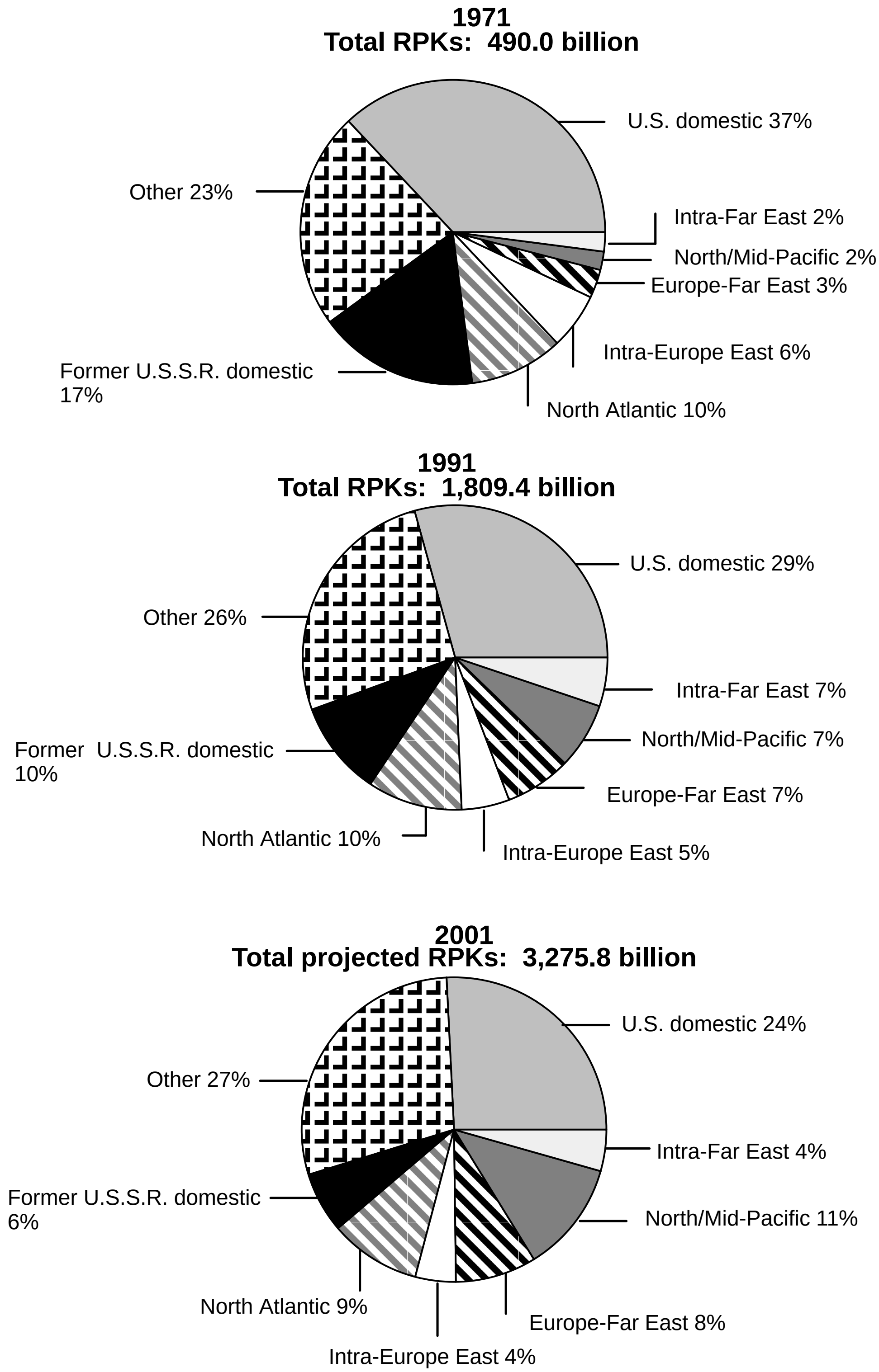
The principal world traffic regions in order of importance in 1971 were as follows: U.S. domestic (182.2 billion RPKs), U.S.S.R. (85.1 billion RPKs), North Atlantic (48.3 billion RPKs), Intra-Europe (27.0 billion RPKs), Europe-Far East (16.3 billion RPKs), North/Mid-Pacific (10.4 billion RPKs), and Intra-Far East (8.2 billion RPKs) (figure 3-4). The remainder of the world market, consisting principally of the remainder of North America, Central and South America, Africa, and the Middle East, had air traffic amounting to 112.5 billion RPKs.[130]

[128] Doug Cameron, "The Right to Buy: Are We Witnessing the End of the National Carrier," *Airline Business,* Aug. 1992, pp. 29-30.

[129] Compiled from responses to USITC airline questionnaire, Feb. 1993.

[130] Victor L. Peterson and Charles A. Smith, presentation entitled "Applied Aerodynamics Challenges and Expectations" (Moffett Field, CA: NASA Ames Research Center, 1992), table CA2858.07.

Figure 3-4
World air traffic (revenue-passenger-kilometers): 1971, 1991, and 2001



Source: Victor L. Peterson and Charles A. Smith, presentation entitled "Applied Aerodynamics Challenges and Expectations" (Moffett Field, CA: NASA Ames Research Center, 1992), table CA2858.07.

During 1971-81, while total world air traffic grew by an average of 9 percent, significantly more rapid rates of growth were recorded in the Europe-Far East region (15 percent), the North/Mid-Pacific region (16 percent), and the Intra-Far East region (18 percent). This trend was sustained by the latter two regions during 1981-91. Thus, while overall world growth during 1981-91 averaged 5 percent, traffic growth in the North/Mid-Pacific and Intra-Far East regions was more than double that, at 10 and 11 percent, respectively. As a result of the 20-year trend in air traffic during 1971-91, the relative shares of total world traffic accounted for by most of the principal regions changed significantly. For example, in 1991, U.S. domestic air travel, which totaled 527.6 billion RPKs, accounted for 29 percent of the world total, compared with a 37-percent share in 1971. The other major decrease in traffic was in the U.S.S.R. domestic region, which declined from 17 percent of the world total in 1971 to 10 percent in 1991. Conversely, the major worldwide gains were recorded by the Europe-Far East region (which increased from 3 to 7 percent of the world total during 1971-91); the North/Mid-Pacific region (2 to 7 percent); and the Intra-Far East region (2 to 7 percent).[131]

Most projections for future growth in air traffic suggest that the regions that accounted for the highest levels of increased traffic during 1971-91 will continue to sustain these trends through the next decade. Current projections call for traffic in the Europe-Far East region to grow at approximately 8 percent annually, so that by the year 2001, traffic in this region will reach approximately 265 billion RPKs, or an estimated 8 percent of the world total. The other two major areas of anticipated higher-than-average growth are the North/Mid-Pacific region (11-percent projected annual increases to approximately 350 billion RPKs in 2001) and the Intra-Far East region (11-percent annual increase to just over 350 billion RPKs). The projected overall annual growth in worldwide air traffic is currently estimated to be approximately 6 percent.

The implication of these trends for domestic airlines and aircraft manufacturers alike is that an increasing proportion of worldwide business in aircraft equipment and services will be conducted away from the domestic U.S. market. Industry sources view it as critical that U.S. LCA manufacturers focus their efforts in emerging markets, while maintaining a high level of participation in established markets. Joint manufacturing agreements can provide market access; the U.S. aircraft-manufacturing companies have entered into joint manufacturing agreements in Europe and the Far East for this purpose (see chapter 2).

[131] Ibid.

Trends in Global Government Noise Regulations

Noise limits on aircraft were mandated by the U.S. Congress in 1968. In response to congressional legislation amending the Federal Aviation Act of 1958, the Federal Aviation Administration (FAA) was given broad authority to adopt regulations limiting aircraft noise. The FAA Federal Aviation Regulations (FAR) Part 36 identify three noise levels, or "stages."[132] Stage 1 regulations applied to the noisiest aircraft (principally early 707s and DC-8s); the operation of most of these aircraft was phased out by January 1, 1985. The more stringent Stage 2 noise standards, which went into effect on December 1, 1969, established requirements for new aircraft designed on or after that date. These standards were extended on December 1, 1973 to cover all aircraft in production at that time.

On November 5, 1990, the Airport Noise and Capacity Act of 1990 (ANCA) was enacted. ANCA requires that the operation of Stage 2 aircraft of over 75,000 pounds in the contiguous United States be phased out by December 31, 1999. Subsequent FAA rulings have provided aircraft operators with two options for the phaseout of Stage 2 aircraft.[133] Under either option, Stage 3 aircraft, the standards for which were implemented on October 10, 1977, must comprise 100 percent of all aircraft fleets by December 31, 1999, unless the Secretary of Transportation has granted a waiver.[134]

[132] FAA official, interview by USITC staff, Feb. 1993.

[133] One option allows the operator to have phased out 25 percent of its Stage 2 aircraft by the end of 1994, 50 percent by the end of 1996, and 75 percent by the end of 1998. The alternative permits the operator to reach a 55-percent Stage 3 fleet composition by the end of 1994, 65-percent composition by the end of 1996, and 75-percent composition by the end of 1998.

[134] Although the law prohibits Stage 2 operations after 1999, it does permit operators to upgrade Stage 2 aircraft to Stage 3 by means of engine replacement or the use of "hush kits." Hush kits run from $1 to $3 million per plane and may impose payload penalties on the operation of the aircraft.

By year-end 1991, approximately 53 percent of the entire U.S. fleet of large civil turbojet aircraft was composed of Stage 3 aircraft (2,224 out of a total of 4,181). This figure rose to approximately 59 percent (2,516 aircraft) by the end of 1992, leaving a total of approximately 1,756 (41 percent) Stage 2 aircraft that will need to be either retrofitted or retired by the turn of the century. In addition, projected growth in domestic air travel will require the addition of approximately 1,475 aircraft to the U.S. fleet by the turn of the century.[135] Therefore, U.S. airlines will have to add approximately 210 newer Stage 3 aircraft to their fleets annually to meet the anticipated growth in air traffic demand by the year 2000. Moreover, an additional 250 aircraft annually will have to be retrofitted or replaced to maintain existing airline fleet inventories. Therefore, the potential exists for world LCA suppliers to provide in excess of 400 Stage 3 aircraft annually to U.S. aircraft customers alone through the year 1999.

According to industry sources, the noise-reduction technology currently embodied in Stage 3 aircraft engines is so advanced that it leaves little room for further reductions in engine noise levels without a substantial decrease in engine power or efficiency. Additional improvements in noise levels beyond Stage 3 requirements likely will require 6 to 8 years of research and development and an estimated $120 to $200 million in funding.[136] In the meantime, compliance with current noise regulations will require significant outlays by air carriers for retrofit packages and may result in lost economic opportunity costs from retiring aircraft before the end of their otherwise useful lives.

[135] U.S. Department of Transportation, FAA Aviation Forecasts (fiscal years 1993-2004), FAA-APO 93-1, Feb. 1993, pp. III-40 and III-41.

[136] Bill Sweetman, “The Probable Pinch of Future Limits,” *Air Transport World*, Feb. 1993, p. 56.

CHAPTER 4:
Determinants of Competitiveness in the Global Large Civil Aircraft Industry

Introduction

The factors or determinants of competitiveness discussed in this chapter may be divided into those that are internal to the firm, and those that are external to the firm. Factors internal to the firm are either controlled or controllable, to some extent, by the large civil aircraft (LCA) manufacturers: for example, firm strategy and private-sector-funded research and development (R&D). External market factors are those beyond the direct influence of the LCA manufacturers, such as market and macroeconomic factors and government policy factors. Examples of market and macroeconomic factors include exchange rates, price of fuel, and availability of capital, while government policy factors include direct and indirect government support, and regulatory policies. This chapter provides a discussion of the internal and external factors that determine competitiveness in the global LCA industry. Government policy-related factors are discussed in greater detail in chapter 5, and R&D, both private-sector- and government-funded, is examined in greater detail in chapter 6.

Factors Internal to the Firm

Corporate Structure

Corporate structure has a notable effect on competitiveness in the global LCA industry. For example, corporate structure determines whether a firm must pay taxes on profits or report financial results, and it influences the internal decision-making process.

Airbus is organized as a groupement d'intérêt économique (G.I.E.) under French law.[1] French law recognizes the G.I.E. as a type of joint venture that has a legal identity separate from its members and which has no formation requirement of a fixed capital contribution. Like a partnership in the United States, a G.I.E. is not required to report financial results. It is also not liable to pay taxes on its profits unless it so elects.[2] Members of a G.I.E. are jointly and separately liable, without limitation, for the G.I.E. debts and obligations. However, such debts and obligations are shared in proportion to the members' respective membership rights.[3]

Airbus member companies need not share information about their costs. Therefore, neither the member companies nor Airbus knows the actual cost of manufacturing Airbus planes (with the exception of the financial director, who has access to the member companies' books).[4] This lack of transparency

[1] This type of organization was created in France by Ordinance No. 67-821 of September 23, 1967, and Decree No. 68-109 of February 2, 1968.

[2] Gellman Research Associates, Inc. for the U.S. Department of Commerce, *An Economic and Financial Review of Airbus Industrie* (Jenkintown, PA: Sept. 4, 1990), p. 1-2; and George Eberstadt, "Government Support of the Large Commercial Aircraft Industries of Japan, Europe, and the United States," contractor document for Office of Technology Assessment, *Competing Economies: America, Europe, and the Pacific Rim* (Washington, DC: Congress of the United States, 1991), p. 236.

[3] "Responses of Airbus Industrie, G.I.E. to Questions Regarding the ITC's Study on Global Competitiveness of the U.S. Aircraft Industry," tab J.1; and Gellman, p. 1-2.

[4] Transcript of hearing, pp. 182-183, 191, 222; and Mary Anne Rose, *Airbus Industrie: High Technology Industrial Cooperation in the EC - Structure, Issues, and Implications with a View Towards Eurofar*, paper for conference on The

decreases the amount of oversight and control the Airbus partners can exert over Airbus.

A French G.I.E. can bring together resources, including financial resources, that individual U.S. corporations may not be able to match. Moreover, the G.I.E. method of pooling resources does not impinge upon the autonomy of its members.[5] In the case of Airbus, this structure may give it certain advantages over the corporate structure of U.S. LCA manufacturers. According to Airbus, the G.I.E. provides the following benefits: enables cooperation on full partnership basis;[6] merges the technical strengths of the participants; receives new members easily; enables partners to vary participation program-by-program;[7] avoids locking up large sums of capital; and provides the ability to deal directly with customers as a single entity.[8] The G.I.E. structure of Airbus also enables the entity to distribute among its member companies the risks, including losses, associated with the high cost of research and development (R&D), manufacturing, and marketing a new LCA.

As corporations, U.S. manufacturers experience restrictions on raising capital to fund operations and are obligated to make business decisions at the behest of their shareholders which tend to focus on short-term results. They also are taxable entities and may be subject to standards imposed by the Securities and Exchange Commission. Airbus is not subject to these types of restrictions to the same degree as U.S. corporations.[9]

According to Airbus, however, its structure as a G.I.E. creates a disadvantage in that "the decision-making process is more complex and sometimes slower than in a fully integrated corporation."[10] Problems also can arise when customers seek product support; Airbus must refer the customer to the responsible consortium member, which results in delays and a lack of cohesiveness in operations. The Commission of the European Communities has noted that for all of its asserted benefits, Airbus has difficulty competing with its highly integrated competitors.[11]

There are other concerns about the Airbus decision-making structure. The division of work on individual aircraft projects may not correspond to the members' percentage of ownership, as a member's share of work on an Airbus project is greatly influenced by the capital it is willing to invest in that project.[12] In addition, influences that may not represent the best interest of Airbus, but rather the best interest of a particular member company, theoretically can enter into the Airbus decision-making process. Airbus notes that each Airbus partner has a dual role — that of owner and subcontractor. This dual role contains an inherent tension that may make it difficult for the partner to identify its own "best" interest, let alone that of Airbus as a whole. U.S. manufacturers' board decisions presumably are made on the basis of the best interest of the company as a whole; theoretically, this could represent an advantage for U.S. LCA manufacturers. Moreover, a German Government source has recognized that Airbus division-of-labor decisions are made on a "political level," suggesting that a task may not always be assigned to the consortium member that can most efficiently or economically perform it.[13]

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[4]—*Continued*
European Community in the 1990s, Emerging Concepts and Priorities, George Mason University, May 24-25, 1989 (San Jose, CA: San Jose State University Foundation for NASA Ames Research Center, May 1989), p. 11.

[5] Ibid.

[6] Airbus members allegedly have an incentive to share their full technical capabilities, in contrast with the arms-length relationships between a contractor and subcontractor. "Responses of Airbus Industrie," tab J.2.

[7] The Airbus internal bidding/contracting rules by which work is assigned to member companies allegedly creates "intense competitive pressures" among its members. Ibid.

[8] Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2-3, 1992; and Artemis March, *The U.S. Commercial Aircraft Industry and its Foreign Competitors* (Cambridge, MA: MIT Commission on Industrial Productivity, 1989), p. 62.

[9] For a discussion of the basic formation, operation, and reporting requirements of U.S. corporations, see, e.g., W.A. Klein and J.C. Coffee, *Business Organization and Finance: Legal and Economic Principles*, pp. 140-155, 183-187.

[10] "Responses of Airbus Industrie," tab J.2.

[11] Commission of the European Communities, *A Competitive European Aeronautical Industry (Communication from the Commission)* (Brussels: Commission of the European Communities, SEC (90) 1456 final, July 23, 1990), p. 9.

[12] Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2-3, 1992; and Gellman, pp. 1-5.

[13] "West German Monopolies Commission Report (providing the report and vote concerning the Daimler-Benz takeover of MBB)," ¶¶ 148-157, 298; and Eberstadt, pp. 238-239.

Firm Strategy

Firm strategy is a critical component in the ability to develop market share and profitability. All of the LCA manufacturers have the same overall goal, which is to offer cost-efficient, technologically advanced aircraft with competitive direct operating costs,[14] commonality[15] throughout their product line, and a global support system, at the best price. As stated in chapter 3, acquisition and operating costs must be outweighed by the revenues generated from flying the aircraft. Although Boeing and Airbus believe that the strategy of offering a family of aircraft is an important competitive advantage, McDonnell Douglas asserts that it can compete effectively while participating only in the 150-seat and 300-seat segments of the market.[16]

Apart from overall strategies, LCA firms have more short-term, specific strategies: for example, to increase production and marketing of a particular type of aircraft in response to predicted market demand. Without a broad product base, it is more difficult to respond to shifting demand across various aircraft types, although the manufacturer still may be competitive in those segments for which it has aircraft. The manufacturers' competitive positions serve to restrict or enhance their ability to assert both their overall and specific strategies.

Importance of Broad Product Lines

Offering the broadest possible product line provides such benefits as commonality, economies of scale, and learning curve effects (these factors are discussed later in this chapter). An LCA manufacturer with a broad product line also is able to respond to changes in market demand. This can be critical to maintaining competitive position given the cyclical popularity of various aircraft types. Boeing competes in five LCA product niches,[17] Airbus competes in four, and McDonnell Douglas competes in two. McDonnell Douglas officials calculate that its product line addresses just 44 percent of the civil transport market.[18]

Launching New Programs

Because of the nature of the LCA industry, investments are large and irreversible. It is often said that a manufacturer bets the company when it invests in a new program. To launch a new aircraft successfully, the manufacturer must identify an area of growing demand that is not well served by its own and its competitors' models. Moreover, because the potential market for a new LCA product is relatively small, the firm that first addresses this market gap typically realizes greater success. Therefore, a successful "first move" affects the competitiveness of LCA firms.[19] Aggressive pricing at this stage can enhance further a firm's competitive position.

In recent years, Airbus has been particularly successful in identifying market opportunities; it targeted the 150-seat market with the A320 and the market below the 747 with the A330/340. The A320

[14] Direct operating costs include such elements as fuel, cabin crew, cockpit crew, depreciation, interest, maintenance, and insurance costs.

[15] Commonality means common parts/systems among aircraft. Examples of aircraft parts/systems that can be common within a manufacturer's product line are fuselage sections, cockpit, engines, avionics, and systems. Commonality benefits the manufacturer in terms of development cost and production efficiencies, and benefits the airlines in terms of maintenance and crew training savings.

[16] Robert H. Hood, Jr., president, Douglas Aircraft Co., posthearing submission on behalf of McDonnell Douglas Corp., p. 3.

[17] These market segments can be defined roughly as 100-150 seats, 150-180 seats, 180-250 seats, 250-350 seats, and 350-500 seats.

[18] Loren B. Thompson, *McDonnell Douglas Corporation (I): Commercial Aircraft Operations are in Decline; MD Will Exit Business in the 1990s* (Washington, DC: National Security Studies Program, Georgetown University, Oct. 23, 1992), p. 7.

[19] For example, the deregulation of the U.S. airline industry in 1978 caused dramatic changes in airline route structures. This in turn changed the type of aircraft airlines needed to purchase. Demand for narrow-body aircraft increased to accommodate the new hub-and-spoke system of more frequent, shorter flights. While Boeing and McDonnell Douglas were prepared to meet this demand with their 737-300 and MD-80 series products (first deliveries occurring in 1984 and 1980, respectively), Airbus did not have a narrow-body aircraft on the market until the A320 was first delivered in 1988. From 1984, when the first A320 orders were recorded, to 1992, Airbus had 656 A320 orders, compared with 929 for MD-80s, and 1,861 for 737s. For commonality and other related reasons, the market presence of the Boeing and McDonnell Douglas narrow-body aircraft before the surge in demand for these aircraft (brought on by deregulation) has favored Boeing and McDonnell Douglas, even though the Airbus A320 incorporates newer technology.

exemplifies how a manufacturer can overcome the first mover advantage of a competitor with other factors, such as newer technology and meeting specific needs of airlines. Although it was introduced only in 1988, the A320 was specifically designed as a 150-seat narrow-body aircraft; neither the MD-80 nor the 737-300 exactly met this specific requirement. Further, the A320 incorporated newer technology and more fuel efficient engines. Thus, although Airbus was late in entering this particular segment of the market, sales of the A320 have been impressive. McDonnell Douglas hopes to achieve first-mover success with the over 500-seat MD-12, which will have the largest capacity of any LCA currently produced.[20]

While the design phase of a new program may be lengthy, the product must be "brought to market" rapidly once the decision has been made to introduce a new aircraft. The ability to manage effectively the design phase and the transition from the design to the production phase has a substantial impact on a firm's competitiveness.[21]

Risk Sharing and Other Partnerships

Because there is substantial risk inherent in aircraft manufacturing, LCA manufacturers increasingly are seeking risk-sharing partners. These partners, which assume a portion of the risk of aircraft development and production, typically are suppliers to the LCA manufacturers, or manufacturers in their own right. Airbus can be considered a consortium of risk-sharing partners; further, the consortium members participate in risk-sharing relationships with their respective subcontractors. Boeing engages in risk-sharing relationships with Japanese and Italian companies, as well as with some of its U.S. subcontractors. McDonnell Douglas has similar arrangements with Chinese entities (see chapter 2).[22]

The choice of partners for multinational production programs can fill gaps in product lines, and they can assist in maintaining or achieving leadership in critical technologies.[23] Foreign suppliers often have a lower cost of capital, longer term strategies, sometimes government backing, and they are more likely than U.S. companies to become risk-sharing partners.[24]

A significant benefit of risk sharing in the realm of subcontracting is the manufacturer's ability to defer a portion of its production costs. Industry sources report that a regular subcontractor recoups its nonrecurring costs up front and is paid for its unit costs as it delivers the components. A risk-sharing subcontractor prorates its investment in such things as tooling and test equipment over an agreed-upon number of aircraft, and shares in the risk of meeting this sales goal. If the goal is exceeded, the risk-sharing subcontractor recoups its costs and earns additional profit. If the goal is not met, the risk-sharing subcontractor must absorb a portion of its nonrecurring costs.[25]

Length of Time in the Industry

Launch Costs

A new entrant must be able to commit billions of dollars to develop a single program, with initial sales of the aircraft several years away. For example, the development costs incurred by Boeing in its 747 program are estimated to have been $1.2 billion—more than triple Boeing's total capitalization at that time.[26] Once this tremendous financial commitment has been made, the funds can be

[20] Production of the MD-12 has been postponed. At the same time, Boeing has begun discussions with the Airbus partners concerning the development of an ultra-high-capacity aircraft, which would have a larger seating capacity than the MD-12.

[21] David C. Mowery, *Alliance Politics and Economics: Multinational Joint Ventures in Commercial Aircraft* (Cambridge, MA: American Enterprise Institute, Bollinger Publishing Co., 1987), pp. 32-33.

[22] Gellman, p. A-10.

[23] March, p. 44.

[24] Jonathan C. Menes, acting secretary for trade development, posthearing submission on behalf of the U.S. Department of Commerce, p. 11.

[25] John F. Hayden, corporate vice president, Washington, DC office, The Boeing Co., testimony before the U.S. International Trade Commission, Apr. 15, 1993.

[26] The 747 program was announced in 1966. Office of Technology Assessment, *Competing Economies: America, Europe, and the Pacific Rim* (Washington, DC: Congress of the United States, 1991), pp. 15-16, as found in Laura D. Tyson and Pei-Hsiung Chin, "Industrial Policy and Trade Management in the Commercial Aircraft Industry," ch. in. *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Washington, DC: Institute for International Economics, 1992), p. 167.

considered “sunk” because they cannot be recovered easily or in full by selling off the underlying assets.[27] Established producers, or incumbents, typically have more capital to draw on from previous program successes for investments in new programs. Additionally, incumbents with a history in the industry are likely to have a better credit rating and better access to commercial capital.[28]

Learning Curve[29] Effects and Economies of Scale

A long-term presence in the industry may provide important cost advantages to LCA manufacturers. Cost efficiencies in the LCA industry may be derived through lengthy production runs, which allow a manufacturer to spread the exorbitant launch costs over more aircraft, and also provide a learning curve effect that causes unit production costs to decline as output increases.[30] One estimate indicates that a doubling of output reduces unit costs by as much as 20 percent.[31] It is imperative that the firm make efficient use of production facilities, since economies of scale can be realized only up to a point by investing in expanded production capacity. As production workers become more efficient at assembling aircraft, marginal costs of production decline.[32]

Cost efficiencies also are realized with the production of derivative aircraft, that allow fixed development costs to be spread further. By using components, systems, and production facilities from an old program in a new aircraft program, development costs of the new program are reduced. In addition, manufacturers’ experience in developing earlier aircraft types enables them to be more efficient in developing and manufacturing new types.

To summarize, in a market setting, a new entrant’s product is unlikely to be as price competitive as an incumbent’s existing product because the incumbent’s product normally reflects benefits of the learning curve and scale economies. Some industry observers have argued that the very nature of the industry, in its present mature stage, effectively bars firms from establishing themselves through purely commercial means.[33]

Industry observers indicate that the West European industry has not achieved the long production runs and extensive economies of scale currently enjoyed by the U.S. industry, largely because Airbus has only been producing LCA since 1970. However, some U.S. industry officials fear that U.S. firms may not continue to realize the same advantages of economies of scale because of increased competition from foreign-built LCA.

LCA Manufacturer Relationships with Suppliers and Customers

Another advantage of incumbent producers is their established relationships with suppliers and customers. In the case of the LCA manufacturer’s relationship with its suppliers, economies of scale can be realized through “managerial economies,”[34] derived from reducing the cost of managing multiple subcontractor relationships. In other words, because LCA programs involve multiple subcontractors, average unit managerial costs decline as rates of production increase.

Incumbent producers also realize advantages in their relationships with their customers, the airlines. The average cost incurred by a manufacturer of providing after-sales support to its airline customers declines significantly as market share increases.[35] Moreover, the upfront cost of establishing a satisfactory and competitive after-sales support network is substantial.[36] Thus, a satisfactory manufacturer-airline relationship in terms of field support cannot be supplanted easily by a new entrant.

In addition, airline officials have indicated that their decisions are significantly influenced by their assessment of whether the manufacturer will be in existence for the long run. The perception that an LCA manufacturer’s future participation in the

[27] Gellman, p. 1-11.

[28] The ability to raise capital is discussed later in this chapter.

[29] The concept of the learning curve was developed in the aerospace industry. Richard Ridge, manager, International Trade Issues, posthearing submission on behalf of General Electric Aerospace and Aircraft Engines, p. 3.

[30] Gellman, p. 1-11.

[31] Mowery, p. 35.

[32] Gellman, p. A-8.

[33] Tyson and Chin, p. 157.

[34] Gellman, p. A-8.

[35] Ibid.

[36] The construction of parts facilities alone runs in the hundreds of millions of dollars. Other components of after-sales support also must be accounted for, such as the cost of shipping parts to worldwide locations.

industry is questionable causes airline concern about such issues as product support and fleet commonality vis-à-vis future purchases. Moreover, the airlines perceive historical associations with a manufacturer as having economic value. For example, airlines assert that a longstanding relationship with a particular manufacturer lends more credibility to that manufacturer's aircraft performance claims. Also, a previously established relationship provides such benefits as understanding the manufacturer's contract process and being familiar with the manufacturer's staff.[37]

Commonality

Commonality Benefits to the Airlines[38]

One of the most important factors affecting competition in the LCA industry is commonality. Commonality refers to an airline's desire to have as homogeneous a fleet as possible in terms of a single manufacturer. Airbus reports that the commonality among the A330, A340, and A320 can result in annual savings of $800,000 and $1 million per additional aircraft.[39] It is estimated that to get an airline to break with commonality, all other things being equal, the new manufacturer's price must be 10-percent below that of the common competing aircraft.[40]

Commonality offers several major economic advantages to airlines. The first is savings in aircrew training. Within a particular manufacturer's line of aircraft, the more a new aircraft is similar to those a pilot is already certified to fly, the less additional training is required.[41] There also is increased aircrew productivity through quicker turnaround time on the ground and more efficient use of the aircraft. Another economic advantage of fleet commonality is in spare parts inventory (both at centralized and field locations). The cost of parts inventory decreases with the number of common planes, since demand for unique parts and maintenance equipment is minimized. Other advantages of commonality are in the areas of maintenance personnel training, scheduling overheads, and cabin crew training. Industry observers note that fleet commonality helps establish an efficient regimen of operating and maintaining aircraft, and increases maintenance labor productivity.[42]

Commonality Benefits to the Manufacturers

The manufacturer with the largest market share tends to dominate orders based on commonality. In this sense, the commonality factor tends to discourage entry by new manufacturers. For example, Russian LCA producers have stated that to sell in the Western market, they must use Western engines and avionics, not just because of quality considerations, but also because of commonality.[43]

Development cost efficiencies are the primary benefit reaped by manufacturers from commonality strategies in their product lines. By using common features and parts on different planes, manufacturers spread development costs across more products.

[37] West European airline officials, interview by USITC staff, Dec. 1992.

[38] One LCA industry official has indicated that the importance of commonality has been decreasing with the evolution of route structures. This official stated that an airline can purchase 10-15 of one type of aircraft that breaks with commonality and "make them work."

[39] The degree of savings is influenced by fleet mix, fleet size, and other airline parameters.

[40] Gellman, p. A-4.

[41] Airbus officials claim that little or no extra training is required for a pilot to fly the A320 and A321 models if trained on one of the two, for a pilot to fly the A300-600 and A310 models if trained on one of the two, and for a pilot to fly the A330 and

[41]—*Continued*

A340 models if trained on one of the two. Moreover, cross-crew qualification has been approved by the FAA for the A320 and A340, requiring a 10-day "difference" training course for an A320 pilot to fly the A340. Douglas officials report that little or no extra training is required for a pilot to fly any aircraft in the MD-80 family; Boeing officials report that a pilot can fly any 737 derivative if trained on a 737 model, and the 767 if trained to fly the 757 and vice versa, with little or no extra training.

[42] There are numerous examples of airline benefits derived from fleet commonality. British Airways estimates that it saved some $100 million by choosing 767s over A310s because it had 37 757s in its fleet, and anticipated significant savings in pilot training, flight training, spare engine parts, ground training and equipment, and test equipment. Another example is American Airlines, which chose MD-80s for the same general reasons at a time when smaller planes would have more ideally suited the routes for which planes were needed. March, p. 28.

[43] Ilyushin Aircraft Association official, interview by USITC staff, Moscow, Nov. 17, 1992.

Moreover, the cost of developing a derivative with common features is significantly cheaper than that of developing an entirely new aircraft. For example, one estimate indicates that the incremental costs of stretching an airframe rarely exceed 25 percent of the original development costs.[44] Common parts and manufacturing requirements also allow for efficient assembly of different aircraft on the same production line, and provide for increased productivity through the use of common production techniques.

There is incentive for manufacturers to employ commonality not just within aircraft families, but also within entire product lines. This provides the airlines with the incentive to choose products from other families by the same manufacturer. In other words, it encourages fleetwide, not just familywide commonality. Airbus has based its design, manufacturing, and marketing strategy on commonalities among its families of planes, using the highest validated technology level in its new aircraft.[45] All Airbus aircraft, except for the A320 and A321, share a common cross-section. The A320, A321, A330, and A340 all have similar handling characteristics, virtually identical cockpits, and similar operating systems; the A330 and A340 have a common wing. Industry observers indicate that Boeing is increasingly marketing its current fleet with commonality in mind, and it is incorporating commonality into future design plans. The 737-300, -400, and -500 have the same cross-section and cockpit, and share engines, systems, and many parts; the 757 and 767 have the same cockpit as well. Industry observers have noted that although McDonnell Douglas has used the same cross-section for the many derivatives of its two basic models, its narrow product line does not appeal to airlines that want to operate as homogeneous a fleet as possible. Moreover, McDonnell Douglas' extensive use of derivatives to the exclusion of a completely new design makes the product line seem outdated.[46]

Commonality does have a drawback. Because it bases an entire range of aircraft on aging technology, manufacturers must assess continually the economic tradeoffs between maintaining a certain level of commonality and introducing new technology. Airbus, the newest entrant in the LCA industry, is basing its commonality strategy on newer technologies than those found in the majority of Boeing and McDonnell Douglas LCA. Because these technologies are newer and more advanced, they may afford Airbus a marketing advantage. As other manufacturers develop their own, newer technologies, however, Airbus likely will confront the same dilemma between providing commonality and replacing aging technology that confronts Boeing and McDonnell Douglas today.

Product Innovation and Technological Advancement[47]

New technology is a selling factor, but it is a key determinant in a purchase decision only if it will reduce operating costs significantly.[48] Changes in product characteristics are driven by the market, by competition, and/or by public mandates regarding safety and environmental standards. Improvements in product characteristics usually fall within the following categories: (1) improved operating costs for airlines (e.g., fuel burn, weight, and maintenance costs); (2) improved environmental performance (e.g., noise, emissions, and materials and manufacturing processes); and (3) improved passenger appeal (e.g., ride comfort, interior environment, ease of deplaning and boarding, and internal noise level).[49]

Industry sources generally agree that one of the decisive factors contributing to LCA manufacturers' competitiveness is the direct operating costs of their aircraft. Particularly since deregulation, U.S. airlines

44 Mowery, p. 33. The ability to alter the length of the aircraft, thereby altering its capacity, is a critical consideration in aircraft design. It is far less expensive to change the length of the fuselage than to change the aircraft wing design. An aircraft wing design dictates its ultimate lifting capacity and speed; therefore, a manufacturer ideally designs its wings for both current and projected lift demands/aircraft programs.

45 Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2-3, 1992. When technology is validated, the manufacturer is assured that the new technology (or an improved technology) will perform as intended and can be incorporated into a specific product. Successful validation of a new technology minimizes the technical risks to the ultimate user before the technology is applied. Technology is validated principally by the manufacturer.

46 Thompson, p. 9.

47 Quality, defined as structural integrity and passenger safety, is not an important determinant of competitiveness in the global LCA industry, because the industry is so highly regulated. Superior quality is expected from all manufacturers.

48 For example, the introduction of the high-bypass turbofan engine.

49 Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2-3, 1992.

are less eager to introduce new aircraft into their fleets that do not offer significant improvements in seat-mile operating costs. Moreover, the decline in fuel prices from the high levels of the early 1980s has made it more difficult for airlines to realize significant improvements in direct operating costs. The recent focus on acquisition cost, longer product lifecycles, rising aircraft prices, postponement of equipment purchases, availability of used planes, the continued serviceability of depreciated planes, and decreased funding from launch customers have decreased the demand for technological innovation that does not significantly improve operating efficiency.[50]

When designing a new aircraft, the LCA manufacturer must weigh the cost of incorporating new technologies and increasing the ultimate cost to the customer against the cost savings the airline will realize. In other words, manufacturers use demonstrable cost-effectiveness as their guide in evaluating whether to develop and apply new technologies. Moreover, the manufacturer that first brings a new technology to the market will be in position to reap "monopoly profits" if that technology has wide market appeal.[51] For example, the A320 is Airbus' best-selling model to date not only because it fills a market niche (150-seat, two-class, twin-engine aircraft), but also because it provides technological innovations such as fly-by-wire, sidestick controller, and digital flight management. The success of the A320 systems led to their incorporation in the A330/340. Airbus now can market validated technologies, instead of new and potentially risky ones. Aircraft incorporating proven new technologies have less downtime and fewer flight deviations. Moreover, the use of proven new technologies in multiple aircraft programs carries with it the allure of commonality.

A manufacturer also may respond to the competition's efforts to meet/anticipate market demand with a new product. This has been the case with Airbus and Boeing. Airlines have acknowledged that, particularly with the 777 program, Boeing has been challenged by Airbus to develop more technologically advanced aircraft.[52]

[50] March, pp. 41-43.

[51] Tyson and Chin, p. 168.

[52] West European airline officials, interview by USITC staff, Dec. 1992.

As a new entrant, Airbus had more incentive to offer airlines a significantly different product from the currently available aircraft to break into the market. Offering technologically advanced aircraft, therefore, was a marketing decision on the part of Airbus. During the 1980s, when Airbus was introducing advanced technologies on its aircraft, Boeing and McDonnell Douglas had an incentive to exploit economies of scale and offer derivatives of existing products. Because of the cost of incorporating high technology features, U.S. manufacturers argue that such features have to "buy their way" onto an aircraft, particularly in times of airlines' overriding concern with aircraft price. U.S. manufacturers allege that they could not compete with Airbus on price with comparable aircraft, because they assert that Airbus can sell planes with more high-technology features without passing the cost on to the customer.

Ability to Raise Capital

The ability of an LCA firm to raise capital for such uses as facility expansion, new equipment purchases, R&D, and new program introductions is a very important determinant of its competitiveness. A tremendous amount of capital is required for a firm to enter a mature and highly capital-intensive industry such as the LCA industry. The ability to raise capital in the commercial market is influenced by the financial commitments, overall financial standing, and the reputation, or creditworthiness of the LCA manufacturer.

As a G.I.E., Airbus reportedly has a better credit rating because the consortium can rely on the financial strength and unlimited liability of its partners.[53] In addition, government ownership or partial ownership in certain Airbus member companies also makes the consortium less of a credit risk in the eyes of commercial lenders.[54] Many argue that a dominant factor in the unusual rise of Airbus in the industry was the funds made available to the consortium by its member countries' governments.

West European officials report that Boeing may have a relatively easier time raising capital in the commercial market because it is well established and successful, with full order books.[55] However,

[53] Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2-3, 1992.

[54] Airbus raised $400 million, denominated in lira, in the bond market for the A321 program. This was the first time Airbus raised funds in the commercial market.

[55] Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2-3, 1992.

Moody's reports that Airbus has a "high grade" corporate bond rating;[56] Boeing's rating is also "high grade," while the rating for McDonnell Douglas is "medium grade."[57]

Production Costs, Productivity, and Production Technology

Production Costs and Productivity

Production costs have a strong impact on a firm's competitiveness. Today, an LCA manufacturer can expect fixed costs in excess of $2-4 billion for development, tooling, and certification of a new aircraft. Derivatives, while cheaper to bring to market, can still cost over $500 million to develop and certify.[58] Production costs are closely guarded in the global LCA industry, and data beyond wage rates for aerospace production workers generally are not available (see figure 4-1).

In terms of external costs, LCA manufacturers point to rising health care costs, regulatory mandates, workforce training and retraining, and environmental compliance as cost factors adversely affecting competitiveness.[59]

Labor productivity, defined as output per employee, improves with the level of commonality in a manufacturer's product line. For example, Boeing's use of the same fuselage and production facilities for its 707, 737, and 757 aircraft has contributed to a very

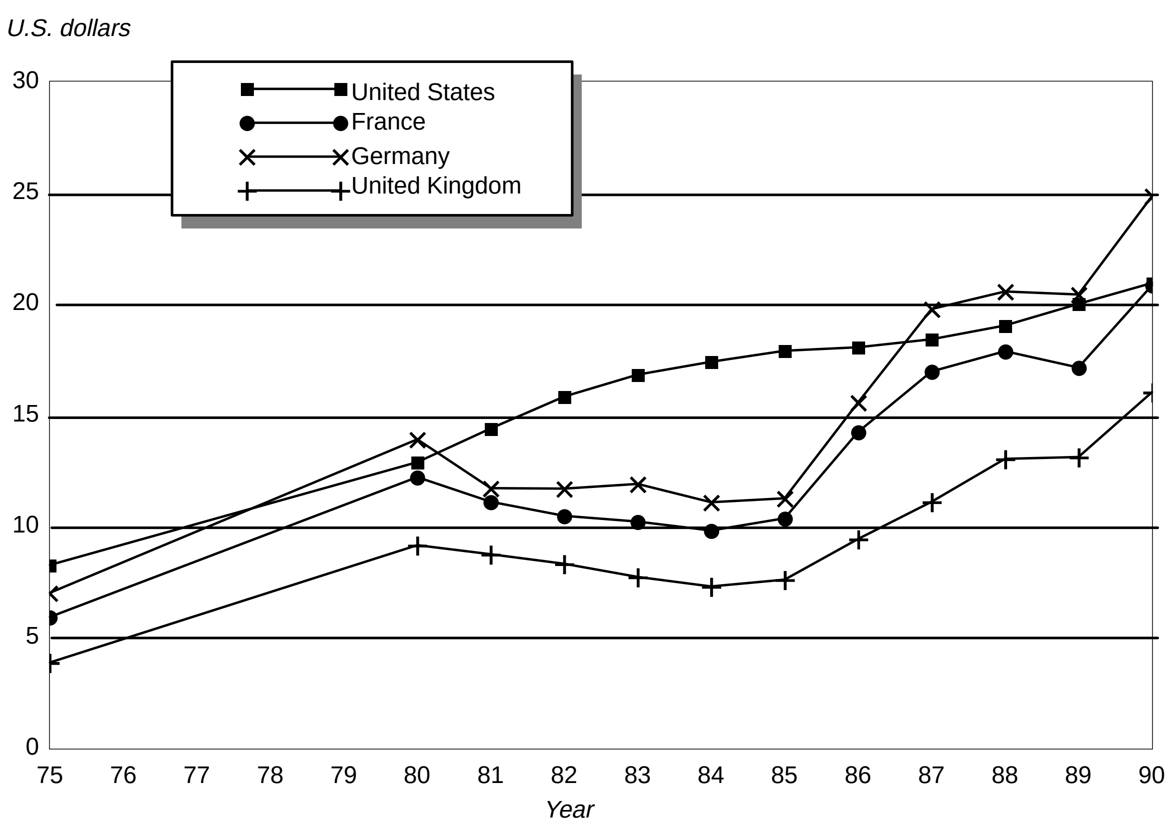
[56] Moody's Investors Service official, telephone interview by USITC staff, July 23, 1993.

[57] Moody's Investors Service, Inc., *Moody's Industrial Manual 1992*, New York, 1992.

[58] Gellman, p. A-7.

[59] Lawrence W. Clarkson, The Boeing Co., testimony before the Senate Finance Committee, June 2, 1992, p. 4; and Airbus Industrie officials, interview by USITC staff, Toulouse, France, Feb. 1993.

Figure 4-1
Hourly compensation costs for aerospace production workers, 1975, 1980-90



Source: Bureau of Labor Statistics. Included are aircraft, space vehicles, and parts thereof.

high level of labor productivity.[60] One industry source reports that Boeing retains a 5-8 percent advantage over McDonnell Douglas in production efficiency.[61] However, McDonnell Douglas claims that over the past 2-3 years, it has reduced the number of person-hours necessary to assemble both the MD-11 and MD-80 by more than one-third.[62] Although commonality is widely evident in the Airbus product line, labor productivity in the West European industry reportedly is not on par with that in the U.S. industry. This is due in part to smaller production scales.[63] Those skeptical about the Airbus G.I.E. system assert that because contributions to aircraft production must ultimately approximate percent ownership regardless of the individual partners' efficiency, the G.I.E. structure does not provide for the maximum economic utilization of resources.[64]

Airbus claims that U.S. manufacturers subcontract production to unrelated suppliers, and that because these suppliers are not always the same for each aircraft, U.S. manufacturers may engage in more costly, and less efficient, production processes.[65]

Production Technology

Production technology is another factor that can strongly influence competitiveness. Advanced production technology and manufacturing equipment offer a clear advantage to the firm that possesses them, in terms of shortened production time, fewer production workers required, and lower overall production costs. Largely because Airbus is the newest entrant to the LCA industry, and because it had the financial support of member company governments, it currently has the most advanced production technology and manufacturing equipment across its product line. Airbus partners have invested heavily in new, flexibly automated and computerized production systems, with the aim of increasing productivity and reducing delivery times and production costs.[66] Airbus officials claim that Airbus is 10- to 15-years more advanced in manufacturing than its competitors.[67]

Production Capacity and Ability to Respond to Changing Demand

Optimum production capacity is determined by balancing the higher cost of maintaining surplus production capacity against the cost of losing customers when production capacity is not sufficient to meet demand.[68] Airlines report that the inability to take delivery of aircraft in a timely manner can result in significant foregone profits, which, depending on their magnitude, can force an airline to purchase from another producer.[69] Airline industry opinion indicates that the three major manufacturers are relatively on par in terms of delivery dates, with one airline mentioning that McDonnell Douglas, because of the "softness" of its order backlog, typically can offer more timely delivery dates.[70]

Flexibility of capacity, or the ability to increase and decrease production easily, is as important as overall capacity for commercial success in the global LCA industry. European Community (EC) officials have reported that the West European industry lacks the flexibility to respond to a sudden upsurge in demand. Further, they have indicated that the U.S. industry has shown great flexibility with regard to delivery times in response to very sharp growth in demand.[71] One reason why the West European industry cannot increase and decrease production rapidly is the social and labor laws in Western Europe, which dictate a relatively conservative approach to

[60] Gellman p. A-10.

[61] Thompson, p. 17.

[62] Hood, p. 7.

[63] Commission of the European Communities, p. 11. However, the higher level of production automation at Airbus contributes to offsetting this labor productivity disparity. Airbus Industrie officials, interview by USITC staff, Feb. 1993.

[64] This is changing, however, as Airbus partners have begun to win bids for work in nontraditional areas of manufacture, and also to expand the use of subcontractors. Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2-3, 1992.

[65] Renee Martin-Nagle, corporate counsel, posthearing submission on behalf of Airbus Industrie, G.I.E. and Airbus Industrie of North America, Inc., p. 7.

[66] March, p. 36.

[67] Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2-3, 1992.

[68] Commission of the European Communities, pp. 7-8.

[69] Compiled from responses to USITC airline questionnaire, Feb. 1993.

[70] Ibid.

[71] Commission of the European Communities, p. 6.

workforce levels to avoid an oversupply of labor during slow production times (see chapter 5).[72]

Generally, growth accounts for 70 percent of LCA sales, and replacement accounts for 30 percent;[73] however, this varies by type of aircraft. The demand for a particular type of aircraft goes in cycles, and airlines tend to replace their planes with the same type (narrow- or wide-body). Therefore, offering a family of aircraft and being capable of production flexibility provide a comparative advantage in this industry. The ability to predict market requirements also is critical in this industry.

After-Sales Support

A very important competitive marketing tool for LCA manufacturers is after-sales support and personnel training. These critical elements in selling aircraft to airlines are stipulated in the purchase contract. Industry officials have acknowledged that offering competitive product support is as important as having a successful aircraft design.[74] As noted earlier in this chapter, economies of scale are realized in the area of after-sales support, since the cost per plane of providing such support declines significantly as market share increases.[75] As previously stated, the upfront cost of establishing a satisfactory and competitive after-sales support network and the cost of maintaining such a network are substantial.

The most important measure of the quality of an LCA manufacturer's product support is its ability to service aircraft on the ground (AOG).[76] Because of the exorbitant cost incurred by an airline when it has an AOG, airlines demand immediate global AOG service. Another measure of product support is dispatch reliability, which refers to the likelihood that an aircraft's departure will not be delayed more than 15 minutes because of airframe or engine malfunctions. Product support also entails the following: training of flight crews and airline maintenance engineers; operations engineering support; sales support; spares and stores; routine maintenance and ground operations; and establishment of an educational program for the airlines concerning the tools, facilities, test equipment, and spares inventory they should maintain.[77] Airline sources report that currently there is little appreciable difference among the three manufacturers in after-sales support.[78]

Lifecycle of an Aircraft

The lifecycle of an aircraft model is both a factor internal to the firm, because it reflects the manufacturer's ability to project market requirements and react accordingly, and an external factor in the sense that changes in market requirements are beyond the manufacturer's control. For example, in an attempt to produce an aircraft that will have the longest possible economic life, manufacturers project future government-imposed environmental and safety regulations that will affect certain parts of the aircraft.[79] A manufacturer that is far into the development stage of a new program when an unanticipated regulation is imposed will incur higher adjustment costs than a manufacturer that is at the beginning of the development stage.[80]

Manufacturers also may attempt to anticipate aircraft-type needs, as Airbus has done with the A340. West European air travel industry observers note that the liberalization of the West European airline industry will increase air travel, congest major hubs, and thereby increase the number of longer-range hops

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[72] Ibid., p. 8.

[73] Boeing official, interview by USITC staff, Seattle, WA, Sept. 4, 1992.

[74] John E. Steiner, "How Decisions Are Made: Major Considerations for Aircraft Programs," speech delivered before International Council of the Aeronautical Sciences, American Institute of Aeronautics and Astronautics, Aircraft Systems and Technology Meeting, Seattle, WA, Aug. 24, 1982, p. 32.

[75] Gellman, p. A-8.

[76] When an airline has an AOG, it incurs lost opportunity costs because the aircraft cannot be flown until it is repaired.

[77] March, p. 29.

[78] Compiled from responses to USITC airline questionnaire, Feb. 1993. However, U.S. industry officials allege that Airbus was able to set up an elaborate global support network in advance of market penetration, ostensibly because of government support. Douglas Aircraft Co. officials, interview by USITC staff, Washington, DC, Feb. 18, 1993.

[79] Officials of McDonnell Douglas point out that the MD-80 was the first fully compliant Stage 3 aircraft offered, and add that the MD-90 will be the quietest plane in the world (first deliveries are scheduled for the fourth quarter 1994). Douglas Aircraft Co. officials, interview by USITC staff, Washington, DC, Feb. 18, 1993.

[80] The product delivery date also may suffer as the result of a new regulation; this becomes an additional cost to the manufacturer, which typically must pay a financial penalty to the airline.

from secondary and regional airports. Airbus believes this particular market niche will not require the full size and range of the 747, but will be addressed by the A340.

Depending on direct operating cost savings, airlines may choose to abandon current fleet plans and replace aircraft before the end of their economic lifecycle to enjoy the increased direct operating cost savings offered by new planes. Therefore, from the initial design phase, manufacturers must be concerned with producing an aircraft that will be profitable for at least 20 years.

LCA manufacturers can extend the lifecycles of their products by introducing derivatives. Economies of scale and learning curve effects are important incentives for proceeding in this manner. Product lifecycles have been longer in recent years because of the cost of launching new programs and the subsequent extensive development of derivatives, and because recent developments in aircraft and propulsion technology have been incremental, as opposed to revolutionary.

Availability of Domestic Airframe Subcontractors and Parts Suppliers

Because of the increasingly global nature of the LCA industry, the availability of domestic airframe subcontractors and parts suppliers is decreasing in importance. The elimination of most impediments to trade in civil aircraft and parts due to the General Agreement on Tariffs and Trade (GATT) Agreement on Trade in Civil Aircraft in the Trade Agreements Act of 1979 prompted a dramatic increase in cross-border subcontracting and component sourcing. In the United States, the number of aircraft parts suppliers has decreased, largely because of rationalization. During the 1980s, the production rates of U.S. LCA manufacturers increased substantially, while the number of suppliers engaged by U.S. LCA producers fell from over 11,000 to below 4,000.[81]

Industry officials have indicated that while it is important to maintain a domestic supplier base for reasons such as price competition and national security (in terms of military production), generally, LCA manufacturers look globally for the best parts at the best price.[82] However, a manufacturer's supplier base can be market driven. Offsets, or the sourcing of components in return for market access, are a disincentive to buying from domestic suppliers. The importance of offsets varies among manufacturers.[83]

The global nature of the LCA industry is illustrated by the trend of foreign content in LCA. Excluding engines, the foreign content of the 727 (launched in 1959) was at most 2 percent;[84] the foreign content of the 767 (launched in 1978) varies between 10 and 26 percent; and the foreign content of the 777 (launched in 1990) will vary from 15 to 26 percent.[85] Airbus reports that on average, foreign content (principally U.S.) including engines accounts for 30 percent of the A310-300; 17 percent of the A320; 30 percent of the A330-300 with U.S. engines, 10 percent with Rolls-Royce engines; 29 percent of the A330-600; and 22 percent of the A340-300.[86] Foreign production accounts for 16 percent of the MD-80 and 20 percent of the MD-11.[87]

Importance of Seeking Airline Engineering Input

In the past, airlines maintained significant engineering departments to collaborate with manufacturers on new programs. Engineers and pilots had substantial input into equipment purchase decisions, which they based on technical criteria. However, in recent years, the importance of airline engineering departments has decreased. Currently, it is more likely for airlines' marketing and financial experts to make equipment purchase decisions, and to base these decisions on financial criteria and

[81] Menes, p. 10.

[82] British industry officials, interview by USITC staff, London, Nov. 11, 1992.

[83] Initially, the structure of Airbus limited the use of offsets, as each partner company felt it had to produce according to its share in the consortium. This has been changing in recent years. Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2-3, 1992.

[84] Menes, p. 10.

[85] John F. Hayden, vice president, Washington, DC office, posthearing submission on behalf of The Boeing Co.

[86] Martin-Nagle, p. 2.

[87] John Wolf, Executive Vice President, Commercial, Douglas Aircraft Co., testimony before the Ways and Means Committee, Subcommittee on Trade, Mar. 31, 1992, pp. 7-8.

performance guarantees.[88] Reports from leading airlines indicate that roughly 50 percent currently maintain an R&D division to support engineering work with the LCA manufacturers.[89] These airlines indicate that the manufacturers' ability or willingness to work with purchasers currently is not a significant factor in competition among the LCA manufacturers.

Some industry experts believe airline engineering participation is going to increase again in the future. For example, Boeing reportedly consulted with eight prime customers in "design-build teams" concerning such features as wings and avionics for the 777.[90]

External Factors

Market and Macroeconomic Factors

Business Cycles

Growth in gross domestic product (GDP) spurs consumer confidence and disposable income, which in turn increases the demand for air travel. Overall demand for air travel is one of the leading determinants of sales and orders for new aircraft; this is universal for all LCA manufacturers. As noted above, fleet growth accounts for some 70 percent of aircraft purchases. Therefore, some 70 percent of new orders depend largely on disposable income, which leads to increased demand for air travel.

Because deliveries of aircraft are realized several years after orders are placed, airlines ideally should order during a recession in anticipation of the growth cycle to follow. However, the airlines' ability to time their orders accurately so that delivery will be taken during a growth cycle is often hampered by available capital and financing, as well as aircraft manufacturers' backlogs. During periods of GDP growth, orders tend to increase, as airlines have easier access to capital.

Business cycles can affect an LCA manufacturer's competitiveness if the firm manufactures products other than civil aircraft. For example, military contract cycles generally run counter to commercial business cycles, and can cushion civil business cycle slumps.[91] Moreover, economic downturns tend to be most damaging to the manufacturer in the riskiest financial position, because this manufacturer is the most dependent on every sale for survival. However, the overall market share of the leading manufacturer(s) may decline during growth cycles, because growth cycles offer more opportunity for new entrants. U.S. industry sources have indicated that in order to increase production, suppliers need 18-24 months lead time; new entrants likely would be poised to fill the gap more rapidly between production and demand.

Growth of the Civil Air Transport Industry

Growth of the civil air transport industry, in terms of the number of air carriers, can have a significant effect on LCA demand. For example, the deregulation of the U.S. airline industry in 1978 opened the door for dozens of new, relatively smaller airlines to compete. The intensified competition in the airline industry resulted in decreased air fares. These low air fares caused passenger travel to explode, resulting in increased demand for additional aircraft. Major U.S. airlines have indicated that their LCA orders have increased as a result of deregulation, and that the demand for more fuel-efficient aircraft has increased especially.

As the civil air transport industry changes, not only does overall demand for aircraft change, but demand for particular types of aircraft changes as well. For example, the more immediate-term results of deregulation increased the demand for smaller aircraft. Today, the trend is toward larger aircraft and wide-bodies. This change is due to the faster turnaround and larger payloads per number of takeoffs and landings desired because of airport overcrowding. Manufacturers that can respond rapidly to changes in demand have a competitive advantage.

Exchange Rates

Exchange rates can have a significant impact on the competitive position of LCA manufacturers. Both because U.S. manufacturers dominated the LCA industry for decades and because the world's airlines prefer to purchase aircraft in U.S. dollars, global

[88] March, p. 32. This is largely because of the financial condition of the airline industry, in terms of both the consequent cutbacks in some airlines' engineering departments and the increased importance of cost considerations in the purchase decision.

[89] Compiled from responses to USITC airline questionnaire, Feb. 1993.

[90] Tyson and Chin, pp. 191-192.

[91] Eberstadt, p. 1.

commerce in the industry is conducted in U.S. dollars.[92] Therefore, to hedge against exchange rate fluctuations, Airbus conducts as much of its business as possible in dollars (e.g., purchases of parts and subassemblies).[93]

A strong dollar works to the benefit of U.S. competitors because the dollars they receive translate into a relatively larger amount of local currency. This implies that U.S. competitors' profit margins increase, which could enable them to lower dollar prices of their aircraft and hence become relatively more competitive as compared with the U.S. industry. However, in times of a weak dollar, these manufacturers are adversely affected because they receive a relatively smaller amount of local currency. In this instance, cash inflow decreases for foreign manufacturers, while production and labor costs denominated in local currencies do not. This implies reduced profit margins and hence may put upward pressure on the dollar price and make non-U.S. manufacturers less competitive relative to the U.S. industry.

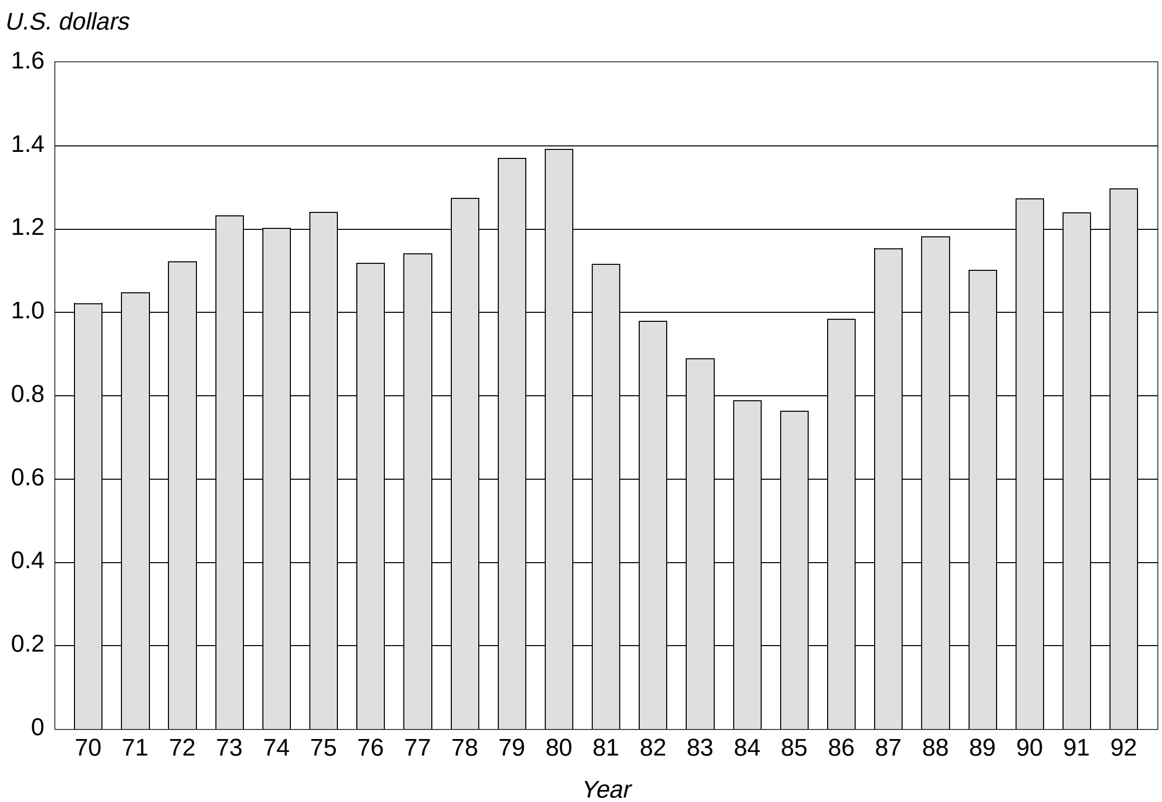
During 1970-92, the average dollar rate per 1 ECU was $1.127 (figure 4-2). During 1982-92, the average exchange rate was below the 23-year average ($1.059), which would have positively affected the Airbus competitive position. In fact, it was during this time that Airbus achieved significant growth in its global competitive standing, from a 2-percent market share of announced global orders in 1982 to a 28-percent share in 1992.[94]

[92] Other products, such as nonferrous metals and oil, also are traded globally in U.S. dollars.

[93] Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2-3, 1992.

[94] Boeing Commercial Aircraft Group, *World Jet Airplane Inventory, Year-End 1992* (Seattle, WA: The Boeing Co., Mar. 1993), p. 12.

Figure 4-2
Exchange rates: Dollar rate per 1 ECU, 1970-92



Source: Commission of the European Communities, *The European Aerospace Industry Trading Position and Figures, 1993*.

Although the dollar was strong during the mid-1980s, recent levels appear to be approaching the lower levels of the mid- to late-1970s. Because of the fluctuating nature of exchange rates in general, the impact of exchange rates as a factor of competitiveness tends to vary over time, having alternatively positive and negative effects on both U.S. and non-U.S. producers of LCA.[95]

[95] The German Government launched an exchange rate guarantee program in 1989. This program was suspended on January 15, 1992, following the GATT ruling that it was a subsidy inconsistent with the GATT.

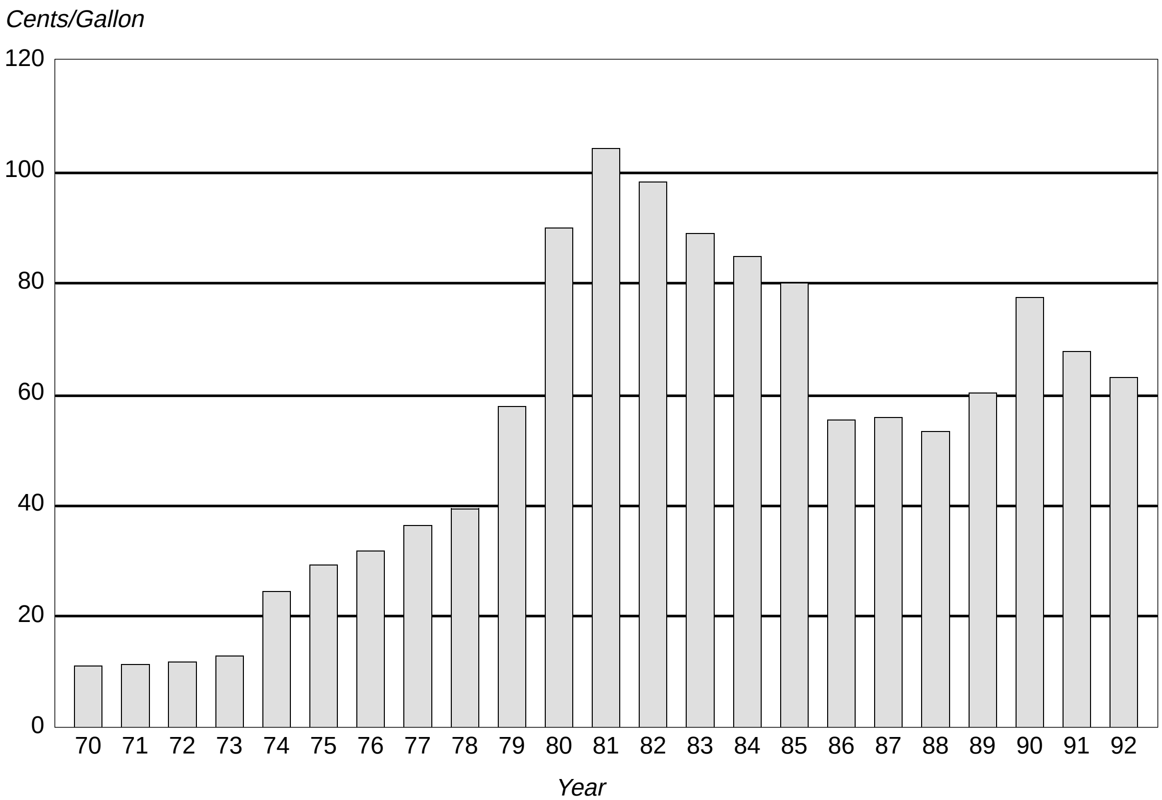
In April 1992, the EC announced that it was considering establishing a “special fund” to protect the West European LCA industry from fluctuations in the relative rate of the U.S. dollar. The EC industry commissioner asserted that this fund would be GATT-legal, and would be financed with aircraft industry funds, as opposed to government funds.

Price of Jet Fuel[96]

After ticketing, sales, and promotion costs, jet fuel and oil accounted for the largest portion of total

[96] A transportation fuels tax bill approved by the Senate in June 1993 is designed to replace the Clinton administration’s proposed Btu tax. The transportation fuels tax, proposed by Senator John Breaux (D-LA), is a 4.3 cents/gallon tax that Aviation Forecasting and Economics projects would cost U.S. airlines $2.5 billion over five years and job losses equivalent to the work force of a medium-sized airline if the tax is imposed on jet fuel. The Senate has exempted airlines from the tax, but the outcome of this issue in a future House-Senate conference to resolve the final budget is unclear at this time. “Btu Tax Impact,” *Aviation Week & Space Technology*, Mar. 8, 1993, p. 29; and “Airlines Win Exemption From Fuel Tax In Senate Budget Bill,” *Airport Report*, Jul. 1, 1993, p. 1.

Figure 4-3
Jet fuel costs, 1970-91



Source: Air Transport Association of America as found in Aerospace Industries Association of America, Inc., *Aerospace Facts and Figures*.

operating costs for airlines in 1991 (see figure 4-3).[97] Narrowed to direct operating costs, fuel was the single largest expense for airlines in 1991.[98] Reportedly, every 1-cent increase in the price of jet fuel raises annual airline operating expenses by $150 million.[99] However, the relative importance of jet fuel prices as a percentage of direct operating costs has declined because aircraft engines have become more fuel efficient. The importance of fuel efficiency also has declined since fuel prices dropped from their high levels in the early 1980s. Thus, a number of older, less fuel-efficient LCA continue to operate economically.

The competitive impact of producing fuel-efficient LCA would appear to increase as jet fuel prices rise, and decrease somewhat as they decline. However, increased sales of a comparatively fuel-efficient model because of an upswing in fuel prices can have a lasting impact on the competitive position of the manufacturer of that aircraft. This is especially true if the revenue gained allows the manufacturer to improve economies of scale, launch a new program, or reinvest in important research projects, or if commonality orders based on original purchases of this fuel-efficient aircraft are received.

Availability of Capital

Interest rates can affect an individual company's competitive position, depending on whether the company has access to sources of capital other than the commercial market. Airbus, whose partners have alternative sources of capital (e.g., direct government support), has had a clear competitive advantage. Aside from receiving government conditional repayment loans at below market rates with deferred interest, Airbus partners also have received government-guaranteed loans made by private lending institutions.[100]

The ability of an airline to finance the purchase of an aircraft will depend on the prevailing interest rates as well as the financing available from the manufacturer. In terms of contracts with airlines, there may be a competitive advantage for the manufacturer that can offer attractive financing to the purchaser, allowing the airline to rely less heavily on the capital markets and thus avoid less attractive interest rates. This is particularly true when airlines are experiencing financial difficulty. U.S. industry sources report that because of recent weak financial performance, the cost of borrowing for U.S. airlines doubled in early 1992.[101]

Government Policies

Government policies that can affect the competitiveness of LCA manufacturers include direct and indirect support, tax, trade, environmental protection, antitrust, and labor policies, and aircraft certification requirements. Because government policies are a leading factor of competitiveness in the global LCA industry, they are examined in greater detail in chapter 5.

[97] International Air Transport Association, 1992 Annual Report, p. 6.

[98] Boeing Commercial Airplane Group, *Current Market Outlook 1993* (Seattle, WA: The Boeing Co., Mar. 1993), p. 2.7.

[99] Brian H. Rowe, president and chief executive officer, General Electric Aircraft Engines, testimony before the National Commission to Ensure a Strong, Competitive Airline Industry, June 4, 1993, p. 3.

[100] Virginia C. Lopez and David H. Vadas, *The U.S. Aerospace Industry in the 1990s: A Global Perspective* (Washington, DC: The Aerospace Research Center, Aerospace Industries Association of America, Inc., Sept. 1991), p. 54.

[101] Virginia C. Lopez and David H. Vadas, *The U.S. Civil Aircraft Industry: Can It Retain Leadership? Keeping America Competitive in the Global Marketplace* (Washington, DC: The Aerospace Research Center, Aerospace Industries Association of America, Inc., Apr. 1993), p. 13.

Chapter 5: Government Policies Influencing Competitiveness in the Global Large Civil Aircraft Industry

Introduction

This chapter addresses government policies that affect competitiveness in the global large civil aircraft (LCA) industry, with a focus on government direct and indirect support programs for LCA manufacturers. Other government programs and laws discussed include policies regarding corporate structure, antitrust and anticompetition laws, environmental laws, the Foreign Corrupt Practices Act, labor laws, aviation laws and regulations, tax policies, export policies and requirements, tariff issues, and certain agreements affecting trade in aircraft.

Although many legal requirements and government policies affect the competitiveness of the LCA industry, only a few are regarded as significant. The findings and conclusions in this chapter are based primarily on reports prepared by or commissioned by U.S. Government agencies and the European Community (EC) Commission or West European governments. These reports, along with other independent studies and sources, show that government direct and indirect support programs appear to have a demonstrable effect on the competitiveness of both U.S. and foreign LCA producers. Sources show that other government programs and laws appear to have only a negligible impact on competitiveness, if any.

Government Direct and Indirect Support for LCA Manufacturers

The terms of the debate over the nature and extent of government support for LCA manufacturers have largely been framed by three reports — *An Economic and Financial Review of Airbus Industrie* ("Gellman Report"); *U.S. Government Support of the U.S. Commercial Aircraft Industry* ("EC-Commissioned Report"), and *U.S. Government Response to the EC-Commissioned Report "U.S. Government Support of the U.S. Commercial Aircraft Industry*" ("U.S. Government Response"). The Gellman Report details the alleged direct government supports provided to the Airbus consortium member companies through 1989. It was prepared for the U.S. Department of Commerce, International Trade Administration, by Gellman Research Associates, Inc. and released on September 4, 1990. The EC-Commissioned Report details the alleged indirect supports provided to the U.S. commercial aircraft industry up to 1991, and is generally considered the EC Commission's response to the Gellman Report. It was prepared by Arnold & Porter, a Washington, D.C. law firm, and released in November 1991. The U.S. Government Response addresses the charges and allegations contained in the EC-Commissioned Report and was released in March 1992. Although other industry observers and experts also have offered other perspectives, these three reports have been the predominant source of recent argument and counter-argument in this area.

U.S. Government Support Programs

The EC Commission states that U.S. public indirect support for the U.S. aerospace industry comprised 16.2 billion ECU for R&D support and 40.2 billion ECU for sales and maintenance support in 1988.[1] A separate report prepared for the EC

[1] Commission of the European Communities, *A Competitive European Aeronautical Industry (Communication from the Commission)* (Brussels: Commission of the European Communities, SEC (90) 1456 final, July 23, 1990), annex p. 15, table 9. In 1988, 1 ECU equaled roughly $1.182; thus, these figures in dollar equivalents are $19.2 billion and $47.5 billion, respectively.

Commission asserts that "[t]he United States government provides massive, systematic support to the U.S. commercial aircraft industry pursuant to a long-standing U.S. policy of striving to maintain U.S. superiority in all areas of aeronautics technology."[2] The report indicates that during 1976-90, this support was indirect and was provided through U.S. Department of Defense R&D, National Aeronautics and Space Administration (NASA) R&D, and the U.S. tax system, and that such support totaled between $18 billion and $22.05 billion in actual, not constant, dollars.[3]

Military R&D and Contracts

The EC-commissioned report asserts that because the U.S. LCA industry is the major component of military aeronautics development and production, and because military and commercial aeronautics technology often overlap, the U.S. LCA industry has derived "very substantial crossover commercial benefits from their participation in military R&D."[4] The report also states that the U.S. Government provided substantial support essential to achieving major breakthroughs in commercial aeronautics technology.[5] The report estimates that of the $50 billion in military aeronautics R&D grants spent by the Department of Defense from 1976 to 1990, between $5.9 billion and $9.7 billion constituted a benefit (direct and/or indirect) to the U.S. LCA industry.[6] The Organization for Economic Cooperation and Development (OECD), in a 1990 report, estimated that the U.S. aerospace industry would spend $24 billion on R&D in 1989, and that the U.S. Government would fund three-quarters of this research primarily through the Department of Defense.[7]

Airbus also recognizes the overlap between commercial and military technologies in the aerospace sector, and the fact that military contracts with aerospace firms cross over into benefits to the commercial side of these firms' operations.[8] Airbus states that such benefits usually result from preferential procurement of military aircraft and support for military and civil R&D, but also result from direct supports, such as loan guarantees. Airbus concludes that "U.S. manufacturers have received far more government support than Airbus, and . . . unlike the loans received by Airbus, the support given to the U.S. manufacturers need not be repaid."[9]

The report commissioned by the EC notes that the U.S. Government reimburses private companies for R&D projects undertaken independently that may have military application (e.g., independent research and development (IR&D)), as well as for certain bid and proposal (B&P) development costs for military contracts.[10] The EC indicates that between 1976 and 1990, such aeronautical reimbursements have benefited the LCA industry in the amount of approximately $1 billion to $1.3 billion.[11] Further, according to the U.S. Department of Commerce, "[t]he Administration's defense conversion initiatives are focusing future government research on areas which have commercial rather than defense possibilities."[12]

The report commissioned by the EC also states that the Department of Defense Manufacturing Technology Program (MANTECH) provides funding to encourage contractors' use of new manufacturing process technologies, and to reduce the cost and risk associated with new and improved manufacturing technology.[13] The report alleges that approximately

[2] Arnold & Porter, *U.S. Government Support of the U.S. Commercial Aircraft Industry*, prepared for the Commission of the European Communities (Washington, DC: Nov. 1991), p. 1.

[3] Ibid., p. 1.

[4] Ibid., pp. 51-57.

[5] Ibid., p. 1. These benefits reportedly can come in the form of direct technology transfers (such as plane-to-plane transfers and major or minor component transfers), which allegedly are supported by the Department of Defense; it promotes any development in the commercial arena in hopes that similar applications can spin off into military applications (e.g., the so-called "dual use policy"). Arnold & Porter, pp. 4-6.

[6] Ibid., pp. 1-2, 6-7. The report states that in current dollars, this figure is between $12.4 billion and $20.2 billion.

[7] OECD, *Internationalisation of Industrial Activities: Case Study of the Aerospace Industry* (Paris: drafted Jan. 8, 1990, distributed Jan. 10, 1990), p. 17.

[8] Renee Martin-Nagle, corporate counsel, prehearing submission on behalf of Airbus Industrie, G.I.E. and Airbus Industrie of North America, Inc., pp. 3-4.

[9] Ibid., p. 5.

[10] Arnold & Porter, pp. 2, 11.

[11] Ibid., pp. 2, 11.

[12] Jonathan Menes, acting assistant secretary for trade development, posthearing submission on behalf of the U.S. Department of Commerce, p. 12.

[13] Arnold & Porter, p. 11.

$300 million in MANTECH funds was used to implement new aeronautics-manufacturing technologies between 1976 and 1990.[14] Other more recent sources indicate that McDonnell Douglas has had five contracts with the U.S. Navy and three with the U.S. Air Force under the MANTECH program, all dealing with composites technology. Some of these have been multiyear contracts, and the total funding for all the contracts has probably been less than $10 million. Boeing has had two contracts with the U.S. Air Force under the MANTECH program—one for helicopters and the other for composites-manufacturing technology for the fuselage of large transports.[15]

According to Airbus, Boeing has had a great deal of success in adapting military technology and production resources to its commercial operations.[16] According to Airbus, examples of these applications include the 707 (closely related to Boeing's KC-135 military transport aircraft), and the 747 (a commercial version of the C-5A military transport).[17] Airbus states that Boeing was able to participate in the commercial market with relatively low investments by using its military aircraft as a basis for its commercial aircraft.[18] A report prepared for the Office of Technology Assessment (OTA) in 1991 draws similar conclusions, stating that technology synergies are the most important way in which the military side of the aerospace industry has advanced the commercial side.[19]

At least one source cites examples concerning McDonnell Douglas, reporting that at a critical moment, government contracts for 60 KC-10s provided the safety net to plummeting McDonnell Douglas commercial sales of the DC-10, which was virtually identical to the KC-10.[20] Allegedly, government funds allocated for defense and civilian R&D programs played an important role in the development of aircraft by the U.S. LCA industry.[21]

> Although US policy has not been designed to guarantee successful performance in the commercial operations of American aircraft producers, R&D support, large backlogs of "safe" military contracts, and the government's unwillingness to allow a huge defense contractor to fail completely "whatever its commercial sins" . . . have emboldened American producers to undertake risky commercial ventures and have helped them raise the considerable financial wherewithal required to do so.[22]

This source concludes that, with the exception of the SST program, the U.S. Government has not directly aided the development and production of commercial aircraft:

> Throughout much of its history, the American aircraft industry has benefited from a makeshift but nonetheless effective industrial policy. Although the goals of this policy have been primarily military in nature, it has had unintended and unavoidable spillovers on the commercial market place.[23]

U.S. Government support for LCA manufacturers also reportedly takes the form of preferred procurement of military-use aircraft; support for defense and civilian aerospace R&D; loan guarantees; and airline regulations that, in the past, promoted competition based on new aircraft design rather than on price.[24]

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[14] Ibid., p. 12.

[15] U.S. Air Force, Air Force Material Command, *Manufacturing Technology Program 1992,* 1993; and U.S. Navy, *Navy MANTECH Project Book 1992*, 1993.

[16] Martin-Nagle, prehearing submission, p. 21.

[17] Ibid. The U.S. military issued an RFP for a heavylift aircraft. U.S. firms competed for this program, and did receive some government monies for development. While Boeing did not win the contract, it did, however, continue to develop the aircraft, which eventually became the 747.

[18] Ibid.

[19] George Eberstadt, "Government Support of the Large Commercial Aircraft Industries of Japan, Europe, and the United States," contractor document for *Office of Technology Assessment, Competing Economies: America, Europe, and the Pacific Rim* (Washington, DC: Congress of the United States, 1991), p. 30. This source states that "[i]n some cases, whole systems developed for the military have been 'spun-off' to commercial applications, reducing development costs and risks to the commercial users. In others, products or technologies designed for commercial uses have achieved higher production runs, and therefore lower costs, from large military orders."

[20] Laura D. Tyson and Pei-Hsiung Chin, "Industrial Policy and Trade Management in the Commercial Aircraft Industry," ch. in *Who's Bashing Whom? Trade Conflict in High-Technology Industries* (Washington, DC: Institute for International Economics, 1992), p. 170.

[21] Ibid. The OECD made similar conclusions in a 1990 report. OECD, pp. 21-22.

[22] Tyson and Chin, pp. 170-171.

[23] Ibid., pp. 172, 157.

[24] Ibid., p. 169.

However, this source concludes that U.S. Government support for the LCA industry is much less important than it was 15 years ago as a result of airline deregulation in the 1980s, relatively constant growth in real funding for aeronautics research by NASA and the Department of Defense, and reduced commercial spillover from military aerospace technologies.[25]

Other sources similarly conclude that the crossover between military and civilian production is diminishing. One industry observer has stated—

> Defense and commercial technologies have been gradually diverging since the beginning of the jet age, so opportunities for the commercial side to benefit from military developments are shrinking. Commercial requirements are driving high reliability, low fuel consumption, and low-noise technologies, while defense needs are pushing low-radar detection, high speeds, and high maneuverability. Some synergies remain, but they are smaller than they once were.[26]

A U.S. Government response to the EC-commissioned report challenges that report's findings and conclusions on the synergies between military and commercial operations. It indicates that the U.S. Government has well-established and transparent rules and regulations to address such potential synergies by (1) limiting government contracting to legitimate government purposes; (2) opening contracting to competitive bidding; (3) auditing contracts to ensure that only government work is being funded; and (4) publishing and releasing the results of government-sponsored research through the National Technical Information Service.[27]

The U.S. Government response also indicates that U.S. military R&D programs indirectly benefit a domestic LCA program only when they provide a capability that is not also available to foreign competitors.[28] Moreover, the manufacturer allegedly must have used the capability commercially without reimbursing the government for its value.[29] The response also indicates that the U.S. Government charges high fees, which are audited by the respective Inspector Generals' offices, for industry-only testing performed at government facilities (including NASA).[30]

The U.S. Government response states further that the findings of the EC place no value on the fact that U.S. spending on science and technology generates basic knowledge that can be used by U.S. and foreign firms alike, and that the analyses used by the report include gross overstatements of the true commercial value derived from these programs.[31] The response also indicates that the report's findings are based on inaccuracies and incorrect assumptions. It points out that "commonalities" between Department-of-Defense-funded aircraft-related R&D programs and LCA are limited, and the technologies of military and civilian aircraft are divergent.[32] It is likely that synergies between military and commercial aircraft operations will decrease as a result of cuts in U.S. defense spending.

The U.S. Government response adds that U.S. recoupment programs merely recognize normal business operations of companies spreading overhead costs across the business base.[33] It also argues that

[25] Ibid., p. 171.

[26] Captain Duane E. Woerth, first vice president, Airline Pilots Association, International, testimony before the U.S. International Trade Commission, Apr. 15, 1993. Almost identical conclusions were reached by the OECD in its 1990 report. However, the latter source states that (military) "transport and tanker aircraft continue to share many features with commercial designs. Technological synergies in systems, materials, and design and production processes continue to be important." Ibid., p. 32.

[27] U.S. Department of Commerce, U.S. Government Response to the EC-Commissioned Report "U.S. Government Support of the U.S. Commercial Aircraft Industry," interagency activity report coordinated by the U.S. Department of Commerce (Washington, DC: Mar. 1992), p. 2, executive summary, pp. ii-iii.

[28] Ibid., p. 1.

[29] Ibid., p. 1.

[30] Ibid., p. 22.

[31] Ibid., pp. 1, 4.

[32] Ibid., pp. 2, 16, executive summary, p. iii.

[33] Ibid., p. 11. The U.S. Government response argues that the regulations allow contractors to spread IR&D/B&P costs over their defense business base, provided the contractors can demonstrate that the costs had a potential relationship to a military function or operation. Therefore, allegedly the IR&D/B&P policy actually limits contractor reimbursement, in that companies may not charge the IR&D/B&P activities conducted solely for their commercial operations.

After the U.S. Government Response was released, in mid-1992, the Administration changed its policy on recoupment fees, abolishing such fees for exports of military items, other than those where recoupment is required by Act of Congress. Press Release from The White House, Office of the Press Secretary, "Fact Sheet on Defense Procurement Reforms," June 15, 1992; 58 F.R. 16497; 58 F.R.

MANTECH-developed technology "must have defense applications, and should be generic," and that any indirect benefits to commercial aerospace resulting from the program are limited.[34]

NASA R&D and Contracts

The EC-commissioned report notes that one of the goals of NASA is to advance the technological superiority of U.S. aeronautics.[35] The EC argues that the U.S. LCA industry benefits from large-scale R&D efforts such as the Aircraft Energy Efficient Program, the noise reduction program, and the High-Speed Civil Transport program (HSCT), as well as smaller scale efforts such as programs addressing aircraft icing sensors, windshear prediction, and various air safety issues.[36] The report also states that NASA provides benefits in conjunction with work with Department of Defense, such as efforts with the National Aerospace Plane.[37] It argues that 90 percent of the R&D conducted by NASA benefits the U.S. LCA industry because U.S. LCA manufacturers receive most of the NASA R&D contracts, and because there is crossover between NASA discoveries and applications for LCA.[38] The report states that "[m]any of the technological advances produced by NASA research have been incorporated by U.S. manufacturers of LCA into their products, resulting in large cost-savings to those manufacturers."[39] According to the EC report, U.S. companies that engage in R&D projects for NASA benefit from the training NASA provides to company personnel, as well as from enhanced in-house research, design, and production capabilities.[40] Airbus states that many of these benefits are continued in future NASA budget allocations, and notes that the projected NASA $1.02 billion aeronautical R&D program for fiscal year 1994 is being directed specifically toward increasing the U.S. share of the LCA market.[41]

The U.S. Government response counters these allegations. For example, it states that the HSCT program is designed primarily to determine whether potential environmental barriers can be overcome and to develop acceptable HSCT operations standards.[42] These issues allegedly must be addressed before any commitment to the development of aircraft can be made, and the results of the research must be made available to foreign companies and governments as well as to U.S. LCA manufacturers.[43]

The response also states that it is impossible to make broad estimations of NASA benefits because the positive externalities associated with NASA-sponsored R&D programs are related to the specifics of each undertaking, and to whether the contract recipient is able to commercialize the results of the program.[44] The response notes that the objective of NASA aeronautics research has been the development of long-term, generic advanced technology, rather than the identification of benefits to specific aircraft programs.[45] Most NASA funds are "absorbed by the U.S. Government or basic research in government labs."[46]

Although NASA data reportedly are made available to foreign and domestic entities alike through technical papers in recognized international symposia and journals, certain information is provided to domestic firms on a preferential basis (sometimes for 2 to 3 years) under the For Early Domestic Distribution (FEDD) program.[47] Even openly reported data not falling under this program, however, may be held for up to 2 years. Moreover, access to the information is a poor substitute for actually doing the research.[48] Despite these constraints, however, research shows that Airbus incorporates NASA developments and discoveries into its aircraft. The

33—*Continued*
16782; and 58 F.R. 18448. Also, in September 1992, changes were made in the treatment of IR&D/B&P by DoD and NASA. 57 F.R. 44264.

34 Ibid., p. 12.

35 Arnold & Porter, p. 2.

36 Ibid., pp. 33, 37-44.

37 Ibid., p. 34.

38 Ibid., p. 34.

39 Ibid., p. 33.

40 Ibid., pp. 33-34.

41 Renee Martin-Nagle, corporate counsel, posthearing submission on behalf of Airbus Industrie, G.I.E. and Airbus Industrie of North America, Inc., p. 7.

42 U.S. Department of Commerce, U.S. Government Response, p. 17.

43 Ibid., p. 17.

44 Ibid., p. 4.

45 Ibid., p. 19; and Eberstadt, p. 84.

46 U.S. Department of Commerce, U.S. Government Response, p. 19.

47 Ibid., p. 19; see also Eberstadt, pp. 84-86.

48 Eberstadt, pp. 84-85.

U.S. industry reports that Airbus is currently using several NASA technologies that were received free (i.e., Airbus did not have to pay U.S. taxes, thereby contributing to the NASA budget).[49] Sources report that there are numerous examples of foreign competitors applying NASA research, noting that Airbus was first to use winglets and apply the supercritical wing, and Japan was first to apply carbon fiber technology.[50]

NASA retains the option of including a recoupment provision in certain contracts for development projects undertaken by private companies.[51] The EC report, however, states that because NASA retains discretion on the recoupment process, it is doubtful that full recoupment is required in many instances.[52]

Sales Support and Intervention

Airbus asserts that the U.S. Government "exert[s] undue pressure on foreign governments whose national carriers have been in the process of re-equipping and updating their fleets."[53] For example, Airbus alleges that after agreeing to terms with Airbus for the purchase of certain A340-300 planes in March 1990, Japan Air Lines canceled the agreement and purchased planes from McDonnell Douglas at the instruction of Japan's Prime Minister Kaifu, shortly after he had met with President Bush over the U.S.-Japan trade imbalance.[54] Another source states that all of the $1 billion in loans at preferential rates that the Ministry of International Trade and Industry (MITI) can allocate to Japanese airlines annually has been made available for the purchase of U.S.-made LCA only.[55] Commission staff has investigated the veracity of these and other allegations of sales support and government intervention and has received comments concerning some of them. However, the Commission was unable to verify or refute the allegations.

Impact on Competitiveness of U.S. LCA Industry

Airbus states that U.S. LCA suppliers have secured their current dominance in world markets largely as the result of extensive indirect government support.[56] U.S. Government R&D support and large backlogs of military contracts, Airbus asserts, have contributed to the development of an extensive U.S. aeronautical R&D and manufacturing infrastructure and a large pool of skilled aerospace workers, which in turn may have allowed U.S. LCA producers to undertake commercial ventures without bearing the full cost of development. However, a source providing information to the OTA states that although large military procurements have improved the finances of firms that also manufacture commercial aircraft, the benefits have been indirect and generally unintended.[57] The United States and the European Commission are currently negotiating the definitions to be used in determining what constitutes indirect support, and the methodology to be applied in determining the amount of such aid provided to U.S. LCA manufacturers and Airbus. Until mutually agreeable terms are developed, accurate measurement of indirect supports is impossible.

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[49] U.S. LCA industry officials, interview by USITC staff, Sept. 1992.

[50] Eberstadt, p. 84.

[51] The instances in which NASA requires recoupment have changed to some extent since the U.S. Government Response. Formerly, NASA required recoupment (or sharing of the costs of a program by the industry) when (1) the program was end-product oriented; (2) offered the potential for market sales by the contractors; and (3) was over $10 million in estimated development cost. U.S. Department of Commerce, U.S. Government Response, p. 20. Currently, NASA may require recoupment (or sharing of the costs of a program by the industry) when an activity conveys a special benefit to the recipient above that accruing to the public at large and/or when specified by statute or is the basis for the congressional approval of a special program. *Recoupment Policy for the Sale, Use, Lease, or Other Transfer of NASA-Developed Technologies*, NASA Management Instruction, effective date March 31, 1993 (NMI 5109.13D).

[52] Arnold & Porter, pp. 46-47. The EC report indicates further that recoupment is based on a percentage of the sales of the commercial item applying the NASA technology, and that difficulties arise in determining whether the commercial item was derived from that technology. The EC report concludes that these factors decrease the frequency with which such recoupment is included in a contract or required after inclusion in a contract.

[53] "Report on U.S. Government Intervention in Sales of Civil Transport Aircraft" (Airbus Industrie: Dec. 1991), tab H.

[54] Ibid., tab H.

[55] Eberstadt, p. 103.

[56] Martin-Nagle, prehearing submission, p. 2.

[57] Eberstadt, p. 29.

West European Government Support Programs

Whereas alleged U.S. government support to the U.S. LCA industry is indirect, West European government supports to Airbus consortium member companies is both direct and indirect. An OECD report states that the governments of the Airbus consortium members have played an important role in the development of their aerospace industries through financial support, public procurement, and government ownership.[58] Although the plan for completing the single European market in 1992 (EC-92) calls for the elimination of government subsidies, Airbus member countries continue to promote and subsidize their individual aerospace industries. Although the European Commission often takes action against national subsidies that create discriminatory or unfair advantages for national producers and hinder the development of an integrated European market, it reportedly is not opposed to support for programs that have a West European rather than a national basis.[59] Thus, supports associated with the Airbus consortium member companies have been determined to be "compatible with the creation of a greater European market and to fit the profile of economic activities that are encouraged."[60]

The EC Commission reported in 1990 that public support to the aerospace industry has risen from almost 5 billion ECU ($5.9 billion) in 1978 to 14 billion ECU ($16.55 billion) in 1988. Of this latter figure, 10.4 billion ECU ($12.3 billion) comprised support for sales and maintenance, 0.7 billion ECU ($0.8 billion) comprised civil R&D, and 2.9 billion ECU ($3.4 billion) comprised military R&D.[61] Other sources detailed below show far greater direct and indirect government support for the Airbus member companies.

Direct Government Support

Airbus asserts that "no [West European] government has any special connection with or financial liability for the activities of Airbus Industrie."[62] However, Airbus reports that although each member company is responsible for arranging its own financing for R&D work assigned to it by the consortium, a percentage of most initial funding or funding guarantees for R&D costs is made available to the consortium partners by their home governments, consistent with bilateral agreements providing for funding that mirrors program progress and a repayment schedule that is spread over a specified number of aircraft.[63] Airbus reports that government financing carried no interest in the case of the A300 and A310 programs, but that after the principal amounts had been repaid, there was a provision for royalties to each participating government from the sale of each subsequently sold aircraft.[64] Airbus states that present government financing includes interest payment royalties to the participating government upon the sale of aircraft and after sales proceeds have been distributed by Airbus,[65] which is not the typical structure of a typical commercial loan.

Direct supports are the principal mechanism used by the governments of the Airbus consortium members to promote their aerospace industries.[66] Of the governments providing those supports, U.S. industry sources report that Germany allegedly provides the most, followed by France, and then the United Kingdom. Spain's support to Construcciones Aeronáuticas, S.A. (CASA) is relatively smaller; thus, Spain's support often is not included in the analysis that follows.[67]

In March 1992, the U.S. Government, responding to EC allegations of U.S. support for the LCA industry, reported that the British, French, German, and Spanish Governments had allocated more than $13.5 billion in direct supports to British Aerospace, Aérospatiale, Deutsche Airbus, and CASA since the late 1960s to develop LCA in competition with U.S. manufacturers.[68] These supports are usually aircraft

[58] OECD, p. 23.

[59] John W. Fischer, et al., *Airbus Industrie: An Economic and Trade Perspective* (Washington, DC: Congressional Research Service, Feb. 20, 1992), p. 21.

[60] Fischer, p. 21.

[61] Commission of the European Communities, annex pp. 14-15, table 9.

[62] "Responses of Airbus Industrie," p. 5.

[63] Ibid., p. 7.

[64] Ibid.

[65] Ibid. It bears noting that, although asked directly, neither Airbus, Aérospatiale nor the French Transportation Ministry appeared able to agree on what amount of interest accrues on the principal.

[66] Eberstadt, p. 185.

[67] Fischer, appendix pp. 63-64, figure 2.2.

[68] U.S. Department of Commerce, U.S. Government Response, executive summary, p. i. The OECD reported in 1990 that "European governments have provided about $15 billion in direct support to Airbus between 1970 and 1989." OECD, p. 23.

development funds, which allegedly come in the form of equity infusions, low-interest loans, loan guarantees, reimbursement of development and production costs, exchange-rate guarantees, and reimbursement of operating losses.[69]

These conclusions are based on a report commissioned by the Department of Commerce and prepared by Gellman Research Associates, Inc. That report provides the amount of funds provided to the Airbus consortium member companies by their governments on a country-by-country and program-by-program basis. It breaks down supports into launch aid and other supports disbursed, or pledged but to be disbursed at a future date. It then subtracts from these figures the repayments made by the consortium member companies to their governments. The report states that launch aid disbursed for Airbus A300/310, A320, and A330/340 programs as of 1989 totaled $5.4 billion.[70] It states that launch aid pledged but not yet disbursed at the time (primarily for the A330/340 program) totaled $2.3 billion. The report states that other support disbursed totaled $2.8 billion, while other support pledged but not yet disbursed totaled $3.0 billion. Repayments by the consortium member companies to their governments totaled $462.4 million according to information at the time the report was prepared. Thus, together these supports, minus repayments, totaled $13.1 billion in net support committed. The report also calculates what Gellman calls the "opportunity cost" or true value[71] of these government supports to derive a figure reflecting the time value of money and to provide a more accurate reflection of the supports. If the funds had been derived on a commercial basis, Airbus costs would have been much higher. Applying the true value of these funds at the government rate of borrowing,[72] the $13.1 billion figure rises to $19.4 billion. Applying the true value of these funds at a private rate of borrowing, the $13.1 billion figure rises to $25.9 billion (table 5-1).

There has been much debate about the accuracy of these figures. Airbus and the EC disagree with the conclusions in the U.S.-commissioned report concerning launch aid to be disbursed and other supports disbursed and to be disbursed. There is also much disagreement about applying "opportunity costs" or true value to these figures to boost them to the higher amounts. Commission staff have visited the source of these data and have verified that the figures comprising launch aid disbursed and launch aid to be disbursed derive from the government budgets in the countries concerned and legislative and administrative reports associated with legislation allocating the funds. Moreover, the report stating these conclusions is transparent in its analysis and reporting of data included in the totals presented. To date, neither Airbus nor the governments of the consortium members have directly refuted the report's conclusions on launch aid disbursed (i.e., the $5.4 billion figure) or provided an alternative figure.[73] The U.S.-commissioned report also is consistent with other sources analyzing Airbus supports.[74]

After the completion of the U.S.-commissioned report, certain supports that had been pledged but not yet disbursed actually were not disbursed.

[69] Ibid., p. 1; Gellman, pp. 2-1 through 2-23; and Tyson and Chin, p. 172.

[70] Gellman, table 2-1.

[71] This "opportunity cost" is calculated by applying the cost of funds of the government and private-sector borrowing rate in each country as appropriate to the net balance of funds committed each year to reflect the true value of support in 1989. Therefore, a more appropriate term is "true value."

[72] This figure is calculated by "applying the cost of funds of the government and private sector borrowing rate in each country as appropriate to the net balance of funds committed each year to reflect the value of support in 1989." Gellman, table 2-1.

[73] Airbus, however, does state that the $26 billion dollar figure quoted by the U.S. Government is "a gross exaggeration; the total amount of development loans received by Airbus' members is only a fraction of that amount" and that the loans are being repaid. Martin-Nagle, prehearing submission, pp. 7-8.

Indeed, the FRG Monopolies Commission admitted that "at the moment the Airbus is completely dependent on subsidies. Actually the Federal Government bears the biggest part of the entrepreneurial risks of Deutsche Airbus GmbH." "West German Monopolies Commission Report," ¶ 76.

[74] For example, *Die zivile Flugzeugindustrie: Konkurrenz zwischen den USA und Europa* (Freie wissenschaftliche Arbeit zur Erlangung des akademischen Grades "Diplom-Kaufman" an der Friedrich-Alexander-Universität Erlangen-Nürnberg Wirtschafts- und Sozialwissenschaftliche Fakultät); and Eberstadt, pp. 196-198, 204-208.

The German Monopolies Commission also made conclusions concerning subsidies to the German aerospace industry that are consistent with the U.S.-commissioned report. "West German Monopolies Commission Report (providing the report and vote concerning the Daimler-Benz takeover of MBB)."

Table 5-1
French, German, and British Government support of Airbus aircraft programs, funds committed through 1989

(Million dollars, current)

Funds committed	France	Germany	United Kingdom	Total
Launch aid disbursed:				
A300/310	988.4	1,489.5	82.9	2,560.8
A320	755.2	790.3	393.9	1,939.4
A330/340	193.0	316.1	421.2	930.3
All Aircraft	1,936.6	2,595.9	898.0	5,430.5
Launch aid to be disbursed:				
A330/340	682.9	1,264.5	325.0	2,272.4
Total launch aid	2,619.5	3,860.4	1,223.0	7,702.9
Other support disbursed[1]	1,035.3	924.2	883.9	2,843.4
Other support to be disbursed:[2]	———-	2,985.2	———-	2,985.2
Total support committed	3,654.8	7,769.8	2,106.9	13,531.5
Repayments to date	373.2	68.5	20.7	462.4
Net support committed	3,281.6	7,701.3	2,086.2	13,069.1
Net support committed at government opportunity cost[3]	6,463.5	9,099.7	3,804.4	19,367.6
Net support committed at private borrowing cost[3]	9,961.2	11,589.1	3,979.8	25,851.5

[1] Other types of support provided, such as equity infusions, long-term loans, research and development funding, production subsidies, or other miscellaneous targeted supports.
[2] Other funds pledged as production subsidies, exchange rate guarantees, or capital infusions.
[3] Calculated by applying the cost of funds of the government and private-sector borrowing rate in each country as appropriate to the net balance of funds committed each year to reflect the value of support in 1989.

Source: John W. Fischer, et al., *Airbus Industrie: An Economic and Trade Perspective* (Washington, DC: Congressional Research Service, Feb. 20, 1992), appendix, p. 61.

Specifically, Germany did not disburse a small amount of funds that it had initially pledged. Moreover, subsequent to the completion of the report, French firms repaid slightly more funds than had been pledged initially.[75] These observations highlight the difficulty involved generally in determining the repayments of Airbus consortium members. The report recognizes that repayment schemes often are not available to the public; therefore, repayment figures in the report could be subject to certain inaccuracies due to subsequent actions.

There also is debate about what "other supports" should be included in calculating supports for Airbus. The U.S.-commissioned report specifically states that "other supports" consist of "equity infusions, long-term loans, research and development funding, production subsidies or other miscellaneous targeted supports" such as compensation for exchange-rate losses.[76] The European government programs comprising these "other supports" are described in detail in the U.S.-commissioned report.

One could conclude, on the basis of the above factors, that certain slight downward adjustments of the figures provided in the U.S.-commissioned report are justified. Other than these adjustments, however, the report appears accurate as regards launch aid disbursed and to be disbursed by West European governments. Indeed, information from other independent sources, including government agencies in the countries of the Airbus consortium member companies, is consistent with the conclusions of the U.S.-commissioned report.[77]

[75] Richard S. Golaszewski, Gellman Research Associates, Inc., interview by USITC staff, Jenkintown, PA, June 3, 1993.

[76] Gellman, pp. 2-3, 2-11; also discussed pp. 2-6, 2-8 - 2-9, 2-11.

[77] OECD, *Internationalization of Industrial Activities;* "West German Monopolies Commission Report;" *Die zivile Flugzeugindustrie*; and Eberstadt, supra.

The legitimacy of boosting the pledged and disbursed funds to reflect the true value derived from such funds is difficult to ascertain. The West European government financing undoubtedly would have been much more costly had the Airbus consortium members obtained it through commercial, nongovernment sources as Boeing and McDonnell Douglas must. Thus, at least some level of true value benefit must be considered in assessing the competitive impact of benefits pledged and disbursed. With or without an adjustment for such true values, however, government support for Airbus consortium members—even merely launch aid for the A300 series programs—has been substantial.

Available data (including copies of West European government budgets and reports) show, and industry experts report, that since 1990, these funding levels have continued, although at slightly lower levels in some cases because no new Airbus programs have been initiated.[78] For example, the Government of the United Kingdom has allocated over £31 million (approximately $47 million) for launch aid associated with the A330/340 airliners and over £2 million (approximately $3 million) for Airbus sales support and other civil aircraft expenditure for 1992-93 (including market research and export promotion activities).[79] Similarly, the Government of France has allocated 895 million francs (approximately $156 million) to the A330/340 program and an additional 170 million francs to the CFM 56 (the engine program that equips the A330/340).[80] These examples are merely meant to show some of the funding that is ongoing and is not meant to be inclusive of all funds that may be allocated or pledged. German launch cost subsidies are to be shifted forward to the development phase of the A330/340 program and, thus, may well become part of other budget entries.[81] Arguably, German supports for its aerospace industry may decrease as a result of the MBB/Daimler-Benz merger as "entrepreneurial risk would be shifted from the Federal Government to the Industry."[82]

It is also noteworthy that certain funds firmly committed by the West European governments have yet to be disbursed. Although the recent agreement between the EC and the United States prohibits future production supports and severely limits future direct and indirect development supports (see discussion on the Aircraft Agreement later in this chapter), funds already firmly committed at the time of the agreement but not yet disbursed are "grandfathered" into the agreement and may be disbursed at a future date.

The Department of Commerce has reported that it expects Airbus to continue to receive subsidies as it launches new aircraft models.[83] Airbus has countered that even though government loans for LCA development have been received, they must be repaid, and that its newest aircraft, the A321, will be fully funded from commercial sources.[84] Other sources indicate that government-provided funding for Airbus consortium members is intended to be repaid mostly from levies on future aircraft sales, depending on the repayment terms between Airbus and the member companies and the member companies' relationships with their governments, the terms of which are usually not made public.[85] However, the Department of Commerce has stated that "[t]here is little likelihood of Airbus member companies ever repaying the funds they have received from their governments."[86] Of the funds provided through March 1992, the U.S. Government alleges that less than 10 percent have been repaid.[87] The U.S. Government argues that, unlike U.S. programs, which are generally available to anyone for review and comment (i.e., transparent), EC policies (and the obscure financial relationships between Airbus members and supporting governments) are not reviewable or transparent.[88] Partial government

[78] Eberstadt, pp. 196-198, 204-208.

[79] See appendix E, which provides sample pages of various West European government budgets and documents showing some of the 1992 allocations to Airbus-related programs.

[80] See appendix E.

[81] See appendix E; see also "West German Monopolies Commission Report," ¶ 120. This source also states that guarantees of the German Federal Government to reduce MBB bank loans are expected to amount to 1 billion deutsche marks at the end of 1994, "which is assumed to be the series end of the programmes A300 / A310." ¶ 121.

[82] "West German Monopolies Commission Report," ¶ 114.

[83] Menes, p. 7.

[84] Martin-Nagle, prehearing submission, p. 27.

[85] Gellman, pp. 2-5, 4-2; and Fischer, appendix p. 165. For example, British Aerospace was bound by a fixed repayment schedule through 1989. Fischer, appendix p. 165.

[86] U.S. Department of Commerce press release, Sept. 7, 1990 (ITA 90-58); and Menes, p. 7.

[87] U.S. Department of Commerce, U.S. Government Response, p. 1.

[88] Ibid., executive summary, p. iii.

ownership of certain Airbus consortium companies also allegedly permits large equity infusions of government funds.[89]

Airbus counters U.S. charges of subsidization by noting that the two members of the Airbus consortium that are state owned—CASA and Aérospatiale—may not receive aid granted by the governments of their countries that may distort competition in the EC, pursuant to article 92 of the Treaty of Rome.[90] Airbus further notes that under article 93 of the Treaty of Rome, the European Commission is "required to keep under constant review all systems of aid existing in the twelve member States. . . . [and to] police the granting of specific aids and to prohibit them when found to be incompatible with terms of Article 92."[91]

Indirect Government Support

The Airbus consortium member countries maintain large, expensive research and test facilities and perform research that would not normally be undertaken by individual firms (see chapter 6).[92] The U.S. Government argues that British Aerospace, Deutsche Airbus, and Aérospatiale are working on studies relating to supersonic aircraft that are being underwritten by the West European Basic Research in Industrial Technology for Europe/European Research in Advanced Materials (BRITE/EURAM) program.[93] The West European firms associated with Airbus also produce military aircraft independently (Aérospatiale and British Aerospace) and jointly (MBB and CASA).[94] Other sources confirm this and suggest that Airbus receives a far greater percentage of indirect subsidies compared with its LCA sales than do U.S. LCA manufacturers.[95] One source approximates the total benefit of indirect support to the three main Airbus member companies to have been $4.2 billion during 1980-89.[96]

The EC Commission has reported that aerospace is the only industry that receives more than 50 percent of its R&D funding from government sources.[97] At the time the EC made this comment, however, the level of government-funded aerospace R&D in Western Europe was declining despite rising production.

Military Contracts and Use of Government Facilities

As in the case of U.S. LCA manufacturers, West European manufacturers that produce military aircraft experience certain synergies that cross over to their commercial production. The U.S. Government response to the EC-commissioned report notes that Airbus consortium companies have major government and military contracts with supporting governments and therefore derive the same benefits, if any, from such relationships that U.S. manufacturers do in performing U.S. Government and military contracts.[98] The U.S. Government response states that the more liberal government procurement policies and less competitive sales environment faced by West European companies in the military aircraft market generates significant levels of surplus funds that can be employed in the LCA market.[99]

The U.S. Government response also states that Airbus partner companies make extensive use of government-owned or -funded R&D facilities, such as

[89] Ibid., executive summary, p. iv.

[90] "Responses of Airbus Industrie," tab I. It is noteworthy that there is likely no EC competitor to Airbus Industrie; therefore, distortion of competition would be difficult to substantiate.

[91] Ibid., tab I.

[92] Eberstadt, p. 177.

[93] U.S. Department of Commerce, U.S. Government Response, p. 17.

[94] OECD, p. 6.

[95] "Indirect Government Subsidies to Airbus" (draft by the Boeing Commercial Airplane Group), p. 3. The OECD reported in 1990 that "European governments . . . support domestic and coproduction programs for military aircraft with government procurement accounting for over 65 per cent of aerospace output." OECD, p. 23.

[96] "Indirect Government Subsidies to Airbus," p. 6, appendix B, table 1.

[97] Commission of the European Communities, annex p. 14.

[98] U.S. Department of Commerce, U.S. Government Response, executive summary, p. iv. The U.S. Government alleges that from 1987 to 1990, government sales are estimated to have accounted for 54 percent of Deutsche Aerospace's total sales, 50 percent of British Aerospace's total sales, and 49 percent of Aérospatiale's total sales and that during the 1980s, the four Airbus partner companies received at least $85 billion in government contracts. Ibid., pp. 2, 16, executive summary, p. iv.

[99] Ibid., pp. iv, 16. The U.S. Government points to the development of "airframes, avionics, engines, and other aerospace technologies for several programs (e.g., European Fighter Aircraft, Tornado, Harrier, Transall, Eurocopter, Hermes, and Saenger) that involve the Airbus partner companies." Ibid., p. 5.

wind tunnels, at reduced rates.[100] One source estimates that use of government-owned facilities allegedly has saved the Airbus partners hundreds of millions of dollars.[101] West European sources that have participated in the use of these facilities claim these allegations are false and argue that they pay commercial rates.[102]

In 1990, one source estimated that Airbus partners have received $9.1 billion in military R&D contracts.[103] The EC Commission reports that—

> [m]ilitary aerospace is the biggest consumer of R&D. Military R&D is partly concerned with fields specific to military applications, but most basic research is dual-purpose, i.e., military and civil. This explains the importance of military hardware production as a form of support for innovation in the civil field.[104]

This source also alleges that recoupment practices (whereby spillovers from the military sector to commercial applications are paid for by participating companies) are not required among Airbus partners.[105] Indeed, the EC Commission has indicated that military equipment constituted the major share of West European aerospace production in 1990, and that military equipment sustained the growth in the West European aerospace industry until 1982.[106]

The limits of the synergies and crossovers from producing both military aircraft and LCA, discussed earlier, with respect to the U.S. LCA industry, also apply to Western Europe.[107] In fact, there may be fewer synergies because of the relatively lower level of defense spending in Western Europe as compared with the United States, although West European LCA firms arguably rely more heavily on military sales than do their U.S. counterparts.[108]

Sales Support and Intervention

West European governments that own their countries' airlines arguably can influence the aircraft purchase decisions of those airlines.[109] The U.S. LCA industry also accuses the governments of Airbus consortium members of exerting other influences as well. One source has indicated that various inducements have been employed by West European governments to promote Airbus LCA sales.[110] Those governments reportedly have offered potential Airbus customers such inducements as landing rights, routes, regional economic assistance, trade agreements, subcontracting offsets, and low-interest financing with attractive export credit assistance.[111] Other reports indicate that "[o]ther instances involve 'high politics,' such as sales to South Africa following French military assistance and to Middle Eastern nations as a result of France's pro-Arab policies."[112] Commission staff has investigated the veracity of these and other allegations of sales support and government intervention and has received comments concerning some of them. However, the Commission was unable to verify or refute the allegations.

Impact on Competitiveness of U.S. LCA Industry

The U.S. Government asserts that direct supports from West European governments to Airbus programs have the specific purpose of lowering the manufacturing and sales costs of Airbus LCA in international markets, thereby distorting trade to the

[100] Ibid., pp. 3, 17.

[101] "Indirect Government Subsidies to Airbus," pp. 11-13.

[102] John E. Green, chief executive, Aerospace Research Association, Ltd., interview by USITC staff, London, Dec. 2, 1992.

[103] "Indirect Government Subsidies to Airbus," p. 7, tables 2, 3.

[104] Commission of the European Communities, annex p. 14.

[105] "Indirect Government Subsidies to Airbus," p. 8.

[106] Commission of the European Communities, annex p. 9.

[107] Eberstadt, p. 173.

[108] Ibid., p. 173.

[109] Ibid., pp. 91-92; and Menes, p. 11.

[110] Tyson and Chin, p. 175.

[111] The U.S. industry has alleged or reported rumors of such inducements, but has not sought action against the West European governments. U.S. LCA industry officials, interview by USITC staff, Sept. 1992.

[112] Mary Ann Rose, *Airbus Industrie: High Technology Industrial Cooperation in the EC-Structure, Issues, and Implications with a View Towards Eurofar*, paper for conference on the European Community in the 1990s, Emerging Concepts and Priorities, George Mason University, May 24-25, 1989, (San Jose, CA: San Jose State University Foundation for NASA Ames Research Center, May 1989), p. 25.

detriment of the U.S. industry.[113] McDonnell Douglas has asserted that the success of Airbus has resulted in the loss of thousands of U.S. aerospace jobs, placed great pressure on the profitability of U.S. manufacturers and their subcontractors, delayed or caused cancellation of new U.S. LCA programs, and promoted the trend in U.S. LCA programs toward risk sharing and globalization.[114]

The U.S.-commissioned report states that West European government loans given to Airbus member companies have reduced the financial risk of Airbus in bringing new products to market.[115] U.S. producers note that their products must be competitively priced, technologically advanced, and substantially supported after the sale, all on the basis of the sale price of their products.[116] The U.S.-commissioned report indicates that in the long run, U.S. LCA manufacturers may not be able to earn market rates of return on their invested capital due to the government supports provided to Airbus member companies, and will be unable to maintain their current level of industry operations.[117] This effect will result from the limited number of LCA units ordered and delivered each year, and the limited number of firms that can sell enough LCA to take advantage of declining unit production costs and cover their "sunk costs."[118] The report concludes that if Airbus were to operate its recent and future programs on commercial terms, the negative long-term impact on competing LCA suppliers and on airline customers would be moderated.[119]

Government Programs and Laws That May Indirectly Affect LCA Competitiveness

Tax Policies

Neither Airbus nor the U.S. LCA industry reported that the differing tax systems in Europe and the United States are a significant factor affecting competition. European and U.S. tax systems as they affect LCA manufacturers are complex and a comprehensive description or analysis is well beyond the scope of this section. Direct comparisons between U.S. and foreign tax rates can be meaningless if not placed in the broader context of the whole tax system. For example, a country with a high nominal rate on taxable income but with many opportunities for deductions and credits may have a lower effective rate of tax than another country with a high nominal rate on taxable income but with fewer opportunities for deductions or credits. Similarly, a liberal system of deductions and credits directed at an industry may be of little or no benefit, and thus provide little inducement for additional investment if the industry tends to have low profits or taxable income.

Also, states and localities within LCA-manufacturing countries impose taxes of various kinds, including income taxes, which have a bearing on overall tax levels. Accordingly, this section is limited to a brief description of key features of U.S. and European tax law, with an emphasis on those provisions identified as being important to LCA manufacturers.

U.S. Tax Benefits

Although there are no U.S. tax programs specifically applicable to the aerospace sector, the EC-commissioned report describes certain provisions of the U.S. Tax Code, including accelerated depreciation, R&D tax credits, and other tax provisions as generally providing indirect benefits to the U.S. LCA industry. The report states that the U.S. LCA industry has received tax benefits by being able to defer income under the completed contract method (CCM) of determining when contract income is subject to tax, and also under the domestic international sales corporation (DISC) and foreign sales corporation (FSC) programs. The report also alleges that investment tax credits (available through 1986) benefited the U.S. LCA industry, and that the U.S. corporate income tax rate for U.S. LCA companies is low (generally 34 percent, but effectively lower when FSC and R&D credit and various deductions are included[120]). The EC estimates that such benefits have totaled approximately $1.7 billion to Boeing and $1.4 billion to McDonnell Douglas.[121] However, Boeing's 1991 Annual Report indicates that the company received a tax benefit under the FSC program for that

[113] U.S. Department of Commerce, U.S. Government Response, p. 1, executive summary, i-ii.

[114] Robert H. Hood, Jr., president, Douglas Aircraft Co., posthearing submission on behalf of McDonnell Douglas Corp., pp. 18-19.

[115] Fischer, pp. 14-15.

[116] Ibid.; and Eberstadt, p. 210.

[117] Gellman, p. 5-1.

[118] Ibid., pp. 5-1, 5-2.

[119] Ibid., p. 5-3.

[120] The Boeing Co., 1992 Annual Report, pp. 23, 40; and McDonnell Douglas Corp., 1991 Annual Report, pp. 43-44.

[121] Arnold & Porter, p. 3.

year of about 3.2 percent of earned income ($2.2 billion), for a tax benefit of $70.5 million.[122] Under the same formula, Boeing's 1992 tax savings (with a benefit of 3.8 percent of earned income of $2.3 billion) equaled about $87 million.[123] Sources show that use of the FSC program is continuing.[124]

The U.S. Government challenges the EC allegations, arguing that (1) the findings fail to recognize that the tax benefits discussed are generally available to all industries; (2) alleged tax savings are overstated in that incorrect tax rates are applied; and (3) similar policies benefit EC companies.[125] The U.S. Government also notes that "[u]nder international law, it is well understood and agreed that such generally available tax benefits are not subsidies and do not create trade-distorting effects."[126] The Aerospace Industries Association (AIA) argues the U.S. tax rules for long-term manufacturing contracts create a disadvantage for industries such as the aerospace industry. It claims that these tax disadvantages result from misplaced provisions that were mistakenly not removed in the recent tax reorganization, or result from a failure to fully recognize R&D and investment tax credits. The current tax system allegedly affects the aerospace industry disproportionately because this industry produces special-purpose products that require high technology and substantial financial commitments for R&D, and which involve substantial time commitments for manufacture.[127]

122 The Boeing Co., 1991 Annual Report, pp. 38, 44. Boeing's 1990 Annual Report shows a tax benefit under the FSC program for that year of about 4.9 percent of earned income ($2 billion), for a tax benefit of $96.6 million. The Boeing Co., 1990 Annual Report, pp. 38, 44. Airbus estimates that the tax savings from the FSC program from 1986-91 for Boeing equalled about $350 million and for McDonnell Douglas equaled about $100 million, based on these companies' annual reports. Martin-Nagle, posthearing submission, p. 6.

123 The Boeing Co., 1992 Annual Report, pp. 34, 40.

124 *Commercial Aviation Report*, Apr. 1, 1993, pp. 11-13; and May 1, 1993, p. 19.

125 U.S. Department of Commerce, U.S. Government Response, pp. 22-23, executive summary, p. iii.

126 Ibid., pp. 2-3.

127 Submission from Aerospace Industries Association of America, Inc., Feb. 1993, p. 25.

West European Tax Benefits

Airbus has claimed that none of its four member countries offers tax exemptions specifically tailored to aerospace producers.[128] However, the U.S. Government response indicates that each Airbus member company benefits from tax incentives analogous to the alleged benefits the EC claims U.S. companies experience, such as accelerated depreciation for R&D.[129] However, due to the lack of financial disclosure required of companies in Western Europe, only estimated tax benefits can be provided.

One source indicates that the member countries of Airbus have extensive tax and nontax incentive programs available to them.[130] This source notes that all member companies may take advantage of accelerated depreciation for fixed assets and for R&D, and that France and Spain have provisions for credit for research expenditures, deferral of tax for foreign subsidiaries, exemption from business tax for depressed areas, and tax holidays in enterprise zones.[131] Within France, Germany, and the United Kingdom, the following nontax incentives are generally available to all industries: (1) R&D job creation subsidies; (2) low-interest loans for buildings and plants; (3) training subsidies; (4) low-rate equipment financing; (5) export credit insurance; (6) exchange-rate guarantees; and (7) marketing cost insurance.[132] Tax disclosure in Western Europe and among the Airbus member companies is limited, differing from regulations in the United States. Therefore, a discussion of the impact of tax benefits must be general and cannot be specific to the West European LCA industry.

Most goods and services sold within EC member states include in their price a value-added or consumption tax (VAT). In 1993, the minimum EC "standard" VAT rate, which applies to most goods and services, is 15 percent ad valorem. Under the system in place in the EC, VAT is owed to the member state

128 "Responses of Airbus Industrie," tab I.

129 U.S. Department of Commerce, U.S. Government Response, p. 3.

130 "Indirect Government Subsidies to Airbus," p. 8.

131 Ibid., appendix D, p. 9.

132 Ibid., p. 10; see also Ian McIntyre, *Dogfight: The Transatlantic Battle over Airbus (Westport, CT: Praeger Publishers, 1992)*, p. 125 (citing a recent study by the international firm of chartered accountants, Coopers and Lybrand, *Tax and Non-Tax Incentives Available in the Countries Participating in the Airbus Enterprise*, May 5, 1988).

in which a good (or service) is consumed, regardless of where it was produced; that is, whether in another member state or in a country outside the EC. Goods and services that are exported are "zero rated" at the border; that is, any VAT paid is rebated. Thus, in the case of aircraft, any VAT paid on Airbus aircraft exported from the EC is rebated at the border, but the applicable VAT rate is imposed on any aircraft that are imported. The VAT rate varies by member state, but in early 1993, the "standard" rate, which is the rate applicable to most goods, ranged from a low of 15 percent in Germany and several other member states to as high as 25 percent in Denmark. Although many individual U.S. States impose sales taxes, the United States does not impose a VAT or equivalent tax that is rebated at the border.[133]

The advantage the VAT provides to Airbus over U.S. producers in the EC and third markets is unclear. The EC VAT system provides an advantage to the extent that the VAT is a substitute for other taxes, such as income taxes, that Airbus and its partners would otherwise pay and (1) that would not be rebatable at the border, and (2) which would not be rebatable in the case of a U.S. producer that exports. Thus, when U.S. manufacturers and Airbus compete in the EC market, they all will include the EC VAT in their price offers, but the U.S. aircraft price also may reflect certain U.S. taxes (such as Federal and state corporate taxes) for which no U.S. rebate is available. Similarly, when the two companies compete in third markets, Airbus may be able to exclude from its price much of its domestic VAT tax obligation.

Policies Concerning Export Activities

Export Promotion Policies

It is unlikely that the general export promotion programs of LCA-manufacturing countries play an influential role in the competitiveness of LCA manufacturers.[134] Export programs that affect competitiveness usually involve either high-level political support or direct and indirect government supports, tax policies, and export financing (discussed below). The AIA states that "[t]he U.S. government does not provide the kind of consistent high level political support for its aerospace exporters that is customarily provided to our competitors by their governments."[135] It notes that the U.S. Government may be less willing to support U.S. LCA exports in part because often both U.S. producers may be bidding for a sale abroad and the U.S. Government may not want to choose the winner of the bid.[136]

Export Financing

Background

West European countries such as France and Germany make credit insurance and export financing highly accessible through networks of regional offices where exporters can obtain export finance assistance.[137] Moreover, many West European countries reduce restrictions on obtaining export financing by granting credit based on entitlement. The governments make broad, long-term determinations about which exports to assist, and then provide sufficient funds and administrative freedom to assist those exports.

A recent General Accounting Office (GAO) report concludes that in the United States, the availability of export financing is limited by access and application restrictions. The U.S. Export-Import Bank (Eximbank) is the most important institution that facilitates U.S. exports by providing loans, loan guarantees, and credit insurance. The GAO report indicates that Eximbank focuses its resources on a narrower range of export transactions than many of its West European counterparts, and that seeking assistance from Eximbank has been fraught with paperwork, uncertainty, and slow processing time. Despite these alleged deficiencies, Eximbank is still recognized as the principal source of export finance

[133] For a further discussion of these issues, see U.S. International Trade Commission, *The Effects of Greater Economic Integration Within the European Community on the United States: Fifth Followup Report*, investigation No. 332-267 (Apr. 1993), USITC publication 2628, pp. 127-132.

[134] U.S. General Accounting Office (GAO), *Export Promotion: A Comparison of Programs in Five Industrialized Nations* (Washington, DC: GAO, June 1992).

[135] Submission from the Aerospace Industries Association of America, Inc., Feb. 1993, p. 29, and also p. 42 (commenting on Department of Defense support for air shows and national demonstrations).

[136] Ibid., p. 29.

[137] "Indirect Government Subsidies to Airbus," appendix C, p. 3 (noting that the financing of export-related investments and cash flow needs is generally at advantageous or subsidized rates of interest).

assistance for U.S. businesses such as the LCA industry.

Export Financing of LCA

Eximbank reports that it has supported a number of export transactions by the U.S. LCA industry.[138] From 1987 to 1991, Eximbank provided guarantees for 26 U.S.-produced aircraft (6 to Bahrain, 6 to Greece, 2 to Colombia, 4 to Morocco, 3 to Algeria, 3 to Yugoslavia, and 2 to Zimbabwe).[139]

Although Eximbank is effectively in competition with the French, German, and British export credit agencies, the official financing systems for both Airbus and the various U.S. manufacturers are similar. Indeed, all institutions reportedly follow the guidelines for officially supported export credits for financing the sales or leases of LCA outlined in the Large Aircraft Sector Understanding (LASU).[140] The LASU standardizes export financing terms that are permissible. Because of the LASU and changes in the way aircraft purchases are made, export financing has become a “less important policy tool.”[141] A 1990 OECD report states that with the LASU, government-supported export financing in the OECD countries was virtually eliminated as a competitive advantage among LCA producers.[142]

Government-supported export financing also has diminished as a competitive factor because private bank rates for aircraft purchase loans approximate the government-supported export financing rate.[143] In transactions with marginally creditworthy foreign airlines or in high political-risk markets, both Airbus export credit agencies and Eximbank occasionally rely on the manufacturers to assume a portion of the risk involved in the transaction. Many recent LCA transactions assisted by Eximbank have resulted from commercial banks’ withdrawing from the marketplace for certain types of transactions. Currently, Eximbank is the only government-based institution available to help promote U.S. aircraft exports and is the major source of financial support for these exports. Despite occasional complaints from U.S. LCA manufacturers that Eximbank does not do as much as it can to promote their exports,[144] Eximbank officials indicated that they are not aware of any export transactions in the last 4 years that have been lost to Airbus because of inadequate financing support.

Export Controls

Current Controls by COCOM on Avionics and Related Materials

The Coordinating Committee on Multilateral Export Controls (COCOM) is the result of an informal arrangement among all North Atlantic Treaty Organization (NATO) members[145] (excluding Iceland) and Japan. As such, COCOM regulations are not legally binding and member nations have the right to act independently to strengthen or weaken domestic implementing laws. The three main functions of COCOM are as follows: (1) to establish and maintain

[138] Eximbank official, telephone interview by USITC staff, Feb. 10, 1993. In general, Eximbank provides repayment guarantees to banks or other financial institutions that then in turn provide funding for the airframe and jet engine manufacturers, and provides preliminary commitments for aircraft manufacturers involved in export sales campaigns and to foreign airlines contemplating the purchase of U.S.-made LCA. Without these guarantees, the financial institutions most likely would not be willing to provide financing due to factors such as commercial and political risk.

[139] Aerospace Industries Association of America, Inc., *Aerospace Facts and Figures: 1992-1993* (Washington, DC: The Aerospace Research Center, Aerospace Industries Association of America, Inc., 1992), p. 136.

[140] To prevent costly competitive export financing, the United States and European governments worked out a bilateral agreement in 1981 that was formalized in the OECD in 1985, and became the LASU. It sets maximum time periods and minimum allowable interest rates that governments may offer on loans for the purchase of LCA. Tyson and Chin, p. 175.

[141] Ibid., p. 175; and transcript of hearing, pp. 156-157.

[142] OECD, p. 18. These conclusions are supported by both the U.S. LCA industry and Airbus. Martin-Nagle, prehearing submission, p. 8; transcript of hearing, pp. 156-157, 236; and U.S. LCA industry officials, interview by USITC staff, Sept. 1992.

[143] Eberstadt, pp. 99-100, 224.

[144] McDonnell Douglas indicates that Eximbank “needs to adopt credit standards consistent with the overall benefits to the U.S. economy of aerospace exports” and needs an increase in the amount of its loan guarantee authority. Hood, p. 30.

[145] The United States and all the governments of the Airbus partners and associate member companies are members of NATO.

lists of embargoed technologies that may not be exported to controlled countries; (2) to process requests by member nations to export controlled goods to proscribed nations; and (3) to coordinate the export policies and enforcement efforts of its member nations.

COCOM does not make its lists public, but they largely are reflected in the export control lists of member nations. In the United States, the Commodity Control List (CCL) is an important source of export control information. The CCL includes validated license requirements for, among other things, avionics, materials, propulsion systems, and transportation equipment.

Through its system of codes (Export Control Classification Number (ECCN)), the CCL specifies those commodities that are restricted from export under COCOM regulations, many of which are aircraft components and navigational equipment. For such products, validated licenses are required for export to most countries.[146] The ECCN includes LCA and restricts their export to Cuba, Cambodia, North Korea, Vietnam, Libya, Syria, Iran, and the South African military and police. The U.S. industry indicates that were it not for export controls in Iran, Cuba, and Vietnam, U.S. LCA manufacturers would be pursuing those markets.[147] The U.S. industry indicates that U.S. export controls are a controversial subject and that the patchwork system involving the Departments of Defense, Commerce, the Treasury, and State is excessively time consuming.[148] The U.S. industry fears that certain hidden aspects of the U.S. export system also cause problems.[149] For example, congressional messages, administrative blacklists, and lack of allied support for certain restrictive positions allegedly hinder U.S. LCA sales. The U.S. manufacturers also fear that these factors cause them to be labeled as "unreliable suppliers."[150]

Under the reexport regulations, export controls receive extraterritorial treatment. The reexport regulations primarily address concerns associated with component parts, the export of which is restricted. When a final product containing components originating in the United States is to be exported from one foreign country to an export-controlled country, the United States maintains export control on the U.S.-made component if it comprises as much as 20-25 percent of the value of the final product.[151]

Thus, Airbus is subject to U.S. export control laws when its finished product contains a sufficient percentage (Airbus alleges 10 percent) in value of U.S.-made components to implicate the U.S. re-export regulations. Indeed, it was only after satisfying stringent procedural requirements that Airbus was able to enter into a contract with Iran to sell two A310s containing engines produced by General Electric (GE) in the United States.[152] Through some vigorous lobbying efforts, GE was able to gain U.S. Government approval for its sale of engines to Airbus for re-export to Iran.

When Airbus manufactures an LCA with U.S. components (e.g., GE jet engines), the Airbus plane is subject to U.S. export controls on those specific components, rather than the U.S. export controls on the entire aircraft. Airbus argues that Airbus planes containing U.S. engines are subject to stricter re-export controls (engines are restricted for national security and missile technology reasons) than are entire Boeing aircraft also containing U.S.-made engines. As a result of these restrictions, Airbus states that it has been deprived of "substantial revenue" and "takes care to abide by the spirit and intent of the U.S. export controls."[153] Airbus is also subject to the COCOM requirements as a European entity. For this reason, some parties argue that a company like Airbus is averse to incorporating U.S.-made components in its planes, despite recent success with GE engines.[154]

The U.S. industry reportedly suffers a competitive disadvantage from unilaterally imposed U.S. export control laws because they are more restrictive than those of COCOM and other countries. Without

[146] 15 C.F.R. sec. 785.

[147] U.S. LCA industry official, interviews by USITC staff, Dec. 18, 1992, and Feb. 23, 1993.

[148] U.S. LCA industry official, interview by USITC staff, Sept. 1992. As an example of the problems U.S. export control laws allegedly cause, the U.S. industry indicated that India requested its state airline to take into account the (alleged) myriad export control laws and their apparent instability before committing to buy U.S.-built aircraft.

[149] U.S. LCA industry official, interviews by USITC staff, Sept. 1992, Dec. 1992, and Feb. 1993.

[150] U.S. LCA industry official, interviews by USITC staff, Dec. 18, 1992, and Feb. 23, 1993.

[151] U.S. LCA industry official, interviews by USITC staff, Dec. 18, 1992, and Feb. 23, 1993.

[152] Airbus Industrie of North America, Inc. official, telephone interview by USITC staff, Feb. 9, 1993; and Boeing official, telephone interview by USITC staff, Feb. 9, 1993.

[153] Martin-Nagle, prehearing submission, p. 13; and Martin-Nagle, posthearing submission, p. 8.

[154] Transcript of hearing, pp. 238-239; and Eberstadt.

multilateral imposition of export controls, sales that U.S. manufacturers currently are prohibited from making will go to their competitor, Airbus. LCA require full-time support; U.S. manufacturers argue that the "unreliable supplier" image they have because of U.S. export controls puts them at a disadvantage.[155] For example, Boeing recently received information from LCA owners in controlled countries, such as Libya, that complained that U.S. export controls are leaving their Boeing aircraft in disrepair and thus inoperable. Many airline officials have informed Boeing they cannot get proper support services for the Boeing aircraft they purchased many years ago before some export controls were put in place.[156]

Antitrust Laws and Competition and Merger Policies[157]

None of the major world producers has been the subject of any antitrust action, and none is regarded as likely to be in the foreseeable future. Moreover, neither of the two current U.S. LCA producers cited U.S. Government antitrust policy as having a significant effect on competition. No mergers concerning the major players involved in the LCA industry have been seriously proposed and thus none have been opposed or approved by the U.S. Department of Justice, which would have jurisdiction over such mergers.[158] However, certain antitrust issues deserve brief mention here.

The AIA asserts that U.S. antitrust laws are "ill-suited" to industries such as the aerospace industry that are characterized by global production, markets, and competitors.[159] The AIA adds that although the National Cooperative Research Act of 1984 allows some opportunities for some joint development, the U.S. aerospace industry still experiences antitrust restrictions that prevent its members from entering into domestic cooperative arrangements to produce and market products resulting from joint development projects.[160]

Certain analysts have indicated that the U.S. LCA industry may be affected by U.S. antitrust laws that generally limit cooperation between competitors in research activities, and allegedly make many U.S. companies "ignorant about the collaborative process" enjoyed by Airbus.[161] Similar conclusions were drawn in a report stating that U.S. antitrust policies inhibit intra-industry interaction and, thus, weaken the competitiveness of the U.S. aerospace industry.[162]

One contentious issue concerning West European competition policies was the EC Commission's controversial approval of the German Government/Daimler-Benz privatization deal.[163] Although the EC Commission noted that the subsidies normally are not permissible, it was ruled that they helped to maintain European competitiveness in the face of indirect U.S. subsidies from study and research contracts, and a waiver should therefore be granted because they promoted common European interests.[164] The United States filed for dispute

155 Submission from the Aerospace Industries Association of America, Inc., Feb. 1993, p. 37.

156 Boeing official, telephone interview by USITC staff, Feb. 9, 1993.

157 For an in-depth analysis of any recent changes to the EC antitrust laws and competition and merger policies, see the USITC's forthcoming *EC 1992 5th Followup Report,* section on EC competition law.

158 In late 1991, McDonnell Douglas reportedly sought relief from its adverse financial situation through a proposed sale of 40 percent of its equity to Taiwan Aerospace Co. The deal is not currently under active consideration (see chapter 2).

159 Submission from the Aerospace Industries Association of America, Inc., Feb. 1993, p. 51.

160 Ibid.

161 Rose, p. 33.

162 Council on Competitiveness, "A Competitive Profile of the Aerospace Industry," research paper for *Gaining New Ground: Technology Priorities for America's Future* (Washington, DC: March 1991), p. 2.

163 Deutsche Airbus was a subsidiary of MBB. The German Government formerly held 30 percent of MBB, but sold its shares to Daimler-Benz, which formed a new subsidiary to replace Deutsche Airbus under Daimler-Benz ownership. Rose, p. 29. The German Government wanted to free itself of the losses to Deutsche Airbus, while Daimler-Benz was concerned about exchange-rate losses after the acquisition. The package included a promise from the German Government to cover exchange-rate losses if the dollar fell below 1.6 deutsche marks. Fischer, p. 38 (citing The Bureau of National Affairs, "Yeutter Criticizes German Decision to Provide Risk Support for Daimler Benz Airbus Venture," *International Trade Reporter*, Nov. 16, 1988, p. 1498). Under other terms, the German Government granted Daimler-Benz 4 billion deutsche marks ($2.2 billion) to write off outstanding debts.

164 Rose, pp. 29-30.

resolution of the exchange rate issue and sought resolution before a panel of the General Agreement on Tariffs and Trade (GATT) Subsidies Committee, which found in favor of the United States.[165] The panel found that funds had been provided without provision for repayment, accrual of interest, or any administrative costs.[166]

Environmental Laws

Generally, West European countries involved in the Airbus consortium have environmental laws and regulations that are similar to those found in the United States. Therefore, U.S. and West European environmental laws and regulations are estimated to have a similar impact on the activities of Airbus, Boeing, and McDonnell Douglas. An OECD report recently concluded that the pollution abatement and control (PAC) expenditures in the private sector as a percentage of GDP in the United States, France, Germany, and the United Kingdom were comparable,[167] and reported the following percentages for 1990: United States 1.4 percent of GDP; France 1.0 percent of GDP; Germany 1.6 percent of GDP; and the United Kingdom 1.5 percent of GDP.[168] However, environmental costs such as these may not include the costs of environmental compliance litigation. Such litigation costs may be substantial, particularly in the United States.

Other than the Stage 3 noise requirements (see chapter 3), there were no other aircraft-specific environmental regulations reported. Therefore, most environmental regulations affect LCA manufacturers no more than they affect similarly situated manufacturing and high technology industries.[169] U.S. manufacturers and Airbus consortium members alike have similar business costs from the effects of generally applicable environmental requirements. For example, top Boeing officials described the company's recent difficulties in attempting to obtain construction permits to expand the plant in Washington State where the new 777 transport will be built. Reportedly, it took Boeing 18 months to obtain the necessary permits.[170] Sources also report that Boeing was assessed $50 million in environmental and other mitigation fees, in addition to consulting fees to the City of Everett, WA, in excess of $3 million.[171] McDonnell Douglas has also expressed concerns about the stringent environmental requirements it faces in California, particularly with respect to restrictions that apply to the painting of aircraft using toxic paints.[172] A special task force is reportedly being formed to address specifically the impact of California's environmental regulatory process on the competitiveness of the aerospace industry in that state. At the time of the preparation of this report, the task force had not established a schedule for completion of any report.[173]

The Stage 3 noise requirements were imposed on airlines and airports and concern noise limitations. In 1992, the EC Council issued a directive to harmonize noise emission standards for civil subsonic aircraft

[165] U.S. International Trade Commission, *The Year in Trade: Operation of the Trade Agreements Program 1991, 43d Report* (Aug. 1992), USITC publication 2554, pp. 45-46.

[166] Fischer, p. 3.

[167] OECD, *Environment Monographs*, summary table 1 (draft prepared by the Environment Policy Committee and Directorate for the forthcoming report on "Pollution Abatement and Control Expenditures in OECD Countries"). The OECD made similar conclusions in an analysis of investment expenditures in PAC as a percentage of Gross Fixed Capital. Ibid., table 2.

[168] Ibid., table 1.

[169] In this regard, the Aerospace Industries Association of America, Inc. estimates that installation of the maximum achievable control technology (MACT) for hazardous chemicals to comply with the Clean Air Act Amendments of 1990 will cost the aerospace industry "several billion dollars in initial capital resources and will significantly increase annual operating costs of facilities." Submission from the Aerospace Industries Association of America, Inc., Feb. 1993, p. 10.

[170] *Aviation Week & Space Technology*, Mar. 8, 1993, p. 11.

[171] Ibid.

[172] These concerns were given attention in a study addressing the competitiveness of certain industries in California. Council on California Competitiveness, *California's Jobs and Future* (Apr. 23, 1992), p. 101. The impact of California's enforcement of environmental requirements on competition has become the focus of study by the State Government. Task Force on Regulatory Streamlining, *Report of the Council on California Competitiveness* (Apr. 23, 1992), and State of California Secretary for Environmental Protection, *Draft Recommendations for Consolidating and Streamlining the Cal/EPA Permit Processes* (Mar. 16, 1992).

[173] California Environmental Protection Agency official, telephone interview by USITC staff, June 1993.

operating at EC airports.[174] This directive requires that aircraft meet specified noise standards set forth in the Convention on International Civil Aviation. The EC Commission proposal,[175] which served as the basis for this directive, is applicable to all aircraft operating at EC airports and not merely aircraft licensed by member states. Therefore, the restrictions will affect Airbus and U.S. LCA manufacturers.

One source suggests it is possible that increased noise limitations may actually improve the condition of the LCA manufacturers as many older aircraft that do not comply with noise limits will have to be modified or taken out of service.[176] Under this scenario, purchases of new aircraft that meet the new noise requirements are more likely to occur; however, this would not benefit one manufacturer over others.

Foreign Corrupt Practices Act

The Foreign Corrupt Practices Act of 1977 (FCPA) (15 U.S.C. secs. 78dd-1 & 78dd-2 et seq.) criminalizes bribery of foreign officials beyond a negligible level of small payments to low-level officials. The extraterritorial effect of the FCPA has been criticized as creating a comparative disadvantage for U.S. businesses in countries where bribes are a common business practice.[177] Although the FCPA permits payments to any foreign agent acting on behalf of a domestic concern, it prohibits the domestic concern from providing such payments to an agent for the purpose of influencing higher officials. The FCPA was amended by title V of the Omnibus Trade and Competitiveness Act of 1988.[178] Prior to this amendment, agents in many countries reportedly would not accept employment representing a U.S. firm because they knew that to act effectively, they would need to offer bribes, thereby subjecting themselves to the extraterritorial reach of the FCPA.[179] This amendment reportedly has reduced the liability that the FCPA poses for U.S. industry operations overseas and has eliminated restrictions that previously had effectively discouraged the use of foreign agents to promote business.[180]

In a survey of aircraft manufacturers (including manufacturers of other than LCA), respondents reported that the aircraft industry has been significantly affected by the FCPA and that the FCPA had adversely affected their overseas business.[181] Moreover, of all companies surveyed, over 60 percent responded that, assuming all other conditions were similar, U.S. companies could not successfully compete against foreign companies that were engaged in bribery.[182] However, the U.S. LCA industry states that it fully complies with the FCPA and has found that it is not a factor affecting their competitiveness.[183]

Labor Laws

Airbus reports that restrictive West European labor laws put it at a competitive disadvantage vis-à-vis U.S. LCA manufacturers, stating that U.S. legal restrictions on the hiring and firing of employees by U.S. companies are "minimal."[184] Airbus indicates that in the absence of discrimination or a specific contractual commitment, U.S. employers, such as Boeing and McDonnell Douglas, have virtual freedom to enter into, as well as terminate, employment relationships; Airbus asserts that this ability gives U.S. companies "a strong competitive advantage over their foreign counterparts."[185] The EC Commission also has stated that the relatively more restrictive social

[174] *Council Directive 92/14/EEC of 2 March 1992 on the Limitation of the Operation of Aeroplanes Covered by Part II, Chapter 2, Volume 1 of Annex 16 to the Convention on International Civil Aviation, Second Edition (1988),* OJ No. L 76 (Mar. 23, 1992).

[175] E.g., *Proposal for a Council Directive on the Limitation of the Operation of Chapter 2 Aeroplanes, COM (90) 445*, OJ No. C 111 (Apr. 26, 1991).

[176] Fischer, p. 11 (citing "Airweather Friends," *Flight International*, Oct. 16, 1991, p. 42).

[177] Barton Fisher, *International Trade and Investment* (Boston: Little, Brown & Co., 1986), pp. 571-572.

[178] Public Law 100-418, 102 Stat. 1107.

[179] Fisher, pp. 571-572.

[180] Thomas F. Clasen, *Foreign Trade and Investment: A Legal Guide* (Salem, NH: Butterworth Legal Publishers, 1990), sec. 11.08.

[181] Fisher, pp. 571-572.

[182] Ibid., p. 571.

[183] U.S. LCA industry officials, interview by USITC staff; and transcript of hearing, p. 87-88.

[184] "Responses of Airbus Industrie," tab B.1., p. 3; and Martin-Nagle, prehearing submission, p. 12.

[185] "Responses of Airbus Industrie," tab B.1., p. 3.

and labor laws in Western Europe promote relatively lower workforce levels to ameliorate the negative impact of excess employment during business downturns.[186]

The European Commission has noted that, although wages are lower in Western Europe than in the U.S. industry, this advantage is more than offset by higher U.S. productivity due to the U.S. industry's scale-of-production advantage.[187] This conclusion suggests that labor law differences between the United States and Airbus member countries may constitute a relatively unimportant competitive difference between the two areas because the different labor issues appear to cancel each other.

Aircraft Certification Requirements

The U.S. Federal Aviation Act requires that LCA registered in the United States have their designs certified as safe, and the Federal Aviation Administration (FAA) is responsible for such certifications on all aircraft produced in the United States or imported by U.S. companies or individuals.[188] West European regulators coordinate certification activities through one organization—the Joint Airworthiness Authorities (JAA)—that has developed its own standards and practices since 1970.[189] In Western Europe, certificates of airworthiness and the certification process come under the purview of national civil aviation authorities.[190] The Joint Airworthiness Requirements is a program in which the member countries of the JAA act together as a common certification team.[191] In addition to the FAA and JAA, there are a multitude of airworthiness authorities in various countries around the world that primarily follow the standards and requirements already promulgated by the FAA or JAA.[192]

There is general industry consensus that there is a need for common international standards and practices that would benefit foreign and domestic LCA manufacturers and airlines by eliminating differences among and duplication of certification standards and practices.[193] In this regard, the European Commission reports that harmonization of the certification procedures in Western Europe under the JAA should reduce the cost of certification and promote the free movement of aerospace products within the Community.[194] The Department of Transportation has noted that the economic benefits to the global LCA industry of harmonization of the FAA and JAA would equal as much as $1 billion. The FAA and JAA are taking steps to this end, although with limited progress.[195] Thus, there currently is no mutual recognition of the two systems; U.S. and EC certification must be sought independently from both the FAA and the JAA.

Manufacturers assert that differences in the FAA and the JAA interpretations of some certification regulations and duplication of activities result in substantial additional cost for all manufacturers and inefficient use of regulatory resources.[196] Examples of the difficulties that arise include the following:

- In a major certification project, a difference in the interpretation of one regulation by the FAA required Airbus to make a late design change in the A340 aircraft that, according to the GAO, unnecessarily increased Airbus A340 production costs by over $20 million for the entire fleet.[197]

[186] Commission of the European Communities, p. 8.

[187] Ibid., annex p. 11.

[188] 14 C.F.R. pt. 25.

[189] U.S. General Accounting Office (GAO), *Aircraft Certification: Limited Progress on Developing International Design Standards* (Washington, DC: GAO, Aug. 1992), p. 2. As of March 1992, the JAA had 19 member countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the former Yugoslavia.

A recent EC regulation required all EC countries to join JAA, adopt all of JAA's Joint Aviation Requirements, and accept imported products certified by JAA without additional technical conditions. Ibid., p. 10.

[190] Commission of the European Communities, p. 11.

[191] Ibid., p. 11.

[192] U.S. LCA industry officials, interviews by USITC staff, Washington, DC, Dec. 18, 1992, and Feb. 18, 1993.

[193] "Responses of Airbus Industrie," tab K; and submission from the Aerospace Industries Association of America, Inc., Feb. 1993, p. 17.

[194] Commission of the European Communities, p. 11.

[195] GAO, *Aircraft Certification*, pp. 11-12, 22-23, 24-31 (quoting *Report to the President: Review of Regulations* (Apr. 1992)).

[196] Ibid., pp. 2, 8-20; and submission from the Aerospace Industries Association of America, Inc., Feb. 1993, p. 17.

[197] Ibid., pp. 16-17.

- An instance in which the FAA interpreted a regulation concerning minimizing risks of engine explosions differently from the way the JAA interpreted its similar regulations required late design changes that cost Airbus $20 million in increased production costs. Later, the JAA interpreted one of its regulations concerning the same issue differently from how the FAA interpreted one of its similar regulations, requiring late design changes that cost McDonnell Douglas $21 million.[198]

- On at least one occasion, late interpretation differences between FAA and JAA regulations on similar issues reportedly increased total costs between $60 million and $90 million on one airline's 747 fleets (Boeing met the FAA standard but initially did not satisfy the JAA standard due to a re-interpretation by the JAA).[199]

Although differences in FAA and JAA regulations and interpretations can necessitate significant cost commitments by LCA manufacturers and cause delays and overruns in production schedules, they do not affect the U.S. manufacturers more discriminately than Airbus. The recent GAO report indicated adverse effects on Airbus, Boeing, and McDonnell Douglas, with no competitive advantages for any manufacturer. However, because Airbus can distribute its costs among its member companies, as discussed above, it may be more able than U.S. LCA manufacturers to absorb the added costs involved.

Tariff and Nontariff Barriers

Tariff Levels and Customs Issues

The GATT Agreement on Trade in Civil Aircraft[200] provides for duty-free treatment of civil aircraft articles described therein; these provisions were enacted into U.S. law by title VI of the Trade Agreements Act of 1979.[201] West European countries that are signatories to the GATT Civil Aircraft Agreement similarly grant duty-free treatment to specifically described articles that are certified for use in civil aircraft. Thus, tariff issues generally have little impact on LCA manufacturers.[202]

However, Airbus reports that the importation of aircraft parts into the United States has been made more complicated and expensive by recent changes in the interpretation of U.S. Customs Service regulations.[203] Airbus charges that because the availability of spare parts is a "crucial factor" in the satisfaction of LCA customers, U.S. Customs impediments provide U.S. manufacturers, which source most of their parts domestically, with a competitive advantage.[204]

Airbus claims that U.S. manufacturers do not face similar types of impediments in Western Europe because the duty-free entry of aircraft parts is more liberally administered.[205] Moreover, a number of parts used in aircraft but not covered by the GATT Civil Aircraft Agreement are granted duty-free treatment under the EC Autonomous Duty Suspension program.[206] If the Airbus allegations are accurate, Airbus may be adversely affected when attempting to service its planes. However, it is doubtful that the Customs issues raised—even assuming their validity—have a significant impact on the competitiveness of Airbus aircraft. At worst, the parts imported by Airbus merely receive a tariff; they are not denied entry. Therefore, the resupply order goes through but at a higher cost.

[198] Ibid, pp. 16-17.

[199] Ibid, pp. 3-4.

[200] The GATT Agreement is discussed in a later section of this chapter.

[201] Trade Agreements Act of 1979, title VI, sec. 601, Public Law 96-39, 93 Stat. 267; see also Presidential Proclamation 4707, Dec. 11, 1979. Three criteria must be met for imported aircraft to qualify for duty-free treatment: (1) the article must be imported for use in civil aircraft; (2) the aircraft will be so used; and (3) the article must be approved for such use by the FAA (or the application for such must be accepted by the FAA) or by the airworthiness authority of the country of export. House Committee on Ways and Means, Overview and Compilation of U.S. Trade Statutes, WMCP Doc. 103-1, 103d Cong., 1st Sess. 11 (1993).

[202] Eberstadt, p. 91.

[203] "Responses of Airbus Industrie," tab E.

[204] Ibid. Airbus notes, for example, that its "fly-by-wire" technology was not expressly contemplated by the current tariff schedules, and despite the fact that "fly-by-wire" components are suitable for and designed only for aircraft use, the U.S. Customs Service does not classify them as duty-free because they are considered general electronic equipment not covered by the GATT Civil Aircraft Agreement. Ibid.

[205] Ibid.

[206] Ibid.

Agreement Concerning the Application of the GATT Agreement on Trade in Civil Aircraft

Introduction

The United States and the EC entered into an agreement in 1992 (1992 agreement) concerning the application of the 1979 GATT Agreement on Trade in Civil Aircraft (1979 GATT Aircraft Agreement),[207] which was negotiated following the successful 1974 Tokyo Round of GATT negotiations that established rules concerning subsidization generally, but did not necessarily apply to trade in aircraft.[208] The 1979 GATT Aircraft Agreement sought to provide a basis for free and fair trade in the civil aircraft sector by eliminating duties and distortions (or restrictions) on trade, and eliminating the adverse effects of government support of civil aircraft production and trade.[209] The 1979 GATT Aircraft Agreement is discussed in appendix F.

The 1992 agreement was drafted to strengthen provisions of the 1979 GATT Aircraft Agreement; to reduce gradually the level of government support; and to prevent "trade distortions resulting from direct or indirect government support for the development and production of large civil aircraft and of introducing greater disciplines on such support and of encouraging the adoption of such disciplines multilaterally within the GATT."[210] The 1992 agreement eliminates future direct government support for production of LCA (i.e., production subsidies)[211] but "grandfathers in" existing government support programs, with some reservations.[212] Direct development support (i.e., development subsidies) is permitted with limitations and requirements. The 1992 agreement also requires parties to ensure that indirect government support does not confer unfair advantages to domestic manufacturers or lead to distortions in international trade in civil aircraft. It places specific limits on the amount of indirect support allowed in relation to annual commercial turnover of the civil aircraft industry and individual firms.[213] The 1992 agreement is discussed further in appendix F.

Multilateralization of the 1992 Agreement

The United States and Europe are working toward the multilateralization of the 1992 agreement, as well as extending the improved disciplines of the agreement to all countries that are major producers of aircraft and aircraft components. The U.S. Government has already begun working with other aircraft-producing countries to strengthen the disciplines of the 1979 GATT Aircraft Agreement to conform its disciplines with the 1992 agreement. U.S. LCA manufacturers indicate that problems will likely arise in multilateralizing the 1992 agreement, or enforcing a multilateralized agreement, because the support and assistance of aircraft and aircraft parts manufacturers in foreign countries differs dramatically from that provided in the United States.[214] They also indicate that they are working toward (1) lowering the

[207] Because this agreement was negotiated under the auspices of the GATT and is a GATT Code, it is often referred to as the "Aircraft Code."

[208] As of 1990, there were 22 signatories to the 1979 GATT Aircraft Agreement, including all of the Western LCA-producing countries: Austria, Canada, the EC and its 12 individual member countries, Egypt, Japan, Norway, Sweden, Switzerland, Romania, and United States. Fischer, p. 37. This source also notes that 19 other countries and 2 international economic organizations have observer status, which means they can participate in debates but cannot vote.

[209] Agreement on Trade in Civil Aircraft, Preamble, *reprinted in, General Agreement on Tariffs and Trade: Basic Instruments and Selected Documents* (Geneva: Mar. 1980, 26th Supp.) (hereinafter "1979 GATT Aircraft Agreement"); and *The Tokyo Round Trade Agreements: Trade in Civil Aircraft*, vol. 3 (Aug. 1981), p. 3.

[210] "Agreement Concerning the Application of the GATT Agreement on Trade in Civil Aircraft," p. 1 (hereinafter "1992 agreement"). The 1992 agreement is to "promote a more favorable environment for international trade in large civil aircraft and to reduce tensions in the area."

[211] "Agreement Concerning the Application of the GATT Agreement," art. 3.

[212] "Agreement Concerning the Application of the GATT Agreement," art. 2.

[213] "Agreement Concerning the Application of the GATT Agreement," art. 5. Airbus claims that this is "the traditional form of support to Boeing and, in particular, to [McDonnell] Douglas." "Responses of Airbus Industrie," tab L.

[214] U.S. LCA industry officials, interview by USITC staff, Sept. 1992.

cap on development subsidies; (2) inclusion of the 1992 agreement in the 1979 GATT Aircraft Code; and (3) encouraging more signatories of the GATT Aircraft Code.[215] There are some aspects of the 1992 agreement that both the United States and Europe appear to agree need refinement, such as the definition of what constitutes an indirect support or benefit to an aircraft manufacturer. It appears that the two parties have made some progress in follow up consultations on many of these issues. Conversely, it will be much more difficult to make such refinements in the context of a multilateralized agreement involving many countries that support their aircraft manufacturers differently.

Moreover, the agreement may need improvement before it is multilateralized. McDonnell Douglas reports that the agreement could be enhanced by — (1) improving the level of transparency, both public and government-to-government; (2) addressing the problem of noncommercial financing (such as walk-away leases) by government-supported aircraft manufacturers; (3) reducing the cap on permitted development support over time; (4) clarifying the disciplines on equity infusions; and (5) clarifying the disciplines and methodologies related to indirect supports.[216]

Competitive Effects of 1992 Agreement

Airbus indicates that it "welcome[s] the resolution of the long-standing transatlantic dispute on government support to the aircraft manufacturing industry," and that the agreement "represents the best balanced package which could reasonably be achieved by the two parties."[217] Airbus notes its interest in "the EC Commission and the U.S. Government monitoring the implementation of the agreement in good faith, to ensure that the main objective of the agreement, i.e., to create a true level playing field, will be fulfilled."[218]

U.S. LCA manufacturers indicate that the 1992 agreement is a step in the right direction because it places limits on future supports, increases disclosure, eliminates sales inducements, and eliminates general-purpose loans to airlines.[219] U.S. LCA manufacturers indicate, however, that the 1992 agreement permits Airbus to skew the forecasts and royalty payment plans associated with government support programs to its advantage, which would not have occurred had Airbus agreed to fixed repayment schemes proposed by the United States but not included in the agreement.[220] Further, certain types of government support are still permitted under the 1992 agreement, and there is some debate over the extent to which the pricing practices of subcontractors and parts suppliers of the LCA manufacturers are covered by the agreement.[221] For these reasons, it is considered unlikely that Airbus will base marketing decisions, including price, wholly on commercial and cost-based factors. On the other hand, U.S. industry officials state that the 1992 agreement will discourage Airbus from offering beneficial terms to customers, such as walk-away leases and purchase orders with no money down.[222]

[215] Ibid.; and Hood, pp. 22-23.

[216] Hood, p. 23.

[217] "Responses of Airbus Industrie," tab L.

[218] Ibid.

[219] U.S. LCA industry officials, interview by USITC staff, Sept. 1992; transcript of hearing, pp. 131-33; and Hood, pp. 21-25.

[220] U.S. LCA industry officials, interview by USITC staff, Sept. 1992.

[221] Indeed, Airbus indicated that "support provided to foreign subcontractors is potentially an important loophole in the 1992 U.S.-EC agreement." Martin-Nagle, p. 5.

[222] U.S. LCA industry officials, interviews by USITC staff, Dec. 18, 1992, and Feb. 18, 1993.

CHAPTER 6: Overview and Comparison of Research and Development in the Global Large Civil Aircraft Industry[1]

Introduction

This chapter compares the aeronautical research and development (R&D)[2] infrastructure and funding levels at the leading research centers in the United States, Western Europe, Russia, and Japan. The 17 major public and private organizations that conduct most of the world aeronautical research are in these countries (table 6-1).

The incorporation of new technologies that advance aircraft performance,[3] reliability, and safety, and that increasingly reduce noise and other environmental effects significantly affect marketability of an aircraft and in turn impact on the competitiveness of large civil aircraft (LCA) manufacturers. However, before new technologies are implemented, LCA manufacturers must consider whether they are compatible with existing systems, what the development and production costs will be, and how they will affect airline direct operating costs (fuel consumption), retraining, and maintenance. The benefits derived from the major areas of aeronautical R&D are shown in figure 6-1.

Although LCA R&D results can be separated into evolutionary changes (resulting in incremental improvements) and revolutionary changes (resulting in entirely new aircraft paradigms), major LCA manufacturers largely rely on evolutionary changes to serve their customers.[4] Revolutionary technologies, such as the introduction of the turbofan jet engine that rendered large piston-engine aircraft obsolete, can completely redefine LCA.

LCA producers concentrate their R&D efforts on aircraft design, but R&D also is important for integration, assembly, flight test, and aircraft certification. However, much of the technological development in propulsion; avionics; control; and structures and materials, has been achieved by engine manufacturers and other LCA subcontractors. Research currently is being conducted in a variety of prototype technology fields, including ultra-high-by-pass engines, very-large/ultra-high-capacity aircraft, supersonic[5] and/or hypersonic[6] aircraft, cryogenic[7] fuels, and new hybrid fiber-metal-laminates such as GLARE (glass fiber aluminum laminates). Other research efforts by LCA manufacturers include advanced-component technology to facilitate commonality in aircraft families and reduce development costs. Research in the advancement of process technology reduces production costs and increases product quality. This chapter describes the elements of aeronautical R&D (funding and expenditures, and infrastructure), the availability of those elements in the various R&D centers, and the contrast among the centers in their R&D capabilities.

[1] See app. G for technical definitions.

[2] See app. G for definition.

[3] Advances in aircraft performance include improved fuel efficiency and increased range and speed.

[4] Evolutionary advances in aerodynamic performance, propulsion technologies, composite materials, computational fluid dynamics (CFD), and

[4]—*Continued*
aircraft computer systems technology are sought to improve aircraft performance (speed and range) and its direct operating costs/operating efficiencies (e.g., fuel consumption).

[5] See app. G for definition.

[6] See app. G for definition.

[7] See app. G for definition.

Table 6-1
Major international organizations conducting subsonic aeronautical R&D, 1991

Organizations	Source of funding	Budget/ sales	Aero-nautical R&D budget[1]	Total employ-ment	Aeronautical R&D focus[2]	Major customers
FRANCE						
Office National d'Etudes et de Recherches Aérospatiales (ONERA)	Public	$237 million	$72 million	2,304	Long-term, up-stream, basic	Public & private sectors
Aérospatiale Group	Public/ private	$8.6 billion	$496 million	1,850[3]	Near-term market-oriented, near-term defense	Airbus, ATR, Defense
GERMANY						
Deutsche Forschungsantalt für Luft- und Raumfahrt (DLR)	Public/ private	$425 million	$112 million	4,500	Long-term, pre-competitive, high-risk	Public & private sectors
Deutsche Aerospace (DASA)	Private	$6.6 billion	$471 million	21,990[4]	Near-term market-oriented, near-term defense	Airbus, Fokker, Defense
JAPAN						
National Aerospace Laboratory (NAL) of the Science and Technology Agency (STA)	Public	$80 million[5]	NA	438	Long-term, pre-competitive, high-risk	Public & private sectors
NETHERLANDS						
Nationaal Lucht- en Ruimtevaartlaboratorium (NLR-National Aerospace Laboratory)	Public/ private	$66 million	$66 million	817	Long-term, up-stream, basic	Public & private sectors
NV Koninklijke Nederlandse Vliegtuigfabriek Fokker (Fokker)	Private	$2.0 billion	$20 million	12,606	Near-term market-oriented, near-term defense	Fokker, Defense
RUSSIA						
Ilyushin Design Bureau	Public	NA	NA	12,000	Long-term up-stream, basic, near-term defense	Public & private sectors
Tupolev Design Bureau	Public	NA	NA	15,000	Lomg-term up-stream, basic, near-term defense	Public & private sectors
Central Aero-Hydrodynamics Institute (TsAGI)	Public	NA	NA	10,000	Long-term up-stream, basic	Public & private sectors

Table 6-1-*Continued*
Major international organizations conducting subsonic aeronautical R&D, 1991

Organizations	Source of funding	Budget/ sales	Aero-nautical R&D budget[1]	Total employ-ment	Aeronautical R&D focus[2]	Major customers
UNITED KINGDOM						
Defense Research Agency (DRA)	Public	$1.3 billion	$195 million	11,500	Long-term, up-stream, basic	Public & private sectors
British Aerospace (BAe)	Private	$19.7 billion	$255 million	9,100[6]	Near-term market-oriented, near-term defense	Airbus, BAe, Defense
UNITED STATES						
National Aeronautics and Space Administration (NASA)	Public	$14 billion	$512 million[7]	15,200[8] (OAST)	Long-term, pre-competitive, high-risk	Private sector, DOD
Federal Aviation Administration (FAA) of the U.S. Department of Transportation	Public	$7.2 billion	$197.9 million	[9]	Aircraft safety, design, and production; quality control	Private sector, DOD, NASA
U.S. Department of Defense (DOD)	Public	$309 billion	$5.8 billion	[9]	Defense	DOD
The Boeing Co.	Private	$29.6 billion	$1.4 billion	87,324[10]	Near-term market-oriented, near-term defense	Boeing, DOD, NASA
McDonnell Douglas Corp.	Private	$18.4 billion	$429 million	109,123	Near-term market-oriented, near-term defense	McDonnell Douglas, DOD, NASA

1 Data for companies are for total corporate, internally-funded R&D.
2 See app. G for definitions.
3 Aérospatiale's design office employment. Total corporate employment was 25,894 persons at the end of 1991.
4 Deutsche Aerospace Airbus GmbH employment.
5 April 1992-March 31, 1993.
6 BAe Airbus Limited employment.
7 Aeronautical Research and Technology Budget.
8 Office of Aeronautics and Space Technology.
9 Figures for employees involved in aeronautical R&D are not available.
10 Boeing Commercial Airplane Group total employment.

NA = Not available

Source: 1991 Annual Reports of British Aerospace, Aérospatiale, DASA, Boeing, McDonnell Douglas, ONERA, DLR, NLR, DRA; NASA, *Budget Estimates*, fiscal year 1992; Office of Management and Budget, *Budget of the United States Government, Fiscal Year 1993* (Washington, DC: GPO, 1992).

Figure 6-1
Aeronautical R&D: Benefits of aeronautical R&D, by discipline[1]

Aeronautical R&D area	Need area/benefits: Lower user cost/ greater convenience	Greater capacity	Reduced environmental impact	Greater safety	Improved performance	Aircraft design and development
Aerodynamics	Lower fuel costs	Not applicable	Less noise on takeoff/landing	Not applicable	Greater range and speed (higher lift/drag ratio)	Shortened develop- cycle, technology validation
Propulsion	Lower fuel costs/ reduced maintenance/ higher reliability	Not applicable	Lower emissions Less noise	Not applicable	Greater range and speed (reduced fuel consumption)	Shortened engine development cycle, technology validation
Avionics and control	More effective crew Increased reliability	Global positioning (ground and air), real-time weather data, optimized air traffic control	Not applicable	Lower demands on crew, fault-tolerant systems	Increased reliability (engine control, actuator control, situational awareness)	Integrated systems, technology validation
Structures and materials	Longer life and lower maintenance	Not applicable	Not applicable	Predictable material fatigue, “smart structures”	Greater range and speed (lower weight)	Shortened development cycle, technology validation

[1] See app. G for definitions.

Source: Compiled by the staff of the U.S. International Trade Commission from Aeronautics and Space Engineering Board, *Aeronautical Technologies For The Twenty-First Century* (Washington, DC: National Research Council , 1992), pp. 33, 99, 111, 151, 189, 223, and 245.

Elements of Aeronautical R&D

R&D Funding and Expenditures

R&D funding is critical to the refinement of major technologies and the introduction of new LCA programs. Today, the $5 to $10 billion in R&D needed to produce a new family of aircraft places an enormous financial burden on the LCA producer and subjects the firm to potential bankruptcy. At the same time, success in the LCA market depends on maintaining R&D funding at substantial levels to minimize costs and reduce the time to introduce new LCA models in the market. The majority of the development costs are incurred in the development of the prototype member of the new LCA family on which new designs and technologies will be proven and refined. Successful technologies then are incorporated into future aircraft. As shown in figure 6-2, the development process for a typical LCA can take about five years.

Military programs continue to account for a large portion of global R&D expenditures for aircraft development. Military expenditures are directed to programs with specific military applications, but most precompetitive[8] military research also can have civil applications.[9] Nevertheless, commercial and military programs have diverged and operational requirements and specifications have changed increasingly since the introduction of the first LCA jet.[10] Today, R&D in the commercial sector focuses on lowering production costs, improving aircraft reliability, increasing fuel efficiency, and reducing engine noise.[11] R&D in the military sector focuses on increasing speed, maneuverability, and radar evasion.

[8] See app. G for definition.

[9] Marcel Benichou, president, Office National d'Etudes Recherches Aérospatiale (ONERA), interview by USITC staff, Paris, Nov. 20, 1992.

[10] John E. Steiner, "How Decisions are Made: Major Considerations for Aircraft Programs," speech delivered before International Council of the Aeronautical Sciences, American Institute of Aeronautics and Astronautics, Aircraft Systems and Technology Meeting, Seattle, WA, Aug. 24, 1982, pp. 20-21.

[11] Victor Peterson, deputy director, NASA Ames Research Center, interview by USITC staff, Moffett Field, CA, Sept. 18, 1992.

R&D Infrastructure

Successful design refinements are achieved through the use of computational fluid dynamics (CFD)[12] and wind tunnel[13] tests to validate aerodynamic designs. CFD and wind tunnels play crucial roles in aircraft design and flight testing by reducing development time and allowing LCA producers to investigate a greater number of design options. CFD is used to numerically simulate flow fields around realistic computational models on a supercomputer.[14] The use of increasingly complex algorithms reduces the dependence on empiricism and experiment. Supercomputer simulations using CFD produce much of the data formerly collected through wind tunnel testing, although at critical junctures in the development process, wind tunnel tests are required to verify the results of the simulations. Since CFD cannot completely model LCA flight characteristics, wind tunnels are still used to perform aerodynamic modeling. Government support for CFD and wind tunnels is regarded as essential to competitiveness in the global LCA industry and to the national defense. Many of the aerodynamic principles, testing techniques, and R&D facilities are common to civil and military aircraft development.

Wind tunnels are enclosed passages in which aircraft flight characteristics can be simulated by directing a controlled stream of air, or other gas, around a scale model of the aircraft and measuring the results with attached instrumentation. Capabilities of a wind tunnel are expressed by its speed value (Mach number),[15] Reynolds number[16] (fluid characteristics of air), flow visualization, data system, and data security. Most of the wind tunnels discussed in this chapter are subsonic[17] tunnels (able to simulate speeds ranging from Mach 0.1 to 0.8), transonic[18] tunnels (Mach 0.8 to 1.2), or supersonic tunnels (Mach 1.2 to 5). Aerodynamic forces created in wind tunnels include aircraft lift, drag, and side forces.

Large capital investments are needed for the purchase and development of aircraft design tools, such as supercomputers, wind tunnels, and test-bed aircraft for flight demonstrations and technology validation.[19] Wind tunnel and computer upgrades are

[12] See app. G for definitions.

[13] See app. G for definitions.

[14] See app. G for definition.

[15] See app. G for definition.

[16] See app. G for definition.

[17] See app. G for definition.

[18] See app. G for definition.

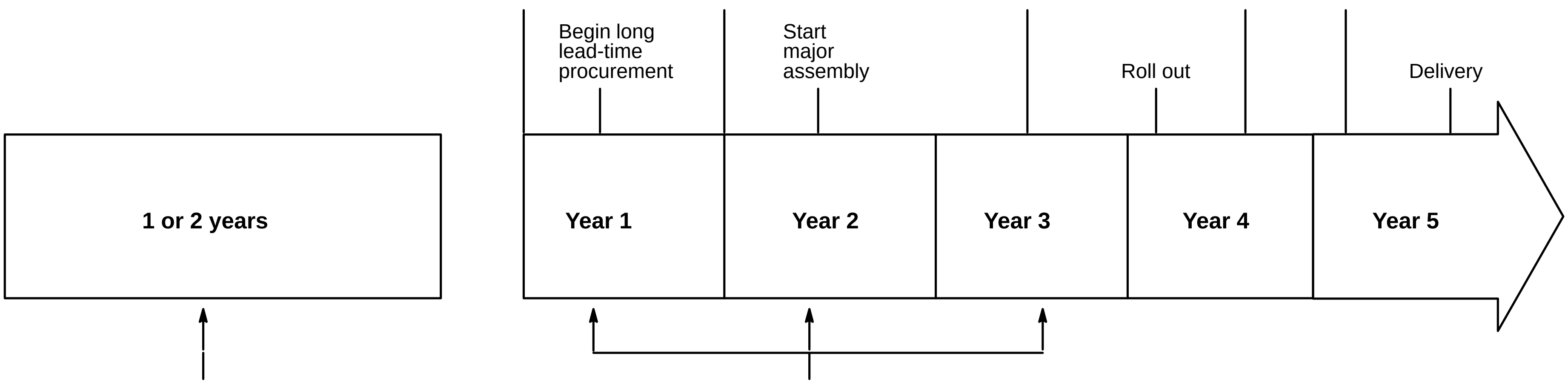
[19] Test-bed aircraft are used in the final phase of technology validation. See app. G for definition.

Figure 6-2
Aircraft development process

Design

- Design
  - Design optimization
    - Design options
      - Technical description presented to customer

Development



Inputs to design kick-off

- Market studies
  - Expertise from technology specialists
    - Airworthiness regulations
      - Previous aircraft experience
        - General design statistics

Analysis/development of airframe

- Aerodynamics
  - Flight and structural dynamics
    - Aircraft weight
      - Materials selection
        - Certification methods/production technolgy
          - Structure, fatigue, and groud vibration tests
            - Equipment systems
              - Interiors

Source: Compiled by the staff of the U.S. International Trade Commission from U.S. and West European industry and Government sources.

required to keep an LCA producer abreast of new technological developments. The R&D areas and the technological infrastructure required to support LCA development are shown in figure 6-3.

R&D Elements Available in the Various Aeronautical R&D Centers

R&D Funding and Expenditures

The private sector in the United States and Western Europe provides most of the global funding for subsonic LCA R&D. Boeing, McDonnell Douglas, and the major Airbus partners (Aérospatiale, Deutsche Aerospace, and British Aerospace) are the major LCA manufacturers and the leading sources of subsonic LCA R&D. Private-sector R&D for civil aeronautical research, as well as private-sector R&D for military research, by the top six countries[20] increased from $14.2 billion in 1980 to $38.9 billion in 1990 (figure 6-4). During that 11-year period, the United States accounted for more than 65 percent of total aeronautical R&D expenditures.

The United States, Western Europe, Russia, and Japan support their aerospace industry through their national research and testing facilities (see table 6-1).[21] However, the role of government in the aerospace industry differs in each of these nations. Government-funded research programs generally are long-term ventures that are not product-oriented and not crucial to short-term projects.

[20] The United States, Germany, France, the United Kingdom, Japan, and Italy.

[21] Other prominent West European national aeronautical R&D institutions not listed in table 6-1 include Instituto Nacional de Téchnica Aeroespacial of Spain, Flygtekniska Försöksanstalten of Sweden, and Centro Italiano Ricerche Aerospaziali (CIRA) of Italy. CIRA, established in 1984, operated under limited funding until September 1992; the institute has yet to construct any of its four proposed wind tunnels.

United States

Private Sector

U.S. LCA R&D is funded principally by the private sector (i.e., Boeing and McDonnell Douglas), but the U.S. aerospace industry is not as R&D-intensive as certain other domestic industries. Traditionally, private-sector aerospace R&D expenditures have amounted to 3-5 percent of total annual sales.[22] The U.S. aerospace industry ranked eighth among all U.S. industrial sectors in R&D expenditures as a percentage of sales, at 3.8 percent in 1991.[23] In contrast, Western Europe's private-sector aerospace R&D expenditures historically have amounted to more than 15 percent of sales, placing aerospace third behind the electrical engineering and electronics and the chemical industries as Europe's leading investor in R&D.[24]

Almost all U.S. private-sector-funded LCA R&D is consumed by new programs or by projects to improve existing products. U.S. private-sector aeronautical R&D tends to be near-term proprietary R&D, which can guarantee a short-term economic return to justify the expenditures. The U.S. private sector tends to underinvest in long-term generic R&D projects that have limited ability to capture a sufficient rate of return in the short term.[25]

During 1980-92, R&D expenditures of Boeing and McDonnell Douglas ranged from a low of $708 million in 1983 to a high of nearly $2.4 billion in 1992 (table 6-2).[26] Boeing and McDonnell Douglas principally perform LCA R&D related to the airframe and its manufacture; typically, they do not perform R&D on the major aircraft systems, such as engines, avionics, hydraulic systems, and landing gear, which is done by subcontractors. Aside from in-house R&D, LCA manufacturers also pursue civil and military contracts (mission-oriented solicitations and concept

[22] Executive Office of the President, Office of Science and Technology Policy, *Aeronautical Research and Technology Policy, Vol. II, Final Report* (Washington, DC: Nov. 1982), pp. I 20-22.

[23] "R&D Scoreboard," *Business Week*, June 29, 1992, p. 107.

[24] Commission of the European Communities, *A Competitive European Aeronautical Industry (Communication from the Commission)* (Brussels: Commission of the European Communities, SEC (90) 1456 final, July 23, 1990), p. 29.

[25] Peterson interview.

[26] Company LCA-specific R&D data is proprietary information; company R&D data reflect civil, military, and space projects.

Figure 6-3
LCA: Research area and corresponding infrastructure

Research area	Major technology infrastructure
Aerodynamics	Numerical simulation; computational fluid dynamics (CFD) using supercomputers; wind tunnel models, sensors, high Reynolds numbers; flight demonstrators for technology validation
Flight dynamics[1]	Supercomputer modeling; flight simulators; wind tunnel simulation; computer programs with modules; structures made for ground vibration tests before first flight
Structural dynamics and assumed loads[2]	Computer modeling of loads; computer programs for finite element method (FEM) or finite element analysis (FEA)
Aircraft weights	Scales
Materials selection	Materials laboratory; manufacturing technology; materials performance data; price data
Manufacturing methods and production technology (long-term)	Research: in-house, at research institutes, at universities, or through government programs; applications-oriented development work, in-house or contracted
Special test and certification methods	Work with certification bodies
Structural design	3-D computer-aided-design workstations and software
Preparation for certification	FEM computer programs; mechanical tests; documentation
Structure, fatigue, and ground vibration tests	Ground facilities with hydraulic actuators and computers to simulate flight and product life cycle conditions
Avionics and flight controls	Integrated aircraft systems laboratory for the integrated testing of avionics; engine controls; flight controls; electrical, hydraulic, and other systems
Equipment systems	Specialist departments in technology areas including error-tolerant computer systems; electronics data transfer (bus) structures; sensors; display technology; optronics; electric drive and actuating systems; diagnosis and testing systems; built-in test

[1] Flight dynamics consists of flight mechanics, flight guidance and control, propulsion technology, and flight performance.
[2] Thousands of load cases, including basic operations and systems failures, are generated and compared. This may continue for about 36 months. Fly-by-wire significantly changed the work of the structural dynamics department by moving the process from conservative design to realistic simulation.

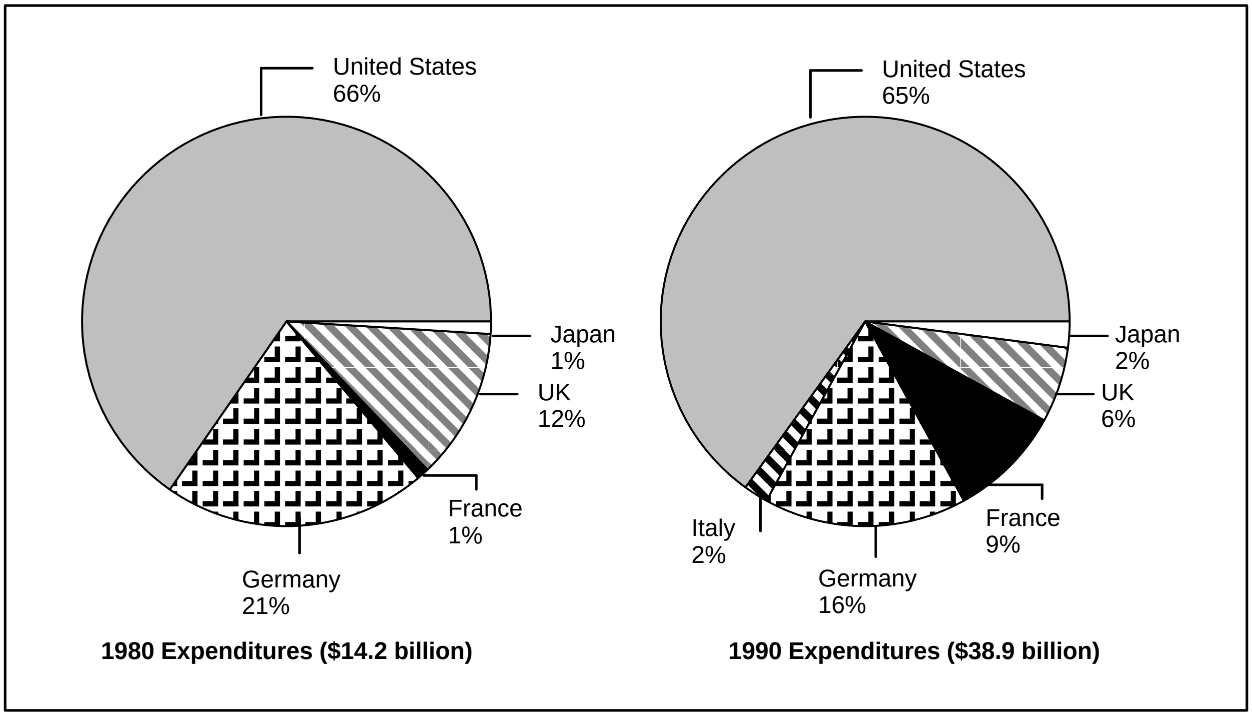
Source: Compiled by the staff of the U.S. International Trade Commission.

exploration, demonstration, full-scale development, and full production contracts) offered by the National Aeronautics and Space Administration (NASA) and the U.S. Department of Defense.[27] These contracts are related primarily to space or defense programs, and the R&D results usually do not spill over directly to LCA R&D. The spillover is more likely to be in the areas of components (e.g., electronics, computers) and production experience. U.S. LCA manufacturers also fund internal R&D activities, known as independent R&D,[28] which by its dual-use (civil and military) nature allows them to recoup a portion of R&D-costs from U.S. Government-related contracts.

[27] These types of contracts include fixed-price contracts, cost-reimbursement contracts (including cost-sharing contracts), incentive contracts, and indefinite delivery contracts.

[28] See app. G for definition.

Figure 6-4
Private-sector aeronautical R&D expenditures, 1980 vs. 1990



Source: OECD, DSTI (STAN/Industrial Database), 1992.

Table 6-2
U.S. private-sector R&D expenditures (LCA and other civil aircraft, military, and space)[1] and R&D expenditures as a share of sales, 1980-92

			Boeing		*McDonnell Douglas[2]*	
Year	*Total expenditures*	*R&D as a share of sales*	*Total R&D expenditures*	*R&D as a share of sales*	*Total R&D expenditures*	*R&D as a share of sales*
	Million dollars	*Percent*	*Million dollars*	*Percent*	*Million dollars*	*Percent*
1980	967	6	768	8	199	3
1981	1,060	6	844	8	216	3
1982	945	6	691	8	254	3
1983	708	4	429	4	279	4
1984	832	4	506	5	326	4
1985	785	3	409	3	376	3
1986	1,206	4	757	5	449	4
1987	1,391	5	824	5	567	5
1988	1,271	4	751	4	520	4
1989	1,325	4	754	4	571	4
1990	1,392	3	827	3	565	4
1991	1,846	4	1,417	5	429	2
1992	2,355	5	1,846	6	509	3

[1] R&D expenses are charged directly to earnings as incurred. Such expenses include independent R&D, bid and proposal efforts (see app. G for technical definitions), and costs incurred in excess of amounts estimated to be recoverable under cost-sharing contracts.

[2] In 1992, McDonnell Douglas lowered its R&D expenses as reported in previous annual reports to account for risk-sharing funds received from vendors and subcontractors participating in the development of LCA. R&D expenses in 1991 were reduced by $20 million and in 1990 by $76 million, and also were reduced for other years during 1985-89.

Source: Compiled by the staff of the U.S. International Trade Commission from annual reports of The Boeing Co. and McDonnell Douglas Corp.

Public Sector

NASA is the chief source of publicly funded aeronautical R&D in the United States. The principal goal of NASA subsonic research is to maintain the status of the United States as the pre-eminent leader in aerospace technology, and to develop a new generation of economical subsonic transport aircraft.[29] Other government sources of aeronautical R&D include the Department of Defense and the Federal Aviation Administration (FAA). As shown in table 6-3, NASA's total budget has grown from $4.9 billion in fiscal year (FY) 1980 to $14.1 billion in FY 1994. However, the NASA aeronautics budget, which does not differentiate between civil and military projects, declined as a percentage of the total agency budget from 6 percent in FY 1980 to 4 percent in FY 1992, though it is expected to rise to an estimated 5 percent in FY 1993 and 6 percent in FY 1994.[30] Actual expenditures have risen from $308 million in FY 1980 to $555.4 million in FY 1992. For FY 1994, expenditures are estimated to grow substantially to $877 million (with personnel costs to $1.0 billion).

The NASA Office of Aeronautics funds programs under its Research and Technology Base Program and its Systems Technology Program (table 6-4). Spending under both programs for civil transports by the Office of Aeronautics' Subsonic Division, also shown in table 6-4, was significantly lower during 1981-89. The Research and Technology Base Program provides design and analysis tools in the following areas: aerodynamics; propulsion and power; materials and structures; controls, guidance, and human factors; flight systems; systems analysis; and hypersonic flight (added in FY 1994). The Systems Technology Program supports technology and validation demonstrations that are valuable for the near-term application of technology by the civil industry. The principal areas of the Systems Technology Program are high-performance computing, materials and structures, rotorcraft, high-performance aircraft, advanced propulsion, numerical aerodynamic simulation, and advanced subsonic technology. In FY 1992, the Advanced Subsonic Technology (AST) Program was initiated under the Systems Technology Program. The AST focuses on the highest payoff technologies that will increase aircraft efficiency and system capacity, and improve aircraft environmental compatibility.[31] Cost sharing between NASA and industry will be sought for commercially applicable projects.[32]

In recent years, most of NASA aeronautics funding has been allocated to its hypersonic programs, supercomputers, and advanced composite materials research. Of the total 1992 Aeronautical Research and Technology (R&T) and Transatmospheric budgets, approximately 16 percent was allocated to advanced-subsonic aircraft (other than short-haul aircraft); 6 percent to short-haul aircraft (also subsonic); and 16 percent to high-speed commercial transports such as the High Speed Civil Transport (HSCT) (figure 6-5).[33] High-performance[34] aircraft, principally jet fighters, accounted for 21 percent of those budgets. The National Aerospace Plane (NASP) accounted for 5 percent.[35] The remaining 35 percent

[29] National Aeronautics and Space Act, 1958. NASA itself does not develop aircraft; if a manufacturer wants to develop an aircraft based on data gained as part of a NASA R&D project, that manufacturer must validate the technology with its own funds. NASA recoupment policy enables the U.S. Government to recover a portion of its investment when technologies developed result in commercial products (see chapter 5). Moreover, aircraft manufacturers (contractors) are required by law to pay the U.S. Government recovery costs on all NASA-generated technologies incorporated into their aircraft if that technology is end-product oriented, offers the potential for market sales by the contractor, and is more than $10 million in estimated development cost. U.S. Department of Commerce, U.S. Government Response to the EC-Commissioned Report "U.S. Government Support of the U.S. Commercial Aircraft Industry," interagency activity report coordinated by the U.S. Department of Commerce (Washington, DC: Mar. 1992), p. 20. In mid-1992, certain recoupment fees were abolished. See chapter 5.

[30] It is the aeronautics budget which funds R&D specifically for aircraft.

[31] Daniel S. Goldin, administrator, posthearing submission in behalf of the National Aeronautics and Space Administration, p. 4.

[32] NASA, *Budget Estimates: Fiscal Year 1994* (1993), p. RD 9-36.

[33] Aeronautics and Space Engineering Board, *Aeronautical Technologies for the Twenty-First Century* (Washington, DC: National Research Council, 1992), p. 37.

[34] High-performance aircraft include jet fighters, helicopters, and short take-off and vertical landing aircraft. Supermaneuverability, which includes achieving stable, maneuverable, and controllable flight at high angles-of-attack (70 degrees and beyond), is a major characteristic of high performance aircraft.

[35] R&T for the NASP is funded under the Aeronautical R&T budget and the Transatmospheric budget. The NASP also receives significant funding from DoD.

Table 6-3
NASA budget expenditures, total and R&D, fiscal years 1980-94

(Millions of dollars)

		Research and development			
Year	*Total budget*	*Total R&D budget*	*Aero-nautical R&T[1,2] budget*	*Transatmo-spheric R&T budget*	*All other R&D including space-related*
1980	4,851.6	4,088.1	308.3	-	3,779.8
1981	5,425.6	4,334.3	271.4	-	4,062.9
1982	6,035.4	4,772.0	264.8	-	4,507.2
1983	6,663.9	1,902.5	280.0	-	1,622.5
1984	7,047.6	2,064.2	315.3	-	1,748.9
1985	7,317.7	2,468.1	342.4	-	2,125.7
1986	7,403.5	2,619.3	337.3	-	2,282.0
1987	7,591.4	3,153.7	374.0	45.0	2,734.7
1988	9,091.6	3,254.9	332.9	52.5	2,869.5
1989	11,051.5	4,237.6	398.2	69.4	3,770.0
1990	12,427.8	5,227.7	442.6	59.0	4,726.1
1991	13,876.6	6,023.6	512.0	95.0	5,416.6
1992	13,959.9	6,827.6	788.2	4.1	6,035.3
1993[3]	14,077.6	7,089.3	865.6	0.0	6,223.7
1994[3]	14,670.0	7,712.3	1,020.7	80.0	6,611.6

[1] Research and technology. NASA does not perform technology development, but validates technologies and performs technology demonstrations.

[2] Data for 1980-91 exclude program management costs (i.e., salaries and support systems costs). Beginning in FY 1992, NASA changed appropriation categories for the civil service workforce and center support systems for its aeronautical R&T budget from the agency's Research and Program Management appropriation to a new category, Research Operations Support, a subcategory of Aeronautical R&T. Data for the aeronautical R&T budget include $232.8 million for research operations support in FY 1992, an estimated $148.8 million for FY 1993, and an estimated $143.5 million for FY 1994.

[3] Estimated by NASA.

Source:Compiled by the staff of the U.S. International Trade Commission from NASA, *Budget Estimates*, FY 1982-FY 1994. Data for FY 1980-82 appear in *Budget Estimates* for FY 1982-84, respectively.

Table 6-4
NASA Aeronautical R&T Budget: Expenditures on the Research and Technology Base Program, Systems Technology Program, and on civil transport, FY 1980-92 and expected expenditures, FY 1993-94

(Millions of dollars)

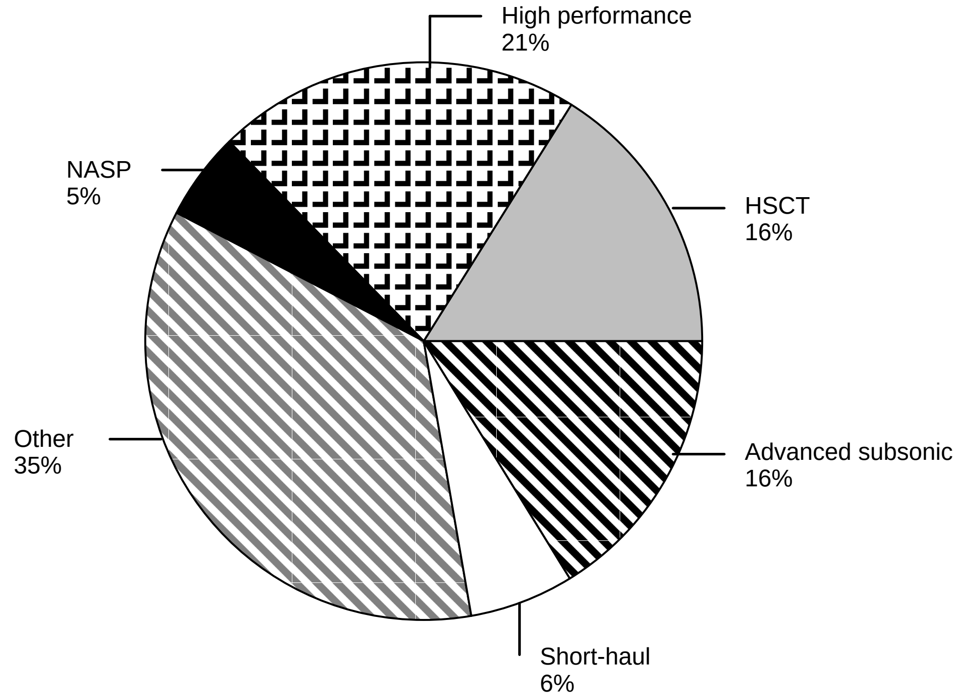
Fiscal year	*Research and Technology Base*	*Systems Technology*	*Civil transport[1]*
1980	120.8	187.5	122.0
1981	133.8	137.6	80.9
1982	172.8	92.0	70.0
1983	198.5	81.5	46.0
1984	228.3	86.9	36.6
1985	223.5	119.1	50.6
1986	228.6	108.7	71.8
1987	271.1	102.9	59.3
1988	257.2	75.8	48.7
1989	309.6	88.6	69.4
1990	321.8	120.8	114.4
1991	336.4	175.6	162.1
1992	343.3	212.1	193.2
1993[2]	436.5	280.3	290.4
1994[2]	448.3	428.9	441.1

[1] Data are for subsonic transport R&T, air traffic management systems, and supersonic transports.

[2] Estimated by NASA.

Source: Compiled by the staff of the U.S. International Trade Commission from NASA, *Budget Estimates*, FY 1982-94 (data for FY 1980-82 appear in *Budget Estimates* for FY 1982-84, respectively), and information supplied by Subsonic Transport Division, NASA.

Figure 6-5
NASA Aeronautical Research & Technology and Transatmospheric Budgets, by aircraft type, 1992



Source: Aeronautics and Space Engineering Board, National Research Council *Aeronautical Technologies for the Twenty-First Century* (Washington, DC: National Academy Press, 1992).

was accounted for by aerodynamics, high-speed computing, numerical aerodynamic simulation, and other critical disciplines.[36]

The Department of Defense and FAA play minor roles in subsonic aeronautical R&D. The FAA is involved in every aspect of LCA design through its principal role of certifying the airworthiness of LCA produced or flown in the United States. Part of its certification process requires that the FAA approve aircraft designs and production quality-control methods. The FAA funds R&D related to its mission, particularly in the area of air traffic control. In FY 1991, the FAA budget for Research, Engineering, and Development totaled $197.9 million, of which $100.5 million, or 51 percent, was expended for R&D on air traffic control. R&D expenditures on aircraft safety technology and environmental research, both areas of interest to LCA manufacturers, totaled $61.0 million and $2.1 million, respectively. The remainder, $34.3 million, was for R&D on advanced computers, navigation, aviation weather needs, and aviation medicine.[37]

Department of Defense R&D support for the LCA industry also has been limited.[38] As discussed, LCA manufacturers have performed R&D as part of U.S. Government contracts and Department of Defense-funded independent R&D contracts. In the past, technology developed with a portion of Department of Defense funding has been transferred to the LCA industry through plane-to-plane, major component, and minor component transfers. In FY 1991, the Department of Defense expended $5.8 billion for aeronautical R&D under its Research, Development, Test, and Evaluation budget, of which $5.4 billion was spent on specific military aircraft, including the NASP. The remainder of the Department of Defense 1991 aeronautical budget was

[36] Percentages may not add to 100 due to rounding.

[37] Office of Management and Budget, *Budget of the United States Government Fiscal Year 1993* (Washington, DC: GPO, 1992), appendix one, p. 751.

[38] U.S. Department of Commerce, pp. 7-16.

spent on aircraft equipment, aerodynamics, CFD, and other generic aeronautical technologies.[39] In FY 1994, the Department of Defense is expected to be the sole funding source for the NASP. Technology spinoffs from the NASP to the LCA industry have been minimal, but recent materials technologies developed in the NASP program may be applied to Boeing's 777.[40] Additionally, LCA manufacturers may have benefitted from manufacturing R&D funded by the Department of Defense Manufacturing Technology Program (MANTECH)[41] (see chapter 5). In FY 1993, the budget authorization for MANTECH (included in the Department of Defense Research, Technology, Test, and Evaluation budget) was $374.6 million.[42] MANTECH funding is not specifically for aeronautics, and is not counted in the figure for the Department of Defense aeronautical R&D cited above.

Western Europe

Private Sector

Airbus, through its member companies, conducts the preponderance of all private-sector R&D for LCA in Western Europe.[43] In 1991, the Airbus consortium members expended approximately $1.6 billion for R&D (civil and military aeronautical, space, and other) (table 6-5). In 1992, this figure rose to $1.9 billion. Airbus consortium R&D during the early 1980s and 1990s has focused principally on the development of advanced technologies for inclusion in its families of LCA.

Airbus employs approximately 350 engineers at its headquarters in Toulouse, France, who organize the design of new aircraft and coordinate and implement the improvement of parts on existing aircraft.[44] These engineers also coordinate engineering efforts among the Airbus partners. Within the Airbus organization, R&D is conducted principally by the member partners: Aérospatiale, Deutsche Aerospace, and British Aerospace. To promote specialization and avoid costly duplication of effort, each partner is responsible for conducting R&D only within its particular aircraft subsection area. This degree of decentralization limits the effective management of Airbus over costs, but it offers the advantage of expanding the consortium's R&D base. The consortium benefits not only from projects undertaken by the member partners, but also from R&D performed by the national aerospace laboratories within France, Germany, and the United Kingdom. Airbus relies heavily on the Office National d'Etudes et de Recherches Aérospatiales (ONERA) for product-oriented R&D and Deutsche Forschungsantalt für Luft- und Raumfahrt (DLR) for theoretical R&D.[45] Much of the R&D performed by the partners is proprietary and its dissemination is limited to companies within the consortium.

Public Sector

The West European aeronautical R&D laboratories are quasi-governmental nonprofit organizations whose principal duties are to develop and guide mid- to long-term precompetitive aerospace research; to provide scientific and technical support to their respective governments and industry; to design, build, and implement the resources needed to conduct this research; and to circulate the results and promote the use of such results by European Community (EC) aerospace and other industries.[46] In the past, Western Europe's aeronautical research institutions relied heavily on government funding, especially from their respective Ministries of Defense.

In recent years, West European governments have reduced dramatically their spending in the aeronautical field, especially on LCA activities. Defense procurement has declined, as have indirect

[39] Aerospace Industries Association of America, Inc., *Aerospace Facts and Figures: 1992-1993* (Washington, DC: The Aerospace Research Center, Aerospace Industries Association of America, Inc., 1992), pp. 109 and 117.

[40] U.S. General Accounting Office (GAO), *National Aero-Space Plane: Restructuring Future Research and Development Efforts*, GAO/NSIAD-93-71, December 1992, p. 6; and Stanley W. Kandebo, "Boeing 777 to Incorporate New Alloy Developed for NASP," *Aviation Week & Space Technology*, May 3, 1993, p. 36.

[41] MANTECH was designed to increase productivity in the defense industrial base and to transfer R&D results to full-scale production. Such technology transfer and adoption also were aimed at reducing contractors' manufacturing costs.

[42] Sec. 202, P.L. 102-484 (106 Stat. 2350).

[43] Construcciones Aeronáuticas, S.A. (CASA) of Spain conducts a limited amount of aeronautical R&D for Airbus Industrie. Both BAe and Fokker conduct R&D on aircraft they produce separately from the Airbus consortium.

[44] Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 2, 1992.

[45] Airbus Industrie officials, interview by USITC staff, Toulouse, France, Nov. 3, 1992.

[46] Benichou interview.

military subsidies.[47] Provisions of the General Agreement on Tariffs and Trade (GATT) and the 1992 United States-EC agreement on aircraft subsidies also have limited direct government R&D funding to Airbus consortium members. These developments have forced these research institutions to compete for business in the marketplace and to rely more heavily on third-party contracts for funding. In 1991, the four major West European aeronautical R&D laboratories (DLR, ONERA, Defense Research Agency [DRA], and National Aerospace Laboratory [NLR]) had a collective budget of $2 billion and aeronautical R&D expenditures of $445 million (table 6-1).

In addition to national governments, the European Commission of the EC also plays an important role in funding aeronautical R&D in Western Europe through programs such as Basic Research in Industrial Technology for Europe/European Research in Advanced Materials (BRITE/EURAM). Another significant program is the Group for Aeronautical Research Technology (GARTEUR), and its subgroup Collaboration on Aeronautical Research and Technology (CARTE).

EC BRITE/EURAM aeronautics projects aim to promote upstream research[48] and strengthen the R&D base in countries that are not currently strong in aircraft development. Of total BRITE/EURAM funding, 50 percent comes from the EC; the remainder comes from the participants, such as DRA, NLR, ONERA, and DLR, or private-sector companies.

The aeronautics programs under BRITE/EURAM resulted from a technology assessment called the European Cooperative Measures for Aeronautical Research and Technology (EUROMART), conducted by a group of nine West European aircraft manufacturers. In March 1988, the EC Commission initiated a 2-year exploratory program valued at 60 million ECU ($71 million), which was implemented during 1989-91.[49] The program goal was to further EC collaboration in the fields of aerodynamics, acoustics, airborne systems and equipment, and propulsion. In September 1991, the EC Council decided to fund another aeronautics program for 1992-94 in section 3 of the Industrial & Materials Technologies research and technology program of 1990-94, which continued the work of the initial program.[50] The proposed level of funding was 53 million ECU over 3 years ($65.8 million).

One of the largest EC Commission-sponsored aeronautical R&D programs funded under BRITE/EURAM is the European Laminar Flow Investigation (ELFIN). Introduced in 1989, ELFIN is a joint R&D project on laminar flow[51] involving 24 private and public partners in 11 European countries. ELFIN is led by Deutsche Airbus; other participants include Aérospatiale, Dassault, BAe, CASA, Alenia, Fokker, NLR, DLR, ONERA, and the Centro Italiano Ricerche Aerospaziali (CIRA).[52]

GARTEUR, founded in 1973, is a five-country[53] consortium with the goal of strengthening collaboration among EC member states in the field of aeronautical R&D through the pooling of resources, exchange of technical information, identification of gaps in facility needs, and avoidance of duplicative efforts. CARTE was founded in 1981 as an industry group within GARTEUR. Neither GARTEUR nor CARTE receives much funding from the EC Commission. Fears of the leaking of information on technological R&D by the participants have limited many of these projects to precompetitive R&D.[54]

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[47] Jean-Pierre Marec, Ingenieur General de L'Armement, Director for Aeronautical Applications, ONERA, interview by USITC staff, Paris, Nov. 20, 1992.

[48] "EC Bolsters R&D Funds," *Interavia Aerospace Review*, Jul. 1992, p. 22.

[49] EC, *Official Journal*, No C 266, Oct. 13, 1988, pp. 5-11.

[50] EC, *Official Journal*, No L 269, Sept. 25, 1991, pp. 30-37.

[51] See app. G for definition.

[52] "The Laminar-Flow Wing in the Winds of Europe," *Aviation Magazine International*, Dec. 15, 1991, pp. 52-53. This four-phase program seeks to produce an airfoil with a laminar flow, which would reduce drag and improve fuel consumption by 15 percent and reduce pollution in subsonic and supersonic flight. Wind tunnel tests have been carried out in the Netherlands at NLR and in France in the ONERA Modane wind tunnel. Another West European laminar flow investigation outside of ELFIN currently is being conducted by Rolls-Royce and DLR. This investigation is examining a low-drag design for an aircraft nacelle aimed at reducing fuel consumption and operating costs.

[53] The United Kingdom, France, Germany, Sweden, and the Netherlands.

[54] John Green, chief executive, Aircraft Research Association, interview by USITC staff, London, Dec. 2, 1992.

Russia

The LCA R&D establishment in Russia is more centralized than in the West. However, as Russia privatizes its LCA and supporting aerospace industry, the organizations that perform R&D, their capabilities, and sources of funds are changing.

The Central Aero-Hydrodynamics Institute (TsAGI) is the premier R&D and test facility in the Commonwealth of Independent States. Under the former Soviet administration, the government funded 100 percent of TsAGI's budget. At the beginning of 1991, just 50 percent of the budget came from the government. By October 1992, approximately 30 percent of the budget came from the CIS; 10 percent was supplied by the military, and another 20 percent by the Ministries of Industry and Science.[55] In mid-1992, because of the lack of funding, the institute began borrowing from commercial banks at interest rates of up to 150 percent. By November 1992, 20-25 percent of TsAGI's budget came from foreign investments.[56] Although much of its revenue comes from contracts with Russian design bureaus, TsAGI has been extending credit to the design bureaus because of their own funding shortfalls. TsAGI has had to reduce energy consumption and payments to subcontractors, decrease capital expenditures for modernization, and raise prices approximately threefold. At the same time, it has had to increase wages to workers to meet the rising cost of living.[57]

Japan

Although Japan has not produced an LCA and most of its R&D efforts are focused on other areas (hypersonic aircraft, space, and composites),[58] Japan has the capability to conduct significant R&D related to LCA. The Japanese Government's LCA R&D efforts largely are limited to materials and component development, and to the financial support of Japanese companies in subcontracting and joint development programs. The Japanese Government also sponsors R&D efforts in hypersonic aircraft design and LCA engines.

LCA R&D is supported financially by Japan's Science and Technology Agency (STA) and the Agency of Industrial Science and Technology (AIST) of the Ministry of International Trade and Industry (MITI).[59] Other agencies involved in aerospace R&D include the National Space Development Agency (NASDA), the Ministry of Transportation (for the development of air transportation capabilities), the Ministry of Posts and Telecommunications (for communications satellites), and the Technical Research and Development Institute of the Japan Defense Agency.

STA has focused its LCA R&D efforts on its National Aerospace Laboratory (NAL), and on funding for R&D performed by the National Research Institute for Metals (NRIM) and the National Institute for Research in Inorganic Materials (NIRIM). NAL conducts R&D on basic aerodynamics, propulsion systems, control and guidance systems, structural mechanics, and space technology. NAL had a 1991 budget of $80 million.[60]

R&D Infrastructure Capabilities

The competitive position of a country's LCA industry is influenced to a large degree by its access to CFD technology, supercomputers, and wind tunnels. The use of wind tunnels is an important indicator of a firm's commitment to undertaking forward-looking technology development.[61] The national research laboratories in the United States, Western Europe, Russia, and Japan furnish testing facilities for their private sectors that otherwise would not be available domestically because of the high costs associated with building and maintaining such large-scale facilities. Most national laboratories

[55] U.S. Department of State, "TSAGI: A Conversion Case Study," telegram, message reference No. 035660, prepared by U.S. Embassy, Moscow, Nov. 23, 1992.

[56] Alexander A. Pogodaev, general director, TsAGI, interview by USITC staff, Moscow, Nov. 16, 1992.

[57] John D. Morrocco, "TsAGI Accelerates Search for Foreign Contracts As Russia Slashes Funding for Research Institutes," *Aviation Week & Space Technology*, Apr. 13, 1992, pp. 60-61.

[58] Stanley W. Kandebo, "Japanese Making Rapid Strides In Hypersonic Technologies," *Aviation Week & Space Technology*, Dec. 16/23, 1991, pp. 60-61.

[59] For more information, see U.S. International Trade Commission (USITC), *Brief Review of Japan's Aerospace Industry*, staff paper, Sept. 1990, p. 6.

[60] For more information, see USITC, *Brief Review*, pp. 6-7. The laboratory aerodynamic research concentrates on designing optimal airframe and lift surface configurations for hypersonic flight and developing ultra-light structures for airframes that can withstand cryogenic to ultra-high temperatures without losing structural integrity.

[61] West European industry sources note that Boeing is known for the amount of wind tunnel testing it conducts.

make their supercomputer networks and wind tunnels, and other R&D infrastructure such as simulators and flight-testing facilities, available to foreign and domestic firms.[62]

CFD

United States

NASA was the world forerunner in aeronautical R&D using CFD. NASA no longer has a monopoly in this area because major foreign laboratories now have access to supercomputers and CFD technology.[63] The NASA Numerical Aerodynamic Simulation (NAS) program is responsible for maintaining and utilizing two state-of-the-art supercomputers at the NASA Ames Research Center (Moffett Field, CA), which are used to solve complex CFD problems.[64] The NAS system is restricted by speed and storage limitations of existing computer systems. NASA plans to replace one of the Ames Cray II (High Speed Processor 1) supercomputers during 1993 with a new state-of-the-art machine. This new computer will allow Ames to remain the pre-eminent aeronautical computational fluid dynamics facility in the world.

The NAS system is used to measure flow fields around aerospace vehicles, study the behavior of gases around the vehicle, and assess the behavior of vehicles in flight. The NAS system can input parameters such as altitude, air temperature, air density, speed, and attitude. This system is more sophisticated than other systems used in global aeronautical R&D; however, the parameters it measures are typical to all such R&D. The results of NAS research routinely are provided free of charge to U.S. universities and firms through seminars and technical papers for incorporation in their design processes. U.S. LCA manufacturers account for 15 to 20 percent of the computer time of the NAS system.

[62] The exception is NASA; NASA facilities are only available to U.S. firms (14 CFR 1210).

[63] Beginning in FY 1991, CFD was cited by the Department of Defense as one of its 21 critical technologies under its Critical Technologies Plan. In FY 1993, CFD was included under Design Automation thrust area under its new Science and Technology Program.

[64] The NAS system is made up of several computer subsystems including 2 Cray IIs, a CDC Cyber 205, a large number of VAX11-780s, more than 80 Silicon Graphics IRIS 4D series scientific work stations, and LIS machines.

Western Europe

Many of Western Europe's major universities, its four major national aeronautical research laboratories, and the members of the Airbus consortium have access to supercomputers capable of solving complex CFD equations. The West European aeronautics industry reportedly has had great success in using CFD to improve designs for gas turbine engines, new transport and business jets, and jet trainers.[65] Industry experts consider the United Kingdom to be Western Europe's leader in CFD development and application because of its experience in using CFD to develop advanced weapons systems. Germany, the Netherlands, and France also have strong CFD capabilities.

Russia

The Russian R&D establishment has developed CFD theory and algorithms, and has produced some work comparable to that done in the United States and Western Europe. This has been accomplished despite the past limited access to large-capacity, high-speed computers, including supercomputers.[66] U.S. industry officials believe that although the Russian industry has basic engineering and computing skills comparable to those in the United States and Western Europe, Russian capabilities lag in some areas in part because of a lack of large capacity, high-speed computers, including supercomputers.[67] Russian industry officials believe that their geometric models are equal to those used in the West,[68] and that they are ahead of the West in aerodynamic models and calculation programs.[69] West European and U.S. private- and

[65] U.S. GAO, *Aerospace Plane Technology—Research and Development Efforts in Europe*, GAO/NSIAD-91-194, July 1991, p. 75.

[66] British aeronautical researchers, interview by USITC staff, United Kingdom, Dec. 1-4, 1992; and Boeing officials, interview with USITC staff, Mar. 26, 1993.

[67] BAe officials, interview by USITC staff, Farnborough, UK, Dec. 1, 1992.

[68] "TsAGI Offers Wind Tunnel Facilities, Develops Laminar Flow Control Software," *Aviation Week & Space Technology*, Apr. 13, 1992, p. 61. For example, TsAGI officials claim that a software program under development for calculating the maximum probability of a runway accident requires 300 to 400 permutations, compared with a Western program that requires 100 million permutations.

[69] Alexander A. Pogodaev, general director, and Leonid M. Shkadov, deputy director, TsAGI, interview by USITC staff, Zhukovsky, Russia, Nov. 18, 1992.

public-sector R&D entities have sought access to Russian CFD capabilities.[70] Boeing has established a small R&D office in Moscow to explore Russian technological capabilities, including CFD.

Japan

The Japanese industry has made rapid progress in developing CFD capabilities. CFD research is performed principally at NAL, the privately owned Institute for Computational Fluid Dynamics, and national universities, such as the University of Nagoya and the University of Osaka. NAL, the institute, and several universities have supercomputers produced by Japanese computer companies.[71] Japanese aerospace companies have access to the supercomputers in the NAL Numerical Simulator System. Japanese CFD development currently lags behind that of the United States, but has the potential to challenge Western capabilities as Japan develops validated databases and sophisticated algorithms.[72] Much of the work in Japan's CFD has been driven by the country's development of hypersonic aircraft; spacecraft; and propulsion technology, including engines for LCA.

Wind Tunnels

Over the past 40 years, there has been a fundamental shift away from small wind tunnels to larger, more sophisticated ones. Today, there are approximately 90 major wind tunnels in the United States and 70 others, principally in Western Europe, Canada, Russia, and Japan.[73] Wind tunnels are owned and operated by major universities, the leading airframe and engine manufacturers, and all of the leading national aeronautical laboratories. Wind tunnel fee structures are similar throughout the world; they are based on wind tunnel "occupancy hour" and charges for pretest setup, post-test reporting, power charges, and computer usage. According to industry officials, there is an overcapacity of wind tunnels with modest aerodynamic scaling capabilities; these tunnels are used principally in conceptual and specific research studies. The leading world subsonic and transonic wind tunnels are listed in table 6-6.

United States

The U.S. aeronautical industry has access to, on a contract basis, a wide range of wind tunnels capable of simulating subsonic through hypersonic speeds. Although U.S. LCA producers maintain their own wind tunnels, they generally rely on wind tunnels operated by NASA and by national laboratories in Western Europe and Canada because these tunnels have high productivity, large size, and high Reynolds number capabilities. In 1982, U.S. private-sector wind tunnels had an estimated total replacement value of $1.6 billion.[74]

Private sector

Boeing owns the largest privately owned wind tunnel complex in the world, and uses its tunnels for aerodynamic, noise, propulsion, and icing testing. Boeing's principal wind tunnels are used for both its commercial and military products. Boeing also has sold wind tunnel time and services to other manufacturers, including foreign aircraft producers of smaller aircraft, such as Embraer of Brazil.[75]

In general, Boeing uses outside wind tunnels to supplement its in-house capabilities. Boeing has performed aerodynamic simulation for the development of high-lift systems and wing design at DRA (low-speed testing) and NASA Ames (transonic testing at the 11 foot tunnel). In February 1992, Boeing announced that it would not proceed with a plan to build a new complex of wind tunnels.[76] A factor in this decision was the projected increase in available time at both U.S. and foreign wind tunnels as defense spending decreases.[77]

McDonnell Douglas owns several wind tunnels but relies more heavily than Boeing on outside test facilities, including foreign wind tunnels. For example, in 1992, McDonnell Douglas began 790

[70] For example, NASA sought access to Russian work on CFD modeling of turbulence and its affects on drag calculations. Craig Covault, "U.S., Europe, Japan Vie for Russian High Technology," *Aviation Week & Space Technology*, Jan. 27, 1992, p. 37.

[71] U.S. GAO, *Aerospace Plane Technology: Research and Development Efforts in Japan and Australia*, GAO/NSIAD-92-5, Oct. 1991, pp. 103-104.

[72] Ibid., p. 85.

[73] Aeronautics and Space Engineering Board, p. 197.

[74] Executive Office of the President, p. A-2.

[75] Edward H. Kolcum, "Transonic Wind Tunnel Tests Completed For Brazilian EMB-145 Regional Jet," *Aviation Week & Space Technology*, Apr. 29, 1991, p. 53.

[76] "Boeing Abandons Wind Tunnel Plans," *Aviation Week & Space Technology*, Feb. 24, 1992, p. 38.

[77] "Boeing Shelves Plans for New Wind Tunnels," *Interavia-Air-Letter*, Feb. 9, 1992, p. 6.

Table 6-6
Principal world subsonic, transonic, and trisonic wind tunnels

A. PRINCIPAL PUBLIC-SECTOR-FINANCED WIND TUNNELS

Country	Organization	Tunnel	Location	Speed Range (Mach)	Operational Year (Upgrade)	Replace-ment Cost[1] ($million)	Special Features[2]
Canada	National Aeronautical Establishment	5 Foot	Ottawa, ON	Transonic 0.1-4.25	1962 (1980)	$24	High R_e/m, pressurized
France	ONERA	F-1	Noe	Subsonic 0.37	1977 (1989)	$59	High R_e/m, productivity
		S-1	Modane	Transonic 0.23-1	1952 (1989)	$151	Size, high R_e/m
Germany	European Transonic Wind Tunnel	ETW	Köln	Transonic 0.15 - 1.3	1994	$312	Very high R_e/m in the transonic range, cryogenic
	DLR	KKK	Köln	Subsonic	1988	NA	Cryogenic, High R_e/m
Nether-lands	German-Dutch Wind Tunnel (DNW)	DNW	Noordoost-polder	0.18 - 0.45	1980	$63	Productivity, largest lowspeed tunnel in Europe
Russia	TsAGI	T-128	Zhukovsky	Transonic 0.15-1.7	NA	NA	Tests range to supersonic
United Kingdom	DRA	5 Meter	Farnborough	Subsonic 0-0.33	1978	NA	Productivity, pressurized
		24 Foot	Farnborough	Subsonic 0.1-0.15	1934 (1970)	NA	Anechoic (Acoustics)
		13’ x 9’	Bedford	Subsonic 0.01-0.27	1953 (1968)	NA	Size
United States	NASA	UNITARY 11 Foot	NASA-Ames Moffett Field, CA	Transonic 0.4-1.4	1956	$146	High R_e/m, size
		40’ x 80’ 80’ x 120’		Subsonic 0.45 0.15	1944 (1982)	$222	High R_e/m, size
		12 Foot		Subsonic 0.6	1946	$38	High R_e/m, pressurized
		NTF	NASA-Langley Hampton, VA	Transonic 0.2-1.2	1982	$136	Cryogenic, pressurized

Table 6-6—*Continued*
Principal world subsonic, transonic, and trisonic wind tunnels

B. PRIVATE-SECTOR-FINANCED WIND TUNNELS

Country	Organization	Tunnel	Location	Speed Range (Mach)	Operational Year (Upgrade)	Replace-ment Cost[1] ($million)	Special Features[2]
United Kingdom	ARA	TWT 9'x 8'	Bedford	Transonic	1956	NA	Productivity, low-cost
United States	Boeing	4' x 4'	Seattle, WA	Supersonic 1.2-4	1957 (1968)	$20	High R_e/m
		8' x 12'		Transonic 0.1-1.1	1968 (1981)	$50	Atmospheric, continuous flow
		9' x 9'		Subsonic 0.36(3)	1967-69	NA	Propulsion tests
	Calspan	8 Foot	Buffalo, NY	Transonic 0-1.35	1947 (1956)	NA	Pressurized
	Rockwell	7 Foot	Los Angeles, CA	Transonic 0.1-3.5	1958 (1960, 1968, 1971, 1983)	$17	High R_e/m, size, propulsion tests, acoustics
	Vought	4 Foot	Dallas, TX	Transonic 0.2-5.0	1958 (1972, 1975)	$25	High R_e/m, flutter tests, polysonic
	Lockheed	4 Foot	Burbank, CA	Trisonic 0.2-5.0	1960 (1966, (1975, 1981)	$20	High R_e/m, polysonic

[1] Replacement cost is the current value of the facility, or the cost to replace the facility with all improvements made, in current dollars. Replacement costs for U.S. private and public wind tunnels are based on their value in 1984.
[2] See app. G for definitions; R_e/m is the symbol for Reynolds numbers.
[3] Not in use at this time.

NA = Not available.

Source: F.E. Penaranda and M.S. Freda, *Aeronautical Facilities Catalogue, Volume 1: Wind Tunnels* (Washington, DC: NASA, 1985); U.S. General Accounting Office, *Aerospace Technology Technical Data and Information on Foreign Test Facilities,* GAO/NSIAD-90-71FS, June 1990.

hours of low-speed wind tunnel tests at ONERA on the wing design for its MD-12.[78]

Public sector

NASA maintains 41 major wind tunnels of various sizes and speed ranges at its Ames (12), Langley (23), and Lewis (6) research centers. As of 1990, the estimated replacement value of NASA wind tunnels is $1.9 billion.[79] Ames was originally created to be the lead NASA subsonic aircraft research facility; almost every civil and military aircraft built in the United States since the 1950s has

[78] "Douglas Continues Work on MD-12 Wing in French Wind Tunnel," *Aviation Week & Space Technology*, Sept. 14, 1992, p. 17.

[79] George Eberstadt, "Government Support of the Large Commercial Aircraft Industries of Japan, Europe, and the United States," contractor document for Office of Technology Assessment, *Competing Economies: America, Europe, and the Pacific Rim* (Washington, DC: Congress of the United States, 1991), p. 72.

been tested in one of the NASA Ames wind tunnels. There is presently a 2-year waiting time to use these wind tunnels. The NASA Ames wind tunnels were built under the Unitary Plan Wind Tunnel Act of 1949. The objective of the act was to enable the National Advisory Committee for Aeronautics (the predecessor of NASA) to conduct applied high-speed aeronautical research through the development, construction, operation, and maintenance of high-speed wind tunnels at Ames. Today, these tunnels, known as the Unitary Plan Wind Tunnels (UPWT), are the most heavily scheduled wind tunnels in NASA. The Unitary Plan Wind Tunnel Act[80] mandated that U.S. industry be given priority in tunnel usage; the needs of the military services were to be secondary.[81] NASA wind tunnel facilities are available to U.S. companies but are closed to all foreign establishments. The results of research conducted by LCA producers on a fee basis is proprietary; however, under cooperative research programs or NASA-funded contracts, research results are generally made available to the global industry.

Test results and productivity at the UPWT, however, are limited by control systems that are nearly 40 years old. The UPWT has been in continual three-shift-per-day operation since 1956, with only minor facility improvements, and is prone to frequent shutdowns and delays due to equipment failure. Downtime at the UPWT has grown to one-quarter of total operating time and is increasing. NASA estimates that comparable foreign wind tunnels are two to three times more productive than the UPWT.[82] Beginning in 1995, the UPWT is scheduled for a 2-year shutdown for repair and upgrading.

Western Europe

As in the United States, there are a wide variety of wind tunnels in Western Europe, owned and operated by universities, LCA and engine manufacturers, and the various national aeronautical research laboratories. The European Transonic Wind Tunnel and the German-Dutch Wind Tunnel are Western Europe's leading wind tunnels. Others of importance include the F-1 and S-1 of ONERA. Wind tunnels owned and operated by Western Europe's public research institutions perform simulation tests on a contractual basis for both foreign and domestic firms. According to industry officials, the fee structure for Airbus Industrie is the same as for all foreign companies at these institutions.[83] [84]

Private sector

Within the Airbus consortium, only BAe possesses extensive wind tunnel testing facilities, and is therefore the consortium's aerodynamics specialist.[85] For Airbus-related tests, however, BAe uses wind tunnels operated by Aircraft Research Association (ARA), a privately-held firm, and DRA on a repayment basis. BAe in-house wind tunnel capabilities are used primarily for research purposes and are of limited capacity.[86]

ARA was founded 40 years ago when the British aircraft industry decided the country needed a new high-speed wind tunnel. ARA opened its large (9' x 8') transonic wind tunnel in 1956.[87] Since that time, ARA has participated in every major British aircraft and weapons development program.

Public sector

The German-Dutch Wind Tunnel (DNW), in the Netherlands, is a bilateral joint venture between DLR and NLR,[88] and operates as an independent, nonprofit foundation under Dutch law.[89] The DNW began operating in 1980, and is the largest and most versatile low-speed wind tunnel in Europe. The DNW

[80] Industry sources typically refer to those tunnels created by this act as the Unitary Plan Wind Tunnels.

[81] According to NASA officials, one-third of its wind tunnel time is devoted to military projects, one-third is for NASA research, and the remaining third is private-sector usage.

[82] NASA, *Budget Estimates*, fiscal year 1993, vol. 2, p. RD 12-2.

[83] Benichou and Marec interviews.

[84] NASA officials stated that DNW charges all foreign customers an additional 10 percent user fee and a 10 percent energy fee.

[85] BAe has designed the wings for all Airbus models.

[86] Submission of C.R.D. Whitfield, director, Business Development, British Aerospace Airbus Limited, annex A.

[87] Green interview.

[88] Both NLR and the Delft University of Technology have wind tunnels that have been used in LCA R&D; however, they do not rank among the leading world tunnels in terms of size or high Reynolds number test capabilities.

[89] F.J. Abbink, deputy director, NLR, interview by USITC staff, Amsterdam, Nov. 26, 1992.

also is the leading world acoustic wind tunnel and has been used by the U.S. military, Airbus, and the global helicopter and automotive industries. West European industry officials state that the DNW is equal, if not superior, to comparable wind tunnels in the United States. The DNW conducts wind tunnel tests on a contractual basis.

The European Transonic Wind Tunnel (ETW) is in Germany, adjacent to DLR. The ETW was established in 1988 as a West European equivalent to the NASA National Transonic Facility (NTF) cryogenic wind tunnel in Hampton, VA. The ETW is an independent joint venture among the quasi-national aerospace research agencies in Germany (DLR), France (ONERA), the United Kingdom (DRA), and the Netherlands (NLR), which wanted to equip Western Europe with a large Reynolds number transonic wind tunnel facility. The German Government paid the largest share of the total construction costs (38 percent of $337 million) to obtain location rights.[90] The remainder of the construction costs were assumed by France and the United Kingdom (28 percent each) and the Netherlands (6 percent). While government funds will pay for development and an initial operation subsidy, the facility will charge user fees to cover its costs. Germany, France, and the United Kingdom will have an equal share in terms of time (31 percent) in the operation of the tunnel; the Netherlands will have access to the remaining 7 percent.[91] As of November 1992, the ETW was 98 percent complete and expected to be in operation by 1995. The ETW will exceed existing West European capacity in its ability to handle bigger models, larger Mach numbers, and higher Reynolds numbers.

ONERA has a number of wind tunnels; LCA R&D is conducted principally at the F-1 wind tunnel at Noe and the S-1 wind tunnel at Modane. The F-1 has been used for testing Airbus programs and for testing regional aircraft, and for developing of Dassault's Rafale jet fighter; it ranks as one of the leading world subsonic wind tunnels with high Reynolds numbers.[92] The S-1 also has been used for testing Airbus programs, including the A340, and fighter jets. It ranks as one of the leading world transonic tunnels in terms of large size and high Reynolds number test capabilities. McDonnell Douglas has also used ONERA wind tunnels for its MD-12 program.

DLR maintains several wind tunnels, the most important of which is its subsonic KKK cryogenic wind tunnel in Köln-Porz, which has high-Reynolds-number-testing capabilities. The KKK uses a gaseous nitrogen medium to simulate the atmosphere.[93]

DRA also has several wind tunnels. Its 5-meter tunnel ranks as one of the largest subsonic wind tunnels in the world in terms of size and high Reynolds number test capabilities.[94] Boeing has used the DRA 5-meter tunnel to conduct low-speed tests for lift, drag, and stability on a 4-meter model of its 777 aircraft.[95]

Russia

TsAGI claims to have capabilities similar to those of the NASA Ames and Langley research centers.[96] Its 50-plus wind tunnels are divided into 5 classes: low- and high-speed subsonic wind tunnels, and transonic, supersonic, and hypersonic wind tunnels. The most popular wind tunnels attracting foreign clients are the T-128 transonic tunnel and the hypersonic tunnel. The T-128 can simulate speeds of Mach 0.15 to 1.7, and can test high Reynolds numbers and low turbulence numbers.[97] This tunnel was crucial in the development of LCA such as the Ilyushin Il-96-300 and the Tupolev Tu-204. TsAGI's hypersonic tunnel is capable of testing from Mach 10 to Mach 20. TsAGI also has several low-disturbance wind tunnels for performing laminar flow control and hybrid laminar flow control research.

[90] Xavier Bouis, director general, and Arno Freytag, managing director, ETW, interview by USITC staff, Köln-Porz, Germany, Nov. 17, 1992.

[91] Ibid.

[92] Aeronautics and Space Engineering Board, p. 138.

[93] Eulrich Huth, executive department, DLR, interview by USITC staff, Köln-Porz, Germany, Nov. 17, 1992.

[94] Roger Jones, director, Aircraft Systems Sector, DRA, interview by USITC staff, Farnborough, England, Dec. 4, 1992.

[95] "Boeing: 777 Final Wind Tunnel Trials Underway," *Flight-International*, Mar. 31, 1992, p. 6.

[96] "Boeing Expects to Begin Using Russian Wind Tunnel," *Russian Aerospace & Technology*, Aug. 10, 1992, pp. 5-6.

[97] Guy Norris and Alexander Velovich, "NASA Studies Russian HSCT Test Proposals," *Flight International*, July 22-28, 1992, p. 4.

Japan

The Japanese aeronautical industry has access to a series of publicly and privately owned wind tunnels in Japan, spanning speed ranges from subsonic to hypersonic.[98] Japanese firm have used these tunnels for research on hypersonic aircraft, space vehicles, and composite materials.

Contrast in R&D Capabilities

R&D Funding and Expenditures

In 1991, less than 1 percent of the total NASA budget was devoted to R&D related to subsonic aircraft. Over the last 15 years, NASA funds once dedicated for subsonic aircraft R&D have been diverted to the NASA space program. In 1992, most of the NASA R&D budget was devoted to manned space programs, with over 30 percent of the total allotted for Space Station Freedom. NASA expenditures on aeronautical R&T declined from 6 percent to 3 percent of its total budget during 1980-91.[99] However, with the introduction of the Advanced Subsonic Technology program, expenditures increased in 1992 and are expected to further rise in the mid-1990s.

U.S. industry has long relied on NASA for technology validation,[100] the longest and most expensive stage in technology development. However, both NASA and the Department of Defense have reduced dramatically the level of their technology validation.[101] Diverse elements within the U.S. aerospace community have called for NASA to—change its policy toward subsonic LCA R&D;[102] increase its involvement in aeronautical R&D by upgrading its facilities (wind tunnels, supercomputer systems, propulsion facilities, and test beds); take the lead in the development of a new subsonic aircraft; and support short-haul aircraft, propulsion, and avionics research.

In 1991, the four major West European aeronautical R&D laboratories (DLR, ONERA, DRA, and NLR) had a collective budget of $2 billion, which represented approximately 14 percent of the NASA total budget. Their aeronautical R&D expenditures totaled $445 million, or 22 percent of their collective budget, compared with $512 million in aeronautical expenditures for NASA. U.S. private sector expenditures for LCA R&D exceeded those of Western Europe during 1991; however, Airbus partner companies performed more third-party-funded R&D than did Boeing or McDonnell Douglas. Overall, aeronautical R&D spending in the Unites States exceeds that of Western Europe.

U.S. industry experts have alleged that the Airbus consortium relies on consortium member governments for the bulk of all development funds for Airbus. Publicly-financed aeronautical R&D in Western Europe, however, is noted for its fragmentation and emphasis on individual national strategies. According to the EC Commission, the rate of duplication in Western Europe of research infrastructure is about 20 to 30 percent. If duplication of operating expenditure is also taken into account, the loss is about 20 percent of total budgets.[103] Although collaboration by West European research organizations has alleviated some of the fragmentation, the lack of a central funding source, as well as the lower level of funding vis-à-vis the United States, inhibits West European R&D efforts.[104]

R&D Infrastructure

CFD

In the past, wind tunnel capacity dictated leadership in aeronautical R&D. This is not as true with the advent of CFD and advanced supercomputer

[98] U.S. GAO, *Aerospace Technical Data and Information on Foreign Test Facilities*, GAO/NSIAD-90-71FS, June 1990.

[99] Mark E. Gebicke, GAO, "Efforts to Preserve U.S. Leadership in the Aeronautics Industry are Limited," testimony before the Subcommittee of Government Activities and Transportation, Committee on Government Operations, U.S. House of Representatives, Mar. 18, 1992.

[100] See app. G for definition.

[101] Gebicke testimony.

[102] "NASA Chief Implores America to Reinvest in Air Transport," *General Aviation News & Flyer*, Second December Issue, 1992, p. A-15.

[103] Commission of the European Communities, *The European Aircraft Industry: First Assessment and Possible Community Actions* (Brussels: COM(92) 164 Final, Brussels, Apr. 29, 1992), p. 13.

[104] F.W. Armstrong for the Commission of the European Communities, Directorate-General for Science, Research and Development, *Focusing on the Future: Aeronautical Research and Technology Acquisition in Europe*, 1992, p. 38.

systems. According to the U.S. General Accounting Office (GAO), the United States currently is the world leader in CFD. However, Western Europe is developing a competitive capability, since CFD is recognized worldwide as a critical technology.[105] GAO also has indicated that Western Europe currently possesses much of the basic scientific knowledge about CFD. The United Kingdom is considered to have the greatest experience among West European countries in applying CFD to weapons systems; Germany, Italy, and France also have strong CFD capabilities. As the number of supercomputers increases in the 1990s, Western Europe's ability to advance in the field of CFD is expected to improve dramatically.[106]

According to NASA officials, supercomputers may give Japanese LCA manufacturers an edge in future aeronautical research. The Japanese computer industry has invested vast sums of money in the development of supercomputer technology,[107] which is critical for CFD research. Only Russia is lagging behind in access to supercomputers.[108] NASA officials indicate that although Russia is several generations behind the leaders in supercomputer development, the Russian R&D establishment has developed excellent aeronautical algorithms to compensate for this deficiency, and has excellent wind tunnels and other test facilities.

Wind Tunnels

According to West European industry experts, the U.S. competitive advantage in aerospace R&D is eroding because many of NASA's aeronautical wind tunnels are old and outdated, thus increasing the dependence of the U.S. industry on West European wind tunnels. According to NASA officials, NASA experienced funding difficulties during the early 1980s when the Office of Management and Budget (OMB) objected to the use of public money to finance subsonic research with near-term commercial application. OMB considered this to be an improper Federal subsidy.[109] OMB and other groups believed that this research would best be done by the private sector, particularly by the LCA manufacturers. However, the NASA aeronautics program was saved by reports from the Office of Science & Technology and the National Research Council that stressed the importance of NASA in sustaining overall industry R&D investments, counterbalancing underinvestment in the private sector, and supporting the Department of Defense and the FAA.[110] According to NASA officials, during the late 1980s, NASA continued to retreat from projects with near-term commercial application. NASA also shifted more of its aerospace budget away from subsonic to fixed-wing research related to the development of the High Speed Civil Transport.[111]

U.S. and West European industry experts presently consider newer subsonic wind tunnels in the Netherlands, Germany, and France, and the new transonic wind tunnel in Germany, to be superior to U.S. facilities with respect to the quality of test conditions and productivity.[112] According to NASA officials, the average age of its wind tunnels is nearly 40 years, certain of its composite materials facilities are no longer adequate, and some wind tunnels have testing backlogs of up to 2 years because of low productivity.[113] NASA officials also state that many of its wind tunnels were designed as research-oriented rather than production-oriented tunnels and thus are of limited use to industry in the development cycle of new aircraft.[114] At present, NASA wind tunnels cannot provide the high Reynolds numbers, or flow conditions, required to test some next-generation aircraft, especially new LCA aircraft, nor can they simulate conditions needed to research laminar flow control, high-lift device design, and adaptive wing configurations. Current tunnel acoustic measuring conditions that are essential for developing an environmentally compatible aircraft also need improvement. Responding to industry concerns, in 1988, Congress authorized $300 million to revitalize six NASA wind tunnels at Ames, Lewis, and Langley.[115]

[105] U.S. GAO, *Aerospace Plane Technology - Research and Development Efforts in Europe* (GAO/NSIAD-91-194, July 1991), p. 75.

[106] Ibid.

[107] Computer industry analyst, interview by USITC staff, June 1993.

[108] Peterson interview.

[109] Gebicke testimony, p. 6.

[110] Ibid.

[111] Ibid.

[112] Goldin, p. 4.

[113] NASA, *Budget Estimates Fiscal Year 1994, Vol. II, Construction Facilities*, p. CF 9A-2.

[114] Goldin, p. 4.

[115] Gebicke testimony, p. 6. In 1988, a NASA taskforce recommended the Aeronautical Facilities Revitalization Program, a 5-year, $260 million program designed to address shortcomings in NASA facilities and wind tunnels. During 1980-88, NASA expenditures on major aeronautical facilities and wind tunnels totaled $242 million.

In anticipation that Ames will close several of its wind tunnels for repair, Boeing has begun wind tunnel tests on its 777 in both the United Kingdom and Russia, while McDonnell Douglas has tested model sections of its MD-12 in France. Industry experts estimate that once the NASA revitalization plan has been completed, Western Europe will continue to maintain an advantage in wind tunnel capabilities because NASA's current refurbishment plans will cover only the most glaring deficiencies. Industry officials assert that NASA will have to allocate additional funding for further repair, or for the construction of new wind tunnels, in order to equal the productivity and measurement capabilities of West European wind tunnels.

Conclusion

During the foreseeable future, U.S. capability in the field of aeronautical R&D will remain strong. Although U.S. expertise is being challenged increasingly by Airbus and Western Europe's aeronautical research institutions, the overall aerospace funding[116] differential between U.S. and West European R&D public- and private-sector organizations will probably ensure U.S. leadership, particularly in such key areas as CFD proficiency and application. However, U.S. R&D infrastructure does not equal West European capabilities with respect to wind tunnels,[117] which remain essential facilities for the development of aircraft.

Aeronautical R&D spending in the Unites States exceeds slightly that of Western Europe. NASA's aeronautical R&D budget totaled $512 million in 1991 compared with $445 million for the four West European laboratories (ONERA, DLR, DRA, and NLR). In the private sector, Boeing and McDonnell Douglas spent $1.8 billion on R&D compared with $1.6 for the major Airbus partners ($2.4 and $1.9 billion, respectively, in 1992).[118] The U.S. Government increased its spending in aeronautical R&D in 1992, and further increases are expected during the mid-1990s. In 1992, NASA's aeronautical R&D expenditures rose to $555.4 million (not including expenditures for staffing) and is scheduled to increase to $716.8 million in FY 1993 and to $877.2 million in FY 1993. NASA officials expect funding at the West European laboratories to remain relatively flat as a result of declines in public funding of LCA R&D.

National governments will continue to play an important role in aeronautical R&D.[119] However, it is at the company level that the majority of LCA R&D likely will continue to take place in the near future because firms can better identify product-oriented R&D. Evolutionary technology will continue to be developed by private-sector firms; revolutionary developments, however, will continue to require government participation because of the risk and cost involved.[120]

NASA plans to conduct more customer-focused R&D and align its subsonic research to the design philosophies of industry leaders such as Boeing, McDonnell Douglas, Pratt & Whitney, and General Electric.[121] According to NASA officials, industry-government cost sharing R&D projects are becoming more politically acceptable. NASA will shift its primary emphasis from precompetitive R&D to R&D with a more mid-term focus. In its 1992-95 budgets, NASA has also increased its budget allocations for large scale demonstration projects and for mid-term technology development and validation.

116 This includes funding for the entire spectrum of aerospace activities, which, in the United States, has focused predominantly on space-related and military activities, and not in the development of civil product-oriented technology.

117 Under the National Aeronautics Facilities Upgrade Program, NASA spent $25 million in FY1993 and requested $181 million in their FY1994 budget proposal for wind tunnel modernization. During budget hearings in May 1993, NASA announced its plans to construct two new high Reynolds numbers tunnels over the next 10 years. These tunnels are to be dedicated to commercial design validation and production, not for pure or abstract research. These tunnels will leapfrog existing West European wind tunnels, including the ETW, in terms of productivity.

118 An exact comparison of corporate R&D is not possible because of national differences in accounting standards.

119 In its FY 1994 budget, NASA announced its intent to emphasize R&D in areas which will advance near-term improvements in aircraft direct operating costs, while reducing LCA development costs. William B. Scott, "NASA Aeronautics Budget Fuels High-Subsonic Research," *Aviation Week & Space Technology*, May 10, 1993, p. 61.

120 Robert Whitehead, director, Subsonic Transportation Division, Office of Aeronautics & Space Technology, NASA, interview by USITC staff, Washington, DC, July 16, 1993.

121 Ibid.

CHAPTER 7: Principal Findings

Since the beginning of the jet age, the United States unequivocally has been the leading supplier of large civil aircraft (LCA) to the global market. The U.S. LCA industry's global market share has never fallen below 60 percent. In recent years, the U.S. LCA industry has faced increased competition from the Airbus consortium. In the 23 years since its inception in 1970, Airbus has increased its market share to 28 percent of global LCA orders in 1992. Competition from Airbus likely will continue to intensify, and competition from Russian LCA producers may also challenge the U.S. LCA industry in the future.

Present Competitive Position of U.S. LCA Manufacturers

In 1992, U.S. LCA manufacturers accounted for 84 percent of the world LCA fleet: 93 percent of the U.S. fleet, 75 percent of the West European fleet, and 74 percent of the Asia-Pacific fleet. U.S. LCA manufacturers' market share of orders (in units) in 1992 was 64 percent, while their market share of deliveries (in units) was 73 percent. Their share of global backlog was 64 percent. Among the key factors underlying the competitive position of the U.S. industry are its length of time in the industry, which has led to orders based on commonality, production cost efficiencies, and market credibility; the U.S. post-war demand for air travel; and access to aeronautical resources and infrastructure, principally in the form of military contracts and government-funded research and development (R&D), which has perhaps indirectly helped the U.S. LCA industry become the global leader in this industry.

Today, the competition for sales in the global LCA industry is based primarily on economics. While advanced technology is attractive to LCA customers—the airlines—a competitive product must offer revenues that outweigh acquisition price and operating costs over the life of the aircraft. Many factors go into this equation. Acquisition costs are a function of the cash outlay, including the financing and any special benefits, training, or other contract terms. Operating costs are a function of the maintenance and repair costs of the aircraft, crew costs, fuel costs, the relative efficiency of the aircraft, and any advantages and disadvantages of commonality with respect to the rest of the fleet. Revenue is influenced by the general state of the economy and the ability of the airline to maximize the economic potential of the aircraft through route application and accurate passenger/cargo forecasting. This is not to say that R&D is decreasing in importance. On the contrary, R&D is critical in reducing operating costs and improving aircraft efficiency.

Major Competitive Differences Between the U.S. and West European LCA Industries

There are several major competitive differences between the U.S. and West European LCA industries that have implications for the future performance of the U.S. LCA industry in the global market. In the past, the most obvious difference was the method of provision and the type of government support received by the industry. In the United States, support for the LCA industry was largely indirect,[1] and many sources suggest incidental, principally through both military contracts and government-sponsored R&D. This support contributed to the development of a skilled aeronautical workforce and helped establish an extensive R&D infrastructure. Over decades, this support may have benefitted the U.S. industry by lowering costs and improving production

[1] As discussed, the U.S. Government provided loan guarantees to both McDonnell Aircraft Corp. and Lockheed Aircraft Co.

efficiencies. Government support for the LCA industry in Western Europe has been direct and indirect, with the Airbus members' governments having made a specific commitment to developing a globally competitive LCA industry. By providing funds for this purpose, these governments have fostered the creation of a world-class company that directly competes with the U.S. industry.

Because of the 1992 U.S.-European Community Agreement concerning the application of the General Agreement on Tariffs and Trade Agreement on Trade in Civil Aircraft, all government support will be reduced in the future. The competitive impact of government support on the industry may be entering a phase of decreased importance (although the effects of past government support, both direct and indirect, will carry over into the future). However, there are other differences between the two industries that will have a significant impact on global competition. The first is in the area of R&D. The U.S. R&D establishment is the global leader in the field of computational fluid dynamics (CFD). However, increased access to supercomputers rapidly is improving CFD capabilities in Western Europe. At the same time, Western Europe holds a competitive advantage with respect to wind tunnel capability, though wind tunnel tests increasingly are being replaced by CFD modeling. Moreover, national laboratories and government-sponsored R&D in Western Europe tend to be more product-oriented, and these laboratories and government research organizations work more closely with the LCA manufacturers than is the case in the United States.

While total government-funded expenditures for aeronautical R&D are similar in the United States ($512 million) and Western Europe ($445 million), there is a major difference in the focus of this R&D between the United States and Western Europe. While NASA R&D will continue to concentrate resources on high-speed computing for aerosciences, its subsonic R&D resources will be focused largely on air traffic control systems.[2] In contrast, West European public-sector R&D organizations will focus resources on product-oriented R&D. This may afford West European firms a competitive advantage with respect to U.S. LCA companies.

Another difference lies in corporate structure of the major LCA manufacturers. The groupement d'intérêt économique structure of Airbus allows for cooperation on a full partnership basis; merges the technical strengths of the partners; avoids locking up large sums of capital; pools a large resource base, in terms of both funds and technology; similarly spreads risk and costs among a large resource base; and permits a lack of transparency in terms of production costs and other internal finances. Moreover, as a G.I.E., Airbus is not liable to pay taxes on its profits if it so elects. U.S. corporate law, particularly antitrust laws and competitiveness and merger policies, does not allow for this type of beneficial cooperation. However, because Airbus shareholders are also the primary source of its manufacturing inputs, influences that may not be in the best interest of Airbus, but rather in the best interests of any one member company, may enter the Airbus decision-making process. U.S. manufacturers' board decisions presumably are made on the basis of what is in the best interest of the company as a whole. U.S. firms, through their accountability to many shareholders that are not manufacturing partners, may have more of a need to make decisions on the basis of cost.

A third important difference is in length of time in the industry. Because U.S. LCA manufacturers have been selling their aircraft to the world's airlines decades longer than has their West European competitor, many airlines have found it more cost-efficient to continue to purchase aircraft from their traditional sources. However, because Airbus now has been selling aircraft for over 20 years, and thus has gained market credibility, this pattern may change. Airbus has been able to improve its productivity and cost efficiencies, expand its product line, incorporate new technologies into its aircraft families, and establish itself with a wide customer base.

Export controls are yet another important competitive difference between the U.S. and West European LCA industries. U.S. Government export controls prevent U.S. LCA manufacturers from entering certain emerging foreign markets, such as Vietnam and Iran. They also affect Airbus sales through re-export constraints. However, Airbus may not face such constraints as it lowers the U.S. content of some of its aircraft with the introduction of Rolls-Royce engines. Export controls discourage U.S. content by foreign producers, and defeat U.S. LCA manufacturers' attempts to gain important first-mover benefits in controlled markets.

[2] Daniel S. Goldin, administrator, NASA, posthearing submission, p. 4.

Future Competitive Position of U.S. LCA Manufacturers

The financial condition of the world's airlines is critical to the health of the world's LCA manufacturers. The U.S. Government and the major global producers project a return to profitability for the airlines. The resultant future market for LCA may require a more diverse mixture of aircraft than in the past. New airlines may create a need for smaller aircraft and higher frequencies, although congestion at major airports may dictate the use of larger aircraft than those currently in service. In addition, global noise standards will dictate the retirement of some aircraft before the end of their economic life. These factors may create an opportunity for LCA producers by expanding the number of replacement aircraft needed.

It is likely that some form of cooperation among the existing global producers will result in a new aircraft, such as a high-speed civil transport or an ultra-high-capacity aircraft. Either venture has the appeal of producing an aircraft for a market not currently addressed by any world aircraft manufacturer. Development and production costs, coupled with the predicted small market for these aircraft, dictate cooperation among the major LCA producers.

Russian firms may become global suppliers of LCA. The structural integrity of their aircraft, coupled with Western engines and avionics, and attractive prices, may gain market share for the two major LCA producers, Ilyushin and Tupolev, particularly if they develop a global after-sales support network. Moreover, the combination of Russian airframes and Western engines and avionics makes Russian-built aircraft more compatible with the Western LCA service infrastructure, eliminating some of the commonality problems associated with a new aircraft type.

Governments obviously will play an important role in the future competitive position of the U.S. LCA industry. As for the most evident government involvement, there will continue to be much debate both in this country and abroad about the desirability of financial support to the LCA industry, either for R&D or more directly for production or financing of exports, and about what form this support should take. In addition, exchange-rate stability (in particular, avoiding extreme appreciations such as those of the mid-1980s) and continued improvement in productivity in the U.S. LCA industry would go a long way toward positioning the industry well in world markets in the 1990s.

It is likely that the growth in demand for LCA anticipated with the end of the worldwide recession and the need for fleet replacements will have somewhat conflicting impacts on the performance of the U.S. industry. Although U.S. orders should recover and grow, this growth will probably not keep pace with growth in global demand. This scenario would provide room for growth in market shares accounted for by Airbus and by potential new entrants from Russia.[3]

[3] U.S. LCA production capacity may be sufficient to meet the expected demand growth. However, Airbus and Russian LCA manufacturers will be actively competing with U.S. producers for a larger share of the projected growth in demand.