Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry

Investigation No. 332-414

Publication 3433 **June 2001**

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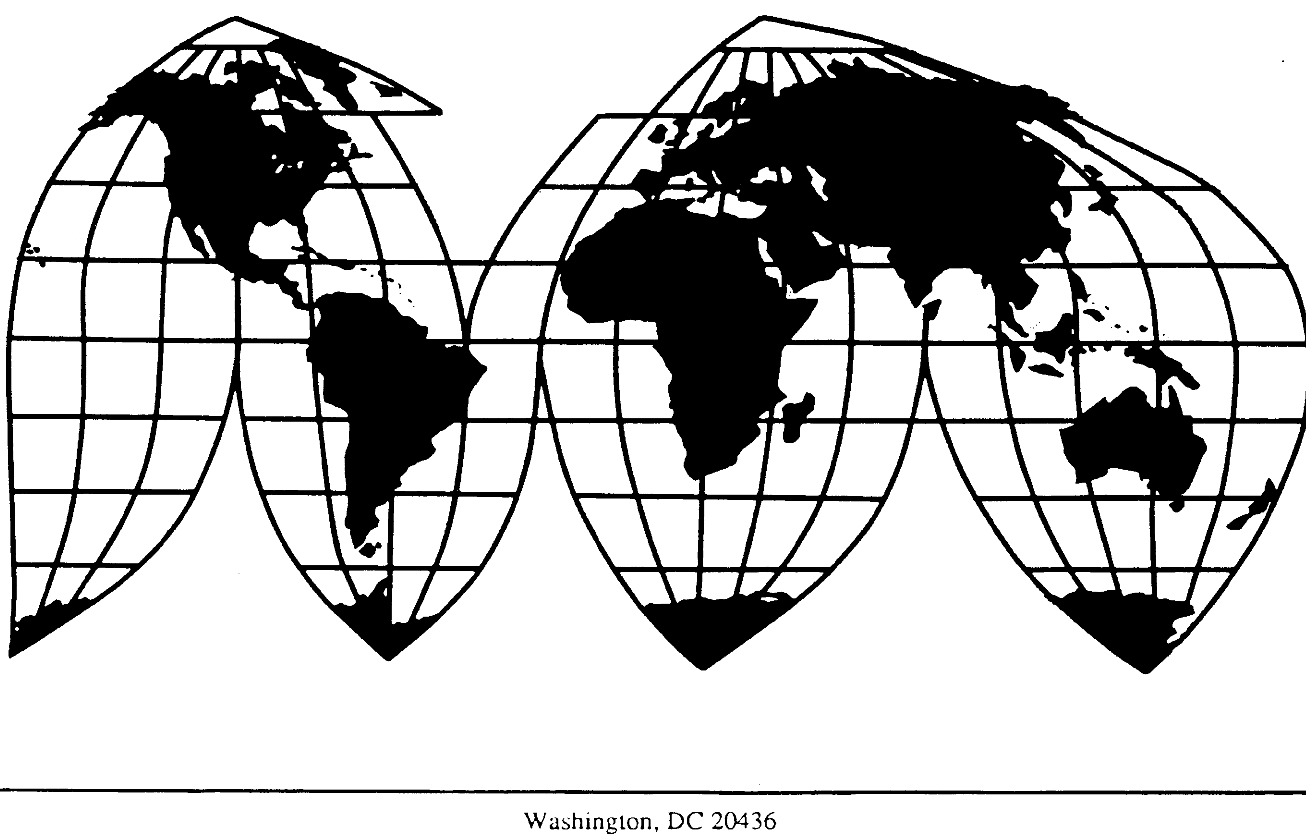

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CONTENTS

CONTENTS–*continued*

Page

Chapter 3: The U.S. LCA Aerostructures Industry

Chapter 4: The European LCA Aerostructures Industry

CONTENTS–*continued*

Page

Chapter 4: The European LCA Aerostructures Industry–*continued*

Chapter 5: The Canadian LCA Aerostructures Industry

Chapter 6: The Asian LCA Aerostructures Industry

CONTENTS–*continued*

Page

Chapter 6: The Asian LCA Aerostructures Industry–*continued*

Chapter 7: Research and Development for Aerostructures

CONTENTS–*continued*

Page

Chapter 8: Government Laws, Policies, and Other Public Sector Involvement Affecting Competitiveness in the Global LCA Aerostructures Industry

Tables

Page

Tables–*continued*

Figures

CONTENTS–*continued*

Page

Appendixes

ACRONYMS

ADD–Agency for Defense and Development (Korea)

AECMA–European Association of Aerospace Industries

AEDC–Arnold Engineering Development Center

AIAC–Aerospace Industries Association of Canada

ATE–Aerospace Technology Enterprise (NASA)

AVIC–Aviation Industries of China

BDLI–German Aerospace Industries Association

BIA–Beijing Institute of Aerodynamics

CAD–computer-aided design

CAD/CAM–computer-aided design and manufacturing

CAE–computer-aided engineering

CARAD–Civil Aircraft Research and Technology Demonstration (U.K.)

CATIA–computer-aided three-dimensional interactive application

CAM–computer-aided manufacture

CASA–Construcciones Aeronáuticas S.A. (Spain)

CCC–Canadian Commercial Corporation

CCIP–continuous cost improvement program

CCL–commodity control list

CEO–chief executive officer

CFD–computational fluid dynamics

CIRA–Italian Aerospace Research Center

COCOM–Coordinating Committee on Multilateral Export Controls

CRJ–Canadair regional jet

DARPA–Defense Advanced Research Projects Agency

DASA–Daimler Chrysler Aerospace

DERA–Defense Evaluation and Research Agency (U.K.)

DIPP–Defence Industry Productivity Program

DISC–Domestic International Sales Corporation

DLR–German Aerospace Center

DNW–German-Dutch Wind Tunnel organization

DoD–U.S. Department of Defense

EADS–European Aeronautic, Defense, and Space Company

EC–European Commission

EMAC–European Military Aircraft Company

EREA–Association of European Research Establishments in Aeronautics

EU–European Union

Eximbank–U.S. Export-Import Bank

FAA–Federal Aviation Administation

FAIT–fuselage assembly support improvement team

FCPA–Foreign Corrupt Practices Act

FDI–foreign direct investment

FFA–Aeronautical Research Institute (Sweden)

FHI–Fuji Heavy Industries

FOI–Swedish Defence Research Agency

FSC-Foreign Sales Corporation

ACRONYMS–*continued*

FTC–Federal Trade Commission

GAAP–Generally Accepted Accounting Principles

GARTEUR–Group for Aeronautical Research and Technology in Europe

GATT–General Agreement on Tariffs and Trade

GDP–gross domestic product

G.I.E.–*groupement d'intérêt économique*

GRI–Government-sponsored research institute (Korea)

IAR–Institute for Aerospace Research (Canada)

IAS–International Accounting Standards

IASC–International Accounting Standards Committee

IRAP–Industrial Research Assistance Program (Canada)

IRS–inherently reliable systems (NASA)

ISA–Italian Space Agency

ISAS–Institute of Space and Aeronautical Science (Japan)

ITAR–International Traffic in Arms Regulation

KAFA–Korea Air Force Academy

KAI–Korea Aerospace Industries

KARI–Korea Aerospace Research Institute

KBE–knowledge-based engineering

KfW–Kreditanstalt fur Weideraufbau

KHI–Kawasaki Heavy Industries

LCA–large civil aircraft

LTA–long-term agreement

METI–Ministry of Economy, Trade, and Industry (Japan)

MHI–Mitsubishi Heavy Industries

MRO–maintenance, repair, and overhaul

NAL–National Aerospace Laboratory (Japan)

NASA–National Aeronautics and Space Administation

NATO–North Atlantic Treaty Organization

NG–next generation

NIA–Nanjing Aeronautical Institute (China)

NLR–National Aerospace Laboratories (Netherlands)

NPU–Northwestern Polytechnic University (China)

NRC–National Research Council (Canada)

OECD–Organization for Economic Cooperation and Development

OEMs–original equipment manufacturers

ONERA–Office of National d'Études et de Recherches Aérospatiales (France)

R&D–research and development

RDT&E–research, development, testing, and evaluation

R&T–research and technology

SEC–Securities and Exchange Commission

SLMFST–Super Lightweight Multi-Functional Systems Technology (NASA)

TPC–Technology Partnerships Canada

TRDI–Technical Research and Development Institute (Japan)

TRL–technology readiness levels (NASA)

WTO–World Trade Organization

GLOSSARY

5S

A lean manufacturing concept that encourages a neat, clean, safe, and efficient workplace, and builds a total quality management environment. 5S includes sort, simplify, sweep, standardize, and self-discipline.

Bilateral oligopoly

A market situation in which there are a few powerful buyers and a few powerful sellers.

Bilateral monopoly

A market situation in which there is one buyer and one seller.

Build to print/build to spec

Manufacturing to the design and materials specifications provided by the customer.

CADDS-5

CADDS (Computer Aided Design and Drafting System) was originally developed by Computervision and is currently owned and supported by PTC. The CADDS-5 suite of products features a hybrid modeling engine, a unique multi-user assembly architecture that allows engineers to work in a true concurrent engineering environment and a broad suite of fully integrated applications. The suite is an integral component of Computervision's Electronic Product Definition solutions, which helps manufacturers improve product quality and reduce new product development costs and time-to-market cycles.

CATIA

Originally developed by Dassault Systèmes for the aerospace industry, CATIA (Computer Aided Three-Dimensional Interactive Application) is a comprehensive CAD/CAM/CAE application designed to maximize concurrent product development practices and process re-engineering by using digital mock-ups instead of physical models. CATIA users are able to create and simulate the entire product life cycle on the computer, from conception through operation, without the need of a single physical model. All necessary changes can be made on the digital model, minimizing the risk of late expensive physical modifications and reducing the number of iterations by designing correctly the first time.

Cellular manufacturing

A productivity improvement tool based on the partitioning of a manufacturing system into smaller subsystems, or cells. Each cell is dedicated to the processing of a family of similar parts. Benefits include reduction in setup time, throughput time, and work-in-process.

Chemical milling

The chemical milling process selectively removes metal, hence weight, from sheet metal and other structural parts. The chemical milling process is not inhibited by material hardness, functions without tool pressure on the work piece, and the work piece surface is not distorted. Use of chemical milling can eliminate the need for "doublers" or stiffening elements in sheet metal assemblies, reducing the cost of such assemblies by as much as 50 percent.

Composite

A material or structure made of physically distinct components that are mechanically, adhesively, or metallurgically bonded together.

Computational fluid dynamics (CFD)

The application of large computer systems for the numerical solutions of complex fluid dynamics equations. CFD can be used to predict the dynamics of air as it flows around an aerostructure.

Computer-assisted automation

This primarily refers to the use of computers in design work (CAD), interactive computing in support of manufacturing (CAM), and computer-aided acquisition and logistic support (CALS), which uses digital techniques to integrate technical information flowing from digital systems to facilitate the design, development, manufacturing, and support of aircraft systems. The goals of computer-assisted automation are to enhance productivity and decrease the product development cycle.

Design-build

Manufacturing to design and materials specifications developed in-house.

Economies of scale

Factors which cause the average cost of producing a commodity to fall as output of the commodity rises.

Empennage

The aft fuselage section which includes the horizontal and vertical stabilizers and their associated control surfaces.

Five axes machining

This type of complex prismatic machining allows for the milling, drilling, and tapping of many different surfaces of a part, at numerous compound angles, with only one setup required.

GLARE

A hybrid material consisting of alternate thin sheets of aluminum and sheets of pre-impregnated glass fiber.

Groupement d’intérêt économique (G.I.E.)

A G.I.E. is a type of joint venture that has a legal identity separate from its members and which has no fixed capital contribution requirements. Each partner operates under the law of the country in which it is incorporated, thus eliminating the need to manage conflicting national tax and legal structures. Like a partnership in the United States, a G.I.E. is not required to report financial results or pay taxes on its profits unless it so elects; however, G.I.E. partners must comply with their respective national legal and tax codes with respect to tax payments on overall corporate profits. Members of a G.I.E. are jointly and separately liable, without limitation and in proportion to their respective membership rights, for the G.I.E. debts and obligations.

Continued on next page

Since under the G.I.E. structure Airbus member companies were not required to share information about their costs, neither the member companies nor Airbus (with the exception of the financial director) knew the actual cost of manufacturing Airbus planes.

Kaizen

A philosophy of ongoing improvement based on a Japanese business philosophy advocating the need for continuous improvement in a person's personal and professional life.

Knowledge-based engineering (KBE)

A software environment that permits businesses to retain their engineers' accumulated experience and knowledge to generate significant time and cost savings. KBE integrates an object-oriented programming language with a geometric modeling tool controlled by encoded engineering "rules." This facilitates "generative modeling" which produces almost instantaneous new design data, with reduced development costs.

Laser welding

Microspot welding with a laser beam.

Lean manufacturing

An approach to reduce waste and streamline operations, lean manufacturing embraces a philosophy of continually increasing the proportion of value added activity through ongoing waste elimination. A lean manufacturing approach reduces the waste chain, reduces inventory and floor space requirements, creates more robust production systems, develops appropriate material delivery systems, and improves layouts for increased flexibility.

Learning effects

Economies of scale associated with "learning by doing." Refers to how one learns to reduce production costs through actual production experience. All else equal, the more a firm has produced, the lower its unit costs tend to be.

Mach number

The ratio of true airspeed to the speed of sound. The speed of sound in air at sea level (Mach 1) is 761.5 mph.

Metal-to-metal bonding

The bonding of two solid, nonporous members.

Monopsony

A market situation in which there is one buyer, known as the monopsonist.

Offsets

Concessions that are required by certain governments as a condition of purchasing defense or commercial products from foreign sources. Offsets may take various forms, including co-production, licensed production, subcontractor production, overseas investment, and/or technology transfers.

Orbital drilling

This technique involves moving the drilling tool simultaneously in both axial and radial directions. Since the center of the tool orbits a stationary hole center, the thrust force is minimized and many of the problems associated with traditional drilling are eliminated. The process allows for efficient chip extraction; it also allows for the drilling of high precision holes with low precision tools, and the drilling of holes of different diameters with a tool of a single diameter.

Resin transfer molding

A process whereby catalyzed, thermosetting resin is transferred or injected into an enclosed mold in which the fiber reinforcement has been placed.

Reynolds number

A dimensionless number used as an indicator of scale of fluid flow. It is significant in the design of a model of any system in which the effect of viscosity is important in controlling the velocities or the flow pattern of a fluid. It is equal to the product of the fluid density, the velocity, and a characteristic length divided by the viscosity. The ability to produce higher Reynolds numbers is a desirable feature for wind tunnels.

Sandwich structures bonding

Structures comprised of a lightweight metallic, composite, or formed plastic core material to which two relatively thin, dense, high strength or high stiffness laminates or metallic sheets are adhered.

Six Sigma

A series of interventions and statistical tools that lead to improved profitability and quality gains, Six Sigma capability means having 12 standard deviations (the variation about the process mean) between the upper and lower specification limits. Essentially, process variation is reduced so that there are no more than 3.4 defects per million parts. The Six Sigma term also refers to a philosophy, goal, or method to reduce waste and improve quality, cost, and time performance of any business.

Statistical process control

A method of monitoring processes and process variation to identify causes for process variations and resolve them. Process variables may include rework, scrap, inconsistent raw materials, and downtime on equipment. Statistical process control increases product consistency, improves product quality, decreases scrap and rework defects, and increases production output.

Stretch forming

The shaping of a piece of sheet metal or plastics sheet by applying tension and then wrapping the sheet around a die form; may be performed cold or the sheet may be heated first. Also known as wrap forming.

Superplastic forming/diffusion bonding

A hot metal operation that allows for the production of unique, high strength, reduced weight, complex shapes from a single piece of material, with extended design freedom and fewer production steps. The process is a strain-rate-sensitive metal-forming process utilizing the characteristics of materials exhibiting high elongation-to-failure. Diffusion bonding is often incorporated in the same process; in diffusion bonding, clean metal sheets are placed in a die under vacuum and temperature for a specific time, and surfaces held in contact by die pressure bond together. The bond produced is of very high integrity, making specific areas of separate sheets metallurgically one sheet.

Visual factory

A system of visual controls that mark the status of processes, machines, and upcoming work orders.

Wind tunnel

Tubelike structures or passages, sometimes continuous, together with their adjuncts, in which high-speed movements of air or other gases are produced (e.g., by fans), and within which objects such as engines, aircraft, airfoils, or rockets (or models of these objects), are placed to investigate the airflow about them and the aerodynamic forces acting upon them. Subsonic wind tunnels simulate speeds ranging from Mach 0.1 to 0.8, transonic wind tunnels simulate speeds ranging from Mach 0.8 to 1.2, supersonic wind tunnels simulate speeds ranging from Mach 1.2 to 5.0, and hypersonic wind tunnels simulate wind speeds in excess of Mach 5.0.

ABSTRACT

On April 14, 2000, at the request of the House Committee on Ways and Means (Committee), the United States International Trade Commission (Commission) instituted investigation No. 332-414, *Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry*, under section 332(g) of the Tariff Act of 1930, for the purpose of exploring recent developments in the global large civil aircraft (LCA[1]) aerostructures industry. The Commission's report includes:

- A description of the composition of the LCA aerostructures industry and recent trends;
- A description of the process of new aerostructures development;
- A review of the means and trends in government support for research and development needs; and
- An evaluation of the relative strengths and weaknesses of the aerostructures industries in the United States, Europe, Canada, and Asia.

For the purposes of this investigation, aerostructures are structural assemblies, primarily constructed of aluminum, titanium, and composite materials, that house passengers, crew, and cargo of an LCA, dictate the aircraft attitude, and support the aircraft on the ground. A total of 27 specific products have been identified as aerostructures, and can be loosely grouped as fuselages, including barrel sections, nose, tail, fin, rudder, tailplane, and elevators; wings, including control surfaces and winglets; and landing gear, and does not include avionics or LCA engines.

The LCA aerostructures industry is truly global, with manufacturers from all parts of the world supplying the two major remaining LCA producers,[2] The Boeing Co. of the United States and the former Airbus Industrie, G.I.E. of France. Airbus is in the final stages of its transformation to a single corporate entity and was recently renamed "The Airbus Company."

The leading LCA aerostructures industries in the world in terms of volume of production and breadth of product line are in the United States and Europe. The industries in Canada and Asia are somewhat smaller. The global industry is undergoing a process of consolidation, necessitated by the trend toward increased responsibility imposed on aerostructures producers by the LCA manufacturers, and cost reduction pressures.

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. 65, No. 79) on April 24, 2000. Nothing in this report should be construed to indicate how the Commission would find in an investigation conducted under other statutory authority covering the same or similar subject matter.

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[1] LCA are traditionally defined as civil aircraft with more than 100 seats and weighing over 33,000 pounds.

[2] BAE Systems, plc produces one LCA, the AVRO RJ100, which can seat up to 116 passengers. Fifty-eight have been delivered since 1993. Paul Jackson, ed., *Jane's All the World's Aircraft 2000-01* (Surrey, UK: Jane's Information Group Limited, 2000), p. 534. Russia is also a producer of LCA and aerostructures, but was not a part of the Committee's request.

EXECUTIVE SUMMARY

This study was requested by the House Committee on Ways and Means in a letter dated March 8, 2000.[1] The Committee requested that the U.S. International Trade Commission (the Commission) examine the ability of the U.S. civil aerostructures[2] industry to compete over the short and long terms with those industries in Europe, Canada, and to the extent possible, Asia. The Commission's report examines the composition and recent trends of the large civil aircraft (LCA) aerostructures industry; the process of new aerostructures development; the means and trends of government support for research and development; and the relative strengths and weaknesses of the aerostructures industries in these countries and regions, for the period 1995-99 and to the extent possible, 2000.

Structural Characteristics and Key Determinants of Competitiveness

- LCA aerostructures manufacturers are assuming greater responsibilities in the manufacturing and systems integration process, and more risk in their relationship with airframers Boeing and Airbus. Key determinants of competitiveness in the LCA aerostructures industry include access to capital, production efficiency, technological capabilities, and the ability to enter risk-sharing agreements with aircraft manufacturers.

The Aerostructures Industry in the United States

- Early global leadership in the aerospace industry enabled the United States to develop a highly competitive aerostructures industry to supply the LCA industry. However, the U.S. aerostructures industry has recently lost some of its competitive edge as a result of LCA industry consolidation, aging U.S. manufacturing equipment, increasing responsibilities placed on suppliers by LCA producers, and increasing foreign competition. Further, a number of U.S. aerostructures firms are concerned that foreign firms may displace U.S. suppliers because of market access and cost considerations. For instance, Boeing's placement of aerostructures work in foreign countries to facilitate sales of LCA to national airlines in such countries reduces potential opportunities for U.S. aerostructures manufacturers.

- Boeing dominates the U.S. aerostructures industry and consumes all the aerostructures it produces. Fourteen additional small- to medium-sized firms also principally support Boeing's aerostructures needs.[3] Although U.S. industry strengths include long-term experience in manufacturing LCA aerostructures and a highly skilled labor base, U.S. aerostructures firms

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[1] The request from the House Committee on Ways and Means is reproduced in full in appendix A. A copy of the Commission's *Federal Register* notice is included in appendix B.

[2] For purposes of this investigation, aerostructures include fuselages, wings, tails, certain structural components, and landing gear. See appendix C for a complete list of covered items.

[3] The preponderance of U.S. civil production goes to Boeing, with little aerostructures work being exported. U.S. industry officials, interviews by USITC staff, June 2000-Feb. 2001.

tend to lag behind European and Japanese firms in manufacturing and design capabilities and risk-sharing experience for LCA programs.

- Some U.S. firms appear to be responding successfully to the challenges of the changing LCA aerostructures market by increasing scale and range of expertise through consolidation, adopting more efficient and cost-saving measures, and taking on more supply chain management responsibilities. U.S. companies not making the necessary adjustments are not likely to prosper as LCA aerostructures suppliers.

The Aerostructures Industry in Europe

- The European LCA aerostructures industry can be characterized by its complex inter-relationships, the dominance of Airbus and its aerostructures subsidiaries (which produce the majority of aerostructures that Airbus consumes), and varying degrees of government participation. Government-influenced European aerospace industry consolidation, most notably the reorganization of Airbus and the formation of the European Aeronautic, Defense, and Space Co. (EADS), is likely to increase the efficiency and, in turn, the competitiveness of the European aerostructures industry. Further, the region's coordinated approach toward designated "centers of excellence" has allowed European manufacturers to specialize in specific production technologies and products to reap the benefits of economies of scale and learning curve effects, and to develop a world-class reputation as specialists in their chosen area.

- The trend toward aerostructures manufacturers becoming "systems integrators" has led aerostructures suppliers in Europe to restructure, shedding noncore activities and acquiring other niche capabilities to become subassembly or full-assembly specialists. Moreover, Airbus encourages its suppliers to contribute research, development, and design to their parts of the aircraft program to a greater extent than Boeing. These suppliers are then able to market themselves as design-build manufacturers, offering a value-added product for which they can theoretically command a greater premium from the airframer.

- The lingering presence of state governments in the ownership structure of EADS and the more participatory nature of many European governments in industrial policy may indirectly impact industry independence and flexibility, and influence its responsiveness to market conditions. Moreover, the lack of worker flexibility and mobility eliminates an option for European aerostructures firms trying to best respond to cycles in LCA demand.

The Aerostructures Industry in Canada

- Continued consolidation of the Canadian aerostructures industry will strengthen financial resources and improve production capabilities, enabling Canadian aerostructures producers to take on greater risk, responsibilities, and supply chain management to accommodate the demands of their LCA customers. Boeing has been a long-time customer of Canadian aerostructures manufacturers; however, the industry anticipates future work from Airbus as it encounters capacity limitations in Europe and looks for additional sources of supply. Canada has the aerospace infrastructure to supply Airbus and will need the European market to increase its global market share, especially as the Asian industry becomes more competitive.

The Aerostructures Industry in Asia

- Asian aerostructures manufacturers are emerging as a definitive force in the global aerostructures industry. Gaps in technological skill and a lack of experience in systems production and integration, however, have thus far prevented Asian firms from ascending to the upper levels of the supply chain. Although Asian manufacturers work closely with LCA producers on procurement contracts for a number of aircraft programs, state-of-the-art technologies reportedly are not transferred to potential Asian aerostructures competitors.

- At the same time, through risk-sharing agreements, offsets, and other cooperative arrangements with LCA producers, producers in Japan, Korea, and China are gaining familiarity with design responsibilities and advanced production techniques and are incrementally improving their manufacturing skills. LCA producers have demonstrated a willingness to give Asian producers aerostructures work in exchange for market access, such that Asian firms are able to secure work without having to compete in the same way as other global aerostructures producers.

- Through progressively ambitious work packages and years of practice, Asian producers have greatly improved their capabilities, with even less advanced Asian producers becoming skilled enough to assume the role of "sole supplier" to LCA manufacturers for certain parts. Finally, conglomerate and government management of the aerospace industries in these nations ensures that Asian firms are somewhat insulated from the typical business pressures that other global firms might experience.

Research and Development for Aerostructures

- U.S. R&D spending for aeronautics decreased in recent years relative to other major aerostructures-producing countries. NASA's R&D budget for aeronautics and the Department of Defense's spending on aircraft R&D decreased during 1995-99, a trend paralleled by reductions in R&D expenditures by Boeing and other U.S. aerostructures manufacturers. On the other hand, competing industries in Europe and Asia increased R&D expenditures during this period, as did Canada, with the exception of 1999.

- Increased competition between the two major LCA producers and consolidation among top-tier suppliers has had a profound effect on the focus and funding of R&D. Competition has created cost pressures that have driven R&D providers to consider revolutionary approaches to aerodynamics, and consolidation has enhanced the ability of top-tier suppliers to take on design and development responsibilities that were formerly undertaken by LCA manufacturers.

- Boeing, the primary U.S. sponsor of R&D for LCA aerostructures, is increasingly using European wind tunnels facilities for aeronautics testing. U.S. Government wind tunnels tend to be older and less efficient than some European facilities. U.S. Government and industry officials as well as numerous studies have expressed concern that the absence of new NASA wind tunnels and inadequate investment in the updating and maintenance of existing ones could have serious adverse consequences for the U.S. LCA aerostructures industry.

Government Laws, Policies, and Other Public Sector Involvement

- Certain legal requirements and government policies have an effect on the competitiveness of U.S. and foreign aerostructures manufacturers. Tax benefits include the United States FSC Repeal and Extraterritorial Income Exclusion Act of 2000; however, the lack of financial transparency by European companies prevents a comparison to various European tax incentives. Restrictive export financing regulations, combined with the United States' complicated system of export controls, put U.S. aerostructures firms at a relative disadvantage compared with European and Canadian companies, which enjoy more flexible export promotion programs.

- U.S. and European industry consolidation policies differ; U.S. merger review law attempts to ensure a market structure that discourages collusion between competitors, whereas EU merger law seeks to prevent the leading firm from abusing its market position. Automation-related productivity gains spurred by rigid EU labor regulations appear to balance the perceived advantage U.S. companies might receive from more flexible labor laws.

CHAPTER 1
INTRODUCTION

Scope

Following receipt of a request on March 13, 2000, from the House Committee on Ways and Means (Committee), the United States International Trade Commission (Commission) instituted investigation No. 332-414, *Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry*, on April 14, 2000. The Committee requested that the study be carried out pursuant to section 332(g) of the Tariff Act of 1930.

The Committee asked the Commission to define and explore recent developments in the global large civil aircraft[1] (LCA) aerostructures industry, including the process of new aerostructures development, and the means and trends in government supports and other financial assistance. The Committee asked the Commission to assess the relative strengths and weaknesses of the aerostructures industries in the United States, Europe, Canada, and to the extent possible, Asia, and the ability of the U.S. civil aerostructures industry to compete over the short and long terms with those industries in the countries/regions listed above.

For the purposes of this investigation, aerostructures are structural assemblies, primarily constructed of aluminum, titanium, and composite materials, that house the passengers, crew, and cargo of an LCA, dictate the attitude of aircraft,[2] and support the aircraft on the ground. A total of 27 specific products have been identified as aerostructures and can be loosely grouped as fuselages, including barrel sections, nose, tail, fin, rudder, tailplane, and elevators; wings, including control surfaces and winglets; and landing gear.[3]

The leading LCA aerostructures industries in the world, measured by volume of production and breadth of product line, are in the United States and Europe. Commission staff identified 15 LCA aerostructures manufacturers in the United States (see Chapter 3), and 18 producers throughout Europe (see Chapter 4). The industries in Canada and Asia are somewhat smaller.

The markets for LCA aerostructures are other LCA aerostructures producers and LCA manufacturers themselves. Both of these markets have undergone considerable consolidation in recent years, most notably consolidation of the global LCA industry to essentially two manufacturers—The Boeing Company of the United States, and the former Airbus Industrie, G.I.E. of France.[4] Both Boeing and Airbus are believed to produce the majority of the aerostructures they consume.

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[1] Large civil aircraft are traditionally defined as civil aircraft with more than 100 seats and weighing over 33,000 pounds.

[2] The orientation of the three major axes of an aircraft (longitudinal, lateral, and vertical) with respect to a fixed reference, such as the horizon, the relative wind, or direction of flight.

[3] Avionics and engines are not included in this investigation. A list of the specific products that are covered appears in appendix C.

[4] Airbus is in the final stages of its transformation to a single corporate entity, first announced on June 23, 2000. The company was recently renamed The Airbus Company (Airbus).

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[2] The orientation of the three major axes of an aircraft (longitudinal, lateral, and vertical) with respect to a fixed reference, such as the horizon, the relative wind, or direction of flight.

[3] Avionics and engines are not included in this investigation. A list of the specific products that are covered appears in appendix C.

[4] Airbus is in the final stages of its transformation to a single corporate entity, first announced on June 23, 2000. The company was recently renamed The Airbus Company (Airbus).

Approach

Many sources of information were consulted for this analysis. Among these were in-person and telephone interviews with domestic and foreign LCA and aerostructures manufacturers, industry associations, domestic and foreign government officials, and investment, academic, and independent industry analysts. Interviews and/or plant visits were conducted in Belgium, Canada, France, Germany, Italy, Spain, the United Kingdom, and the United States. A review of the available literature, including pertinent national and regional laws, policies, and standards was also conducted. No public hearing was held for this investigation, but submissions from interested parties were integrated into the report.

Because there are no published data on key indicators such as production, sales, and profitability specific to the aerostructures industry, the Commission sent questionnaires to U.S. and foreign producers. Ten U.S. producers, two Canadian producers, and two European producers provided questionnaire responses, although not all U.S. producers were able to provide a comparable level of detail. As a result, quantitative data from the questionnaires were not used. However, qualitative responses were incorporated as applicable. This study examines the trends in the global aerostructures industry over the past 5 to 10 years and assesses the likely implications of these trends. This analysis makes use of all of the information available to the Commission. The study does not include any type of formal economic modeling given the data limitations described above.

Organization

Chapter 2 develops the analytical framework for competitiveness in the LCA aerostructures industry. Accordingly, this chapter discusses the structure of the global LCA aerostructures industry; the recent change toward two major manufacturers of LCA, namely, Boeing and Airbus; and the effects on suppliers. This chapter also discusses the key cost and noncost determinants of competitiveness in the LCA aerostructures industry.

Chapters 3, 4, 5, and 6 examine the aerostructures industries in the United States, Europe, Canada, and Asia, respectively, and provide available data on capacity, employment, production, and sales. Each chapter discusses recent developments in the global LCA and aerostructures industries, including globalization and consolidation of the aerostructures industry, foreign direct investment, and the changing role of the aerostructures manufacturer in the development of new LCA programs (e.g., increased risk sharing and research and development expenditures on the part of aerostructures producers). In addition, findings relevant to the strengths and weaknesses of each region's industry are presented.

Chapter 7 provides an in-depth analysis of the development process for aerostructures in the United States, Canada, Europe, and Asia, beginning with an explanation of the basic definition of research and development (R&D), followed by a review of the R&D process, infrastructure requirements, and the significance of government participation and military influences on civil R&D. This is followed by a discussion for each region of the primary government and industry entities conducting R&D, the available infrastructure, and the types of programs and funding available for R&D in the countries under consideration. The chapter concludes with a discussion of the potential implications that these trends will have on the competitiveness of the U.S. industry.

Chapter 8 describes laws and policies in the United States, Europe, and Canada identified as conferring a competitive advantage on a nation or region's aerostructures industries.

Chapter 9 summarizes implications for the competitiveness of the U.S. aerostructures industry. The chapter draws from the previous chapters to provide an assessment of the competitive position of the U.S. LCA aerostructures industry vis-à-vis its competitors in Europe, Canada, and Asia.

CHAPTER 2
STRUCTURAL CHARACTERISTICS OF THE LCA AEROSTRUCTURES INDUSTRY AND KEY DETERMINANTS OF COMPETITIVENESS

Introduction

Over the past decade the LCA aerostructures industry has undergone important structural changes. Airline deregulation[1] imposed new pricing pressures on Boeing and Airbus, causing them to demand cost concessions from their suppliers and require suppliers to assume more risk and responsibility. In addition, the shrinking pool of LCA producers, coupled with an increasing number of new aerostructures manufacturers, has encouraged suppliers to consolidate. Some suppliers have pursued product specialization, while others have opted for diversification. From such changes, a consolidated and more technologically advanced LCA aerostructures industry is emerging.

Business transactions in the LCA aerostructures industry are normally concluded on a contractual basis. The main barriers to entry in the LCA aerostructures industry are the criteria necessary to enter the bidding process: capital, program experience, a skilled workforce, and regulatory approval. Key determinants of competitiveness in the LCA aerostructures industry are those factors that are decisive in winning contracts. Quality is a necessary, but not solely sufficient, criterion to enter the bidding process, as airframers expect all of their suppliers to pass the necessary certification and qualification tests. Thus, firms compete for contracts, not on the ability to produce quality aerostructures, but rather on cost and noncost factors. Cost factors include production efficiency, labor, capital, and economies of scale and learning effects. Principal noncost factors include core competencies and on-time delivery and flexible production capacity. Accounting methods may also affect competitiveness in the global LCA aerostructures; a discussion of these is presented in appendix D.

This chapter examines the structural characteristics of the LCA aerostructures industry. The chapter also includes a discussion of key determinants of competitiveness in the aerostructures industry, and in doing so, develops an analytical framework for the study.

Background

The global LCA aerostructures industry, which comprises roughly 50 major firms, is dominated by producers in North America and Europe, the headquarters of Boeing and Airbus, respectively. There is a hierarchy of tiers within the industry. First-tier suppliers are differentiated from lower-tier

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[1] In 1978, the U.S. Congress passed the Airline Deregulation Act; deregulation was to be completed by December 31, 1985. See *Global Competitiveness of U.S. Advanced-Technology Industries: Large Civil Aircraft*, USITC publication 2667, Aug. 1993, p. 3-12.

suppliers by the magnitude of sales to Boeing and Airbus, or by the complexity of the aerostructures they supply.[2] Second- and third-tier suppliers manufacture the parts and subassemblies for integration by the first-tier suppliers. In addition, the industry is segmented by product, with a limited number of producers manufacturing the most complex aerostructures. Since Boeing's acquisition of McDonnell Douglas in 1997, Boeing and Airbus have been the primary customers of LCA aerostructures and also the leading manufacturers of these products. Figure 2-1 illustrates the downstream flow of LCA aerostructures and figure 2-2 depicts the composition of the LCA aerostructures industries in the regions covered in this study.

In addition to Boeing, 14 LCA aerostructures manufacturers operate in the United States. Most are independent producers that have traditionally supplied Boeing. The 11 major Canadian LCA aerostructures producers, many of which are subsidiaries of foreign companies, are relatively small.[3] The 18-producer European LCA aerostructures industry is dominated by Airbus and its four subsidiaries; most of the remaining European producers are state-owned operations or are affiliates of larger corporations. The leading Asian aerostructures producers, many of which are subsidiaries of conglomerates, are concentrated in Japan, Korea, and China. Although there are producers in Argentina, Brazil, India, Israel, Malaysia, Taiwan, and Turkey, their output is largely limited to non-LCA applications outside the scope of this study.

Because of product design and manufacturing commonalities, many aerostructures firms produce for both the civil and military markets and offer other aerospace-related products, such as regional jets, and services, such as maintenance, repair, and overhaul (MRO). Although North American and European firms generally have diversified product portfolios, most have traditionally supplied only one LCA manufacturer (usually the aircraft manufacturer in their respective region). Asian LCA aerostructures manufacturers produce for both LCA manufacturers, although Boeing has made greater inroads into this region, particularly in Japan.

Demand for LCA aerostructures depends directly on cyclical demand for LCA by airlines, which, in turn, largely depends on business cycles. Figure 2-3 illustrates the positive relationship between LCA orders and business cycles. Growth in gross domestic product (GDP) spurs consumer confidence and disposable income, which increases demand for air travel and aircraft. While trends in LCA deliveries tend to lag behind global business cycles by about 36 months, trends in aerostructures shipments tend to precede LCA deliveries by 18-24 months.

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[2] In Europe, first-tier aerostructures suppliers generally supply aerostructures with complex systems integrated directly to Airbus, while first-tier suppliers to Boeing generally supply the largest aerostructures, but without systems installed. Boeing may be migrating towards the Airbus model of supplier responsibility, as it enables Boeing to lessen its procurement costs and manufacturing inputs while concurrently shifting more responsibilities to its suppliers.

[3] Two of these aerostructures producers are subsidiaries of Boeing.

Figure 2-1
Downstream Flow of LCA Aerostructures

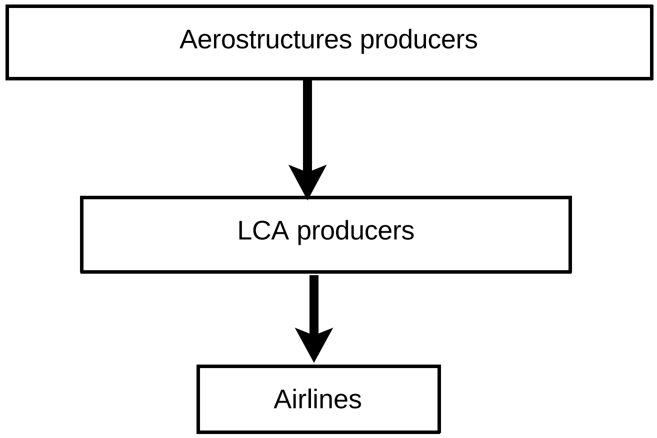


Figure 2-2
Composition of the LCA Aerostructures Industries in Europe, North America, and Asia

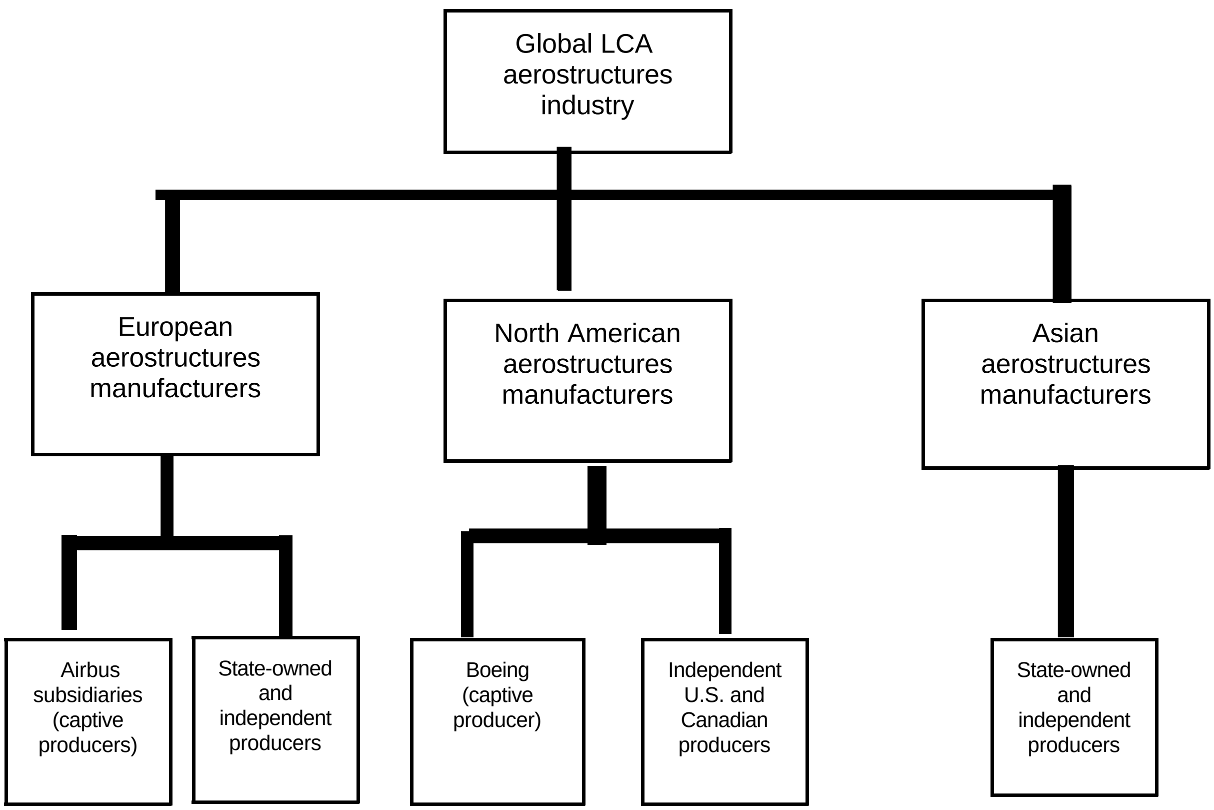
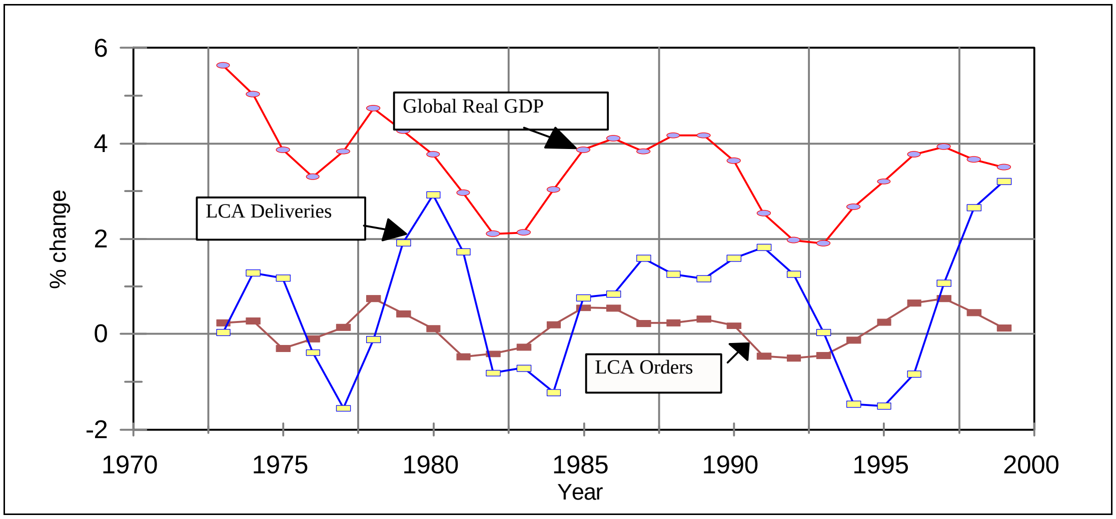


Figure 2-3
Real GDP, LCA Deliveries, and LCA Orders, 3-year Moving Average, 1970-99



Source: International Monetary Fund, *World Economic Outlook 2001,* and *World Jet Inventory, at Year-End*, 1999.

Airbus and Boeing predict that total deliveries of LCA for fleet renewal and growth will reach 14,661 and 18,121, respectively, during 1999-2019. This change represents a 47- to 82-percent increase over the period 1978-98, when 9,972 LCA were delivered. Both Boeing and Airbus more than doubled deliveries during 1995-99 (table 2-1). During 1999-2000, however, Boeing's aircraft deliveries dropped by 21 percent and its share of total deliveries fell to 61 percent, while Airbus's deliveries grew by about 5 percent and its share of total deliveries rose to 39 percent. While LCA aerostructures output data are not available, suppliers likely would have experienced comparable shifts in output related to deliveries of LCA programs for which they have supply contracts.

Table 2-1
LCA deliveries, by manufacturer, 1995-2000

Year	Boeing	Boeing's share	Airbus	Airbus's share	Total	Percentage change of total
		Percent		*Percent*		*Percent*
1995	257	68	123	32	380	
1996	270	68	126	32	396	4.21
1997	376	67	182	33	558	40.91
1998	563	71	229	29	792	41.94
1999	620	68	294	32	914	15.40
2000	489	61	311	39	800	-12.47

Source: Boeing, found at Internet address *http://www.boeing.com/commercial/orders/delsumbyyear.html*, retrieved Apr. 5, 2001; Jet Information Services, Inc., *World Jet Inventory Year-End 1997*, Mar. 1998, p. 14; and Airbus letter Jan. 2001, found at Internet address *http://www.airbus.com/media/letter.asp#8*, retrieved Apr. 5, 2001.

Structural Characteristics

Bilateral Oligopoly

Because the LCA manufacturing industry and many of the segments of the aerostructures industry are dominated by a few large firms, the markets in which these companies sell can be characterized as oligopolies. Certain segments of the aerostructures market can be viewed as bilateral oligopolies: a few buyers facing a few sellers, both with market power. Powerful buyers facing powerful sellers means prices are negotiated. Indeed, in this situation, prices have been characterized as "indeterminant with a vengeance."[4] For example, there are several major manufacturers of body panels. In this case, the buyers are fewer in number and larger in size than the suppliers, and so they may have more leverage in contract negotiations. This leverage was likely enhanced by Boeing's acquisition of McDonnell Douglas, eliminating a rival outlet for aerostructures suppliers. As a result, Boeing and Airbus may have sufficient buying power to restrain the pricing power of the aerostructures suppliers when they are bidding for major contracts.

Two key factors have led to increased price pressure on the suppliers. First, airline deregulation generated pricing pressure on LCA manufacturers, which have been passed on to the suppliers. In addition, Boeing's acquisition of McDonnell Douglas and the concurrent cancellation of some McDonnell Douglas programs added to existing excess global capacity in the aerostructures industry.[5] Excess capacity allowed Boeing and Airbus to exploit their bargaining power by offering volume contracts and negotiating discounted prices.[6]

Figure 2-4 describes a simple microeconomic model of supply and demand for aerostructures suppliers. It characterizes the effect of the decrease in the number of buyers from three to two on bargaining positions and price.

The framework presented in figure 2-4 characterizes a basic feature of the aerostructures market. As the number of aerostructures buyers fell from three to two and a number of LCA programs were cancelled, Boeing and Airbus gained market power. With the resulting excess capacity, Boeing and Airbus gained additional bargaining power, further restraining aerostructures firms' pricing power. Consequently, aerostructures manufacturers have felt increased pressure to cut costs, as well as increase their production responsibilities.[7]

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[4] There is no single theory of oligopoly because the behavior of oligopolistc firms is determined by the reaction and behavior of their rivals, and the assumptions they make about those reactions. See Jean Tirole, *The Theory of Industrial Organization* (MIT Press: 1988), pp. 218-234; and F.M. Scherer and David Ross, *Industrial Market Structure and Economic Performance* (Houghton Mifflin; 1990), pp. 17, 527-536.

[5] U.S. and European industry officials, interviews by USITC staff, United States, Jan. 2001, and Europe, Sept.-Oct. 2000.

[6] U.S. and European industry officials, interviews by USITC staff, United States, Jan. 2001, and Europe, Sept.-Oct. 2000.

[7] This discussion does not address Boeing's status as a major aerostructures producer. However, including this consideration would only strengthen the case for increased buying power, since Boeing could use its ability to produce aerostructures as further leverage.

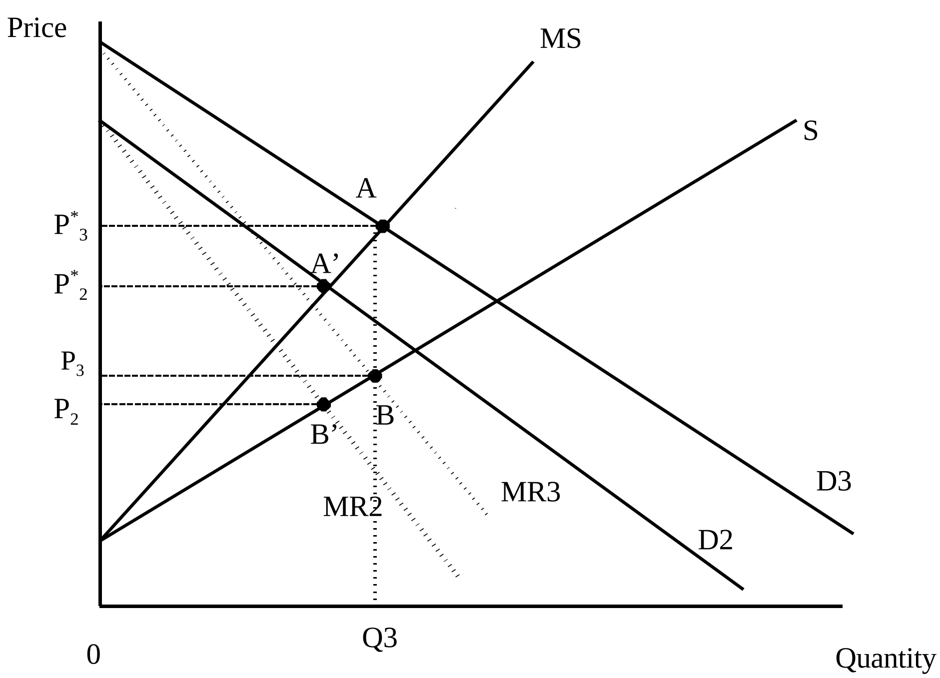
Figure 2-4: Bilateral Monopoly and Effects on Pricing

Because there is no single theory of oligopoly, the increased pricing pressures facing aerostuctures suppliers may be best illustrated by building from a bilateral monopoly model.[1] Consider a single aerostructures supplier facing three LCA buyers who, because they are few in number, may be able to exercise near monopsonist power. The figure below represents supply and demand for a given aerostructures supplier. The demand curve for the firm is derived from the demand for LCA and corresponds to the marginal revenue product of aerostructures as used in LCA.

Prior to Boeing's acquisition of McDonnell Douglas, the initial demand for the input factor (aerostructure) by Boeing, Airbus, and McDonnell Douglas is D3, the marginal revenue with respect to the derived demand for the aerostructure is MR3, and the supply is S. A single buyer facing an upward-sloping supply curve must pay a higher price to induce the supplier to supply additional units of the factor. In order to increase purchases by one more unit, the buyer must move to a higher point on the supply curve. This will involve paying not only a higher price for the additional unit but also a higher price for those units already employed. Consequently, the monopsonist's consumption decision will be made along the marginal supply curve MS, which lies above the supply curve.

Buyers' (Boeing, Airbus, and McDonnell Douglas) maximum willingness to pay for a given quantity (Q3) of aerostructures is P_3*. (Quantities are determined by other variables outside the scope of this discussion. While the graph suggests a decrease in quantity sold, a fuller model would leave the change in quantity ambiguous.) Aerostructures suppliers are willing to accept as little as P_3. The market price, which lies between P_3 and P_3*, is determined by the respective bargaining power of buyers and sellers. If buyers (sellers) have more bargaining power the price will be near P_3 (P_3*).

When the number of buyers decreases from three to two, demand falls from D3 to D2 and the MR curve shifts accordingly to MR2. The new price range is between P_2 and P_2*. As power shifts toward buyers, the bargaining range shifts downward from P_3 to P_3*, to P_2 to P_2*. Once again, the market price (and, in a fuller model, service) is determined by the respective bargaining powers. It is likely that the merger would increase the bargaining power of the buyers. Such an outcome would be consistent with the evidence in the following chapters that aerostructures suppliers are facing increased price pressures and more aggressive contract terms.



[1]See Scherer and Ross, *Industrial Market Structure and Economic Performance*, pp. 17, 527-536.

Another aspect of the decrease in buyers of aerostructures is the polarization of the supplier industry. Aerostructures manufacturers typically supply only one LCA manufacturer–Boeing or Airbus. To the degree that the suppliers are dependent on only one buyer, the suppliers' bargaining power is further compromised, which explains suppliers' interest in participating in both Boeing and Airbus programs.[8]

Consolidation and Globalization

Consolidation has been prevalent in the United States and Europe over the past decade, particularly among the higher-tier suppliers, which are closer to the LCA manufacturer and typically assume more responsibilities than lower-tier suppliers. Consolidation and globalization of the aerostructures industry have been driven largely by pricing pressures and overcapacity. The resulting consolidation of LCA aerostructures firms should lower capacity, increase firms' bargaining power (although not enough to outweigh that of the two buyers), encourage the emerging consolidated aerostructures firms to focus on core competencies,[9] and allow suppliers to pool their capital and technical resources to increase their ability to enter risk-sharing agreements. This trend is encouraged by the preference of Boeing and Airbus to simplify their supplier networks and reduce handling and transactions costs by relying on fewer but larger, more capable suppliers.[10] This supply base reduction strategy extends to aerostructures manufacturers as well, which continue to reduce their own supplier base.[11]

The LCA aerostructures industry is increasingly global, as LCA manufacturers and their suppliers source, produce, and sell their products around the world. One force behind industry globalization has been the desire to gain market access for LCA (i.e., offsets). By subcontracting aerostructures production to industries in targeted markets, LCA manufacturers hope to gain a competitive advantage when the purchase of new aircraft is considered by airlines in those regions. Decisions to subcontract from a foreign source often involve weighing the benefits of market access and low labor costs against the disadvantages of infrastructure deficiencies and the significant resources needed to ensure that the final product meets stringent quality requirements.

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[8] Also, industry experts have noted other advantages to a diversified customer base, such as improved access to technology, greater ability to be more selective on contracts and programs, and the ability to offset regional or LCA manufacturer-specific business cycles. U.S. and European industry officials, interviews by USITC staff, United States, Jan. 2001, and Europe, Sept.-Oct. 2000. For more information, see ch. 3.

[9] Prehearing submission of Aerospace Industries Association, Inc. in connection with inv. No. 332-414, *Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry,* Jan. 8, 2001, p. 5.

[10] William B. Scott, "Industry Consolidation Seen Shifting to Subcontractors, Suppliers," *Aviation Week & Space Technology,* Jan. 1, 2001, pp. 63-64; and, U.S. industry officials, interviews by USITC staff, June-Aug. 2000 and Jan.-Apr. 2001.

[11] U.S. industry officials, interviews by USITC staff, June-Aug. 2000 and Jan.-Apr. 2001.

Risk-sharing and R&D Arrangements

Because of the high investment, high risk nature of the LCA business and the increasing pressures to reduce costs, airframers increasingly look to aerostructures producers as potential risk and revenue sharers in new LCA programs.[12] Risk-sharing partners are expected to devote time, labor, capital, and R&D resources to design a specific part; decide with which suppliers to subcontract; integrate systems; and ensure that the final product meets quality standards. Such arrangements not only provide much needed funds, but also allow airframers to assign the time-consuming management of lower-tier suppliers to their aerostructures partners. As a result, the role of the supplier has been enhanced and elevated.

Industry sources report that build-to-print/build-to-spec subcontractors typically recover nonrecurring costs up front and unit costs as they deliver the components, while risk-sharing partners typically prorate their investments in such items as tooling and test equipment over an agreed-upon number of aircraft. If the sales goal is exceeded, the risk-sharing partner recoups its costs and earns additional profit. If the goal is not met, the risk-sharing partner must absorb a portion of the nonrecurring costs.[13]

Risk-sharing arrangements that allow suppliers to work with airframers in the product development, planning, and process stages familiarize suppliers with the airframer's needs and enhance suppliers' R&D capabilities, which may help in bidding on a program.[14] In addition, suppliers are better positioned to manage costs when they are involved in the R&D and design phases. This is an important advantage when the LCA producer requires that cost reductions coincide with increases in production.[15]

Contract Terms

Traditional supplier contracts with airframers involve competitive bidding, whereby potential suppliers provide an estimated cost of production for the part being outsourced.[16] By comparison, airframers using a directed procurement method dictate a predetermined price to a chosen aerostructures

[12] The level of financial investment necessary to develop a new aircraft program often requires an LCA producer to effectively wager the future of the company. See *The Changing Structure of the Global Large Civil Aircraft Industry and Market,* USITC publication 3143, Nov. 1998, p. 2-1.

[13] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000; and *The Changing Structure of the Global Large Civil Aircraft Industry and Market*, p. 2-2.

[14] U.S. industry officials, interviews by USITC staff, United States, May-Sept. 2000.

[15] U.S. industry officials, interviews by USITC staff, United States, May-Sept. 2000; and European industry officials, interviews by USITC staff, Europe, Sept.-Oct. 2000.

[16] Final supplier lists are determined after existing suppliers put forward proposals on how they would meet specific criteria. Increasingly, such criteria include taking responsibility for the complete design, development, and manufacture of an aerostructure, and support of larger and more complex work packages. Other criteria considered by purchasers include on-time delivery, quality benchmarks, and performance guidelines formally established between the customer and supplier. Those suppliers not meeting the criteria may no longer be considered for current and/or future programs. PricewaterhouseCoopers LLP, *Canadian Aerospace Suppliers Base Strategy for Change*, June 1999, p. 44.

manufacturer.[17] The supplier then evaluates the proposed work along with the price to be received and determines whether an agreement is feasible. A third type of contract involves risk sharing on the part of the supplier, as explained above. The use of risk-sharing partnerships and directed procurement has increased overall as airframers seek to reduce costs. In general, producers prefer to have more than one supplier per component, though they require fewer suppliers than they did a decade ago.[18]

Along with these trends, contracts have been extended in time and expanded in scope.[19] Long-term agreements (LTAs) are multiyear contracts between LCA producers and aerostructures manufacturers that promise suppliers a guaranteed volume of business over a number of years in exchange for achieving aggressive annual productivity goals. Specifically, LTAs incorporate productivity increases over time, which involve lower unit prices paid to the supplier as production increases. LTAs typically replace competitive bidding, are reserved for top-performing suppliers, and tend to provide a measure of stability to aerostructures suppliers. Accordingly, LTAs theoretically afford the supplier more efficient production planning and effective control over costs than shorter-term contracts, as well as the ability to recoup fixed investment costs.

Recently, airframers reportedly have been breaking and renegotiating LTAs, demanding production schedule changes and price reductions. This trend seems to follow the cyclicality of LCA demand.[20] Airframers prefer to use LTAs when aircraft orders are abundant; however, when new orders start to decline, pressure on profit margins often spurs airframers to try to renegotiate contract terms.[21] With declining LCA demand rendering cost reductions essential, LCA producers are looking to suppliers for more favorable pricing,[22] and have been building year-to-year price reductions into original LTAs. In addition, the trend toward consolidation in the aerostructures industry has prompted airframers to attempt to renegotiate contracts to benefit from the economies of scale that suppliers claim will emerge from their merger and acquisition activity.[23] Because of the nature of the supplier/customer relationship, suppliers have little recourse when airframers request changes to contract terms.[24] As a result, it has become increasingly important for suppliers to be operationally flexible in order to respond to changes in production schedules and delivery dates.[25]

As LCA manufacturers work to decrease the number of suppliers and reduce costs, contracts have expanded in scope to allow for increased responsibilities on the part of first-tier suppliers. These suppliers are increasingly expected to provide completed structures with systems installed, guarantee that all systems will operate within the aerostructure, and ensure that the structure and systems will be

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[17] Airframers may predetermine prices based on a supplier's prior experience, overhead and labor costs, and available manufacturing techniques. U.S. industry officials, interviews by USITC staff, United States, May-Sept. 2000.

[18] U.S. industry officials, interviews by USITC staff, United States, June 2000.

[19] For example, a typical contract currently may cover a 5- to 10-year period versus 1- to 3-year terms previously. U.S. industry officials, interview by USITC staff, United States, Feb. 1998.

[20] Many LTAs date from 1996, when there were large numbers of new aircraft orders.

[21] Anthony L. Velocci, Jr., "Pattern of Broken LTAs Raising Supplier Angst," *Aviation Week & Space Technology*, Sept. 13, 1999, p. 73.

[22] Velocci, "Pattern of Broken LTAs," p. 73.

[23] Jean Dupont, "Mega-suppliers take on the airframers," *Interavia*, Jan. 2000, p. 16.

[24] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000.

[25] Excerpt from a supply-chain management benchmarking study conducted by The Performance Management Group LLC, reported in Anthony L. Velocci, Jr., "Aerospace Still Trails Commercial Electronics," *Aviation Week & Space Technology*, Sept. 13, 2000, p. 69.

entirely compatible with other structures and systems. As noted, first-tier suppliers are also expected to manage the supply chains that contribute to these assemblies and assume some of the nonrecurring costs of design and manufacturing. In some cases, these responsibilities are pushed down the supply chain.

Subcontracting

Aerostructures manufacturers subcontract with other suppliers for the same reasons that airframers subcontract. Subcontracting noncore activities, in addition to providing aerostructures manufacturers the opportunity to share manufacturing burden and financial risk, allows firms to focus R&D and workforce skills on the more profitable aspects of their business. In some cases, subcontracting allows increased market access and a measure of foreign exchange protection.

Manufacturing Trends

LCA aerostructures production involves highly complex design and manufacturing processes. Innovative manufacturing techniques such as lean manufacturing can lead to significant productivity gains, cost savings, and better customer service. Such gains can outweigh the costs of lean manufacturing that include flexible tooling, enhanced support functions, and extensive training over time. Several industry officials indicate an increased use of such innovative manufacturing techniques in their operations.[26] According to other industry analysts, however, the aerostructures industry has been slow to implement lean manufacturing techniques fully.[27] One possible reason is that meeting unexpected changes in delivery dates or quantities during the manufacturing cycle can be prohibitively expensive with lean manufacturing.[28]

Given the large cost share of tooling and equipment, the only economical time to add or upgrade expensive tooling significantly is at the inception of a new program.[29] As newer programs utilize more technologically advanced tooling and equipment, suppliers involved in new LCA programs learn to develop and use new technologies and manufacturing methods that they otherwise would not. Thus, a supplier's manufacturing capabilities and competitiveness are related to its involvement in the latest LCA programs.

Computer-aided design and manufacturing is a significant upgrade in manufacturing technology that is playing an increasingly important role in the working relationship between airframers and aerostructures suppliers. Today, most parts of an aircraft can be designed on the computer, with the entire manufacturing process planned and the aircraft's lifetime maintenance needs dictated. Digital manufacturing simulates the manufacturing process by using three-dimensional computer-aided design software models, which provide communication and visualization capability to support collaborative

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[26] U.S. and European industry officials, interviews by USITC staff, United States, May-Sept. 2000, and Europe, Sept.-Oct. 2000.

[27] "Effective Application of Lean Remains Disappointing," *Aviation Week & Space Technology*, Jan. 22, 2001, p. 60.

[28] "Correspondence," *Aviation Week & Space Technology*, Feb. 19, 2001, p. 9.

[29] U.S. industry officials, personal and telephone interviews by USITC staff, United States, May-Sept. 2000.

work on digital mockups. By linking manufacturing centers, digital manufacturing can help to facilitate the manipulation of the knowledge base across several stages, so pieces of the LCA "fit together" on the first attempt. The goal is to streamline the manufacturing process by catching errors in simulation instead of in practice. Digital manufacturing contributes to more efficient, less costly aerostructures production.

Specialization and Diversification

Due to the limited number of new aircraft programs and buyers of LCA aerostructures, the loss of a contract or inability to win a contract on a specific aircraft program may result in the failure of a firm. As a result, some industry participants try to lessen the risk by diversifying into either related businesses, such as aircraft MRO, or businesses outside of the scope of LCA aerostructures. On the other hand, specialization in the production of certain types of aerostructures can help suppliers establish themselves as leading producers in a particular niche of the industry by allowing them to develop technical expertise in design and gain supply chain management experience. While some analysts assert that product specialization in aerostructures is viewed favorably by larger aerostructures firms and airframers, since it allows suppliers to take on more responsibilities, other analysts suggest that more diversified aerostructures producers may have the advantage during periods of lower demand by airlines for LCA.[30]

Determinants of Competitiveness

LCA manufacturers invite select suppliers from among the more competitive firms to bid on aircraft programs. The LCA industry is highly regulated, and Boeing and Airbus expect all of their aerostructures suppliers to pass several comprehensive certification and qualification tests.[31] Thus, the ability to produce quality aerostructures is the minimum requirement to be considered in the bidding process and is not considered a key determinant of competitiveness.

Firms compete on both cost and noncost factors to win contracts. The cost factors that affect price include production efficiency, labor, capital, and economies of scale and learning effects. The principal noncost factors include technological capabilities and on-time delivery and flexible production capacity. Finally, a factor external to the firm that can affect competitiveness is exchange rates.

The determinants of competitiveness in the aerostructures industry depend on the tier of the supplier. Generally, the higher the tier, the more important is a supplier's ability to share risk, which requires a sufficiently large financial base and high level of technical expertise. As airframers continue to shift responsibilities to their suppliers, many of the determinants of competitiveness in the

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[30] "Big Orders for Big Airplanes," *Air Transport World*, Sept. 2000, p. 54.

[31] U.S. and European industry officials, interviews by USITC staff, United States, May 2000, and Europe, Sept.-Oct. 2000.

aerostructures industry, particularly at the higher tiers, tend to resemble those of the LCA industry itself.[32]

Cost Factors

Production Efficiency

Airframers are increasingly requiring their suppliers to improve productivity over time and incorporate efficiency-enhancing manufacturing techniques, which contribute to cost-effective aerostructures production. The ability of LCA aerostructures suppliers to accommodate airframers' requests for productivity and efficiency step increases (an increase in productivity or decrease in unit cost along a specified production schedule) is often a function of their technological capabilities and financial resources.

Labor

Wages and other benefits affect labor costs in proportion to the size of the workforce. In general, low labor costs (wages and other benefits) and the ability to adjust the size of the workforce are considered competitive advantages at all tiers of the aerostructures industry. The ability to expand or contract the size of the production workforce in accordance with production levels minimizes labor costs. Restrictive labor laws may cause firms to be under-staffed in boom periods and over-staffed in recessionary periods. In contrast, the ability to reduce staffing levels in slow times and then re-hire in boom times means that firms must incur (re) training costs.[33] Substituting capital for labor can be a means of increasing efficiency when constraints exist on the flexibility of a country's labor force, either by legislation, regulation, or a lack of human capital.

The labor cost share of the total production cost depends on the type of aerostructure being produced, i.e., the complexity of the aerostructure, and the age of the production equipment. Newer production equipment usually requires less labor input than older equipment. Therefore, the efficiency of the equipment and the labor cost can be gauged by the age of the LCA program they serve. As Airbus programs are generally more recent than Boeing programs, they likely require less labor input for the same level of production, or have a lower labor cost share.

Capital

The magnitude of investment required to become an aerostructures supplier sets the highly capital-intensive aerostructures industry apart from most other manufacturing sectors. Because participation in LCA programs normally requires large sums of capital, the ability to obtain necessary

[32] For example, some of the key determinants of competitiveness in the global LCA industry include availability of capital, design capabilities, and direct and indirect government support. See ch. 4, *Global Competitiveness of U.S. Advanced-Technology Manufacturing Industries: Large Civil Aircraft*; and ch. 2, *The Changing Structure of the Global Large Civil Aircraft Industry and Market: Implications for the Competitiveness of the U.S. Industry.*

[33] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

financing is a competitive advantage.[34] Capital may be used for several purposes, such as acquiring or developing new manufacturing and tooling equipment, managing the supply chain, conducting R&D, training, and investing in new infrastructure. Availability of capital also enables suppliers to enter increasingly prevalent risk-sharing arrangements. Much of the capital required for risk sharing is used for up-front or "sunk" costs. Established aerostructures suppliers are likely to have a higher credit rating and greater access to lower-cost commercial capital than new entrants, thus providing an inherent advantage in this regard.

Government assistance contributes to an aerostructures firm's ability to raise capital and/or participate in risk-sharing agreements. Government assistance may consist of low interest loans or launch aid that may include R&D funding and contribute to the acquisition of new, technically advanced equipment.[35] In this way, government support can subsidize long-run production costs and ultimately allow firms to offer a lower bottom line price to purchasers.

Economies of Scale and Learning Effects

Cost efficiencies may be derived through lengthy production runs that allow a manufacturer to spread high development costs over more units of aerostructures and realize scale economies through both direct and indirect costs. Direct costs are affected by raw material prices, the efficiency of the equipment being utilized, and the skill levels of the workers operating that equipment. For example, achieving scale economies might result in volume price discounts for raw materials or allow an increase in automation that could reduce direct costs. Indirect or overhead costs are largely a function of the overall corporate structure.

Production runs also provide a learning effect that can reduce unit production costs as output increases.[36] This provides an incumbent supplier with an advantage over a new entrant. There are two types of learning-related effects that arise from prior experience. The first is learning-by-doing, whereby the firm increases its productivity on a certain aerostructure because of the expertise gained in the long-term production of the item. The second learning effect results from a supplier working with an airframer on a program and over time learning procedures, such as quality control, that are specific to that airframer. This type of learning benefits the experienced supplier in future contracts with that LCA manufacturer since the time required to learn such procedures has already been invested.

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[34] For instance, new aircraft programs are estimated to cost up to $13 billion, which includes designing, developing, and bringing a product to market, assuming the manufacturing and supplier infrastructure is in place. Chris Avery, *Industry Analysis: European Civil Aerospace Industry* (London: J.P. Morgan Securities Ltd. Equity Research, 2000), p. 61.

[35] U.S. industry officials, interview by USITC staff, United States, June 2000.

[36] *Global Competitiveness of U.S. Advanced-Technology Manufacturing Industries: Large Civil Aircraft*, p. 4-5.

Noncost Factors

Core Competencies

The core competencies of a supplier, such as technological and management capabilities, determine whether it is able to build to an airframer's specifications, assume R&D and design responsibilities, and maintain a supply network. New technology is considered viable if it reduces operating costs significantly. Firms may develop in-house technological capabilities through (1) investing in R&D, (2) gaining experience on programs in which they participate, e.g., risk-sharing agreements involving design and R&D, (3) hiring highly skilled workers, and (4) entering into licensing agreements or acquiring other more technologically advanced firms.

A supplier's ability to establish and maintain an efficient supply network is also important, since suppliers are increasingly required to manage their own supply chains. This is particularly true for the higher-tier suppliers as Boeing and Airbus seek to deal with fewer, larger suppliers. Also, as LCA manufacturers work to meet airlines' increasing demands to reduce the purchase price and operating costs of aircraft, aerostructures suppliers must search for lower-cost suppliers, and make their own supply network more efficient. In downsizing a supply network, a firm faces the inherent tension between maintaining only the efficient and low-cost suppliers, and maintaining a sufficiently diversified supply network so as not to become overly dependent on one supplier at any level.

On-time Delivery and Flexible Production Capacity

The ability to meet delivery schedules is essential to the success of aerostructures firms. If a supplier misses the delivery date, the LCA manufacturer must either find an alternative source (which may not exist) or, in most cases, delay production until the supplier delivers,[37] thus disrupting the manufacturing process. The LCA manufacturer, in turn, risks not meeting the promised delivery date to the airline, which may jeopardize the terms of present and future contracts.[38] Also, a flexible production capacity is important because airframers may change their production needs or delivery dates. Thus, the ability to increase or decrease production on short notice helps suppliers meet the customer's changing needs.

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[37] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[38] 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. See *Global Competitiveness of U.S. Advanced-Technology Manufacturing Industries: Large Civil Aircraft*, p. 4-10.

CHAPTER 3
THE U.S. LCA AEROSTRUCTURES INDUSTRY

Introduction

Early global leadership in the aircraft industry resulted in the development of a highly competitive aerostructures industry in the United States. However, the U.S. aerostructures industry has lost some of its competitive edge over the past decade due to LCA industry consolidation, aging U.S. manufacturing equipment, increasing demands placed on suppliers by LCA producers, and rising foreign competition, as the only U.S. LCA producer increases its placement of aerostructures work overseas for market access and cost reasons.

In a more competitive, deregulated airline market, LCA producers are attempting to increase LCA manufacturing efficiencies and cut costs by placing more design, manufacturing, risk-sharing, and supply chain management responsibilities on suppliers, while concentrating on their own core competencies of overall aircraft design, systems integration, and sales. To survive in this new environment, aerostructures producers must be capable of accepting these new responsibilities while at the same time reducing their own manufacturing costs if they are to retain sufficient profit margins to be successful.

Some U.S. aerostructures firms appear to be successfully responding to these new conditions by increasing the scale of their operations and the depth of their expertise through consolidation, adopting more efficient and cost-saving measures, such as lean manufacturing and digital technology methods, and taking on more supply chain management and other responsibilities previously held by LCA producers. However, U.S. firms that are unable to make the required adjustments likely will not prosper in the LCA aerostructures industry.

This chapter will discuss U.S. structural and market indicators, including the identification of major aerostructures producers and recent trends in production, trade, and employment; significant U.S. industry developments; and implications for the competitiveness of the U.S. industry.

Industry Structure and Market Indicators

Composition of the Industry

The U.S. LCA aerostructures industry consists of 15 firms (table 3-1), with the Boeing Co. (Boeing), Vought Aircraft Industries, Inc. (Vought), Goodrich Corp.[1] (Goodrich), and the Aerostructures Corp. (Aerostructures) accounting for a majority of U.S. production.[2] Boeing is by

[1] On April 17, 2001, shareholders of the BFGoodrich Company approved Goodrich Corporation as the company's new legal name, effective June 1, 2001.

[2] Based on responses to USITC producer questionnaire in connection with inv. No. 332-414, *Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry*, and telephone, facsimile, and e-mail communications from U.S. industry officials, Jan.-Apr. 2001.

Table 3-1
U.S. aerostructures producers, plant locations, aerostructures produced, and LCA customers

U.S. aerostructures producers (parent)	Plant location(s)	Aerostructures produced	LCA customer(s)
Advanced Technical Products, Inc.: Marion Composites Division	Marion, VA	Flap track fairings	Airbus
Aerostructures Corp. (Carlyle Group)	Nashville, TN	Wing and tail sections	Airbus
BAE Systems North America	Palmdale, CA	Wing sets	Boeing
Boeing Co.	Greater Seattle, WA; Greater Southern CA; Wichita, KS	Fuselages, wings, tails	Boeing
Castle Precision Industries	Sylmar, CA	Landing gear	Boeing
Compass Aerospace Corp. (MacLuan Capital Corp.)	Santa Ana, CA; Gardena, CA; Shelton, WA; Wichita, KS	Wing control surfaces	Boeing, Airbus
Composite Structures	Monrovia, CA	Flaps	Boeing
Ducommun Inc.	Long Beach, CA	Leading edge assemblies	Boeing, Airbus
Goodrich Corp.	Brecksville, OH	Landing gear	Boeing
Hexcel Corp.	Kent, WA	Wing-to-body and flap track fairings, leading and trailing edge panels, wing skins	Boeing
Hitchcock Industries	Minneapolis, MN	Leading edge flaps	Boeing
LMI Aerospace, Inc.	St. Charles, MO	Leading edges, slats, flaps, fuselage skins	Boeing
Stellex Aerostructures, Inc. (Stellex Technologies, Inc.)	Amityville, NY	Frames and stringers for fuselages	Boeing
Triumph Group, Inc.	Wayne, PA	Wing components and wing skins	Boeing
Vought Aircraft Industries, Inc. (Carlyle)	Dallas, TX; Hawthorne, CA	Fuselage and tail sections (including horizontal stabilizers), wing spoilers, center wing sections, trailing edge flaps	Boeing

Source: Aerospace Industries Association, company annual reports, and industry officials and analysts.

far the largest producer of aerostructures, assembling wings, fuselages, and tails for use in its own finished LCA. Vought, the second-largest U.S. LCA aerostructures producer, supplies aerostructures for numerous Boeing programs as well as for business and military aircraft.[3] Goodrich is one of the two largest producers of landing gear in the world, with production in Ontario, Canada, and Cleveland, Ohio. Aerostructures specializes in the manufacture of wing components and assemblies and has been the largest U.S. supplier of aerostructures to Airbus through its contracts with former Airbus partners BAE Systems and DaimlerChryslerAerospace (DASA).[4]

Many U.S. aerostructures producers also manufacture parts for general and regional aircraft, military aircraft, helicopters, and space vehicles, or products entirely unrelated to the aerospace industry. Vought and Aerostructures are the most specialized of the large aerostructures producers; however, both firms manufacture for military as well as commercial airplane markets. By contrast, Boeing and Goodrich are more diversified. Boeing, the sole U.S. customer of LCA aerostructures, manufactures commercial airplanes, aerostructures, military aircraft and missiles, and space and communications systems. Boeing also provides customer financing of airplanes. Reportedly, Boeing's present strategy is to reduce its dependence on cyclical civil aircraft demand by becoming more involved in the aviation services and support sector, an industry with an estimated market worth $2.6 trillion through 2019, compared to a market worth $1.5 trillion for new aircraft during the same period.[5] Goodrich manufactures complete LCA landing gear assemblies and many aircraft components and systems not covered in this study, in addition to producing engineered industrial products for a broad segment of the aerospace and other industries.

Although the U.S. aerostructures industry is less specialized than its European counterpart,[6] there appears to be a trend toward increasing specialization in the U.S. industry by certain firms.[7] Some U.S. industry officials and analysts believe that specialization improves the competitiveness of small- and medium-sized U.S. manufacturers as such firms develop greater expertise in their particular area.[8] On the other hand, some aerostructures producers do not want to become too dependent on one line of work due to the cyclical nature of LCA production.[9]

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[3] Vought was the aerostructures unit of Northrop Grumman until Northrop divested the unit in July 2000. Vought is a supplier of aerostructures for all Boeing commercial programs, except the 777. Vought has been a principal airframe subcontractor for the Boeing 747 since the program began in 1966, manufacturing fuselage sections, vertical and horizontal stabilizers, and other structural components. SEC 10-K filing, 1999, Northrop Grumman Corp.

[4] Portions of these two companies recently have been renamed Airbus U.K. and Airbus Germany, respectively.

[5] "Big Orders for Big Airplanes," *Air Transport World*, Sept. 2000, p. 54. Also see Bruce A. Smith, "Boeing Widens Reach to Generate Growth," *Aviation Week & Space Technology*, Mar. 19, 2001, pp. 100-102.

[6] For more information, see ch. 4.

[7] Anne Marie Squeo and Andy Pasztor, "Boeing Seeks to Overhaul Aircraft Manufacturing," *Wall Street Journal*, Mar. 26, 2001, pp. 1-3, found at Internet address *http://public.wsj.com*, retrieved Mar. 26, 2001; and U.S. and European industry officials, interviews by USITC staff, United States, June-Aug. 2000 and Jan. 2001, and Europe, Sept.-Oct. 2000.

[8] U.S. industry officials, in-person and telephone interviews by USITC staff, Aug.-Oct. 2000 and Jan.-Mar. 2001.

[9] U.S. industry, investment, and academic officials, in-person and telephone interviews by USITC staff, May-Oct. 2000 and Jan.-Mar. 2001.

U.S. shipments of aircraft and parts (table 3-2), including aerostructures (which are estimated to account for less than 10 percent of the total),[10] increased by an average annual rate of 11 percent to $95 billion during 1995-99.[11] This rise reflected the increasing global need to replace aging LCA; strong demand for additional passenger service in the United States and Western Europe, resulting in new routes begun by U.S. airlines; and the world airlines' efforts to maintain two reliable LCA producers.

Table 3-2
Aircraft and parts: U.S. producers' shipments, exports of domestic merchandise, imports for consumption, and apparent consumption, 1995-99

Year	U.S. producers' shipments[1]	Exports	Imports	Apparent consumption	Ratio of exports to shipments
		(*Million dollars*)			(*Percent*)
1995	62,158	23,684	6,072	44,546	38
1996	63,416	30,467	7,285	40,234	48
1997	73,908	38,477	9,356	44,787	52
1998	89,055	49,922	12,472	51,605	56
1999	95,280	47,492	12,273	60,061	50

[1] Includes U.S. producers' shipments of aircraft (SIC 3721) and aircraft parts and auxiliary equipment (SIC 3728), but does not include aircraft engines and engine parts (SIC 3724).

Source: Compiled from official statistics and estimates of the U.S. Department of Commerce.

As indicated in chapter 2, U.S. shipments of aircraft decreased in 2000.[12] Slowing demand by U.S. airlines for LCA,[13] ongoing inventory reductions by Boeing, and a strike at Boeing that reduced production all contributed to the decrease in U.S. shipments of aircraft.[14] Further, declining orders of aircraft by Asian airlines during the 1997-98 financial crisis in that region also contributed to reduced U.S. shipments of LCA in 2000. Most aerospace industry analysts and officials expect U.S. sales of

[10] Estimated by USITC staff based on responses to USITC producer questionnaire, and U.S. industry officials, telephone, facsimile, and e-mail communications, Mar.-Apr. 2001.

[11] The U.S. producers' shipment and trade data in this section are from official statistics and estimates of the U.S. Department of Commerce. The data represent U.S. producers' shipment and trade data for completed aircraft (SIC 3721) and aircraft parts and equipment not elsewhere classified (SIC 3728). There are no standard industrial classification (SIC) categories or U.S. harmonized tariff schedule (HTS) headings or subheadings that exclusively cover aerostructures.

[12] Official statistics and estimates of the U.S. Department of Commerce; David Napier, Director Aerospace Research Center, Aerospace Industries Association (AIA), *2000 Year-End Review and 2001 Forecast–An Analysis*, pp. 1-3, and tables 5 and 9, found at Internet address *http://www.air-aerospace.com*, retrieved Mar. 28, 2001; "Boeing Reports $1.01 EPS for the Fourth Quarter, Up 36% and 2000 EPS of $2.88, up 22%, Excluding Non-Recurring Items," *Boeing News Release*, Jan. 17, 2001, pp. 3, 5, and 8, found at Internet address *http://www.boeing.com/news/releases*, retrieved Apr. 4, 2001; and *Boeing 2000 Annual Report.*

[13] According to an AIA official, "Reduced shipments of commercial jetliners pulled civil aircraft sector sales down $5.9 billion in 2000. Sales of large civil transport aircraft declined approximately $2.7 billion to an estimated $31 billion." Napier, *2000 Year-End Review*, pp. 1-3.

[14] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, June-Dec. 2000 and Jan. 2001.

aircraft to recover in 2001 to 1999 levels and continue to grow moderately for the next several years as airline demand for new LCA recovers.[15] U.S. shipments by aerostructures producers showed similar trends, except that the decline in growth of aerostructures shipments occurred in 1999, rather than 2000, after relatively steady growth in aerostructures production during 1994-1998.[16] This earlier reduction in aerostructures production, compared to aircraft production, reflects the time it takes for aerostructures production to be incorporated in final aircraft assembly by LCA producers. Exceptions to this trend included several U.S. suppliers with sales to Airbus that experienced continued growth in shipments of aerostructures throughout the entire period 1995-99.[17]

Despite the decline in U.S. shipments of LCA aerostructures in 1999 and LCA in 2000, general aviation aircraft manufacture in the United States, and regional jet production in Europe, Canada, and Brazil, continued to grow.[18] A number of industry officials assert that such new programs present growth opportunities for U.S. LCA aerostructures manufacturers desiring to increase their customer base.[19]

Trade

U.S. trade in aerostructures consists both of direct exports of completed aerostructures for Airbus and imports of aerostructures from European, Asian, and Canadian producers for Boeing. Aerostructures accounted for less than 5 percent[20] of total U.S. trade in aircraft and parts, and less than 10 percent of total trade in aircraft parts alone, which amounted to $20 billion in 1999.[21] U.S. exports of aircraft and parts more than doubled to $47 billion during 1995-99 (table 3-2).[22] U.S. imports also more than doubled to $12 billion during the period, resulting in a U.S. trade surplus for aircraft and parts of nearly $35 billion in 1999. The largest portion of total U.S. aircraft and parts trade consisted of completed aircraft. Principal U.S. trading partners for aerostructures were Asian countries such as Japan, Korea, and China. Australia and Italy were also important U.S. trading partners in aerostructures. The largest share of U.S. aerostructures trade reportedly consisted of imports.[23]

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[15] Napier, *2000 Year-End Review*, p. 3; David M. Ainsworth, Byron K. Callan, and Suzanne E. Kecmer, "Aerospace Conferences Confirm Our Cautiously Positive View," *Merrill Lynch Reports*, Mar. 23, 2001, pp. 1-4; Ainsworth, Callan, and Kecmer, "Boeing Company: Change in the Air and on the Ground," *Merrill Lynch Reports*, Mar. 26, 2001, pp.1-2; and U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan. 2001.

[16] Responses to USITC producer questionnaire; company annual reports; U.S. industry officials, interviews by USITC staff, United States, Aug. 2000 and Jan. 2001; and Napier, *2000 Year-End Review*.

[17] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan. 2001; company annual reports and SEC 10-K filings; and responses to USITC producer questionnaire.

[18] Ibid.

[19] Ibid.

[20] Estimated by USITC staff based on responses to USITC producer questionnaire, official statistics of the U.S. Department of Commerce, and telephone, e-mail, and written communications from U.S. industry officials, Mar.-Apr. 2001.

[21] In 1999, U.S. imports of aircraft parts totaled $5 billion and U.S. exports of aircraft parts totaled $15 billion. The data are based on official statistics of the U.S. Department of Commerce.

[22] Based on official statistics and estimates of the U.S. Department of Commerce.

[23] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan. 2001.

According to some industry officials,[24] one of the reasons for these imports is the placement of aerostructures work in foreign countries in the form of offsets or as the result of "offset-like arrangements"[25] to facilitate sales of finished aircraft to indigenous airlines.[26] LCA aerostructures work placed by U.S. companies overseas results in aerostructures products that are eventually exported to the United States for final use in the assembly of LCA.[27]

Further, U.S. trade in aerostructures consists of the shipments of aerostructures assemblies and subassemblies in various stages of completion among U.S. and foreign contractors and subcontractors and LCA producers.[28] For instance, Boeing has subcontracted aerostructures production to manufacturers in Japan, China, Korea, Taiwan, and Italy.[29] Further, Boeing engages in intracompany trade of aerostructures parts and assemblies with subsidiaries in Canada and Australia.[30] Vought, a leading contractor and systems integrator for a number of Boeing airplane programs, has begun to produce a limited number of assemblies in China that are ultimately destined for use in the final assembly of LCA in the United States. Similarly, Aerostructures shares various stages of production of aerostructures for Airbus programs with Airbus U.K. and Airbus Germany.

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[24] U.S., European, and Canadian industry officials, interviews by USITC staff, United States, June-Aug. 2001 and Jan. 2001, Europe, Sept.-Oct. 2000, and Canada, Jan. 2001.

[25] The terms "offsets" and "offset-like arrangements" encompass a broad range of compensation practices required, implied, or otherwise expected by certain governments and commercial entities as a condition of purchasing defense or commercial products from foreign sources. Offsets may take different forms, including coproduction, licensed production, subcontractor production, overseas investment, and technology transfers. According to a recent report of the Presidential Commission on Offsets in International Trade, "foreign governments frequently negotiate offsets in connection with the imports of U.S. aerospace systems (e.g., military or commercial aircraft)..." and goods and services in other high-technology industries. "Presidential Commission on 'Offsets' in International Trade Issues Report," *Executive Office of the President Press Release*, Feb. 15, 2001, p. 1, found at Internet address *http://www.offsets.brtrc.net*, retrieved June 7, 2001; and *Status Report of the Presidential Commission on Offsets in International Trade*, Jan. 18, 2001, pp. 14-20. For more information on offsets, see USITC, *The Changing Structure of the Global Large Civil Aircraft Industry and Market: Implications for the Competitiveness of the U.S. Industry*, publication 3143, Nov. 1998, pp. G-3 to G-4.

[26] The roles played by Japanese airlines and aerospace manufacturing firms in Boeing's commercial transport programs have been increasing in recent years. Pierre Sparaco and Bruce A. Smith, "Airbus Makes Move on Boeing's Japan Turf," *Aviation Week & Space Technology*, Feb. 19, 2001, pp. 45-46; and Tsukasa Furukawa, "Mitsubishi emphasizes strong links with Boeing," *American Metal Market*, Mar. 12, 2001, p. 14. Boeing officials indicated they expected the recent placement of aerostructures work in Italy would lead to additional sales of aerospace products to that country. "Boeing to Move 757 Work to Wichita," *Reuters*, Mar. 26, 2001, pp. 1-2, found at Internet address *http://www.dailynews.yahoo.com*, retrieved Mar. 26, 2001. For more information, see chs. 4 and 6; and USITC, *Changing Structure of the Global Large Civil Aircraft Industry*, Nov. 1998, pp. 5-1 to 5-43.

[27] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan. 2001.

[28] Ibid.

[29] Ibid.; and Boeing annual reports and SEC 10-K filings, 1995-99.

[30] Ibid.

Workforce Characteristics

The U.S. aerostructures industry has benefitted from a highly skilled and experienced workforce. However, according to U.S. industry sources, some firms are presently having difficulties attracting new engineering and technical staff.[31] Total employment in the aircraft and parts industry increased from 357,500 in 1995 to 421,800 in 1998, before declining to 395,000 in 1999.[32] Aerostructures employment, which accounted for less than 10 percent of the total, followed the same trend as that for aircraft and parts, with increases during 1995-98, followed by a decline in 1999.[33] The recent employment decline reportedly occurred as manufacturers consolidated their operations and attempted to reduce production costs by eliminating duplicative manufacturing activities.[34] Despite these trends in the U.S. industry as a whole, several U.S. aerostructures producers continued to increase their employment in 1999 to meet recent long-term contracts signed with Boeing and Airbus.[35]

Most production jobs in the U.S. aerostructures industry entail highly skilled labor. Almost all aerostructures suppliers provide company-sponsored training through apprentice programs, sometimes supplemented through local college training programs.[36] Workers for many of the larger aerostructures manufacturers are predominantly represented by the International Association of Machinists and Aerospace Workers; the Society of Professional Engineering Employees in Aerospace; and the United Automobile, Aerospace and Agricultural Implement Workers of America.[37] However, employees at other aerostructures firms, including many of the smaller ones, have no union representation and are not subject to collective bargaining agreements.[38] Some U.S. aerostructures suppliers report that they are currently having difficulty attracting engineering and other technical graduates, who are more interested in high-technology computer networking and electronics careers.[39] According to these suppliers, this could present a problem for them because a large percentage of engineering staff in their companies will be retiring over the next decade.[40]

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[31] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan. 2001.

[32] Bureau of Labor Statistics, "Employment and Earnings" (Monthly), for SIC 3721 (aircraft) and 3728 (aircraft parts), which do not include aircraft engines and engine parts.

[33] Responses to USITC producer questionnaire; company annual reports and SEC 10-K filings; and U.S. industry officials, interviews by USITC staff, United States, Aug. 2000 and Jan. 2001.

[34] Company annual reports and SEC 10-K filings; and U.S. industry officials, interviews by USITC staff, United States, Aug. 2000 and Jan. 2001.

[35] Responses to USITC producer questionnaire; company annual reports and SEC 10-K filings; and U.S. industry officials, interviews by USITC staff, United States, Aug. 2000 and Jan. 2001.

[36] U.S. industry officials, interviews by USITC staff, United States, Aug. 2000 and Jan. 2001.

[37] U.S. industry officials, interviews by USITC staff, United States, June-Aug. 2000 and Jan. 2001; and company SEC 10-K filings.

[38] Ibid.

[39] U.S. industry officials, interviews by USITC staff, United States, Jan. 2001.

[40] Ibid.

Industry Developments

Globalization

According to many U.S. industry officials, Boeing and several of the larger U.S. aerostructures producers manufacture and subcontract an increasing amount of aerostructures production overseas,[41] reducing opportunities for other U.S. aerostructures suppliers[42] and adversely affecting their competitiveness.[43] Global sourcing is primarily being driven by market access considerations.[44]

In the U.S. industry, only Boeing has a significant international presence in LCA aerostructures manufacturing.[45] Boeing has contracted aerostructures work out to firms in Asia and Europe, and invested in its own facilities in Canada and Australia, in an attempt to enter new markets or increase its share of LCA sales to indigenous airlines. International partnerships based on technology or capability often are in the minority.[46] Goodrich likely became the second-most globalized U.S. aerostructures producer after obtaining the large Canadian landing gear manufacturer, Menasco, although its global manufacturing network is not nearly as extensive as that of Boeing.[47] Vought has also been experimenting with aerostructures manufacturing overseas, particularly in China.[48] Other U.S.

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[41] Sparaco and Smith, "Airbus Makes Move on Boeing's Japan Turf," pp. 45-46; "Mitsubishi emphasizes strong links with Boeing," p. 14; "Boeing to Move 757 Work to Wichita," pp. 1-3; USITC, *Changing Structure of the Global Large Civil Aircraft Industry*, pp. 5-1 to 5-43; telephone, e-mail, and facsimile communications from U.S. industry officials to USITC staff; and company SEC 10-K filings.

[42] Submission of the Aerospace Industries Association and the International Association of Machinists and Aerospace Workers, AFL-CIO in connection with inv. No. 332-414, *Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry*; U.S. industry and academic officials, in-person and telephone interviews by USITC staff, May-Dec. 2000 and Jan. 2001; and written communications from U.S. industry officials, Nov. 2000 and Jan. 2001.

[43] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, Aug. 2000 and Jan.-Mar. 2001.

[44] U.S. and European LCA producers both have cited market access as a key factor in overseas subcontracting; accordingly, countries with strong potential demand for aircraft are in a favorable position to solicit work packages, including joint-development arrangements with LCA producers such as Boeing, and to a lesser extent, Airbus. U.S. and European industry officials, interviews by USITC staff, United States, Feb. 1997, May-Aug. 2000, and Jan. 2001, and Europe, Apr. 1998 and Sept.-Oct. 2001.

[45] U.S. industry officials, interviews by USITC staff, United States, June-Aug. 2000 and Jan.-Mar. 2001; U.S. industry officials, telephone, facsimile, and e-mail communications, Jan.-Apr. 2001; and company annual reports and SEC 10-K filings, 1997-99.

[46] One example of a growing technology relationship between Boeing and a foreign manufacturer is the extensive collaboration Boeing has with Mitsubishi Heavy Industries, Ltd. (Mitsubishi) in stretching metal and building fuselage panels for Boeing on important projects such as the relatively new Boeing 777 program. Nevertheless, market access is still cited by U.S. industry officials as the major purpose for placing aerostructures production in overseas markets. U.S. industry officials, interviews by USITC staff, United States, Feb. 1998, June-Aug. 2000, and Jan. 2001.

[47] Goodrich obtained Menasco, which is a landing gear company with headquarters in Ontario, Canada, when Goodrich merged with Menasco's parent company, U.S.-based Coltec Industries, in 1999. Anthony L. Velocci, Jr., "BFG, Coltec Conclude Merger: Allied Signal Compensated," *Aviation Week & Space Technology*, July 19, 1999, p. 33; and SEC 10-K filing, Goodrich, 2000.

[48] U.S. industry officials, interviews by USITC staff, Jan. 2001; responses to USITC producer questionnaire; and Northrop Grumman annual reports and SEC 10-K filings, 1998-99.

aerostructures firms are less globalized and, according to U.S. industry officials and aerospace industry experts, are losing aerostructures assembly and manufacturing opportunities to foreign producers.[49]

Consolidation

Consolidation and rationalization of the U.S. aerostructures industry[50] ultimately have been driven by LCA producer efforts to significantly reduce manufacturing costs in order to address airlines' demands for reduced LCA prices due to greater airline competition resulting from airline deregulation.[51] Some U.S. aerostructures firms believe that ongoing consolidation will make acquisitions an increasingly important component of their future growth, as LCA airframers look for fewer,[52] larger, and more capable suppliers.[53] Accordingly, U.S. aerostructures firms indicated that they will continue to seek attractive acquisition opportunities and support long-term aerostructures contracts for both commercial and military programs.[54]

The most notable example of consolidation in the North American aerostructures industry during the past 5 years was the 1999 acquisition of Menasco by Goodrich in the Coltec merger. According to some industry analysts, the merger allowed Goodrich to eliminate excess capacity in the company.[55] The merger also increased the size and scale of the company, which should provide it with more leverage in future dealings with Boeing and Airbus.[56]

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[49] U.S. industry officials and investment analysts, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan. 2001; Sparaco and Smith, "Airbus Makes Move on Boeing's Japan Turf," pp. 45-46; and "Boeing to Move 757 Work," pp. 1-2.

[50] According to some aerospace industry analysts, LCA producer customers want to deal with "fewer, more capable subcontractors and suppliers." Therefore, as the aerospace business shrinks from a number of prime-level customers to only several, small- and medium-sized companies must consolidate to increase their clout. William B. Scott, "Industry Consolidation Seen Shifting to Subcontractors, Suppliers," *Aviation Week & Space Technology*, Jan. 1, 2001, pp. 63-64; and U.S. industry officials and academic analysts, in-person and telephone interviews by USITC staff, United States, June-Dec. 2000 and Jan.-Apr. 2001.

[51] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan. 2001.

[52] Boeing reported that that it wants to cut its supply chain by as much as 40 percent. Paul Proctor, "Boeing Shakes Up Its Supplier Chain," *Aviation Week & Space Technology*, Sept. 27, 1999, p. 30.

[53] According to the chief executive of Boeing's commercial aircraft unit, "as the drive for greater efficiency pushes an increasing volume of work to a smaller number of suppliers and subassemblers.... [Boeing] envisions making planes much the way Japanese and U.S. auto makers now build vehicles: 'Using fewer parts and moving assembly lines that reduce required time and manpower, combined with just in time inventories that cut down on handling storage and other expenses by assuring that parts arrive precisely when they are needed.'" Squeo and Pasztor, "Boeing Seeks to Overhaul Aircraft Manufacturing," Mar. 26, 2001, p. 1. Also see *1999 Ducommun Inc. Annual Report*, pp. 1 and 15.

[54] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, June-Oct. 2000 and Jan.-Apr. 2001.

[55] As a result of the merger, Goodrich was able to close a plant in Texas. Graham Warwick, "Non-core businesses put up for sale in US consolidation," *Flight International*, Apr. 25-May 1, 2000, p. 23; *BFGoodrich 2000 Annual Report*, p. 28; and U.S. industry officials, in-person and telephone interviews by USITC staff, United States, June-Aug. 2000 and Jan.-Apr. 2001.

[56] U.S. industry officials, investment analysts, and academic officials, in-person and telephone interviews by USITC staff, June-Dec. 2000 and Jan. 2001.

Other mid-sized aerostructures suppliers like Compass Aerospace (Compass) and Ducommun Inc. (Ducommun) have also consolidated their operations to increase their scale, efficiency, and focus.[57] Compass, for instance, was founded in October 1997 by combining several aerostructures machining and component manufacturers under a single corporate umbrella[58] to become a major supplier of precision-machined individual metal parts, high value-added subassemblies, and structural components such as wing control structures to Boeing. Compass is in the process of organizing these acquisitions in a complementary fashion to enable the firm to move beyond machining and smaller subassembly work to production and final assembly of larger, complex aerostructures.

Ducommun owns four companies involved in manufacturing aerostructures, electro-mechanical avionics products, and aircraft seating and cabin interiors. Three of the subsidiaries, A.F. Ducommun, Aeromil, and MechTronics, are soon to be consolidated into a single company to improve synergies and efficiencies in better serving their LCA customers.[59] Ducommun has stated that its acquisition priorities have been to purchase businesses that permit it to move up the manufacturing chain from components to subassemblies and subsystems.[60] Stellex Aerostructures, Inc., Triumph Group, and several other companies have engaged in similar strategies.[61]

Northrop Grumman Corp.'s divestiture of its aerostructures business could pave the way for more consolidation in the U.S. industry. Northrop sold its aerostructures division to the Washington, DC-based Carlyle Group in a deal worth $1.2 billion in July 2000.[62] According to some sources, Carlyle plans to consider a consolidation of its new acquisition, renamed Vought Aircraft Industries, with the Aerostructures Corp., which Carlyle also owns.[63] Since Vought is a supplier of fuselage sections to Boeing, and Aerostructures is a major supplier of wing parts and sections to Airbus,[64] such a consolidation could result in greater opportunities to supply both LCA producers.[65] The increase in scale

[57] Company annual reports and SEC 10-K filings.

[58] In 1999, Compass acquired six additional operating companies. SEC 10-K filing, Compass, 1999, pp. 1-6.

[59] Ducommun officials expect the consolidated company, named Ducommun Aerostructures, to take effect in January 2002.

[60] *1998 Ducommun Inc. Annual Report*, p. 3.

[61] U.S. industry officials, telephone interviews by USITC staff, United States, Oct. 2000; and company SEC 10-K filings.

[62] Northrop was concerned that the cyclical nature of LCA aerostructures was not in line with the corporation's long-term corporate strategy emphasizing growth in defense electronics, information technology, and systems integration. The mainstay of Northrop's aerostructures unit was its long-running contract with Boeing to produce 747 fuselages; however, Boeing's 747 manufacturing line had slowed down and was under increasing pressure from the Airbus A340-500/600, the new Boeing 777 models, and the Airbus A380. Bruce A. Smith, "Sale Will Boost Carlyle Aerospace Operations," *Aviation Week & Space Technology*, June 19, 2000, pp. 1-2; and "Northrop Grumman Back from the Brink," *Interavia*, Sept. 2000, pp. 18-19.

[63] Greg Schneider, "Northrop Moving Unit to D.C. Area: Carlyle to Buy Part of Division," *Washington Post*, June 13, 2000, pp. E1 and E5; Smith, "Sale Will Boost Carlyle," pp. 1-2; and U.S. industry officials, in-person and telephone interviews by USITC staff, United States, Apr.-Oct. 2000 and Jan. 2001.

[64] Carlyle also has a partial investment in a specialized U.S. aerostructures producer, Composite Structures.

[65] U.S. industry officials, telephone interviews by USITC staff, United States, Apr.-Sept. 2000; and U.S. industry officials, interviews by USITC staff, United States, Jan. 2001.

resulting from a merger of these two major U.S. aerostructures producers could also give the new company greater leverage in its dealings with Boeing and Airbus.[66]

There are hundreds of U.S. machine shop suppliers of various components used in the aerostructures industry. Not only is it possible that some of these could become targets for acquisition, but some could become aerostructures suppliers themselves by selective acquisitions, taking on more supply chain management and risk, and expanding their technological expertise into areas that LCA producers would like them to pursue. For instance, one nascent aerostructures supplier, Thayer Aerospace, obtained an important contract in September 2000 to manage 20 smaller suppliers to complete subassemblies for certain Vought aerostructures intended for the Next Generation Boeing 737 (737NG).[67] The company plans to continue to strategically acquire and integrate more machine shops and parts processors in the future to broaden its manufacturing capabilities and provide better value to its customers.[68]

Other U.S. aerostructures firms have had less success in obtaining merger partners or making themselves attractive as acquisition candidates to larger aerostructures producers. Some of these firms have already exited the LCA aerostructures industry, or are going through reorganizations to avoid bankruptcy.[69] However, other firms are trying to remain suppliers to the LCA industry as producers of detailed parts and components for larger LCA aerostructures producers rather than producing aerostructures themselves.[70] Finally, some former LCA aerostructures firms have re-focused their efforts to supply aerostructures for regional jet, general aviation, and military aircraft markets rather than continuing to supply LCA producers.

Foreign Direct Investment

Aerostructures-related foreign direct investment (FDI) by Boeing and other U.S. aerostructures producers has been minimal. To date, the primary examples of FDI by U.S. firms consist of the previously described Goodrich acquisition of Canadian-based landing gear producer Menasco, and Boeing investments in manufacturing facilities in Canada[71] and Australia, which supply wing parts and other aerostructures to Boeing's U.S. LCA manufacturing facilities.[72] Such production supplements offshore aerostructures production by independent Asian and European manufacturers resulting from subcontracting arrangements with Boeing rather than from Boeing FDI.[73] The lack of significant FDI may not significantly disadvantage U.S. producers, since labor laws in many foreign countries are more

[66] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, Apr.-Sept. 2000.

[67] "Thayer Aerospace," *SPEEDNEWS*, Sept. 15, 2000, p. 1.

[68] "Overview of Thayer Aerospace," *Thayer Aerospace*, 2000, pp. 1-2, found at Internet address *http://www.thayeraerospace.com/overview.htm*, retrieved Jan. 11, 2001.

[69] U.S. industry officials, telephone interviews by USITC staff, Sept.-Oct. 2000 and Jan.-Mar. 2001; and company SEC 10-K filings.

[70] U.S. industry officials, in-person and telephone interviews by USITC staff, June-Oct. 2000 and Jan.-Mar. 2001.

[71] The largest of the Canadian facilities, Boeing Toronto, was inherited by Boeing in its merger with McDonnell Douglas. It is primarily responsible for manufacturing wings for the Boeing 717 program.

[72] On January 27, 2000, Boeing's workforce levels in Canada and Australia were 3,000 and 2,100, respectively. SEC 10-K filing, 1999, Boeing Co., pp. 5-6.

[73] U.S. industry officials, interviews by USITC staff, United States, June-Aug. 2000 and Jan. 2001.

restrictive than in the United States, making it difficult for companies to adjust labor force levels in the cyclical LCA industry.[74]

FDI in the U.S. aerostructures industry is even more minimal than U.S. investment overseas[75] despite the fact that a number of foreign companies have expressed interest in acquiring greater access to the U.S. market.[76] Non-U.S. aerostructures producers generally believe that the U.S. Government inhibits FDI by mandating lengthy and complex reviews of all such contracts by several U.S. Government agencies.[77] The primary hinderance to FDI in the U.S. industry stems from the fact that most U.S. aerospace firms have a military component,[78] and the U.S. Departments of State, Defense, and Commerce must approve FDI[79] and trade[80] in both civilian and military aerospace projects in the United States.[81] According to Canadian and European industry officials, such approval requirements add to the complexity and costs of investing in the U.S. aerospace and aerostructures industries.[82] Some industry officials and analysts indicate that the U.S. Government has recently begun taking steps to facilitate transatlantic industrial links among aerospace producers.[83] For instance, in 2000, the U.S. Government revised U.S. export and foreign investment licensing laws and policies, facilitating cooperative ventures and alliances between U.S. companies and companies in allied countries.[84] However, so far, the U.S. Department of Defense is addressing these prospects on a country-by-country basis.[85] Examples of

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[74] For more information, see chs. 4 and 6.

[75] At least one U.S. aerostructures producer disagrees with the more common view expressed by a number of other U.S. and foreign industry officials that it is more difficult for a foreign company to invest in aerostructures facilities in the United States than for a U.S. firm to invest in aerostructures facilities in overseas markets, particularly in Europe. Response to USITC producer questionnaire.

[76] U.S. and European industry officials, interviews by USITC staff, United States, June-Aug. 2000 and Jan. 2001, and Europe, Sept.-Oct. 2000.

[77] Canadian and European industry officials, in-person and telephone interviews by USITC staff, Canada, Jan. 2001, and Europe, Sept.-Oct. 2000.

[78] U.S. and European industry officials, in-person and telephone interviews by USITC staff, United States, May-Aug. 2000, and Europe, Sept.-Oct. 2000; and Aerospace Industries Association (AIA), "Continue Reform of Export Controls," *AIA Issues and Policies*, 2000, p. 1, found at Internet address *http://www.aia-aerospace.org,* retrieved Feb. 15, 2001.

[79] The U.S. Department of Defense is a member of the interagency Committee on Foreign Investment in the United States (CFIUS). The Department's role on the CFIUS is to evaluate the national security aspects of proposed foreign acquisitions of U.S. Defense contractors, which include aerostructures companies that produce for both military and civilian markets. U.S. Dept. of Defense, *Annual Industrial Capabilities Report to Congress*, Jan. 2001, pp. 7 and 39.

[80] Section 38 of the Arms Export Control Act (22 U.S.C. 2778) authorizes the President to control the export and import of defense articles and defense services. The statutory authority of the President to promulgate regulations with respect to exports of defense articles and defense services was delegated to the Secretary of State by Executive Order 11958 (42 FR 4311). By virtue of delegations of authority by the Secretary of State, the regulations are primarily administered by the Director of the Office of Defense Controls, Bureau of Politico-Military Affairs, Department of State. The intended use of an article or service after its export (i.e., for a military or civilian purpose) is not relevant in determining whether the article or service is subject to required controls.

[81] European industry officials, interviews by USITC staff, Europe, Sept.-Oct. 2000.

[82] European and Canadian industry officials, interviews by USITC staff, Europe, Sept.-Oct. 2000, and Canada, Jan. 2001. For more information, see chs. 4 and 5.

[83] John D. Morrocco, "Consolidation Poses Transatlantic Quandary," *Aviation Week & Space Technology*, July 24, 2000, pp. 100-101; and U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan. 2001.

[84] U.S. Dept. of Defense, *Industrial Capabilities Report*, p. 7 and pp. 37-41.

[85] Ibid., p. 8.

successful FDI in the United States are U.K.-based BAE's investment in aerostructures facilities in Sylmar, CA, where it joins Boeing 717 wing halves from subassemblies manufactured in Canada,[86] and Canadian-based MacLuan Capital Corp.'s investment in Compass.[87]

Asian firms also have approached U.S. companies to invest in or partner with them.[88] In 1999, Hexcel and Boeing formed a joint venture with Aviation Industries of China (BHA Aero Composite Parts Co., Ltd.) to manufacture composite parts for secondary aerostructures. Although the resources gained through such investments are welcome, U.S. firms are wary of the potential amount of technology transfer to Asia, which, in the long term, could increase the relative competitiveness of Asian versus U.S. aerostructures producers.[89]

Changes in the Relationship Between LCA Manufacturers and Aerostructures Manufacturers

The relationship between LCA manufacturers and suppliers has evolved over 1995-99, with the loss of McDonnell Douglas as a customer,[90] the increased reliance on outsourcing aerostructures from foreign vendors, and the changing nature of contract terms between suppliers and customers. LCA manufacturers face greater pricing pressures imposed on them by airlines due to increased competition in a deregulated air travel market and have tried to increase LCA manufacturing efficiencies by placing more design, manufacturing, and supply chain management responsibilities on suppliers, while concentrating on their core competencies of overall aircraft design, systems integration, and sales.[91] LCA producers have also started asking their aerostructures suppliers to share more of the risk involved in the development of new LCA programs. In response to these trends, U.S. aerostructures suppliers report that the following courses of action are likely: merging with or acquiring other companies to form critical skills and financial mass, becoming a supplier to newly formed "super-suppliers," broadening their market outside of LCA, or pursuing new lines of business other than aerostructures manufacture.

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[86] "More 717 Wing Sets from BAE," *Regional Airline World*, July 2000, p. 5; U.S. industry official, telephone interview by USITC staff, Mar. 2001; and "BAE Systems Marks Three Years of Boeing 717 Wing Manufacture," *BAE Systems Press Release*, found at Internet address *http://www.baesystems.com*, retrieved Oct. 16, 2000.

[87] MacLuan Capital Corp. website, found at Internet address *http://www.macluan.com*, retrieved Apr. 25, 2001.

[88] U.S. industry official, interview by USITC staff, United States, Aug. 2000.

[89] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000.

[90] Consolidation of the U.S. LCA manufacturing industry to just one producer has reduced the number of program launches and, therefore, the number of opportunities for aerostructures suppliers. U.S. industry officials, in-person and telephone interviews by USITC staff, United States, June-Aug. 2000 and Jan.-Mar. 2001; and written communications to USITC staff by U.S. industry officials, Nov. 2000 and Jan.-Feb. 2001.

[91] "This delegation of responsibility....results in a sharing of inventory carrying costs and a reduction in product cycle time, thereby freeing cash flow" to the LCA producers. The LCA producers "are then able to focus their resources on product design, large-scale systems integration and customer service." John W. Douglass, President & CEO, AIA, *Assessment of the U.S. Large Civil Aircraft Aerostructures Industry*, Jan. 4, 2001, written submission in connection with USITC inv. No. 332-414, *Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry*, received Jan. 9, 2001; and U.S. industry officials, interviews by USITC staff, United States, June-Aug. 2000 and Jan. 2001.

Risk Sharing

U.S. producers may be increasingly disadvantaged with respect to European and Asian competitors as risk sharing becomes more commonplace in contracts with LCA producers.[92] This is because U.S. aerostructures producers generally have not been involved as much in the past as European or Japanese suppliers in risk sharing with their LCA manufacturer customers on aircraft programs. Airbus, in effect, was created as a risk-sharing entity between former Airbus partner companies in Germany and France in 1970 (joined by Spanish and British members shortly thereafter), with each responsible for sharing in the risk and development of Airbus programs. Risk sharing by Airbus continued in the 1980s and 1990s with a number of its other major aerostructures suppliers.[93] Boeing's first notable instance of risk sharing with aerostructures suppliers was in 1978, but it was with Japanese aerostructures producers on the Boeing 767 program.[94]

However, Boeing is increasingly requiring U.S. aerostructures producers to share more in the risk of developing new aircraft programs and absorb nonrecurring costs for design, engineering, and tooling for the aerostructures they are responsible for in a new program.[95] Previously, Boeing often reimbursed aerostructures producers for some or all design and tooling costs upon the first LCA shipment of a new program.[96] Now, instead of being reimbursed for such expenses, aerostructures suppliers increasingly must amortize the costs over the length of the LCA program. Thus, their risk has grown along with that of the LCA producer, if the LCA program does not achieve a certain minimum level of sales.

Boeing has risk-sharing arrangements with its major U.S. aerostructures suppliers and has indicated it will require more such arrangements with suppliers in the future.[97] Further, Aerostructures has engaged in some risk-sharing activities with Airbus partners in the past. Airbus reportedly would like to have more risk and revenue partners from the United States, which might help boost sales and

[92] U.S. and European industry officials, interviews by USITC staff, United States, June-Aug. 2000 and Jan. 2001, and Europe, Sept.-Oct. 2000; "European Business Briefs," *Bloomberg, AP, Reuters*, Mar. 7, 2001, pp. 1-2, found at Internet address *http://iht.com*, retrieved Mar. 8, 2001; and John D. Morrocco, "Finmeccanica Weighs Airbus Options," *Aviation Week & Space Technology*, Oct. 2, 2000, pp. 48-49.

[93] For more information, see ch. 4.

[94] For more information, see ch. 6.

[95] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan. 2001; and responses to USITC producer questionnaire.

[96] U.S. industry officials, interviews by USITC staff, United States, June-Aug. 2000 and Jan. 2001.

[97] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan. 2001; and responses to USITC producer questionnaire.

improve Airbus's public image in the United States.[98] On March 12, 2001, Goodrich announced an agreement with Airbus that will make it the exclusive supplier of the main landing gear assemblies for Airbus's new A380 program.[99] The agreement also gives Goodrich the primary responsibility for designing and maintaining the systems.[100] Goodrich is the first U.S. aerostructures producer to sign on as a risk-sharing partner for the new A380 program.[101] Before selling its aerostructures business to the Carlyle Group, Northrop Grumman (now Vought) had decided that it would undertake work on this Airbus project only on a contract rather than a risk-sharing basis.[102] Another U.S. aerostructures producer indicated that it had been asked to be a risk-sharing partner, but that the amount of risk involved was unacceptable.[103] U.S. aerostructures suppliers unable to engage in risk-sharing agreements with Boeing and Airbus for financial reasons or because of limited experience with such agreements could face a competitive disadvantage with respect to those U.S. and foreign suppliers able to implement risk-sharing agreements.

Design Responsibilities

U.S. aerostructures suppliers to Boeing undertake fewer design responsibilities for their aerostructures products and systems than European suppliers to Airbus.[104] However, Boeing hopes to shift some of its own costs downward in the supply chain by asking major U.S. subcontractors to take on more responsibility for the engineering and design of assemblies and subassemblies.[105] While Boeing is substantially less reliant on suppliers for their design services than is Airbus, it is attempting to identify and designate noncritical components for outside design.[106] Although not all U.S. aerostructures suppliers have taken on more design responsibilities, firms that are able to develop or acquire such capabilities will be better able to obtain future contracts with LCA producers, as Goodrich has with its

[98] Industry analysts believe that Airbus will try to persuade another major U.S. aerostructures producer such as Vought to become a risk-sharing partner in the program and outsource additional work to other U.S. aerostructures producers. "US 'Pressure' Not to Join A3XX," *Flight International*, Aug. 1-7, 2000, p. 17. In a January 11, 2001, meeting of the European Commission, the Commission stated that Airbus will likely outsource a significant share of its work to U.S. companies. "EU Blasts U.S. Support for Boeing, Warns Against Airbus WTO Case," *Inside US Trade*, Jan. 19, 2001, p. 1, found at Internet address *http://www.insidetrade.com*, retrieved Feb. 5, 2001.

[99] Andy Pasztor, "Goodrich Lands Airbus Pact To Supply Landing-Gear Systems," *Wall Street Journal*, p. 1, found at Internet address *http://public.wsj.com*, retrieved Mar. 12, 2001; "Goodrich Selected to Supply Landing Gear for the A380," *Goodrich Newsroom*, Mar. 12, 2001, p. 1, found at Internet address *http://www.bfg-aerospace.com*, retrieved Mar. 12, 2001; and U.S. industry official, telephone interview by USITC staff, Mar. 2001.

[100] Pasztor, "BFGoodrich Lands Airbus Pact," p. 1; and U.S. industry official, telephone interview by USITC staff," Mar. 2001.

[101] "US 'Pressure' Not to Join A3XX," p. 17.

[102] Ibid.

[103] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, Apr.-Sept. 2000.

[104] For more information, see ch. 4.

[105] U.S. industry officials, interviews by USITC staff, United States, May and Aug. 2000.

[106] Interiors on Boeing's 747-400 will be designed and produced by Northwest Composite (a wholly owned subsidiary of C&C Aerospace). U.S. industry officials, interviews by USITC staff, United States, Nov. 2000.

recent agreement to supply Airbus's A380 main landing gear.[107] An example illustrating why U.S. aerostructures firms lag European companies in assuming design responsibilities is landing gear, where Boeing traditionally maintained much of the design responsibility. According to both U.S. and European industry officials, French-based Messier-Dowty, heretofore the sole supplier of landing gear to all of the major Airbus programs, had been much more involved in the overall research and design of its aircraft landing gear than Goodrich, which was limited by Boeing to manufacturing such gear based on designs and specifications developed by Boeing.[108] Although Goodrich is expected to increase its competitiveness by gaining design responsibilities on the new Airbus A380 program, the lack of design experience by other U.S. aerostructures producers on past Boeing programs could disadvantage them inasmuch as such capabilities are increasingly required of aerostructures producers by LCA manufacturers.[109]

Contract Terms

Three changes in contractual conditions that have taken place over the last 5 years stand out as areas of concern for the U.S. LCA aerostructures industry. These areas are greater responsibilities imposed on suppliers by LCA manufacturers, changing conditions of long-term agreements (LTAs), and the shortening lead time given to suppliers to decide on contracts. The changes favor larger U.S. suppliers or firms able to effectively develop or maintain supply management capabilities through partnerships, acquisitions, or consolidation.

As previously stated, customers increasingly require LCA aerostructures producers to take on responsibilities previously assumed by LCA manufacturers. Some of the larger U.S. LCA aerostructures producers have effectively been able to take on more of these responsibilities.[110] Other U.S. producers are currently increasing their abilities to meet these new requirements by gaining greater scale and expertise through strategic acquisitions, consolidation, and taking on more supply chain management responsibilities.[111] However, not all producers have been able to make the necessary adjustments to meet the increased demands of LCA airframers.

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[107] Also see Pasztor, "BFGoodrich Lands Airbus Pact," p. 1; "Goodrich Selected to Supply Landing Gear for the A380," p. 1; and James Ott, "A380 Landing Gear Work Started Early at Goodrich," *Aviation Week & Space Technology*, Mar. 19, 2001, p. 120.

[108] Although Boeing has maintained primary design control over landing gear supplied to it by Goodrich, Goodrich had developed in-house design capabilities with respect to contracts with non-LCA aircraft manufacturers, including large military and other civilian transport aircraft. On the other hand, most industry officials agree that even though Goodrich's design capabilities were considered sufficient enough to enable it to obtain the Airbus contract for the design and manufacture of the main gear on the new Airbus A380 program, Airbus's past practices of delegating more design work to subcontractors than has traditionally been the case with Boeing may have improved the capabilities and competitiveness of their suppliers vis-á-vis U.S. aerostructures suppliers to Boeing. U.S., European, and Canadian industry officials and investment analysts, in-person and telephone interviews by USITC staff, United States, Jan.-Mar. 2001, Europe, Sept.-Oct. 2000, and Canada, Jan. 2001.

[109] U.S. industry officials, interviews by USITC staff, United States, May and Aug. 2000 and Jan. 2001.

[110] Ibid.

[111] U.S. industry officials, interviews by USITC staff, United States, May and Aug. 2000 and Jan. 2001; and company annual reports and SEC 10-K filings.

Many U.S. aerostructures suppliers welcomed the perceived stability of LTAs; however, they were not prepared to have them renegotiated by their customer.[112] Rather than offering a predictable set of contract guidelines, LTAs are now seen by aerostructures producers as tools used by LCA manufacturers to leverage better prices from their suppliers, with no commensurate guarantee that the terms will be mutually honored.[113] Suppliers do not have realistic recourse should the terms be breached by an LCA manufacturer, as they have limited market opportunities beyond accepting whatever new terms are dictated by the LCA manufacturer, short of refusing to supply under the new terms.[114] Such tactics on the part of LCA manufacturers, while not commonplace, encourage consolidation among suppliers, so that they may achieve the critical financial size to more effectively deal with such situations.

The ability of aerostructures suppliers to respond quickly to requests to bid on certain aspects of an LCA project or program contract has been a key factor of competitiveness, again benefitting larger U.S. aerostructures suppliers or motivating smaller firms to either consolidate or develop supply chain management capabilities.[115] One smaller U.S. aerostructures supplier reported that there is often only a 2-week deadline in which a potential supplier can submit a completed bid although, in some circumstances, it may request extensions.[116] This requires the bidder to rapidly confirm pricing, delivery, materials, capabilities, and other pertinent factors with its own subsuppliers. It is particularly difficult to confirm the availability and pricing of raw materials to be used in a 3-year project during the 2-week bid period. In the past, it was common for LCA manufacturers to organize the production, manage the supply chain, and even supply the raw materials to aerostructures producers.[117]

Manufacturing Trends

The U.S. aerostructures industry is using more efficient manufacturing practices, including digital manufacturing techniques, and advanced engineering and tool design, particularly on their newer programs. However, U.S. aerostructures firms typically possess less advanced machinery than do other global manufacturers.[118] During the 1960s, 1970s, and 1980s, the U.S. aerostructures industry was the most advanced in the world.[119] But U.S. programs and production facilities from that earlier period are aging, and other competitors have emerged. European and, to some extent, Asian suppliers, such as Japan and Korea, have been able to take advantage of the manufacturing technology that new

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[112] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan.-Mar. 2001.

[113] Anthony Velocci, Jr., “Pattern of Broken LTAs Raising Supplier Angst,” *Aviation Week & Space Technology*, Sept. 13, 2000, pp. 73-75.

[114] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan.-Mar. 2001.

[115] Smaller firms and firms lacking effective supply chain management resources and skills do not possess the expertise increasingly required by LCA producers as more complex supply relationships are pushed down the supply chain by LCA producers. U.S. industry officials, in-person and telephone interviews by USITC staff, May-Sept. 2000 and Jan.-Mar. 2001.

[116] U.S. industry official, telephone interview by USITC staff, Oct. 2000.

[117] U.S. industry official, telephone interview by USITC staff, Nov. 2000.

[118] David J. Pritchard, *The Global Deindustrialization of Commercial Aircraft Production: Implications to U.S.-Based Manufacturing Activity*, forthcoming dissertation, State University of New York at Buffalo, 2001, pp. 11, 18, 59, 64-66, and 70. For more information, see ch. 4.

[119] This period also coincided with the introductions of Boeing’s major LCA programs.

programs such as the Airbus A318/319/321 and A330/340 and Boeing 777 and 737NG offer.[120] Because the majority of assembly line methods, technologies, and tooling are established at the beginning of new programs, these foreign suppliers have been able to establish more advanced manufacturing methods and technologies than U.S. aerostructures producers supplying older Boeing programs.[121] This is because the new manufacturing technologies and tooling developed for a new aircraft program are quite expensive, with fixed-costs amortized over the length of a 20- to 30-year program, making it exceedingly expensive to economically upgrade manufacturing and tooling once a program has been initiated.[122] It is imperative, therefore, for U.S. aerostructures producers to become involved significantly in any new LCA programs in order to develop and use new technologies and manufacturing methods. U.S. producers may otherwise have a difficult time improving their manufacturing capabilities and competitiveness.

Manufacturing Operations and Lean Manufacturing

U.S. aerostructures suppliers generally lag Japanese and European manufacturers in the use of modern techniques such as lean manufacturing. As indicated in chapter 2, lean manufacturing concepts, which enable producers to improve costs and efficiencies and provide faster, cheaper, and more reliable services to LCA customers, have been slow to take hold in the U.S. aircraft and aerostructures industries (table 3-3). Nevertheless, in 1994, Boeing instituted its version of lean manufacturing, known as "Lean Enterprise."[123] The primary focus of this effort is the continuous elimination of waste in the company's manufacturing processes. Boeing trained not only its own employees, but those of its aerostructures suppliers as well, in what were termed "accelerated improvement workshops." Both Boeing and a number of other aerostructures companies that have been trained in such workshops or other lean

[120] Each of these programs was launched within the past 10 years; thus, tooling for these programs would be of a similar age. Boeing continues to manufacture a number of airplanes developed prior to Airbus's entry into the business, including the Boeing 747, which came into service over 30 years ago. Other older programs that continue include the Boeing 757 and 767. U.S. industry officials, in-person and telephone interviews by USITC staff, United States, Sept.-Oct. 2000 and Jan.-Mar. 2001.

[121] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, June-Oct. 2000 and Jan.-Mar. 2001.

[122] Retooling generally refers to manufacturing modern tools for the production process. Updating processes can mean lean manufacturing, CAD, and other activities that are less expensive than retooling.

[123] According to Boeing, implementing lean practices involves changing a work area or a business process to maximize efficiency, improve quality and safety, eliminate unnecessary motion and inventory, and save time. Implementing lean principles begins with an assessment whereby workers from every function perform an evaluation of their current business situation and performance. Once the evaluation is complete, the team develops an implementation plan that uses lean methods and techniques to simplify and improve business processes. According to the company, completion of the plan ensures that the workers have made a step-by-step improvement in process efficiency and costs. "Lean Enterprise," *Boeing Commercial Airplanes,* p. 1, found at Internet address *http:// www.boeing.com*, retrieved June 7, 2000.

Table 3-3
Lean manufacturing principles

Manufacturing Features	Traditional Manufacturing	Lean Manufacturing
Scheduling	Forecast–Push	Customer Order–Pull
Production	Stock	Customer Order
Lead Time	Long	Short
Batch Size	Large Batch & Queue	Small–Continuous Flow
Inspection	Sampling	100%–Source
Layout	Functional	Product Flow
Empowerment	Low	High
Inventory Turns	Low	High
Flexibility	Low	High
Cost of Goods Sold	High and Rising	Lower and Decreasing

Source: Manufacturing Engineering Inc.

manufacturing techniques have reported significant cost and time savings.[124] According to Boeing, since the lean manufacturing program began in 1994, reductions in cycle time, defects, and other performance measures have reached as much as 86 percent in individual work areas.[125] Boeing now requires its principal aerostructures suppliers to engage in similar lean manufacturing and encourage their own suppliers to do the same.

Regardless of whether lean manufacturing becomes required of U.S. aerostructures producers in their contracts with LCA producers, such implementation will increasingly become a practical necessity if aerostructures suppliers are to meet the continuous cost reductions required to fulfill their contractual obligations. Industry officials contend that aerostructures suppliers that do not implement lean manufacturing concepts will go out of business.[126]

One expert on lean manufacturing suggests that although awareness of lean principles has increased throughout the U.S. aerospace industry, and while a growing number of companies are implementing lean initiatives tactically, other firms have faced difficulty in applying such principles to the whole configuration of work largely because of structural issues in the industry.[127] This allegedly is because the industry is burdened with 30 to 50 percent more capacity than is needed to support the present level of production. Such "asset overhang," the expert states, has resulted from mergers and acquisitions in the 1990s.[128] According to the expert, before lean manufacturing efforts realize their full potential, overcapacity issues need to be addressed by each firm.

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[124] U.S. industry officials, telephone interviews by USITC staff, Sept.-Oct. 2000 and Jan. 2001.
[125] "Lean Enterprise," p. 1.
[126] U.S. industry officials, interviews by USITC staff, United States, May-Aug. 2000 and Jan. 2001.
[127] Anthony L. Velocci, Jr., "Effective Application of 'Lean' Remains Disappointing," *Aviation Week & Space Technology*, Jan. 22, 2001, p. 60.
[128] Velocci, "Effective Application of 'Lean' Remains Disappointing," p. 60.

Computer-Aided Design and Manufacturing

Digital manufacturing capabilities and the ability to share design and manufacturing information are not only essential technologies for reducing manufacturing costs, they are now required of many LCA aerostructures suppliers throughout the world. As such, they likely confer competitive advantages on specific U.S., European, Asian, and Canadian suppliers who have incorporated them rather than on particular countries or regions.[129]

Some U.S. aerostructures producers have taken advantage of the latest advances in computer technology to improve their manufacturing processes. For example, digital manufacturing, using computer-aided design/computer-aided manufacture (CAD/CAM) software models, has enabled Boeing to cooperate with Goodrich to reduce the design and manufacture of landing gear from 5 years to 18 months.[130] Boeing moved to digital manufacturing with a French-developed version of CAD/CAM software, Computer Aided Three-Dimensional Interactive Application (CATIA),[131] on both the 737NG and 777 aircraft for easier aircraft assembly, faster delivery, and reduced costs. Boeing also strongly encouraged major suppliers, such as Kaman and Ducommun, to adopt this technology.[132] Ducommun believes its success in 1999 in winning long-term contracts to manufacture the leading edge wing skins for the Airbus A330/340 was due in large part to its demonstrated digital manufacturing capabilities.[133]

In another example, Vought participated with Boeing in its Accurate Fuselage Assembly Program in the mid-1990s to create an electronic product definition for the fuselage panels for the Boeing 747 and to implement precision assembly in their manufacture.[134] In this program, fuselage assembly support teams used digital database driven machines to shape fuselage panels in various required configurations that could be changed by manipulating computer programs. The flexibility in this manufacturing process enabled Boeing to reduce dramatically the number of machine tools previously required to shape different panels of the aircraft.

Despite these successes, other U.S. aerostructures firms generally are behind European manufacturers in the number of modern technologies, techniques, and types of machinery used in producing LCA aerostructures. Most U.S. firms also generally have less modern machinery than Japanese firms working on the newer Boeing programs.[135]

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[129] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000.

[130] U.S. industry official, telephone interview by USITC staff, United States, Oct. 2000.

[131] Originally developed by Dassault Systèmes of France for the aerospace industry, CATIA is a comprehensive CAD/CAM/CAE application designed to maximize concurrent product development practices and process re-engineering by using digital mock-ups instead of physical models. CATIA users are able to create and simulate the entire product life cycle on the computer, from conception through to operation, without the need of a single physical model. All necessary changes can be made on the digital model, minimizing the risk of late expensive modifications and reducing the number of iterations by designing correctly the first time. See Internet addresses *http://www.concentric.com* and *http://www.catia.com* for more information.

[132] *Ducommun 1999 Annual Report*, p. 3; and *Kaman Corp 1999 Annual Report*, p. 6.

[133] *Ducommun 1999 Annual Report*, p. 3; and *Ducommun 2000 Annual Report*, pp. 1 and 5.

[134] Edward H. Phillips, “3D Database For 747 Panels,” *Aviation Week & Space Technology*, Oct. 20, 1997, p. 67; “On-machine probe speeds fuselage assembly,” *Manufacturing Engineering*, June 2000, pp. 48-50; and U.S. industry officials, interviews by USITC staff, United States, May-Aug. 2000 and Jan. 2001.

[135] For more information, see ch. 6.

Composite Structures

According to some industry analysts, the U.S. LCA and aerostructures industry lags Airbus and its partners in the manufacture and use of composite structures for LCA.[136] To date, the manufacture of reliable, maintainable, large composite primary aircraft structures in the United States has not been cost-effective.[137] Boeing reportedly converted some metal parts to graphite composite structures for the 737-400 and 500, but eventually reverted back to bonded metal structures following complaints of service problems from airline customers.[138] Boeing is currently trying to address its problems in this area by developing an all-composite wing[139] for the 737, which could be in use in 2003-04.[140] The 737 was selected for development of composite wings because of the high production rate of the 737 aircraft, which will allow Boeing to spread the cost over the largest number of sales.[141]

Quality Audits and Cost Reduction Efforts

U.S. aerostructures industry officials state that although quality manufacturing audits on their operations are essential to firms in maintaining competitiveness, the increased number of quality audits required in recent years by LCA manufacturers and other aerostructures firms they supply has added costs and delays to U.S. aerostructures suppliers' processes, thus reducing U.S. competitiveness.[142] They state that many of the audits required by their customers duplicate one another and after a certain point add little more to firms' manufacturing capabilities or product quality to justify the increased costs and manufacturing delays resulting from the additional requirements.[143] In response to these concerns, LCA airframers and other customers indicate they will: (1) help suppliers develop and implement a single quality system based on an international quality management standard, ISO 9000, and minimize supplemental quality requirements; (2) encourage suppliers to share the results of quality audits; and (3) implement a schedule for auditing supplier processes based on business risks rather than arbitrary calendar dates. Implementation of the audit-reduction program reportedly is expected to reduce costs by eliminating duplication.[144]

Boeing also is reportedly working closely with its suppliers through its Continuous Cost Improvement Program (CCIP) to reduce costs.[145] This program involves on-site Boeing-sponsored lean workshops, inspections of processes and practices, and recommendations for improvements. The CCIP program was designed to achieve 3- to 5-percent annual reductions in what Boeing pays for materials

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[136] U.S. and European industry officials, in-person and telephone interviews by USITC staff, United States, May-Oct. 2000, and Europe, Sept.-Oct. 2000.

[137] "Breaking the Composite Cost Barrier," *Interavia*, Sept. 2000, pp. 22-26.

[138] U.S. industry official, interview by USITC staff, United States, Jan. 2001.

[139] The all-composite wing being developed by Boeing is manufactured largely of carbon fiber rather than aluminum to reduce aircraft weight while preserving sufficient strength and durability.

[140] "Business Briefing," *Interavia*, Sept. 2000, p. 12.

[141] Ibid.

[142] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, June-Oct. 2000 and Jan.-Mar. 2001.

[143] Ibid.

[144] Anthony L. Velocci, Jr., "Primes Pledge to Cut Excessive Audits," *Aviation Week & Space Technology*, Sept. 13, 2000, p. 77.

[145] Tom Stundza, "Boeing careful when picking 'the best,'" *Purchasing*, Nov. 16, 2000, pp. 106-107.

and parts.[146] Boeing is also encouraging aerostructures suppliers to suggest methods of squeezing costs out of existing production runs, with a promise to review these suggestions and initiate an engineering change when warranted. Moreover, Boeing suppliers are encouraged to identify areas where excess design requirements, unnecessarily tight tolerances, or outdated material specifications add to supplier costs.[147]

Implications for the Competitiveness of the U.S. Industry

As a result of globalization, consolidation, market access issues, increased foreign competition, and growing requirements for risk sharing on new LCA programs, the U.S. LCA aerostructures industry is facing tremendous challenges. Although some U.S. firms are responding successfully to these new conditions by becoming stronger and more efficient through mergers and acquisitions, other U.S. firms are having a more difficult time adjusting. As market access demands drive LCA manufacturers to place more work in foreign countries, U.S. aerostructures firms are winning fewer contracts on new LCA programs.[148] Further, the United States has likely fallen behind European and certain Asian aerostructures producers in manufacturing over the past two decades.[149]

U.S. industry officials indicate that the production offsets expected of Boeing by foreign governments to sell airplanes to national or indigenous airlines are a major competitive disadvantage for U.S. LCA aerostructures manufacturers.[150] Not only do U.S. aerostructures firms lose these opportunities, but aerostructures firms in Japan, Korea, China, Taiwan,[151] and Italy[152] are able to

[146] Ibid.

[147] Paul Proctor, "Boeing Shakes Up Its Supplier Chain," *Aviation Week & Space Technology*, Sept. 27, 2000, p. 30.

[148] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, June-Oct. 2000 and Jan.-Mar. 2001.

[149] U.S. and European industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Jan. 2001, and Europe, Sept.-Oct. 2000.

[150] U.S. industry officials, in-person and telephone interviews by USITC staff; written communications to USITC staff, United States, May-Sept. 2000 and Jan.-Mar. 2001; and submission of Aerospace Industries Association and International Association of Machinists and Aerospace Workers, AFL-CIO. Also see U.S. Dept. of Commerce, ITA, Office of Aerospace, "Presidential Offsets Commission," *Export Aerospace News*, Jan. 2001, p. 2; "President's Council on the Use of Offsets in Commercial Trade," *Release of White House Office of the Press Secretary*, Dec. 4, 2000, pp. 1-2, found at Internet address *http://www.offsets.brtc.net*, retrieved May 7, 2001; and *Status Report of the Presidential Commission on Offsets*, Jan. 18, 2001, pp. 14-20.

[151] Sparaco and Smith, "Airbus Makes Move on Boeing's Japan Turf," pp. 45-46; and FuruKawa, "Mitsubishi emphasizes strong links with Boeing," p. 1. For further background, also see USITC, "Changes in the Structure of the Asian Aerospace Industry," ch. in *Changing Structure of the Global Large Civil Aircraft Industry*, Nov. 1998, pp. 5-1 to 5-43.

[152] On Mar. 23, 2001, Alan Mulally, chief executive of Boeing's commercial airlines division, indicated Boeing would "move some sub-assembly work to Italian manufacturer Alenia.....[A] Boeing statement said, 'By placing this additional work in Italy, we expect it will help Boeing gain access to other....business opportunities there."' "Boeing to Move 757 Work to Wichita," *Reuters*, Mar. 26, 2001, pp. 1-2, found at Internet address *http://www.dailynews.yahoo.com*, retrieved Mar. 26, 2001.

improve their manufacturing capabilities with the work that is placed.[153] This will likely make them stronger competitors as they gain experience.[154] A number of U.S. aerostructures producers expressed the belief that Boeing's placement of aerostructures work with foreign producers is only likely to increase at the expense of U.S. aerostructures production.[155]

The prohibitive expense of retooling aerostructures manufacturing processes once a program has been initiated presents a major difficulty in manufacturing modernization. Despite increasing use by U.S. aerostructures producers of such new methods as lean manufacturing and digital manufacturing, U.S. aerostructures producers have not been able to upgrade their manufacturing capabilities and reduce their costs to compete effectively with the more advanced manufacturing methods found in typically more modern plants in Europe and certain Asian countries.[156] This is partly because U.S. LCA programs are generally older than the relatively newer Airbus programs. European aerostructures producers have participated in Airbus programs such as the A318/319/321 and A330/340, which are newer than many of Boeing's established programs.[157] Although Boeing has developed some new programs such as the recently developed 777 program, foreign suppliers, particularly from Japan, have been integrally involved in that program.

U.S. aerostructures producers may be at a competitive disadvantage with respect to European and Asian competitors as risk sharing becomes more commonplace in contracts with LCA producers, since U.S. firms have not been as involved as their foreign competitors in those types of contracts.[158] Increased demands for such risk sharing could increase the competitiveness of U.S. firms able to fund such costs while reducing opportunities and competitiveness for firms unable to do so. Still, until U.S. firms gain greater experience in such risk-sharing arrangements, European and Japanese LCA aerostructures firms likely will retain an edge in this area.

Despite the challenges faced by U.S. firms, some U.S. aerostructures producers appear to be adjusting successfully to the new LCA environment by increasing the scale and capabilities of their

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[153] U.S. and European industry officials, and U.S. investment and academic aerospace specialists, in-person and telephone interviews by USITC staff, United States, May-Dec. 2000 and Jan.-Mar. 2001, and Europe, Sept.-Oct. 2000.

[154] U.S. industry officials, interviews by USITC staff, United States, June-Aug. 2000 and Jan. 2001.

[155] To attempt to address this problem, the National Commission on the Use of Offsets in Defense Trade and President's Council on Offsets in Commercial Trade held their first meeting on December 4, 2000. These groups are responsible for reporting back to the President and Congress, within 12 months, with recommendations on U.S. Government policies that might lead to a reduction in the use of offsets. Executive Order, National Commission on the Use of Offsets in Defense Trade and President's Council on the Use of Offsets in Commercial Trade, *White House Office of the Press Secretary Release*, Dec. 4, 2000, pp. 1-2, found at Internet address *http://www.offsets.brtc.net,* retrieved Feb. 5, 2001; U.S. Dept. of Commerce, ITA, Office of Aerospace, "Presidential Offsets Commission," *Export Aerospace News*, Jan. 2001, p. 2; and U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000 and Apr. 2001.

[156] U.S. and European industry officials, and investment and academic aerospace specialists, in-person and telephone interviews by USITC staff, United States, May-Oct. 2000 and Jan.-Mar. 2001, and Europe, Sept.-Oct. 2000; and Pritchard, *Global Deindustrialization of Commercial Aircraft Production*, 2001, pp. 11, 18, 59, 64, 65, 66, and 70.

[157] U.S. and European industry officials, and investment and academic aerospace specialists, in-person and telephone interviews by USITC staff, United States, May-Dec. 2000 and Jan.-Mar. 2001, and Europe, Sept.-Oct. 2000.

[158] "European Business Briefs," pp. 1-2; and Morrocco, "Finmeccanica Weighs Airbus Options," *Aviation Week & Space Technology*, Oct. 2, 2000, pp. 48-49.

operations through consolidation, adopting more efficient manufacturing methods, and taking on more responsibilities increasingly being asked of them by LCA manufacturers, including more supply chain management, increased financial risks, and more involvement in design, engineering, and development of the LCA aerostructures they produce. Particular U.S. aerostructures industry strengths include long-term experience, a highly skilled labor base, advanced engineering and design capabilities, greater access to market-based financing, and a competitive drive expressed by many firms to make the necessary adjustments to retain their competitiveness.

A potential benefit for aerostructures producers may be Boeing's stated interest in shifting more of its aerostructures production to major suppliers and concentrating on its core competencies of aircraft design, systems integration, and final assembly of completed airplanes. The major question is whether U.S. aerostructures producers will be able to compete effectively with Asian and European aerostructures producers for aerostructures work traditionally done by Boeing internally.[159]

[159] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, June-Oct. 2000 and Jan.-Apr. 2001.

CHAPTER 4
THE EUROPEAN LCA AEROSTRUCTURES INDUSTRY

Introduction

As Europe's only large civil aircraft (LCA) manufacturer and one of the world's two remaining LCA producers, Airbus strongly influences the overall direction and organization of the European aerostructures industry. The formation of Airbus in 1970 provided the groundwork for a cohesive European LCA strategy by creating four specialized aerostructures producers that dedicate their output to the assembly of Airbus LCA and consume a significant portion of the production of many other European aerostructures manufacturers.

European industry consolidation, most notably the reorganization of Airbus and the formation of the European Aeronautic, Defense, and Space Company (EADS) in 2000, is likely to increase the efficiency and, in turn, the competitiveness of the European supplier industry as the two companies streamline operations, reduce redundancies, and consolidate purchases. Moreover, as Boeing and Airbus delegate more responsibilities to their suppliers (i.e., design, supply chain management, systems integration, and certification), mergers and acquisitions are providing suppliers with the critical mass necessary to meet the growing demands of their customers.

The following chapter discusses the structure of the European industry, including major participants, sales, trade, and workforce characteristics; and industry developments regarding consolidation and globalization, foreign direct investment, and changes in the LCA manufacturer and aerostructures supplier relationship. The chapter concludes with implications for the competitiveness of the European industry.

Industry Structure and Market Indicators

Composition of the Industry

The European LCA aerostructures industry can be distinguished from its U.S. counterpart in part by its complex corporate inter-relationships, varying degrees of national government participation, specialized aerostructures production and technology centers, and the dominance of Airbus and its aerostructures subsidiaries. The industry, which comprises 18 known firms in addition to Airbus, manufactures a complete array of LCA aerostructures, as well as many other aerospace-related products and services for military; regional, general, and business jet; and space/satellite applications.

The leading players in the French, German, and Spanish aerospace industries were consolidated under the direction of EADS in mid-2000 (see appendix E). The new aerospace corporation was formed to aggregate European defense and aerospace interests to improve production and purchasing efficiencies, gain critical mass, and better compete with larger, primarily U.S., aerospace firms. Of the four Airbus partners—BAE Systems Airbus U.K., Aérospatiale Matra Airbus, DaimlerChrysler Aerospace Airbus GmbH (DASA), and Construcciones Aeronáuticas S.A. (CASA)—only BAE Systems declined to join EADS and remains an independent aerospace corporation. As a result, Airbus is now owned jointly by EADS (80 percent) and BAE Systems (20 percent).

The Airbus Company

As part of the European industry restructuring, Airbus undertook a major structural reorganization designed to improve its competitiveness, leading to the formal launch of The Airbus Company in late February 2001 (retroactive to January 1, 2001). The urgency to launch the A380[1] led BAE Systems[2] and EADS to reach an agreement on the terms for the formation of the limited company on June 23, 2000.[3] Although the former partners had indicated a willingness to transform Airbus from a *groupement d'intérêt économique*[4] (G.I.E.) into a single corporate entity, years of discussions and negotiations over workshare and other production arrangements had failed to produce a reorganized Airbus. The partners agreed, however, that the A380 could not be launched without this transition, in part because launch aid from certain governments was contingent upon Airbus's reorganization,[5] such a large project required a clear system design authority,[6] and a large portion of A380 funding would have to be raised on financial markets, requiring Airbus to operate as a more market-oriented company.[7]

The newly restructured Airbus is now Europe's largest civil aerostructures manufacturer, and is believed to produce the majority of the aerostructures it consumes. Airbus is also Europe's only producer of LCA. Prior to the reorganization, the four partners shared in the design and manufacture of Airbus aircraft, with each member specializing in the production of specific aerostructures and integrated systems.[8] They owned and operated their individual aerostructures operations (table 4-1), which subcontracted to supply aircraft parts and assemblies to Airbus for final assembly at Toulouse, France, or Hamburg, Germany. As part of the restructuring, the partners relinquished control of their Airbus-related LCA design, manufacturing, and engineering assets to the new Airbus. The former partners' operations now function as 100-percent owned subsidiaries of Airbus.[9]

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[1] The A380 (formerly called the A3XX), a 555-seat super jumbo aircraft, is Airbus's new aircraft program, launched in December 2000.

[2] In exchange for its approval of the new Airbus, BAE Systems gained a few key compensations. BAE will (1) retain a veto at Airbus because its structure requires unanimity on key board decisions, such as those pertaining to business plan approval and the addition of new partners; (2) receive enhanced dividend rights valued at up to ^237.5 million (about $384.3 million) for the next 10 years because of the higher profitability of its wing operations; and (3) retain an option to sell its 20-percent share of Airbus to EADS after 3 years at market value. *Global Commercial Aerospace Monthly*, Credit Suisse First Boston Corporation, vol. 9, July 2000, p. 20.

[3] Although Airbus will remain headquartered in Toulouse, a chairman and CEO will be located in both Toulouse and Hamburg. A shareholder committee comprised of five EADS appointees and two delegates from BAE Systems will be responsible for the company's shareholder and strategic decisions.

[4] See glossary for definition.

[5] "Airbus Ministerial: Touchy Feely A3XX," *Interavia*, June 2000, p. 9.

[6] Barry Grindrod, "The Forgeard Interview," *Orient Aviation*, July/Aug. 2000, p. 25.

[7] Barry James, "Public Offer Set to Fuel Airbus Project," *International Herald Tribune*, June 8, 2000, found at Internet address *http://today.newscast.com*, retrieved June 14, 2000.

[8] In addition to developing initial aircraft design, Airbus served principally as the management, marketing, sales, and service arm for the consortium's aircraft lines.

[9] For the purposes of this report, the former Airbus partners will hereafter be referred to by their current subsidiary names, as shown in table 4-1.

Table 4-1
Former Airbus partners (subsidiary name), plant locations, aerostructures produced, and LCA customer

Former Airbus partner (subsidiary name)	Plant locations	Aerostructures produced	LCA customer
BAE Systems (Airbus U.K.)	United Kingdom -- Chester, Weybridge, Warton, Samlesbury, Broughton, Filton	Completed wings, wing skins, flap track fairings, leading and trailing edges, spoilers/speed brakes, barrel sections	Airbus
Aérospatiale Matra (Airbus France)	France -- St. Nazaire, Meaulte, Nantes, Tarbes	Barrel sections, body panels, frames and stringers, cockpit structures, wing-to-body fairings, ailerons, keel beams	Airbus
DaimlerChrysler Aerospace (Airbus Germany)	Germany -- Hamburg, Varel, Augsburg, Nordenham, Stade, Bremen	Barrel sections, body panels, frames and stringers, keel beams, tail planes, fins, rudders, flaps, completed wings, spoilers/speed brakes	Airbus
CASA (Airbus Spain)	Spain -- Puerto Real, Tablada, Getafe, Illescas	Body panels, frames and stringers, tail planes, elevators/horizontal stabilizers	Airbus

Source: Various sources, including the *World Aviation Directory 2000, Jane's All the World's Aircraft 2000-2001*, and other industry sources.

With the reorganization, Airbus is expected to accrue annual savings of i 350 million (about $329 million) by 2004 by eliminating duplication, standardizing and pooling procurement, streamlining management, aligning production processes, and sharing expenses for items such as research and development and engineering.[10] Airbus will operate under one legal and management structure that will have sole responsibility for corporate decision-making, creating a stronger, quicker, and more efficient competitor with one point of contact for its aircraft customers. This new structure should allow Airbus to concentrate on the interests of the company rather than those of the former partners, focus on earnings and shareholder value because of its greater financial transparency,[11] improve customer support, and enhance operating performance. With a central management structure, Airbus may also be in a better position to explore new business opportunities, such as aircraft financing, leasing, and support.[12]

Airbus may also gain certain synergies and benefits from its affiliation with EADS, such as softening the cyclicality of the LCA industry with defense business.[13] One of the more significant advantages derived from its relationship with EADS may be its access to funding from international financial markets through EADS's public stock offering, which may become an important source of funding for new Airbus programs. To date, Airbus programs have been funded in part with government-

[10] "Global Commerical Aerospace Monthly," Credit Suisse First Boston Corporation, vol. 9, July 2000, p. 19, and Julian Moxon, "New Airbus is Formed, But Official Launch Must Wait," *Fllight International*, Jan. 9-15, 2001, p. 8.

[11] As part of the overall European industry restructuring, Airbus's financial performance has been publicly reported for the first time as the largest division of EADS. Airbus reported pro forma revenues of i 14.9 billion ($14 billion) in 2000, up nearly 18 percent from 1999 pro forma revenues of i 12.6 billion ($11.8 billion). "EADS Achieves Record Order Intake of EUR 49.3 Billion in 2000, Up 50.8%," EADS press release, Feb. 16, 2001, found at Internet address *http://www.defense-aerospace.com*, retrieved Feb. 16, 2001.

[12] Chris Jasper, "The Shareholder's View," *Flight International*, Jan. 2-8, 2001, p. 61.

[13] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

sponsored launch aid and internally generated funds, both of which have been sourced from the partners. Additional financial resources may be necessary as Airbus may commit an estimated $18 billion to launch two major programs simultaneously**S**the A400M military transport and the A380[14]**S**a major financial outlay that will impact earnings and may not be fully recouped. The expected strain on company resources is also forcing Airbus to seek risk-sharing partners for the A380 to partially fund its development and production.

However, Airbus may not immediately benefit from the possible advantages of restructuring. The reorganization of a company often entails a lengthy adjustment period as business cultures are merged and administration, operating procedures, and business activities are evaluated to develop efficient, streamlined management and manufacturing structures.[15] One European government source indicated that the new Airbus can survive only if the four former partners share information and essentially operate from the same knowledge base.[16]

Airbus will also be fully subject to the disciplines of the market and outside shareholder demands for the first time. Although several of the Airbus partners currently operate in this type of environment, responsiveness to financial markets and public attention to profitability levels will be additional challenges for the new Airbus. One British industry source suggested that Airbus could be distracted from its operational performance by its efforts to form the ideal organizational structure.[17]

Despite the change in Airbus's corporate structure, the essential role of the four subsidiaries is likely to remain unchanged, at least for the short to medium term. The former partners are established manufacturers of their respective aerostructures, and have maintained their design and manufacturing expertise in these areas.[18] Little direct competition with outside aerostructures producers currently exists for the Airbus subsidiaries with regard to their respective aerostructures. To help maintain operational excellence in the absence of direct contract competition, Airbus subsidiaries benchmark the performance of their major competitor**S**Boeing**S**and strive to meet or surpass internally designated performance targets.

While restructuring its corporate organization to better meet the competition and become more market-oriented, Airbus remains a focused aerostructures manufacturer and consumer with a well-defined business strategy. Airbus is developing new and derivative aircraft to broaden its product offering and satisfy anticipated market demand. These aircraft programs provide opportunities for aerostructures manufacturers worldwide to improve their manufacturing and technological skills base through contract awards. These additional program demands, however, may strain European supplier capacity as well as financial and labor resources, providing possible contract opportunities for U.S., Canadian, and Asian aerostructures producers.

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[14] "Testing Time for Soaring European Aero Industry," Reuters, June 7, 2000, found at Internet address *http://www.auto.com*, retrieved June 7, 2000.

[15] The former partners will be fully integrated during the next 3 years. Julian Moxon, "The manager's view," *Flight International*, Jan. 2-8, 2001, p. 61.

[16] European government officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[17] Max Kingsley-Jones, "UK takes to the wing," *Flight International*, Jan. 2-8, 2001, p. 70.

[18] Under the former Airbus structure, the partners could enter technical design competitions that were fashioned to produce the best possible design for a particular component. The new Airbus must ensure the same results with little or none of the duplicative effort. Kingsley-Jones, "UK takes to the wing," p. 70.

Other European Aerostructures Producers

In addition to their leading role in European aerostructures production, the four Airbus subsidiaries have extensive linkages with a number of other European aerostructures producers through their mutual inclusion in EADS or designation as Airbus associate members (e.g., Belairbus). Sogerma, Socata, Dornier-Fairchild, and Eurocopter are members of the EADS umbrella of aerospace companies. These firms supply aerostructures to Airbus directly or subcontract to larger aerostructures producers. The interrelationship of these aerostructures companies is a vestige of earlier government efforts to strengthen their respective national aerospace industries through consolidation prior to their recent absorption into EADS.

Many of the remaining European aerostructures producers operate independently of Airbus/EADS, but are state-owned or affiliated with other larger, diversified corporations. Government-owned firms may be insulated from full exposure to the market, and the aerospace subsidiaries of larger firms may benefit from the diversification and financial position of its corporate parent (table 4-2). For example, Hurel-Dubois and Messier-Dowty are subsidiaries of SNECMA, a large state-owned French multinational encompassing aerospace propulsion and equipment manufacturers. Hamble Structures (U.K.) is part of the Dowty Group, a subsidiary of Smiths Aerospace, whose core capabilities include information management systems, vehicle managements systems, and detection and protection systems.

Several of these independent European aerostructures manufacturers also supply Boeing, most notably Alenia Aerospazio, a subsidiary of Finmeccanica[19] of Italy. Alenia is a leading supplier of aerostructures to Boeing, with the U.S. LCA manufacturer accounting for about 80 percent of Alenia's aerostructures work.[20] Alenia has been offered an ownership share in Airbus, but is reportedly still evaluating that option[21] as it would prefer not to jeopardize its ongoing supply relationship with Boeing.[22]

With regard to supplying both airframers, European suppliers (excluding the former Airbus partners) as well as their LCA customers recognize that their best interests may be represented by supplying both LCA manufacturers, since a supply chain that relies on one major customer may be vulnerable to the shifts in demand for that customer's aircraft.[23] Consequently, efforts to develop a broader LCA customer base are receiving greater attention. Under this scenario, however, suppliers

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[19] Finmeccanica intends to strengthen its aerospace and defense business segments through acquisitions funded by government and market sources, and divest itself of former core businesses, such as energy and transport. Andy Nativi, "Ambitious Italians Eye Expansion," *Flight International*, Feb. 27 - Mar. 5, 2001, p. 6.

[20] Michael A. Taverna, "EADS, Finmeccanica Set Stage for Aeronautics Joint Venture," *Aviation Week & Space Technology*, July 24, 2000, p. 134.

[21] See appendix E for a further discussion of EADS's offer of an ownership share of Airbus to Alenia.

[22] James Blitz, "Well-Planned Alliances Have Revived Italy's Industrial Giant," *Financial Times*, Apr. 5, 2001.

[23] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

Table 4-2
Europe's non-Airbus aerostructures producers (known affiliation), plant locations, aerostructures produced, and LCA customers

Non-Airbus aero-structures producer (known affiliation)	Plant location(s)	Aerostructures produced	LCA customer(s)
Alenia Aerospazio (Finmeccanica)[1]	Pomigliano and Nola, Italy	Barrel sections, body panels	Airbus, Boeing
Dornier-Fairchild (EADS)[2]	Oberpfaffenhofen, Germany	Barrel sections, body panels, flaps	Airbus
Eurocopter (EADS)[2]	Donauworth, Germany	Wing-to-body fairings	Airbus
Fischer Advanced Composite Components (Fischer and Austrian Salinen)	Reid im Innkreis, Austria	Flaps, spoilers/speed brakes	Airbus, Boeing
Fokker Aerostructures (Stork)	An Oude-Meer, Netherlands	Body panels, flaps, wing tips, leading edge skin panels	Airbus, Boeing
Hamble (Dowty Group)	Hamble-le-Rice, United Kingdom	Wing panels	Airbus, Boeing
Hellenic Aerospace Industry[3]	Schimatari, Greece	Body panels	Airbus, Boeing
(Société Construction des Avions) Hurel-Dubois (SNECMA)[4]	Meudon-la-Fôret, France	Wing-to-body fairings	Airbus
Latécoère	Toulouse, France	Body panels	Airbus
Messier-Dowty (SNECMA)[4]	Villacoublay, France; Gloucester, United Kingdom	Nose landing gear, main landing gear assemblies	Airbus
Pfalz-Flugzeugwerke GmbH	Speyer, Germany	Wing-to-body fairings	Airbus
Reims Aviation	Reims, France	Body panels	Airbus
SF Swiss Aircraft & Systems Enterprise Corp. (RUAG Suisse)[5]	Emmen, Switzerland	Wing tips	Airbus, Boeing
Short Brothers plc (Bombardier)	Belfast, United Kingdom	Rudders, trailing edge flaps	Boeing
Socata (EADS)[2]	Tarbes, France	Wing-to-body fairings	Airbus
Sogerma Socea (EADS)[2]	Rochefort, France	Body panels, wing-to-body fairings	Airbus
Sonaca (Belairbus)	Gosselies, Belgium	Slat tracks and moving slats	Airbus

[1] The Italian Government owns 35 percent of Finmeccanica.
[2] See appendix E for a discussion of the ownership structure of EADS.
[3] The Greek Government owns 100 percent of Hellenic Aerospace Industry.
[4] The French Government holds 97.2 percent of SNECMA.
[5] RUAG Suisse is a 100-percent Swiss Government-owned holding company.

Source: *World Aviation Directory 2000; Jane's All the World's Aircraft 2000-2001;* "Western European Aerospace & Defence Industries - The Ownership Jigsaw," *Defence Systems Daily,* Mar. 7, 2001, found at Internet address *http://defence-data.com/current/pagerip1.htm*, retrieved Mar. 29, 2001; and other industry sources.

will need to manage their relationships with each LCA customer skillfully, being careful not to develop a notably closer relationship with one airframer at the expense of the other. As one Boeing official stated, "you can be a supplier to both, but not a partner to both."[24]

Although Airbus subsidiaries currently only manufacture aerostructures for their own LCA, most other European aerostructures producers supply other aerospace markets or provide aircraft-related services. Short Brothers, for example, provides aerostructures to its parent company Bombardier (Canada) for its regional jet lines. Dornier-Fairchild not only supplies aircraft subassemblies for Airbus, but also develops and produces turboprop aircraft and regional jets. Such diversification may offset cyclical downturns in the LCA market and bolster European industry health. Other firms, however, see their success linked to specializing in certain market niches, such as composites, by developing product expertise and quality that increases their attractiveness to LCA producers and other aerostructures manufacturers.[25]

Sales[26]

European industry rationalization and reduced government involvement, which has focused companies on profitability, have contributed to the improved profit margins and increased sales of the European aerospace industry (including aerostructures).[27] The European aerospace industry experienced a 44-percent increase in sales during 1995-99 to nearly **i** 65.6 billion (about $61.5 billion), and reportedly accounted for approximately one-third of global aerospace sales (excluding China and Russia). LCA industry sales totaled about **i** 1.5 billion ($1.4 billion) in 1999, roughly 23 percent of the overall total. The civil aerospace sector represented an increasing share of the overall total, accounting for nearly 69 percent of sales in 1999 compared to nearly 55 percent in 1995. Overall profit margins as a percentage of revenues reached 7 percent in 1999, continuing a rising trend begun in 1996. The European aerospace industry is now considered on par with its U.S. counterpart in terms of profit margins, which are critical in terms of attracting private capital.[28]

The British aerospace industry is Europe's largest in terms of sales (table 4-3).[29] However, its civil sector accounted for the lowest share of total aerospace revenues, reflecting the United Kingdom's strong military sector led by BAE Systems. Less than 10 percent of British industry sales is represented by the LCA sector, including LCA aerostructures.[30]

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[24] Chris Jasper and Andrzej Jeziorski, "Airbus Ups Bid to Add Japan to A380 Team and Foil Boeing," Feb. 20, 2001, found at Internet address *http://www.flightinternational.com/ficurrent/business.asp*, retrieved Feb. 21, 2001.

[25] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[26] Except where noted, data for this section are from *The European Aerospace Industry 1999 Statistical Survey*, provided by the European Association of Aerospace Industries (AECMA). Data specific to the European aerostructures industry are not available.

[27] Includes civil and military aircraft, missiles, and space final products; aircraft maintenance; aircraft equipment; aircraft engines; and aerostructures.

[28] John D. Morrocco, "European Aerospace Maintains Uptrend," *Aviation Week & Space Technology*, July 10, 2000, p. 51.

[29] Because of data gathering and reporting differences among the various European aerospace associations, the European and individual national figures presented in this section do not represent the same industry groupings, but are provided to indicate relative size and position within the industry.

[30] *UK Aerospace Facts and Figures 1999*, Society of British Aerospace Companies (SBAC).

Table 4-3
European aerospace sales and share represented by civil sector, by country, 1999

Country	1999 aerospace industry sales (in local and U.S. currencies)	Share represented by civil sector (percent)
France	[161.8 billion ($23.2 billion)	75
Germany	DM25.5 billion ($12.2 billion)	[1]58
Spain	403 billion pesetas ($2.2 billion)	76
United Kingdom	^17.6 billion ($28.5 billion)	55

[1] Figure is for 1998.

Source: Data from *UK Aerospace Facts and Figures 1999,* Society of British Aerospace Companies (SBAC); the *Annual Report of the French Aerospace Industry 1999-2000,* French Aerospace Industries Association (GIFAS); table entitled "German Aerospace Industry Sales," found at Internet address *http://www.bdli.de/english/stat5.htm#english,* retrieved Feb. 6, 2001, the *Annual Report 1998/99 of the German Aerospace Industries Association* (BDLI); and the *1999 Anexo Estadístico* of ATECMA (Asociación Técnica Española de Constructores de Material Aeroespacial), the Spanish aerospace industry association.

Trade[31]

The European aerospace industry (including aerostructures) maintained a global 1999 trade surplus of i 21.9 billion ($20.6 billion) in aerospace products, and a surplus of i 6.8 billion ($6.3 billion) with the United States. The United States was Europe's leading trade partner for aerospace products, accounting for 86 percent of European imports and nearly 50 percent of European exports.

Bilateral industry-to-industry trade (trade of aerospace products between aerospace manufacturing industries) grew significantly during 1996-99, reflecting the increased globalization and interdependence of the world's leading aerospace industries. European industry exports to its U.S. counterpart nearly doubled during the period to i 8.1 billion ($7.6 billion). European industry imports from the U.S. aerospace industry, however, grew at a slower pace, increasing by 57 percent to i 9.7 billion ($9.1 billion) in 1999.

Workforce Characteristics

Despite an emerging skilled labor shortage and different national government regulations, cultures, and languages that reportedly hamper labor flexibility and mobility, the European aerospace industry has seemingly adapted to these labor conditions to fully benefit from its highly skilled and technically competent workforce. Reflecting European aerospace industry growth, employment in the European industry rose by 10 percent during 1995-99 to 426,700 employees in 1999.[32]

[31] Data for this section are taken from *The European Aerospace Industry 1999 Statistical Survey*.

[32] *The European Aerospace Industry 1999 Statistical Survey*. In 1999, the British aerospace industry employed 154,000 workers; the French aerospace industry employed roughly 97,000 workers; and the Germany aerospace industry had total employment of 67,500 workers.

Some European industry sources indicate that the inability to adjust workforce requirements to reflect demand conditions is a costly structural impediment that hinders industry competitiveness and limits industry options to meet unplanned production increases.[33] Some industry officials concede that because of these restrictions, the European aerospace industry has a tendency "to manage the order book" to stabilize employment levels.[34]

Workforce mobility is also a concern, according to European industry sources. Cultural, language, and legal differences among European nations present challenges for companies desiring to shift work and employees between countries. For example, pension fund requirements and transportability vary among EU countries, which can negatively affect an employee's future retirement package and thus deter worker mobility and limit a firm's employment flexibility.[35]

European industry sources indicate that availability of skilled workers and engineers has emerged as an important issue, particularly as the demand for such workers will likely grow with increased European production of LCA and military aircraft[36] and requirements for R&D programs. Demand for European aerospace workers, who are highly skilled and technically comparable to their U.S. counterparts, is also growing at the lower tiers of the industry. These producers are increasing their technical staffs to handle the added work and responsibilities outsourced to them by other aerostructures firms, a movement driven in part by financial considerations.[37] U.S. industry sources have noted, however, that in the future, West European companies may be able to tap the large and competitively priced worker pool in Eastern Europe to help meet their employment needs.[38]

In response to inflexible national labor policies regarding termination of employment in a highly cyclical industry, European aerostructures producers carefully manage employment levels, in part by implementing innovative employment schemes. For example, Italian aerostructures manufacturers report that they hire workers on 3- to 5-year contracts, providing a measure of much-needed employment flexibility; in Germany, employees can be borrowed from other aerospace firms;[39] and Airbus U.K. employs a significant number of contractors that can be released in periods of slack demand.[40] Airbus itself will place an increased number of staff on temporary contracts to provide greater employment flexibility.[41] Moreover, some European aerostructures producers have greatly automated their operations to reduce the impact of any labor imbalances and improve productivity. With labor unions generally supportive of the growth in outsourcing, some European manufacturers also subcontract work when demand exceeds their production capacity.[42] Airbus has reportedly made a concerted effort to cooperate with the European national unions representing their aerospace workers.[43] Despite the reported

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[33] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.
[34] Ibid.
[35] Ibid.
[36] Ibid.
[37] Ibid.
[38] U.S. industry officials, interview by USITC staff, United States, Aug. 2000.
[39] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.
[40] Kingsley-Jones, "UK takes to the wing," p. 70.
[41] Moxon, "The manager's view," p. 61.
[42] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.
[43] For example, the former Airbus partners provided Airbus executives and unions with the same corporate information so that Airbus employees are informed about the firm's competitive challenges. Prehearing submission of Airbus Industrie G.I.E. and Airbus Industrie of North America, Inc. in connection with inv. No. 332-414, *Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry*, Nov. 22, 2000, from an article entitled "Airbus: Europe's Well-Oiled Machine," *Seattle Times*,

difficulties imposed by these workforce policies, retention of its employees throughout the LCA business cycle does allow the industry to maintain its labor skills base.[44]

Industry Developments

Globalization and Consolidation

The lack of a unified European legal and political framework, as well as different languages and cultures, contributed to the slower pace of consolidation in the European aerospace industry vis-à-vis its U.S. counterpart. Differing policies regarding merger and acquisition activity, intellectual property rights protection, R&D, employee mobility, and arms exports presented barriers to European industry restructuring. Despite these obstacles, further consolidation of the European aerospace industry is likely to occur to meet the greater financial and technological demands of airframers and prime contractors, particularly to second- and third-tier suppliers seeking to reduce costs and enhance bargaining power. Consolidation may also better position European aerospace firms to more actively pursue partnerships with and equity participation in non-European aerospace firms offering market access or new technologies and manufacturing techniques.

The recent formation of EADS (see appendix E) and a restructured Airbus was preceded by the government-supported consolidation of numerous European aerospace (including aerostructures) companies at the national level during the 1990s to strengthen their competitiveness and better position themselves in an integrated European aerospace industry. Germany began the consolidation process earlier than the other leading European aerospace countries, as DASA had absorbed most of the German aerospace industry by 1990. Aérospatiale led the consolidation in France; as part of its privatization, the state-owned company merged with the Matra Haute Technology Group to form the Aérospatiale-Matra Concern in June 1999. Finmeccanica, Italy's leading aerospace firm, has led the consolidation of the Italian aerospace and defense industry during the past 5 years.

The rapid consolidation of the U.S. civil and military aerospace industry during the mid-1990s accelerated efforts by European industry and governments to integrate the European defense and commercial aerospace sectors. The December 1997 Heads of Government Agreement tasked aerospace prime contractors to develop a rationalization program, and pledged to "implement the necessary measures in national policies" to facilitate restructuring.[45] However, political and national differences, divergent industrial philosophies, and the lack of cohesive European defense and procurement policies stalled the initiative. The reduced presence of the Spanish, Italian, and French Governments in their national aerospace industries and the political and business support for a Franco-German aerospace nucleus following the collapse of a similar British-German attempt were critical formative steps in the development of a consolidated European aerospace industry.

Globally, the changing requirements of airframers are driving further consolidation. As they reduce their supply base, shift greater design and supply chain responsibilities to their suppliers, and demand continued cost reductions, some European aerostructures firms are pursuing acquisition and

June 20, 1999, p. 15.

[44] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[45] Pierre Sparaco, "EU Leaders Promote Restructuring Initiatives," *Aviation Week & Space Technology*, Dec. 15, 1997.

merger strategies to solidify their position in the supply base. Companies are motivated to relocate production to low-cost zones[46] to reduce overall production costs, and to respond to the perceived undercapitalization of European companies vis-à-vis their U.S. counterparts, which they believe hampers their ability to compete on price and take on risk-sharing responsibilities.[47]

Globalization plays a significant role in the business plans of larger European LCA aerostructures firms, such as Airbus and Messier-Dowty. These firms have the financial resources, purchasing power, and customer base required to develop a global footprint. Their globalization strategies, however, generally encompass global sales and sourcing and delve less frequently into equity participation in non-European aerospace firms.

Foreign Direct Investment

The investment climates in France, Germany, and the United Kingdom are considered to be relatively attractive to foreign investors, according to reports from the U.S. Department of State. The United Kingdom, in particular, is highly receptive to U.S. investment, in part because of a perceived shared cultural heritage and common language. These commonalities attract U.S. companies looking for access to the EU market. As a result, the United States and the United Kingdom are each other's largest foreign investors overall.[48] France, however, is cited as imposing foreign investment restrictions on certain service and industry sectors, including aircraft production, that tend to favor EU investors over other foreign investors.[49]

State ownership in the European aerospace industry may also deter foreign direct investment (FDI). The British aerospace association, for example, considers the French defense and core aerospace sectors to be essentially closed to non-French investors[50] in part because of state participation in many aerospace companies. Government ownership does not necessarily bar companies from equity participation, but it may discourage more market-oriented investors.

The European industry generally views itself as far behind its U.S. counterparts in terms of investment in the other's market, in part because of the U.S. Department of Defense's assessment of U.S. security concerns and the stringent regulations often applied to FDI in military-related businesses.[51] Because of the Department of Defense's relative comfort with British aerospace companies, BAE Systems is one of the few foreign aerospace firms that has relatively liberal equity access to the U.S. aerospace community. Its U.S. affiliates operate at arms length from the British parent, however, which limits the flow of potentially sensitive information to safeguard U.S. security interests. Other European firms have approached the U.S. market by subcontracting with a U.S. supplier rather than taking an

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[46] Nicole Beauclair, "Europe's equipment suppliers looking good," *Interavia*, Jan. 2000, p. 14.

[47] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[48] Country Commercial Guide for the United Kingdom, U.S. Department of State, July 1999. Since January 1997, the British and U.S. aerospace industries have arranged more than 50 transactions valued at over $13 billion, 23 of which involved British investment in the U.S. aerospace and defense industry. *U.K. Aerospace Facts and Figures 1999,* The Society of British Aerospace Industries.

[49] Country Commercial Guide for France, U.S. Department of State, July 1999.

[50] "Global Rationalization and the U.K. Aerospace Industry," Society of British Aerospace Companies, Oct. 1998.

[51] For more information, see ch. 3.

equity position in a U.S. firm.[52] On the European front, France appears to share the U.S. sensitivity associated with foreign equity participation in its defense firms.[53]

Some European sources claim that a foreign firm must have a U.S. subsidiary to operate effectively in the U.S. market.[54] Certain U.S. firms have made the same claim concerning investments in Europe, noting that European governments seem to favor their own countries' firms when awarding government contracts. Therefore, partnerships and joint ventures with indigenous firms may best provide the desired access to European markets.[55]

Sheer market and company size can also be an impediment for European aerospace firms interested in investing in the U.S. industry, according to European industry sources. While European aerostructures manufacturers report that FDI in the United States would only be warranted if they had a significant role on a U.S. LCA program, the amount of capital required to make such an investment can be an impediment to such activity. Because U.S. firms are often larger than their European counterparts, European companies are often at a financial disadvantage in these situations. Small- and medium-sized firms contend that only the prime contractors have sufficient capital to engage in FDI.[56]

Changes in the Relationship Between LCA Manufacturers and Aerostructures Manufacturers

Airbus's aggressive position with respect to optimum supply chain management requires its suppliers, mostly European, to be flexible and highly competitive in terms of their contributions to an LCA program. Beginning in the late 1980s, as a response to various internal and external factors, the Airbus partner companies began "the application of the concept of 'ownership cost,' i.e., analyzing purchases not only based on price, but on all aspects of the acquisition including quality, supplier risk, integration into the supply chain, and total impact throughout the economic life of the aircraft."[57] To improve the operations of its supply chain, Airbus and the partner companies also employed techniques such as standardization through reduction of unnecessary customization, innovative financing, lead time reduction, and risk sharing.[58]

The consolidation of the European industry**S**specifically the creation of EADS–is expected to alter the relationship between Airbus and European aerostructures manufacturers, as the new, large entity will have greater leverage with suppliers than under the previous G.I.E. system.[59] With respect

[52] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[53] Bradley Perrett, "Boeing Sees Global Defense Mergers," Reuters, Jan. 31, 2001, found at Internet address *http://dailynews.yahoo.com*, retrieved Feb. 2, 2001.

[54] European industry association officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[55] Robert Wall, "Raytheon Seeks Way into Fortress Europe," *Aviation Week & Space Technology*, Dec. 4, 2000, p. 36.

[56] European industry officials, interview by USITC staff, Sept.-Oct. 2000.

[57] Airbus submission, p. 14.

[58] Airbus submission, pp. 14-15.

[59] Moxon, "The manager's view," p. 61. However, European aerostructures suppliers to Airbus report that, while the restructured Airbus will present a more traditional business model for purchasing and a single customer interface, they do not foresee many changes in their relationship with Airbus as a direct result of the single corporate entity transformation. European industry officials, interviews by USITC staff, Europe, Sept.-Oct. 2000.

to nonrelated suppliers, the new EADS entity has expressed its intentions to (1) merge the supply chains and practices of the four former Airbus partners into one integrated supply chain, and (2) renegotiate contracts that were originally entered into between suppliers and the original Airbus partners. Reportedly, those suppliers unwilling to renegotiate contract terms may not be considered as potential future suppliers.[60] EADS reportedly also plans to increase its use of offsets by purchasing more from suppliers in markets in which it wants to increase its share of LCA sales, thereby potentially impacting traditional European suppliers.

The trend toward airframers becoming "systems integrators" has led aerostructures suppliers in Europe to restructure, shedding noncore activities and acquiring other niche capabilities to become subassembly or full assembly specialists. Airbus increasingly expects its first-tier suppliers to assume supply chain management responsibilities, and would like to include second- and third-tier suppliers in this role.[61]

Contract Terms

European suppliers, which work primarily for Airbus, benefit from Airbus's tendency to foster long-term, collaborative relationships with each supplier. Airbus believes that long-term relationships between itself and its suppliers are critical to the overall integration of the supply chain and to productivity. Although long-term agreements (LTAs) reportedly put pressure on suppliers to decrease costs and increase efficiency, they also allow suppliers to make long-term investment, employment, and materials purchasing decisions.[62] Aerostructures suppliers report that Airbus honors its LTAs to a greater extent than Boeing;[63] however, as noted earlier, EADS does plan to renegotiate contracts entered into by the former Airbus partners and suppliers.

Airbus recognizes that its relationships with suppliers are unique, and that the terms and length of a contract must be tailored to each supplier. The length of a contract is determined by such factors as previous relationships, experience, the criticality of the part, and the supplier's capacity constraints.[64] According to the company, "contract terms that are too short require frequent re-negotiation and significant resources from the procurement workforce; contract terms that are too long can lead to a loss of control over pricing and conditions."[65] Airbus also crafts its LTAs to allow it some degree of flexibility; for example, clauses may require manufacturing improvements on the part of the supplier.[66] Such flexibility may inspire underperforming suppliers to improve their competitiveness.[67]

A major European aerostructures producer with experience in the European and U.S. markets asserts that, in Europe, contracts tend to be for longer terms than in the United States, and that European

[60] Jens Flottau, "EADS Integration Team Targets Suppliers," *Aviation Week & Space Technology*, Dec. 4, 2000, p. 45.

[61] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[62] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000; and responses to USITC producer questionnaire in connection with inv. No. 332-414, *Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry*.

[63] U.S. industry officials, interviews by USITC staff, United States, Jan. 2001.

[64] European industry officials, interviews by USITC staff, Europe, Sept.-Oct. 2000.

[65] Airbus submission, p. 21.

[66] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[67] European industry officials, interviews by USITC staff, Europe, Sept.-Oct. 2000.

OEMs and first-tier suppliers work with their suppliers to drive down costs rather than fostering competition to reduce costs.[68] However, another European supplier reports that, in recent years, there is a trend toward re-opening negotiations on price and lead times as a response to market pressures to reduce aircraft prices.[69] Still another European supplier reports that suppliers are increasingly expected to provide service, customer support, maintenance, product support, testing, and warranties; however, while the responsibilities increase, the compensation reportedly does not.[70]

The trend in Europe toward LTAs is extended down the supply chain to the second and third tiers. For example, Hurel-Dubois reports that it negotiates LTAs with its leading suppliers, either on a program-by-program basis, or on a multi-program basis.[71]

Risk Sharing and Supply Chain Management

The new risk-sharing procurement strategy of EADS, requiring suppliers to (1) contribute toward the general development costs of the program, (2) adjust production levels to match the pace of EADS's output, and (3) assume the same pricing and currency risks as EADS, is expected to force the pace of consolidation among smaller aerostructures suppliers that are unable to assume this type of role. In return for the assumption of risk on the part of suppliers, EADS plans to share the benefits of program sales during market upswings.[72] Risk sharing is increasingly expected of aerostructures suppliers, and increases the capabilities and therefore the competitiveness of suppliers that are willing and able to participate. Moreover, because airframers are increasingly demanding that aerostructures suppliers share program risk, similar risk-sharing arrangements are emerging among the aerostructures supplier base.[73]

The new A380 program is a prime example of the use of risk sharing by an airframer. Airbus plans to offer up to 40 percent of the value of the A380 program to risk-sharing partners globally.[74] Risk-sharing partners are expected to provide an estimated $1.9 billion;[75] some of this funding reportedly will come with government assistance. For example, Finmeccanica will reportedly have access to low-interest loans offered by the Italian Government to partly fund its share in the A380 program. Similarly, Belgium ratified a multiyear program in late 2000 to provide nearly i 200 million ($180 million) to a consortium that will develop and produce wing components.[76]

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[68] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[69] Responses to USITC producer questionnaire.

[70] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[71] *Hurel-Dubois 1999 Annual Report*.

[72] Flottau, "EADS Integration Team Targets Suppliers." However, the potential for disaster for risk-sharing partners is very real. European suppliers Alenia, CASA, and Latécoère report that, as risk-sharing partners, the demise of the McDonnell Douglas MD-11 program hurt them significantly. European industry officials, interviews by USITC staff, Europe, Sept.-Oct. 2000.

[73] Responses to USITC producer questionnaire.

[74] Airbus submission, p. 19. European manufacturers that have agreed to take on a risk-sharing role include Belairbus (Belgium), Eurocopter (Germany), Hurel-Dubois (France), Finavitec (Finland), Finmeccanica (Italy), GKN Westland Aerospace (U.K.), Latécoère (France), Saab (Sweden), and Fokker (Stork) Aerospace (Netherlands).

[75] Pierre Sparaco, "Europe Embarks On $11-Billion A380 Gamble," *Aviation Week & Space Technology,* Jan. 1, 2001, p. 22.

[76] Sparaco, "Europe Embarks," p. 23.

Suppliers view the A380 as a critical program on which to work because it is expected that this aircraft will be a technology platform for future Airbus aircraft. However, many if not most suppliers consider the risk-sharing conditions placed on A380 suppliers to be difficult to bear. Even if the program is successful, there is no guarantee that the aircraft will sell in the volume necessary to recoup their investments and earn a profit. One European supplier observed that, "with the exception of a handful of top-tier suppliers, most companies are in a worrying state of dependence in relation to the primes, which will make it hard for them to negotiate fairer conditions."[77]

In Europe, along with increased responsibility in terms of risk sharing, the nature of the partnership between Airbus and suppliers is changing in that Airbus wants its leading suppliers to take a larger role in the management of the supply chain. According to one European aerostructures supplier, Airbus demands "packed parts," i.e., completed structures with systems installed, and a 100-percent guarantee by the supplier that all systems will operate within the aerostructure, and that the structure and systems will be 100-percent compatible with other structures and systems with which it must integrate. The supplier states that this is a new role for mid-level suppliers; failure to be able to deliver packed parts relegates a firm to what many consider to be the less advantageous role of a build-to-print supplier.[78] Likewise, first-tier aerostructures manufacturers are producing fewer parts and assemblies, instead buying assemblies and subassemblies or kits of parts from lower-tier suppliers for incorporation in the structures they produce.[79]

Airbus tends to encourage its suppliers to contribute research, development, and design to their parts of the aircraft program to a greater extent than Boeing. These suppliers are then able to market themselves as design-build manufacturers, offering a value-added product for which they can command a greater premium from the airframer. For example, in the landing gear segment of the industry, European manufacturer Messier-Dowty has engaged in significantly more risk sharing and bears considerably more supply chain management responsibility for Airbus than its U.S. counterpart, Goodrich Corp., in its relationship with its primary customer, Boeing.[80]

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[77] Jean Dupont and Nicole Beauclair, "Airbus suppliers under pressure," *Interavia*, Nov. 2000, p. 22.

[78] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000. Although build-to-print suppliers may not be required to make sizeable investments to secure a position on a program, they may be seen as less integral to the program because they typically do not contribute any in-house R&D and design.

[79] Responses to USITC producer questionnaire.

[80] Goodrich recently contracted to supply the main landing gear for the A380; for more information, see ch. 3.

Manufacturing Trends

The European aerostructures industry is highly competitive in terms of manufacturing technologies and techniques. Manufacturing experts note that the Airbus approach to manufacturing is highly automated, with manufacturing processes that are more advanced than those of Boeing.[81] With the creation of The Airbus Company, there will be a realignment of engineering, manufacturing, quality assurance, and certification processes in order to streamline and consolidate the company's operations and drive down costs; however, the traditional division of labor under the centers of excellence principle will not be altered, as it has allowed for production efficiency with minimal duplication.[82]

North American competitors assert that aerostructures companies in Austria, France, Italy, the Netherlands, Spain, and the United Kingdom enjoy a competitive advantage in terms of manufacturing technology because of the availability of subsidies and/or low cost loans for technology development and capitalization, and because of government ownership of some aerostructures companies.[83] These competitors allow that the support may be within levels agreed to in the 1992 U.S.-EU Large Civil Aircraft Agreement (1992 Agreement); however, they report that a lack of commensurate support from the U.S. Government puts them at a competitive disadvantage.[84] For example, as reported to the U.S. Government by the European Commission on April 23, 2001, the Governments of France, Germany, the United Kingdom, Spain, Belgium, the Netherlands, and Finland have committed support for the A380, and Italy and Sweden may commit to support the program in the near future. This support, in the form of low-interest loans at 0.25 percent above the rate at which the governments can borrow, is reportedly in line with the requirements of the 1992 Agreement.[85] Direct support reportedly will be used to develop the A380 as well as expand production facilities; for example, local authorities reportedly will spend [1 billion on an urban development project near Toulouse, France, centered on building a new assembly hall for the A380.[86]

The level of European government assistance directed toward manufacturing technology is not readily available; however, there is a coordinated approach among European governments and industry with respect to the promotion of the domestic industries. This began in the 1960s, as the Governments in France, Germany, and the United Kingdom fostered discussions among their leading aerospace companies in order to find a strategy to compete with the strong U.S. civil aircraft industry. These discussions eventually led to the formation of Airbus Industrie, G.I.E., in 1970. The pro-active involvement of European governments in their aeronautics industries continues today. For example,

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[81] Airbus submission, p. 16, ref. exhibit 10 (Andrea Rothman for Bloomberg News, "Boeing rival Airbus won't rest on laurels," Sept. 29, 1999, found at Internet address *http://seattlep-i.nwsource.com/business/airb29.shtml*, retrieved Nov. 1, 2000).

[82] Moxon, "The manager's view," p. 61.

[83] Responses to USITC producer questionnaire; and U.S. industry officials, interviews by USITC staff, United States, Jan. 2001. One U.S. producer states that, through a joint venture with a European supplier, it has witnessed the subsidies and other support offered by European governments.

[84] U.S. industry officials, interviews by USITC staff, United States, Jan. 2001.

[85] "EU Says Subsidies for Airbus A380 Respect Air Pact With U.S." (a reformatted version of a press release dated April 23, 2001, and issued via e-mail by the European Commission), found at Internet address *http://www.bloomberg.com*, retrieved Apr. 23, 2001.

[86] U.S. Department of State telegram, "Airbus A-380: Additional French Infrastructure Expenses," message reference No. R031255Z, U.S. Embassy, Paris, May 2001.

the Spanish aerospace trade association, ATECMA, reports that the Spanish Government worked with industry in the development of Aeronautical Technological Plans.[87] The second plan covering the period 1999-2003 aims, among other objectives, to promote "basic research into materials and technological developments of aerostructures in which new manufacturing and assembly methods are included: Aerostructures in composite materials; aerostructures in metallic materials; and aerostructures in other materials."[88] Another example can be found in Italy. According to Alenia, in the 1980s, government-granted funding[89] allowed its predecessor (the company became known as Alenia in 1990) to establish its Nola facility, a fully automated center of excellence for aerostructures production.[90]

New Manufacturing Technologies and Techniques

For the most part, European aerostructures manufacturing sites are modern, highly automated, and very capital-intensive. This is due in large part to the industry's more recent formation as compared to the U.S. industry, the relative newness of Airbus programs as compared to Boeing programs, and the myriad employment laws that have encouraged European manufacturers to employ a minimal number of factory workers. The European aerostructures industry has made significant investments during the 1990s in new manufacturing technologies, as well as new manufacturing techniques, such as lean manufacturing. European producers report that their investments in modular, flexible assembly lines with improved components flow have improved production cycle times by as much as 60 percent.[91] Moreover, the high level of automation in European factories allows for less variation in tolerances and overall quality. Industry officials report an extensive list of high-technology manufacturing processes currently in use, including:[92]

- Computer-assisted automation
- Laser welding
- High speed cutting and machining
- Automated drilling and riveting
- Orbital drilling
- Automatic five axes machining
- Advanced automated materials handling
- Resin transfer molding
- Sandwich structures bonding
- Metal-to-metal bonding
- Superplastic forming/diffusion bonding
- Stretch forming
- Chemical milling

[87] ATECMA reports that the first plan resulted in (1) the consolidation of the Spanish aeronautical sector both on a European and an international level, with increased participation of Spanish firms on international programs; and (2) the promotion of specialization among companies in the sector, resulting in the achievement of technological excellence in various disciplines. *ATECMA 1999 Annual Report*, p. 15.

[88] *ATECMA 1999 Annual Report*, p. 15.

[89] This was pursuant to a law for the reindustrialization of the areas affected by the iron and steel industry crisis. Alenia Nola Plant brochure.

[90] Alenia Nola Plant brochure. See section on Specialization for a discussion of centers of excellence.

[91] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[92] See glossary for definitions of these manufacturing terms.

While some of these processes are also used by the U.S. aerostructures industry, their use does not appear to be as widespread. The more prevalent use of these technologies in Europe means the European industry is gaining relatively more experience with them, enhancing its manufacturing competitiveness vis-à-vis the U.S. industry. European suppliers are also developing several new manufacturing technologies, which are not currently in use in the United States (table 4-4).

Airbus and the partner companies recognized that lean manufacturing could significantly improve productivity over 10 years ago, and heavy investments were made in automation to improve efficiency and quality control.[93] Airbus is increasingly demanding its suppliers to adopt lean manufacturing techniques;[94] however, suppliers report that Airbus has not offered assistance with lean manufacturing training.[95] Manufacturing techniques employed by European producers include lean manufacturing, cellular manufacturing, just-in-time inventory practices, rationalized production among plants, Statistical Process Control, 5S, Six Sigma, and *Kaizen*.[96]

Advanced Materials

The European LCA aerostructures industry is highly competitive in the research, development, and application of advanced materials such as composites, carbon fiber, GLARE,[97] and titanium. Composites are currently used on various Airbus vertical fins and tailplanes; when used in the fabrication of major components, the weight savings offered by composites could be more than 20 percent, which would have a marked effect on aircraft fuel burn.

Airbus estimates that 40 percent of the A380 structure and components will be carbon composites and advanced metallic materials, including carbon fiber for the wing box; carbon fiber reinforced plastic for the fin box, rudder, elevators, horizontal stabilizers, upper deck floor beams and pressure bulkhead; and a thermoplastics fixed wing leading edge. The upper fuselage shell will be made of GLARE.[98] The A380 is expected to include more titanium than previous programs, necessitating new production processes such as superplastic forming/diffusion bonding.

With respect to the other new Airbus program, the A340-500/600, Airbus Spain has delivered the first horizontal stabilizer, which is fabricated entirely of carbon fiber and is the largest carbon fiber structure for commercial aircraft manufactured today.[99] Thermoplastic composites are used on the fixed leading edge, or "J-nose" of the A340-500/600 wing; this is likely the first large-scale application of a thermoplastic composite component on an LCA.[100] Benefits include a reduction in number of joints, parts, fabrication time; improved damage tolerance; and weight reduction of 20 percent.[101]

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[93] Airbus submission, pp. 14-15.

[94] Airbus submission, p. 27.

[95] European industry officials, interviews by USITC staff, Europe, Sept.-Oct. 2000.

[96] See glossary for definitions of these manufacturing terms.

[97] GLARE is a hybrid material consisting of alternate thin sheets of aluminum and sheets of pre-impregnated glass fiber.

[98] *Speednews*, Sept. 29, 2000, p. 2. There are many advantages to using GLARE, including its lower density; greater damage tolerance; improved resistance to fatigue, corrosion, and fire; and improved ease of repair. Nicole Beauclair, "Airbus A380 Special," *Interavia*, Oct. 2000, p. 40.

[99] CASA website, *http://www.casa.es/*, retrieved May 2000.

[100] Boeing is currently considering development of a composite wing for their 737NG; for more information, see ch. 3.

[101] Oliver Sutton, "Breaking the composite cost barrier," *Interavia*, Sept. 2000, p. 22

Table 4-4
Selected new manufacturing technologies in the European aerostructures industry

Company	Technology	Application	Benefits
Airbus and Airbus Germany	Laser welding	To replace traditional riveting techniques to attach stringers to fuselage skins; will be introduced with A318 (delivered in 2001) and the A380	Laser welding is faster than traditional riveting, reducing manufacturing costs of a fuselage by approximately 20 percent; potential for structural weight reduction of up to 10 percent; improved in-service quality with respect to reduced risk of corrosion
Airbus U.K.	Friction stir welding	To replace bolted and/or riveted joints typically used in the joining of aluminum alloys in the manufacture of aircraft wings; will be tested on the A340-600 wing ribs for possible use on A380 ribs	Cost, weight, joint quality and in-service performance benefits; highly automated manufacturing leading to faster throughput
Airbus U.K.	Low-voltage electro-magnetic riveting	To attach stringers to top-skin wing panels for the A340-500/600	Increased productivity anticipated when at full operational capacity
Airbus U.K.[1]	Automated Wingbox Assembly Program	To change wing box structural component designs in order to facilitate and demonstrate automated assembly of LCA wing structures, and allow for flexible manufacturing within a single manufacturing cell	Improved productivity and reduced manufacturing costs
Airbus U.K.[2]	Affordable Manufacture of Composite Aircraft Primary Structures Program	To explore the feasibility of applying stitched (spot welded) materials to wing box structures; and to determine the costs and facilities required to manufacture composite wing boxes, as well as the impact on lead times and process flow developments	Airbus will lead the follow-up to AMCAPS II through a 4-year project known as Technology Application to the Near-Term Business Goals and Objectives (TANGO). TANGO's goals are to achieve a 20-percent cost reduction in both structural weight and current manufacturing processes and design

[1] As a member of a seven-partner project partially funded by the British Government.
[2] As member of a pre-competitive collaborative project comprising 13 United Kingdom-based manufacturers and various academic establishments and partially funded by the British Government.

Source: "Aerospace joining technology," *Aircraft Technology Engineering and Maintenance*, Aug./Sept. 2000, p. 24; Oliver Sutton, "Breaking the composite cost barrier," *Interavia*, Sept. 2000, p. 22; David A. Lombardo, "Developing Technologies in Aviation," *Aviation International News*, Jan. 2001, p. 42; and Nicole Beauclair, "Airbus A380 Special," *Interavia*, Oct. 2000, p. 38.

Specialization

Perhaps the most important competitive advantage of the European LCA aerostructures industry is derived from the region- coordinated approach toward designated "centers of excellence" (table 4-5). European manufacturers have recognized the strategic advantage of specializing, either company wide or by plant, in specific production technologies and products: the company/plant is able to maximize its investments by focusing them on specific technologies, reap the benefits of economies of scale and learning curve effects, and develop a world-class reputation as a specialist in its chosen area. Within the European research community, the centers of excellence concept is promoted by the European Commission as a way to improve the efficiency of aeronautics research throughout Europe.[102]

The centers of excellence approach began with the birth of Airbus Industrie, G.I.E. in 1970, at which time the partner companies were allotted specific workshares based on parts of the aircraft they would build and equip. Airbus's technologically specialized plants ensure an optimum level of productivity and performance for specific applications; for example, Airbus Germany reports that this strategy has allowed it to optimize logistics, manufacturing processes, and flow to achieve a 50-percent reduction in costs.[103] European manufacturers not related to Airbus report that price pressures often cause firms to specialize and increase their area of expertise.[104] One supplier in particular reports that, while 10 years ago it was a more diversified manufacturer, the cost of financing for development has forced it to focus on the manufacture of fewer types of aerostructures.[105]

Subcontracting

Knowing when to outsource and having a reliable network of subcontractors are critical factors of competitiveness. European suppliers cite the relative importance of the part, the potential to enhance price competitiveness, and capacity constraints as the leading factors in the decision to outsource.[106] European manufacturers also use outsourcing to maintain stability in production and capacity by keeping in-house what they can sustain during cycle downturns and outsourcing the remainder. European industry officials report that the network of suppliers is relatively more developed in the EU, facilitating the subcontracting of subassemblies.[107]

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[102] AECMA, "Aerospace within the European Research Area: Contributions to the Debate on the European Commission Initiative, Paper No. 1, Centres of Excellence," Jan. 2001, found at Internet address *http://www.aecma.org*, retrieved Apr. 20, 2001, Executive Summary.

[103] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[104] European industry officials, interviews by USITC staff, Europe, Sept.-Oct. 2000.

[105] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

[106] European industry officials, interviews by USITC staff, Europe, Sept.-Oct. 2000; and Pierre Sparaco, "Aerostructure Provider Plans Expansion," *Aviation Week & Space Technology*, Apr. 17, 2000, p. 77.

[107] European industry officials, interviews by USITC staff, Europe, Sept.-Oct. 2000.

Table 4-5
Selected European "centers of excellence" for aerostructures

Company	Plant location(s)	Technological and/or aerostructure specialty
Airbus France	Meaulte	Body panels, cockpit structures
	Nantes	Composites Fuselage panels, frames, and stringers
	St. Nazaire	Composites Forward and center fuselage barrel sections, body panels, frames and stringers
Airbus Germany	Augsburg	Barrel sections, body panels, keel beams
	Bremen	Completed wings
	Hamburg	Front and rear fuselage barrel sections
	Nordenham	Body panels, frames and stringers
	Stade	Composites Tail planes, fins, rudders, flaps
	Varel	Machining, frames and stringers
Airbus Spain	Getafe	Carbon fiber component development and manufacture Tail planes, elevators/horizontal stabilizers
	Puerto Real	Body panels
	Tablada	Integrated numerical control component machining, stretch forming and chemical milling Frames and stringers
Airbus U.K.	Broughton	Wing skins, wing final assembly
	Chester	Completed wings, wing skins
	Filton	Wing design, barrel sections, leading and trailing edges
	Warton	Leading and trailing edges
	Weybridge	Flap track fairings
Alenia (Italy)	Foggia	Composites
	Nola	Mechanical machining, sheet metal fabrication Body panels
	Pomigliano	Barrel sections

Source: Staff interviews with European industry officials, Sept.-Oct. 2000; company informational brochures and annual reports.

Airbus began "the systematic outsourcing of techniques and technologies outside the scope of the centers of competence" more than 10 years ago.[108] This is an important strategy for the company, since constraints on resources make it unfeasible to retain all components and technologies as core competencies. Other factors that lead it to outsource include capacity constraints when production volumes are high, and fluctuations in costs.[109] However, Airbus only considers outsourcing noncore components or technologies.[110]

Suppliers that are likely to be chosen as Airbus subcontractors are those that are willing to contribute to nonrecurring costs, accept exchange rate risk, be flexible in terms of volume commitments, or those in countries where Airbus would like to sell its aircraft (i.e., offsets).[111] For example, Airbus U.K. has subcontracted some wing fabrication to China;[112] a company official states that "we are not going to get the Chinese to order Airbus aircraft unless we are in there, like Boeing."[113] Airbus has also indicated its intention to secure a 50-percent share of the Japanese market, as well as the broader Pacific Rim LCA markets,[114] which may lead it to offer more aerostructures work to producers in these markets. U.S. industry officials predict that Airbus will subcontract more aerostructures work to suppliers in Eastern Europe in the future as well.[115] One European aerostructures producer reports that competitors in Asia and Eastern Europe have a competitive advantage in terms of wage rates.[116]

Airbus reportedly currently subcontracts 45 percent of its airframe work, and plans to increase this to over 50 percent by the end of 2003.[117] This strategy allows the company to cope with boom and bust cycles without having to increase and decrease its own production capacity. Boeing reportedly subcontracts a similar amount of its airframe work to outside suppliers.[118] Airbus France reportedly has the most extensive subcontractor network of the Airbus shareholders, aiming to subcontract more than one-half its total workshare on Airbus programs. Independent producer Latécoère subcontracts up to 50 percent of its workload to companies in China, Denmark, France, Korea, Poland, Portugal, and the United Kingdom.[119]

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[108] Airbus submission, pp. 14-15.

[109] Airbus submission, pp. 18-19.

[110] Airbus considers a component or technology to be core if (1) the function is fundamental to the aircraft's performance, reliability, and quality; (2) no other supplier can demonstrate sufficient commitment to continuous improvement in the area; and (3) it believes it has a competitive advantage in the component or technology and wants to maintain its edge.

[111] Airbus submission, p. 19.

[112] BAE Systems has agreed to shift some work on the A320 wings to AVIC I (China), creating an undetermined amount of savings for BAE and EADS derived from China's lower labor costs. Flug Revue, found at Internet address *http://www.flug-revue.rotor.com/FRweek1htm*, retrieved Nov. 13, 2000.

[113] Kingsley-Jones, "U.K. takes to the wing," p. 70.

[114] "News Roundup," *Aviation Week & Space Technology*, Apr. 2, 2001, p. 29; and Pierre Sparaco, "Airbus Foresees Healthy Asian Sales," *Aviation Week & Space Technology*, Apr. 16, 2001, p. 60.

[115] U.S. industry officials, interviews by USITC staff, United States, Jan. 2001.

[116] Responses to USITC producer questionnaire.

[117] Moxon, "The manager's view," p. 61.

[118] U.S. industry officials, telephone interviews by USITC staff, Apr. 2001.

[119] Sparaco, "Aerostructure Provider Plans Expansion," p. 77; and *Latécoère 1999 Financial Highlights and Products*.

Manufacturing Software Developments

The European aerostructures industry avails itself of state-of-the-art manufacturing software, including CATIA. The A380 will be the first Airbus program for which CATIA's computer-aided design, engineering, and manufacturing will be used from the beginning of the program's development. Financial analysts note that the use of computer-aided design and manufacturing on the A380 will likely minimize the risk of cost over-runs,[120] which is important given the projected cost of the program's development and the stated goal of Airbus to be more cost conscious. Airbus selected CATIA as the replacement for the CADDS-5 package that Airbus used on previous programs, and it will eventually become the principal CAD/CAM package for new projects.[121] Airbus will also begin implementing Windchill, a product data management tool created by the makers of CADDS-5, to assist in data management as well as to provide communication and visualization capabilities to support collaborative work on digital mockups. In addition, Airbus is implementing the Enovia Internet portal. By linking the company's manufacturing centers, Enovia will facilitate the manipulation of the knowledge base of the subsidiaries and their suppliers, thereby making it unnecessary to stop the production process when design changes are made.[122]

Although state-of-the-art manufacturing software can provide a competitive advantage, it must be implemented clearly and consistently. In late 2000, Airbus admitted that a 3-month delay in the first deliveries of the A340-600 was the result of confusion between BAE and its suppliers over design standards concerning CADDS-5. Thus, the inconsistent application of manufacturing software resulted in component manufacturing delays that affected the entire program schedule.[123]

Airbus U.K. has been a proponent and user of knowledge-based engineering (KBE), a software environment that permits businesses to more effectively retain their engineers' accumulated experience and knowledge to generate significant time and cost savings.[124] Airbus U.K. gained substantial benefits from its application of KBE techniques on the A340-600 development program by automating the design of most of the repetitive structural components in the wing box and other areas. In addition, Airbus U.K. has applied KBE to select wing designs for the A380, thereby reducing development time and achieving 50-percent cost savings in the engineering of key components, as well as significant production savings.[125]

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[120] Credit Suisse/First Boston, "European Aeronautic Defence and Space Company (EADS)," Mar. 14, 2001, p. 5.

[121] Dupont and Beauclair, "Airbus suppliers under pressure," p. 22.

[122] Michael Mecham, "Airbus Switches to Catia for A380 Development," *Aviation Week & Space Technology*, Aug. 7, 2000, p. 57.

[123] Julian Moxon, "Design standards mix-up delays Airbus A340-600 by three months," *Flight International*, Nov. 21-27, 2000, p. 10.

[124] See glossary for definition.

[125] Sutton, "Breaking the composite cost barrier," p. 22.

Implications for the Competitiveness of the European Industry

The reorganization of Airbus and the formation of EADS will likely have a significant impact on the European aerostructures industry as they optimize their manufacturing operations and streamline many administrative procedures, thereby contributing to operational efficiencies and improved productivity for Airbus and its subsidiary aerostructures producers, and encouraging such developments among nonrelated European aerostructures suppliers. Consolidation and rationalization at all levels of the supplier industry will likely reduce the number of underperforming suppliers and enhance the portfolios of remaining producers.

Through its participation in EADS, Airbus will gain access to financial markets to fund new aircraft programs. International financial markets represent a new and important source of funding for Airbus as it seeks to expand its aircraft lines and possibly enter new business activities. The more performance-driven requirements of this type of funding will likely compel the company to focus more intently on profitability and to pursue less risky ventures that offer a better guarantee of success. The impact of such funding on the availability of government launch aid to the former Airbus partners and their aerostructures units is unclear.

Airbus's focused business strategy and development of new and derivative aircraft will contribute to the ability of many other European aerostructures suppliers to retain and improve their skills base by gaining access to new technologies and manufacturing processes, and provides opportunities for upgrading equipment and machinery when new contract awards are made. The production capacity and financial and labor resources of European aerostructures suppliers, however, may be insufficient to meet new program demands, forcing them to subcontract less critical work or commit already strained funds for questionable returns.

Because of European workforce rules, most European companies retain a stable core pool of knowledgeable, highly skilled employees capable of taking on new assignments and projects with little disruption in production. Workforce limitations also encourage European firms to automate and computerize to reduce the labor intensity of their production operations, thereby improving productivity and enhancing product quality and standardization. Although European firms have generally developed creative approaches to offset the impact of labor restrictions, reduced worker flexibility and mobility does eliminate an option for European aerostructures firms trying to best respond to cycles in LCA demand.

The inter-relationship of many European aerostructures firms may hamper their ability to pursue their own best interests, thus restricting opportunities to broaden their product offering and customer base, enhance their revenue stream, and expand their manufacturing and technological skills. Although governments can provide important financial and political support, the lingering presence of state governments in the ownership structure of EADS and the more participatory nature of many European governments in industrial policy may also indirectly impact industry independence and flexibility, and influence its ability to best respond to market conditions.

The competitiveness of the European aerostructures industry is heightened significantly by its investments in and application of advanced materials and manufacturing technologies. These technologies and techniques can lead to important cost savings for suppliers, which in turn may allow them to offer more competitive prices to LCA manufacturers during the bidding process. In particular, Europe's coordinated centers of excellence system has allowed for maximum production efficiencies and the development of highly specialized production sites for all facets of aerostructures manufacture.

However, European companies have considered themselves as undercapitalized in contrast to their U.S. counterparts, which may hamper their ability to compete on price and take on risk-sharing responsibilities. This undercapitalization is spurring the consolidation movement currently evident in the European industry. Although the results are expected to enhance the efficiency of operations and profitability by increasing economies of scale, eliminating duplication, streamlining corporate organization and industrial processes, and providing for the pooling of assets and purchasing power, the time and resources that are currently being directed toward these efforts are a drain on corporate operations.

CHAPTER 5
THE CANADIAN LCA AEROSTRUCTURES INDUSTRY

Introduction

As part of the global aerospace industry, Canadian aerostructures manufacturers generally follow the same trends and experience the same pressures as other aerostructures manufacturers around the world. Canadian firms indicate that competition for Boeing and Airbus programs has increased as these aircraft companies seek to reduce their overall number of suppliers, while at the same time new suppliers, particularly in Asia, enter the aerostructures market. In addition, Boeing and Airbus want their suppliers to participate in developing integrated systems and take part in risk-sharing partnerships. Further consolidation of the Canadian aerostructures industry is needed to meet these challenges and develop a systems integrator capability.

In order to succeed, Canadian aerostructures manufacturers will likely require greater capitalization, resource availability, and technical and management expertise, areas identified as challenges for Canadian aerostructures manufacturers.[1] These firms recognize that they will not be able to rely solely on past relationships, but must develop new strategies such as further consolidation to meet increased risk-sharing responsibilities; greater diversification of the customer base to include Boeing and Airbus, as well as Bombardier, and their suppliers; and implementation of cost-reducing concepts, including lean manufacturing, to remain viable in the international aerostructures market.

This chapter discusses the industry structure and market indicators for the Canadian aerostructures industry, such as the composition of the industry, sales, trade, and workforce characteristics; industry developments, including globalization and consolidation, foreign direct investment, changes in the relationship between large civil aircraft (LCA) manufacturers and aerostructures manufacturers, and manufacturing trends; and, finally, implications for the competitiveness of the Canadian industry.

Industry Structure and Market Indicators

Composition of the Industry

Canada has a well-established, albeit modest, LCA aerostructures industry consisting of both home-grown companies and foreign subsidiaries of major corporations (table 5-1). Canadian aerostructures manufacturers primarily supply Boeing, and to a lesser extent, Airbus, and produce

[1] Kim Laudrum, “The Future of Aerospace,” *Canadian Machinery and Metalworking*, Jan.-Feb. 2000, pp. 18-21.

Table 5-1
Canadian aerostructures producers, plant locations, aerostructures produced, and LCA customers

Aerostructures producer (affiliation)	Plant location(s)	Aerostructures produced	LCA customer(s)
Avcorp Industries	Delta, British Columbia	Wing panel skins, parts for wings, small frame fuselage attachments	Boeing, Airbus
Boeing Canada Technologies (The Boeing Co., USA)	Winnipeg, Manitoba Arn Prior, Ontario	Trailing edge panels, wing-to-body fairings	Boeing
Boeing Toronto (The Boeing Co., USA)	Toronto, Ontario	Wing sets	Boeing
Bombardier Aerospace	Montréal, Québec	Fuselage components, trailing edges	Boeing, Airbus
Bristol Aerospace (Magellan Aerospace, Canada)	Winnipeg, Manitoba Rockwood, Manitoba	Wing fillet panels, fixed trailing edge panels, wing-to-body fairings, strut components	Boeing
Chicopee Manufacturing (Magellan Aerospace, Canada)	Kitchener, Ontario	Wings and components	Boeing
Composites Atlantic[1]	Lunenburg, Nova Scotia	Fairings and panels	Boeing, Airbus
Fleet Industries (Magellan Aerospace, Canada)	Fort Erie, Ontario	Wing flaps, vanes, ailerons, wing fillet panels	Boeing
Goodrich[2]	Oakville, Ontario	Landing gear	Boeing
IMP Group	Amherst, Nova Scotia	Rudders, flaps	Boeing
Messier-Dowty (SNECMA, France)	Ajax, Ontario	Landing gear	Boeing, Airbus

[1] A joint venture between Aérospatiale Matra (France) and the Province of Nova Scotia.
[2] Menasco Aerospace, including its Canadian facilities, was obtained by Goodrich (USA) in 1999.

Source: Compiled from various sources by USITC staff.

regional jet aerostructures for Bombardier.[2] In addition to business and regional jet aircraft, Canadian firms have developed a broad range of niche markets including large landing gear assemblies, commercial flight simulation and visual systems, commercial helicopters, small gas turbine engines, and space applications.[3]

[2] Regional aircraft account for a substantial portion of the Canadian aerospace industry; Bombardier is the third-largest aircraft producer in the world, but does not produce LCA. Bombardier recently announced its intention to postpone indefinitely development of its 110-seat BRJ-X, due in part to current commitments and the significant presence of Boeing and Airbus in this market segment.

[3] Aerospace Industries Association of Canada (AIAC), "Sales by Canada's Aerospace Industry Soar to Record Level," *Speaking Out*, Oct. 2000, p. 1.

Bombardier produces aerostructures for Boeing and Airbus in Montréal, Québec, and in Belfast, Northern Ireland, through its subsidiary Short Brothers. However, Bombardier's production for Boeing and Airbus accounts for less than 4 percent of its revenues and is based on long-term contracts (dating from 1979-96) and relationships developed by companies acquired by Bombardier. The success of Bombardier's aerospace division, which has introduced a new aircraft or derivative aircraft every year since 1992, reduces Bombardier's interest in pursuing additional Boeing or Airbus work.

Canadian manufacturers of complete landing gear assemblies represent the only aerostructures systems integrators in Canada and accounted for 60 percent of the world market for new large aircraft landing gear systems in 1999.[4] The LCA component of this market niche has been captured by U.S.-owned Goodrich and France-based Messier-Dowty.[5] Goodrich primarily produces landing gear at the Menasco Aerospace facilities in Ontario, Canada, and until recently, Texas.[6] Messier-Dowty's Canadian operations, along with its European facilities, design, develop, and produce landing gear for all of Airbus's programs and, through an agreement with Goodrich, Boeing's 777.

Sales

Canadian sales of aerospace and defense products reached $11.3 billion in 1999, a 57-percent increase from 1995 levels (table 5-2). Total sales are export-driven as exports accounted for 67 percent to 78 percent of total sales during 1995-99. Although detailed data are unavailable, it is likely that LCA aerostructures comprise a small portion of aerospace sales, given the success of other high

Table 5-2
Economic indicators of the Canadian aerospace and defense industry, 1995-99

Economic indicators	1995	1996	1997	1998	1999[1]
			(Millions of U.S. dollars)		
Total sales	7,218	8,387	9,020	10,315	11,325
Exports	4,844	5,786	6,374	8,054	8,617
			(Number of employees)		
Total employment	57,232	62,849	66,025	68,715	68,141
Production workers	29,007	36,831	38,850	41,496	40,211
Engineers	12,363	12,907	13,571	13,689	13,918

[1] Estimated.

Source: Industry Canada, Aerospace and Defence, Statistical Survey Results, found at Internet address *http://strategis.ic.gc.ca/SSG/ad03411e.html,* retrieved Dec. 20, 2000.

[4] Ibid.

[5] A third landing gear producer in Canada is Héroux, which merged with Devtek in 2000. Héroux currently produces landing gear for military programs, while Devtek performs high-speed machining and specialty machining.

[6] Goodrich also produces landing gear in Cleveland, Ohio. For more information, see ch. 3.

value aerospace sectors in Canada, such as the regional jet and engine markets. Furthermore, electronics, avionics, and simulators reportedly account for one-third of total Canadian aerospace sales.[7]

Trade

Important export markets for Canadian aerospace products include the United States, followed by the United Kingdom, France, and Germany. These same countries, in addition to Japan, are the primary Canadian import sources. The United States is a key supplier of raw materials to the Canadian aerostructures industry; for example, one firm indicated that as much as 90 percent of its materials come from the United States.[8] Canadian aerostructures manufacturers commonly cite the exchange rate for the Canadian dollar against major world currencies as a Canadian competitive advantage.[9] The value of the Canadian dollar decreased by more than 8 percent vis-à-vis the U.S. dollar during 1995-99. However, currency depreciation, which has spurred exports, works against Canadian firms with respect to imports of raw materials and subsystems.

Workforce Characteristics

Although a skilled workforce was identified as a significant competitive advantage for the Canadian aerospace industry, potential shortages of skilled workers in Canada may undermine this asset.[10] Despite increased employment at some aerospace companies, attributed in part to cyclical employment patterns, shortages have occurred for machinists, tool and die makers, and software and systems engineers.[11] Industry officials attribute these shortages to a number of factors, including competition for recent graduates from other high-technology sectors, the attractiveness of the United States due to lower taxes and generally higher wages, similar competitive pressures in Europe that have reduced the number of foreign workers moving to Canada, and movement of skilled and experienced workers from aerospace into other industries.[12]

Employment in the Canadian aerospace and defense industry grew steadily during 1995-98, before decreasing slightly in 1999 to 68,141 employees (table 5-2).[13] Many of these workers are represented by the National Automotive, Aerospace, and Agricultural Implement Workers of Canada (50 percent) and the International Association of Machinists and Aerospace Workers (20 percent).[14] Industry officials report that union membership increased slightly in recent years.

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[7] PricewaterhouseCoopers LLP, *Canadian Aerospace Suppliers Base Strategy for Change*, June 25, 1999, p. 21.

[8] Canadian industry official, interview by USITC staff, Canada, Jan. 2001.

[9] Canadian industry officials, interviews by USITC staff, Canada, Jan. 2001.

[10] A 1997 AIAC survey identified the availability of skilled and experienced workers as the leading issue facing the Canadian aerospace industry. Industry Canada, Aerospace and Defence Branch, "Assessment of the Skills and Training Situation in the Canadian Aerospace Industry," Jan. 1999, p. 3.

[11] Ibid., p. V.

[12] Canadian industry officials, interviews by USITC staff, Canada, Jan. 2001.

[13] Industry Canada, Aerospace and Defence, Statistical Survey Results, found at Internet address *http://strategis.ic.gc.ca/SSG/ad03411e.html*, retrieved Dec. 20, 2000.

[14] Industry Canada, "Sector Competitiveness Series: Aircraft and Aircraft Parts," Aerospace and Defence Strategis, Sept. 11, 1996, found at Internet address *http://strategis.ic.gc.ca*, retrieved Sept. 18, 2000.

Industry Developments

Globalization and Consolidation

Smaller Canadian aerostructures suppliers confront problems related to capitalization, resource availability, management, and technical issues.[15] Risk-sharing arrangements with LCA producers require greater capital and research and development (R&D) capabilities on the part of their suppliers. Consolidation with other firms would address these issues and enable small- and medium-sized suppliers to compete for aerostructures contracts and move beyond their present status as lower-tier suppliers to the aerostructures industry. The consolidation that has occurred within the Canadian aerostructures industry has been driven by market changes faced by small- and medium-sized Canadian aerostructures suppliers and the trends of larger companies with subsidiaries in Canada. Such consolidation has generally taken one of two forms: consolidation among Canadian firms, and consolidation among multinational corporations that have Canadian operations.

First, consolidation has occurred among domestic Canadian companies of various production capabilities and sizes, in part to meet the demands of the changing aerospace industry. Bombardier's aerospace division grew after its acquisition of Canadair (1986), a producer of business jets, followed by the development of the CRJ series of regional jets.[16] In 1989, Bombardier obtained Northern Ireland-based Short Brothers (Shorts) from the British Government.[17] In contrast, Magellan, reportedly the largest aircraft component manufacturer in Canada,[18] aggressively sought growth through acquisitions of aerostructures and aeroengine suppliers, acquiring six companies since 1996.[19] Magellan plans additional acquisitions, primarily looking for companies of value that require cash and management discipline and complement Magellan's current capabilities. Avcorp anticipates that future consolidation through mergers or acquisitions "may lead to stronger financial resources and increased revenues,"[20] which will be necessary in order to remain competitive in the global aerostructures market.

Second, consolidation has also occurred among multinational aircraft and aerostructures companies that have operations in Canada. Although these consolidations affect Canadian subsidiaries, they are not usually the result of factors inherent in the Canadian business environment. France-based Messier merged with United Kingdom-based Dowty, which has manufactured landing gear in Canada

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[15] Laudrum, "The Future of Aerospace," pp. 18-21.

[16] U.S. industry officials, telephone interviews by USITC staff, Aug. 2000.

[17] Shorts, a manufacturer of aircraft as well as aerostructures, is a supplier to Boeing and Bombardier. Other nonaerostructures-related acquisitions include Learjet in 1990, based in Wichita, Kansas, and deHavilland Canada in 1992, based in Ontario.

[18] Peter Verburg, "A Midas Touch," *Canadian Business*, June 26-July 10, 1998, found at Internet address *http://proquest.umi.com,* retrieved Oct. 17, 2000.

[19] Magellan was formed in 1995 from two Canadian companies, Fleet Industries and Langley Aerospace, and U.S.-based Aeronca, and became known as Magellan Aerospace in 1996. Subsequent acquisitions in the United States and Canada include Orenda Aerospace, Middleton, Bristol Aerospace, Ambel Precision, Chicopee, and Ellanef.

[20] Avcorp Industries, press release, "Fiscal 2000 Results," Jan. 10, 2001, found at Internet address *http://www.avcorp.com,* retrieved Feb. 15, 2001.

since World War II.[21] Goodrich obtained Canadian landing gear manufacturer Menasco in its 1999 merger with U.S.-based Coltec Industries, enabling Goodrich to compete with Messier-Dowty. Furthermore, Boeing is in the process of incorporating McDonnell Douglas's former Canadian operations into the Boeing family.

Foreign Direct Investment

Most foreign-owned aerospace companies in Canada are subsidiaries of U.S.-based aerospace companies with well established histories of operating in Canada. Canadian firms closely aligned themselves with U.S. producers after Canadian defense policy shifts during the early 1960s prompted Canadian firms to seek U.S. defense contracts.[22] In addition, U.S. commercial aircraft manufacturers established substructure production facilities in Canada during the mid-1960s.[23] Recent investments in Canada include France-based Aérospatiale Matra's joint venture with the Province of Nova Scotia in Atlantic Composites, which was formed in 1993 from Cellpack Aerospace Ltd., a subsidiary of Cellpack AG of Switzerland. Goodrich and Messier entered the Canadian aerostructures market as the result of consolidation within the global industry rather than new foreign direct investment (FDI).

The aerospace industry in Canada is receptive to foreign ownership, which accounts for 60 percent of the industry.[24] According to industry officials, factors that attract FDI include proximity and access to the U.S. market; availability of skilled workers; a favorable relative exchange rate; developed technological infrastructure, including the Canadian university system; beneficial tax structure including reduced corporate tax rates and attractive R&D tax credits; government support of R&D through Technology Partnerships Canada and the National Research Council; lower wage rates than in the United States or Europe; low energy costs; and low levels of litigation.[25]

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[21] According to Messier-Dowty Chairman Louis Le Portz, his firm would like to form a joint venture with Goodrich to gain more of the Boeing market. Thus far, Messier-Dowty has only reached a subcontracting deal with Goodrich Landing Systems in Canada on the Boeing 777. Furthermore, Mr. Le Portz indicated that a "partnership with BF Goodrich would actually increase competition (sic)" as it would give both companies entry to Boeing and Airbus. Mr. Le Portz stated that cooperation and partnerships are crucial for the future, especially as the launch of the Airbus A380 places large investment demands "on an already stretched world landing gear industry." John Morris, "Messier-Dowty Will Pursue Partnerships," *Aviation Week's Show News Online*, July 25, 2000, found at Internet address *http://www.aviationweek.com*, retrieved July 25, 2000.

[22] Industry Canada, "An Historical Perspective," *Aerospace and Defense Strategis: Canada's Aircraft Industry*, Oct. 2, 1997, found at Internet address *http://strategis.ic.gc.ca/SSG/ad02641e.html*, retrieved Sept. 18, 2000.

[23] Ibid.

[24] Canadian officials maintain that Canada receives less foreign direct investment (FDI) than the United States, despite Canada's favorable business climate. Industry officials attribute the lack of FDI in Canada in part to political instability surrounding the province of Québec independence issue, but indicate that this explanation needs to be examined further. Canadian industry officials, interviews by USITC staff, Canada, Jan. 2001.

[25] Canadian industry officials, interviews by USITC staff, Canada, Jan. 2001.

Changes in the Relationship Between LCA Manufacturers and Aerostructures Manufacturers

Canadian aerostructures producers are subject to similar changes in their relationship with LCA manufacturers as aerostructures producers around the world.[26] Canadian aerostructures suppliers have to adjust to the same cost-conscious environment as other global producers, i.e., cost pressures flow from airlines to airframers and down to the aerostructures suppliers. They cite the need for further consolidation to become strong suppliers as airframers are requiring more investment, risk sharing, and flexibility from their supplier base. The shift in integration practices of LCA producers may become more apparent as integrated packages become larger and more complicated along with the emergence of a capability gap at the systems and subsystems integration level.[27] Although some Canadian companies are focusing their capabilities on the LCA market, most others indicated that they would like to supply both the LCA and regional jet market.[28] However, lacking a systems integrator's financial capabilities, financing such ventures is a formidable hurdle that hinders Canadian aerostructures manufacturers from taking on additional risk-sharing roles.

Risk Sharing

Aerostructures manufacturers in Canada indicate a willingness to take on more risk-sharing responsibilities, including R&D, but note a reluctance on the part of Boeing to engage them for these purposes.[29] Canadian companies suggest that Boeing's position is due, in part, to its emphasis on cost reduction rather than engineering collaboration.[30] However, a risk-sharing arrangement whereby aerostructures manufacturers designed the assembled pieces that they supply would help reduce production costs and enable these companies to grow.[31] Avcorp invested in a new state-of-the-art facility to better serve Bombardier as a design-build partner on the CRJ 700 series regional jet program. The success of this investment strategy depends on the success of the program; Avcorp did not receive financial assistance from Bombardier nor payment until the first jet deliveries.[32] Avcorp is a build-to-print supplier to Boeing, but given its risk-sharing experience with Bombardier and the investment in new production facilities with design capabilities, Avcorp could become a design-build partner to any LCA producer.

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[26] Such changes are generally reflected in the contracts between LCA manufacturers and aerostructures producers, such as contract length, risk sharing, and delivery. These obligations are passed along the supply chain to aerostructures industry suppliers.

[27] PricewaterhouseCoopers LLP, *Canadian Aerospace Suppliers Base*, p. 25.

[28] Canadian industry officials, interviews by USITC staff, Canada, Jan. 2001.

[29] Canadian industry official, interview by USITC staff, Canada, Jan. 2001.

[30] Canadian companies also suggest that union challenges to Boeing's move to non-U.S. production facilities hinders Canada's ability to attract more Boeing work. Canadian industry officials, interviews by USITC staff, Canada, Jan. 2001.

[31] Boeing appears to be reviewing its policies regarding risk sharing. For more information, see ch. 3.

[32] In 1997, Avcorp received a Technology Partnerships Canada repayable loan to help fund research and development on the CRJ 700 series regional jet. Avcorp then sold some intellectual property related to the CRJ 700 contract to Bombardier in 1999 in order to help finance the project. However, the facility largely was internally funded, despite the substantial risk of the investment. Deliveries of the CRJ 700 regional jet began in January 2001.

Canadian subsidiaries of European firms appear to have met the demand by airframers for their suppliers to participate more in the design and development of aerostructures, which has helped these firms prosper in Canada. For example, the Toronto facility of Messier-Dowty maintains extensive design, development, manufacturing, and support capabilities for integrated landing gear systems on commercial aircraft. Programs include studies on adaptive and active landing gear systems, which permit landing gear to be adjusted to compensate for variable runway conditions.

As Airbus begins moving toward production of the A380, Canadian aerostructures suppliers anticipate that the company will need to look overseas to help fulfill its production requirements for existing Airbus programs.[33] Canada's experience with risk sharing will be a valuable asset when competing for Airbus contracts. While Canadian companies recognize the potential opportunities for increased work within Europe, they have yet to make significant inroads into this market. In 1999, acknowledging the need to enter the European market, Avcorp contracted to supply ram air turbine doors for Airbus programs through its affiliation with Austria-based Fischer Advanced Composites Components. Avcorp anticipates that this initial Airbus contract will "pave the way for future work by our approvals to rigid Airbus quality specifications."[34]

International Competitors

Industry observers suggest that emerging nontraditional suppliers are a competitive threat to Canadian aerospace suppliers.[35] For market access purposes, the trend towards sourcing aerostructures appears to be moving overseas, especially to Asia.[36] One report offered data regarding Canadian and foreign suppliers' share of aerospace inputs, such as materials and supplies, as evidence of these competitive pressures.[37] Suppliers from outside of North America increased their share of the Canadian market for aerospace materials and supplies from10 percent in 1991 to 15 percent in 1997, and this share may increase to 22 percent by 2001.[38] U.S. suppliers' share of the Canadian market for material inputs is expected to fall by 2001; however, Canadian firms are not expected to benefit from this decline.[39]

The competitive advantages of the Canadian industry, such as an aerospace manufacturing infrastructure and skilled workforce, may help reduce the trend towards placing new production in developing countries. There are several instances of production that has gone outside of Canada only to return due to insufficient manufacturing capabilities overseas. For example, even though Boeing Toronto worked on the design and initial production of the Boeing 717 wing, Boeing intended to move production to Korea-based Hyundai and possibly close the Toronto facility. However, Hyundai was

[33] Both Latécoère and BAE have, in the past, obtained parts for their Airbus work outside of the EU. For more information, see ch. 4.

[34] Avcorp Industries, press release, "Avcorp Wins Airbus Work with Austrian Customer," July 6, 1999, found at Internet address *http://www.avcorp.com*, retrieved Oct. 19, 2000.

[35] AIAC, Supplier's Council, report of the Integrator Working Group, June 12, 2000, pp. 1-11; PricewaterhouseCoopers LLP, *Canadian Aerospace Suppliers Base*, p. 2; and Christopher Cummings, "Canada Fights for Aero Business," *Canadian Machinery & Metalworking*, Jan./Feb. 1997, found at Internet address *http://www.themediaiaco.com*, retrieved Sept. 21, 2000.

[36] PricewaterhouseCoopers LLP, *Canadian Aerospace Suppliers Base*, p. 25.

[37] PricewaterhouseCoopers LLP, *Canadian Aerospace Suppliers Base*, pp. 25-27.

[38] Ibid., p. 27.

[39] Ibid.

unable to meet production expectations and some production of the 717 wing remained in Canada.[40] Similarly, Bombardier reportedly cancelled plans for production of CRJ 900 series components in Spain, preferring its established supplier in Canada.[41]

Manufacturing Trends

Canadian aerostructures manufacturers have typically relied on their U.S. and European counterparts to develop new manufacturing technologies.[42] Recent cumulative experience gained in labor- and skills-intensive assembly, test, and systems integration activities has begun to lead to reductions in manufacturing times, and thus yield learning economies;[43] meanwhile new manufacturing techniques have been implemented. Prior to these initiatives, a 1995 study characterized the aircraft and aerostructures industry as among the least capital-intensive sectors in Canadian manufacturing.[44] In contrast to European producers, the study suggested that aerostructures manufacturing in Canada has generally been a labor-intensive, low-volume business with few opportunities for automation.[45] Moreover, productivity rates of Canadian aerospace workers reportedly trail those of their U.S. counterparts.[46] Because of its low-volume production and historic emphasis on product performance rather than price, the industry also has lagged other Canadian sectors in its use of cost-reducing manufacturing techniques.[47] Aircraft and aerostructures production, with its relatively low production volumes, typically has required only 40 to 60 percent of the capital per worker utilized in the manufacturing industry overall.[48] Increasing emphasis on prices and costs in the LCA industry has had negative implications for the Canadian aerostructures industry's competitiveness with respect to manufacturing capabilities.

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[40] Hyundai sued Boeing for $750 million over Boeing's transfer of wing production for the 717 from Korea to Boeing's Toronto facilities. Cho Myeon-Chin, "Korea Unveils New-Look Aerospace Industry," *Interavia*, Feb. 2000, pp. 18-19.

[41] Canadian industry officials, interviews by USITC staff, Canada, Jan. 2001.

[42] For example, CATIA, a manufacturing software, is widely used by aerostructures manufacturers in Canada, including Bombardier, Magellan, and Avcorp. In addition, Messier-Dowty and Goodrich have strong manufacturing capabilities, benefitting from technology of their parent firms in Europe and the United States as well as technology developed in their Canadian operations. Design capabilities are augmented by integrated computer-aided design and manufacturing systems and specialized analytical modeling software that ensure on-schedule and cost-effective programs and enable improved coordination with customers via computer links.

[43] Canadian Government officials, telephone interviews by USITC staff, Apr.-Sept. 2000; and Industry Canada, "Sector Competitiveness Series."

[44] Industry Canada, "Economics of the Industry," *Aerospace and Defense Strategis: Canada's Aircraft Industry*, Dec. 6, 1995, found at Internet address *http://strategis.ic.gc.ca/SSG/ad01473e.html*, retrieved Sept. 18, 2000.

[45] Ibid.

[46] PricewaterhouseCoopers LLP, *Canadian Aerospace Suppliers Base*, pp. 21-23.

[47] Industry Canada, "Sector Competitiveness Series."

[48] Ibid.

Lean Manufacturing

Primary Canadian aerostructures manufacturers participate in lean manufacturing along with their customers by adopting processes that complement the airframers' programs.[49] One company indicated that not only is lean manufacturing part of its contractual obligations to its customers, but it is something that it requires of its own suppliers.[50] However, because the Aerospace Industries Association of Canada reported that the percentage of Canadian content in Canadian aerospace products declined during 1995-98,[51] a recent study advised Canadian manufacturers to remain competitive by adopting lean manufacturing techniques, among other recommendations,[52] indicating that lean manufacturing has not been widely adopted in Canada.

Concepts associated with lean manufacturing were introduced to Boeing Toronto during the mid-1980s while it was a McDonnell Douglas company; however, changes were not fully implemented and the initiative generally was abandoned. The Boeing-McDonnell Douglas merger gave Boeing Toronto access to Boeing resources, including training opportunities, and the company recently re-applied lean manufacturing to its production activities and moved to continuous flow operation. Since the implementation of lean manufacturing in mid-1999, Boeing Toronto has experienced improvements in areas such as parts travel, people travel, and inventory levels. Suppliers to Boeing Toronto have not yet been included in this initiative.

Composites Atlantic also adopted lean manufacturing, with encouragement and support from Goodrich, as part of their continuous improvement process.[53] Composites Atlantic applied the 5S and visual factory concepts of lean manufacturing to eliminate waste in inventory, transportation, processing, scrap, motion, overproduction, and human effort, and to streamline manufacturing processes and move to a just-in-time work flow.[54] Subsequently, Composites Atlantic achieved a 15-percent improvement in productivity in 1999.[55]

As a complement to their lean manufacturing initiatives, several Canadian aerostructures manufacturers have implemented Six Sigma to identify points in the production process that can be changed in order to reduce production time and defects, and improve work flow and efficiency, with or without investment in new machinery.[56] For example, Bombardier introduced Six Sigma to the aerospace group in 1997 intending "to reduce costs and improve margins in a context of declining prices."[57] Since then, Bombardier has attributed substantial savings to Six Sigma.[58] In mid-2000, Magellan Aerospace, building on the previous experience of two of its divisions, launched Six Sigma and lean manufacturing companywide to improve performance and reduce costs.[59]

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[49] Canadian industry officials, telephone interviews by USITC staff, Sept.-Oct. 2000.

[50] Canadian industry official, telephone interview by USITC staff, Sept. 2000.

[51] AIAC, Supplier's Council, report of the Integrator Working Group, June 12, 2000, p. 1.

[52] PricewaterhouseCoopers LLP, *Canadian Aerospace Suppliers Base*, p. 64.

[53] Industry Canada, Aerospace and Defence Branch, "Best Practices in the Aerospace and Defence Industry," prepared by Underdown Associates, Nepean, Ontario, June 2000, p. 10.

[54] Ibid.

[55] Ibid., pp. 12-13.

[56] Canadian industry officials, interviews by USITC staff, Canada, Jan. 2001.

[57] Bombardier Aerospace, "Six Sigma Providing Growth Tools for Bombardier," *World*, vol. 3, No. 2, found at Internet address *http://www.aero.bombardier.com/world/vol_3_2/htmen/2_2.htm*, retrieved Jan. 12, 2001.

[58] Ibid.

[59] "Magellan Aerospace Corporation," Nov. 14, 2000, found at Internet address *http://www.newswire.ca/releases/November2000/14/c4300.html*, retrieved Dec. 20, 2000.

Implications for the Competitiveness of the Canadian Industry

Currently, most Canadian aerostructures producers lack the necessary resources to compete globally and are regarded as parts producers rather than complete systems suppliers. Canadian aerostructures producers therefore face the twin challenges of changing the world's perception of their capabilities and the need to amass greater financial resources in order to aggressively pursue new risk-sharing contracts. If the global industry continues the trend toward greater risk sharing, Canadian companies will be at a disadvantage if they are unable to take on this responsibility. Canadian aerostructures producers' experience with risk sharing largely has been through their relationship with Bombardier to supply non-LCA aerostructures; risk sharing has not been fully implemented for LCA business. To obtain more work with Boeing and Airbus, Canadian companies will be required to better position themselves financially to accept a greater portion of the risk of a new program.

Canadian firms, despite their strong ties to U.S. companies, cite increasing competitiveness from Asian aerostructures companies in the LCA supplier market. Industry observers have noted intensified competition from Asian companies due in part to offset requirements, and because they have greater access to capital and lower labor costs, which make them an attractive alternative to traditional airframer suppliers.[60] Canadian aerostructures suppliers differ in their ability to respond to new competitors; while a few companies have corporate autonomy, proprietary product design capability, production technologies, and resources that allow them to forge strategic links, most other Canadian aerostructures producers may be at a disadvantage as they face competitors with similar capabilities but lower operating costs.

The overall strength of the Canadian regional aircraft industry may contribute to the perception that Canadian aerostructures suppliers can rely on the regional aircraft market and therefore do not need to supply LCA producers with integrated systems, or that they are unwilling to accept the partnership risks associated with new programs, with the exception of landing gear manufacturers.[61] This is not the case, as Canadian aerostructures manufacturers indicate a desire to maintain and increase LCA customers, and a willingness to consider risk-sharing arrangements. However, Canadian firms seem to prefer supplying the North American market, and have limited involvement in Airbus programs currently being developed. Canada has the aerospace infrastructure to supply Airbus; however, Canadian aerostructures manufacturers have been slow to pursue this market. The Canadian industry will need to focus on the European market in order to expand its global market share, especially as the Asian industry becomes more competitive.

[60] Cummings, "Canada Fights for Aero Business."

[61] PricewaterhouseCoopers LLP, *Canadian Aerospace Suppliers Base*, pp. 51-52.

CHAPTER 6
THE ASIAN LCA AEROSTRUCTURES INDUSTRY

Introduction

Consolidation of the global large civil aircraft (LCA) industry into two manufacturers and the resulting concentration of competition for market share has heightened the need for risk-sharing partners and market access for LCA sales. As a result, the role of Asian aerostructures manufacturers has expanded. Primary Asian countries producing aerostructures—Japan, Korea, and China—offer to varying degrees manufacturing proficiency, affordable labor, research capabilities, and the means and inclination to assume financial responsibility on new aircraft programs. Further, such nations are large existing and potential markets for aircraft, which encourages LCA producers to place work packages with Asian aerostructures firms to promote aircraft sales. These factors, which have promoted rapid growth in the Asian aerostructures industry, will serve to maintain Asia's place as a strategic supplier to both Boeing and Airbus. At the same time, certain obstacles exist that make it improbable that Asian suppliers will significantly displace their North American or European counterparts. Primary impediments include technological deficiencies, a lack of systems manufacturing experience and capabilities, and inefficiencies in terms of capacity and employment.

This chapter includes a discussion of the structural characteristics of the Asian LCA aerostructures industry, including major participants, products produced, and workforce characteristics, followed by a review of industry developments and changes in the relationship between LCA manufacturers and Asian aerostructures firms. The chapter concludes by drawing on information presented in previous sections to assess the competitive position of Asian manufacturers in the global LCA aerostructures industry.

Industry Structure and Market Indicators

Composition of the Industry

With certain exceptions, Asian aerostructures producers are principally lower-tier suppliers, providing relatively basic inputs to LCA producers or their primary suppliers. Although some Asian suppliers have assumed responsibility for larger components such as wing production, such producers are not experienced or reliable enough to pose a competitive challenge to other global producers in this product area. Nonetheless, the corporate structure of participating Asian producers is advantageous in that participation of firms in the industry is facilitated through corporate diversification or government ownership. This means that Asian aerostructures manufacturers are somewhat insulated from the negative effects of lag time between contracts, dips in the business cycle for aircraft, or changes in the amount of aerostructures work received—factors that might cause other global producers to contract, consolidate, or in severe cases, exit the industry.

Japan, by far the largest and most advanced aerostructures producer in Asia, supplies a variety of aerostructures to the world's LCA manufacturers (table 6-1). Japanese firms Mitsubishi Heavy Industries, Ltd., Kawasaki Heavy Industries, Ltd., Fuji Heavy Industries, Ltd., ShinMaywa Industries, Ltd., and Japan Aircraft Manufacturing Co., Ltd. began producing minor inputs and lower-tech components in the late 1960s and gradually assumed responsibility for larger segments of LCA.[1] Although producers do not supply integrated systems, such as fuselage sections, wings, or landing gear, those products produced by Japanese aerostructures firms are reportedly superior in quality to other global producers, with manufacturing defects virtually nonexistent.[2]

Table 6-1
Japanese aerostructures producers, plant locations, aerostructures produced, and LCA customers

Aerostructures producer	Plant location(s)	Aerostructures produced	LCA customer(s)
Fuji Heavy Industries, Ltd.	Utsunomiya, Japan	Ailerons, elevators, spoilers, wing sections, wing-to-body fairings	Boeing
Japan Aircraft Manufacturing Co., Ltd.	Yokohama, Japan	Elevators	Boeing
Kawasaki Heavy Industries, Ltd.	Gifu, Japan Nagoya, Japan	Body panels, keel beams, outboard flaps	Boeing, Airbus
Mitsubishi Heavy Industries, Ltd.	Nagoya, Japan	Body panels, dorsal fins, inboard flaps, stringers, wing boxes	Boeing, Airbus
ShinMaywa Industries, Ltd.	Kobe, Japan	Elevators, horizontal stabilizers, wing-to-body fairings	Boeing

Source: Compiled from various sources by USITC staff.

Unlike Japan, Korean aerostructures producers--Daewoo Heavy Industries, Ltd., Samsung Aerospace Industries, Ltd., Hyundai Space & Aircraft Co., Ltd., and Korean Air, Aerospace Division, each belonging to one of Korea's large industrial conglomerates or *chaebol*--produce larger aerostructures systems, but with varying degrees of success; Korean producers largely remain build-to-print suppliers (table 6-2). The widely disparate characteristics and capabilities of the industry are evident in the different approaches used and mixed success met by Korean firms producing major structural components. For instance, Korean Air's production of the Boeing 717 nose, for which quality is said to be only slightly behind that of Japan, evolved from a 20-year history of aerospace manufacturing and a foundation of successful supplier contracts with Boeing, Airbus, and the former McDonnell Douglas. In contrast, Hyundai entered the aerostructures industry in 1994 and bypassed the traditional bottom up approach by promptly signing a contract to supply the 717 wing, which the company is reportedly having trouble producing.[3]

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[1] U.S. industry officials, interview by USITC staff, United States, June 2000.

[2] USDOC, International Trade Administration, National Trade Data Bank, "Japan—Civilian Aircraft," *Market Research Reports*, July 1, 1997, Stat-USA Database, found at Internet address *http://www.stat-usa.gov*, retrieved Oct. 28, 1997; and U.S. industry officials, interview by USITC staff, United States, Feb. 1998.

[3] Cho Myeong-Chin, "Korea Unveils New-look Aerospace Industry," *Interavia*, Feb. 2000, p. 19. For more information, see ch. 5.

Table 6-2
Korean aerostructures producers, plant locations, aerostructures produced, and LCA customers

Aerostructures producer	Plant location(s)	Aerostructures produced	LCA customer(s)
Daewoo Heavy Industries, Ltd.[1]	Changwon, Korea	Body panels	Airbus
Hyundai Space & Aircraft Co., Ltd.[1]	Sosan, Korea	Control surfaces, wings	Boeing
Korean Air, Aerospace Division	Pusan, Korea	Body panels, flap support fairings, noses, wing tip assemblies, wing tip extensions	Boeing, Airbus
Samsung Aerospace Industries, Ltd.[1]	Changwon, Korea Sachon, Korea	Stringers, trailing edges	Boeing

[1] The aerospace divisions of Daewoo, Hyundai, and Samsung are now part of Korea Aerospace Industries (see discussion under "Globalization and Consolidation").

Source: Compiled from various sources by USITC staff.

The Chinese aerostructures industry is comparatively small, and Chinese firms have experience in LCA wing and fuselage production, albeit with limited results.[4] At present, Chinese producers appear focused on a limited product area, which may ultimately help the industry overcome the pervasive quality issues associated with Chinese manufacturing. Of the country's 18 aerospace firms involved in aircraft and parts manufacturing, only Xi'an Aircraft Co., Shenyang Aircraft Corp., Shanghai Aircraft Manufacturing Factory, and Chengdu Aircraft Industrial Corp. produce LCA aerostructures (table 6-3). These producers primarily manufacture aerostructures for the tail section and, although not covered by this study, doors and hatches. Such specialization will likely bolster the competitiveness of the Chinese industry by allowing Chinese manufacturers to hone specific skills and better organize and manage their production facilities and techniques. According to U.S. industry sources, LCA producers generally procure from an alternate second source when placing aerostructures work in China; however, if Chinese producers are allowed to produce an item for an extended period of time, they are likely to gain enough skill to become the sole supplier of such an item.

Irrespective of the varying degrees of quality, product mix, and experience among Asian aerostructures producers, each of the region's firms is supported by other profitable ventures or through government intervention. For example, the parent companies of Japanese and Korean aerostructures manufacturers are primarily involved in other key industries, including shipbuilding, automobiles, electronics, and machinery, with sales of aerostructures accounting for only a small portion of total sales of the company.[5] Modest or falling aerospace sales are easily offset by the more profitable prime

[4] Chinese firms began manufacturing the complete fuselage and wing for the MD-90 Trunkliner, to be assembled in Shanghai, but abandoned the project in August 1998 because of lack of demand, both domestic and global, for the finished aircraft. In total, only 3 MD-90s were completed out of a planned 40 aircraft.

[5] For example, in Japan, the aircraft operations of each individual firm represent between 10 and 20 percent of the total business of the company. "Japan's Aircraft Industry—Current, Future," *Tokyo Kikai Shinko*, July 1997, pp. 20-23, FBIS translated text FBIS-EAS-97-322.

Table 6-3
Chinese aerostructures producers, plant locations, aerostructures produced, and LCA customers

Aerostructures producer	Plant location(s)	Aerostructures produced	LCA customer(s)
Chengdu Aircraft Industrial Corp.	Chengdu, China	Horizontal stabilizer, tail sections, vertical fins	Boeing
Shanghai Aircraft Manufacturing Factory	Shanghai, China	Horizontal stabilizers	Boeing
Shenyang Aircraft Corp.	Shenyang, China	Tail sections	Boeing
Xi'an Aircraft Co.	Xi'an, China	Composite wing-to-body fairings, horizontal stabilizers, vertical fins	Boeing, Airbus

Source: Compiled from various sources by USITC staff.

business ventures, allowing such firms to remain involved in aerostructures production despite sales fluctuations. Chinese producers, on the other hand, are centrally controlled state-owned enterprises. Industry sources report that both participation of individual firms in aerostructures production and the dissemination of aerostructures subcontracts are largely determined by government authorities rather than the contracting LCA producer or primary supplier. As with the Japanese and Korean industries, this permits Chinese aerostructures firms to remain viable regardless of capacity or capabilities.

Workforce Characteristics

Recognized in the global aerostructures industry as an attractive source of labor, China boasts an abundant supply of low-wage workers and a stable and practiced aerospace workforce. The lure of low-cost manufacturing has benefitted Chinese firms immensely, with LCA producers, their primes, and even lower-tier suppliers such as those in Korea and Singapore placing work in China in an effort to alleviate the intense cost pressures they face from their customers by downloading labor-intensive processes. Further, China has a long history of aerospace manufacturing, and the state-owned enterprise system is such that the industry can support and retain experienced workers throughout downturns in the aerospace sector or downtime between contracts.

At the same time, the Chinese industry's inability to fully utilize and modernize its personnel resources may prevent Chinese aerostructures firms from moving beyond their current secondary role in the global aerostructures industry. For example, despite the low wages earned by Chinese aerospace workers, industry sources note that the amount of training and oversight required to ensure delivery of a quality, usable product means that it is sometimes more expensive to source from Chinese factories than U.S. sources. This is particularly true with respect to more complicated structures—exactly the type of work Chinese industry officials indicate that the country's aerostructures firms would like to undertake.[6] Chinese industry sources also report that Chinese producers are weak in terms of management and have trouble taking full advantage of the country's engineering talent.[7] Finally, the

[6] Chinese industry officials, interview by USITC staff, China, May 1998.
[7] Chinese industry officials, interview by USITC staff, China, May 1998.

sheer volume of China's aerospace workforce at approximately 281,000 employees,[8] combined with the government's insubstantial efforts to trim aerospace employment,[9] essentially commit China to a role as a labor-intensive manufacturer of lower technology items rather than a primary systems supplier.

In Japan and Korea, the aerostructures industries benefit from a greater concentration of skilled workers and engineers, coupled with an employment system conducive to workforce stability. As with the Chinese industry, however, such factors may work against the ultimate competitiveness of the industry by hindering flexibility and promoting inefficiencies. For example, while aerospace engineers in Japan and Korea are well educated and production workers highly skilled, industry sources note that many aerospace workers in these countries are actually too specialized, such that they cannot be used in other industries.[10] Further, while the conglomerate structure of Korean and Japanese firms allows aerostructures participants to keep talent within the company during downturns, the rigidity of such a system translates into cost inefficiencies and personnel redundancies. For example, because of the lingering system of lifetime employment, Japanese aerostructures firms are limited to using intracompany transfers, work hour reductions, voluntary retirement, and hiring freezes to cut personnel costs and trim aerospace employment,[11] numbered at 25,800 in 1998.[12] Moreover, industry sources report that Korean *chaebol* support of the four separate aerospace divisions has resulted in gross overcapacity and repetition among the Korean aerospace workforce[13] of approximately 11,958 employees.[14]

Industry Developments

Globalization and Consolidation

Although consolidation among Asian aerostructures firms would help address the inherent problems of overcapacity and better position the industry to address the changing dynamics of the industry and the increasing demands of LCA producers, few substantive developments have taken place within the Asian aerostructures industry. The most notable if not effectual changes have occurred in Korea. Prompted by the government's push for *chaebol* reform following the 1997 currency crisis, the aerospace divisions of Samsung, Hyundai, and Daewoo merged into a single company, Korea Aerospace Industries, Ltd. (KAI), officially formed on October 1, 1999.[15] The new company should allow the

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[8] China's state holding company that manages the aerospace industry, Aviation Industries of China (AVIC), was split into AVIC I and AVIC II in late 1999. AVIC I enterprises include all factories producing LCA aerostructures. The employment figure presented represents employment for AVIC I. Total employment for the entire aerospace sector is approximately 501,000. Paul Jackson, ed., *Jane's All the World's Aircraft 2000-01* (Surrey, UK: Jane's Information Group Limited, 2000), p. 63.

[9] In early 1998, China indicated that it would attempt to lay off 150,000 aerospace workers. The state-owned system reportedly makes it difficult to cut jobs, and to date only 34,000 workers have actually been let go, with another 14,000 transferred to non-aerospace operations. Michael Mechem, "Industry Watches Reform of Chinese Aerospace," *Aviation Week & Space Technology*, Mar. 2, 1998; and Jackson, *Jane's*, p. 63.

[10] U.S. industry officials, interview by USITC staff, United States, June 2000.

[11] Japanese industry officials, e-mail communication with USITC staff, Feb. 19, 2001.

[12] The Society of Japanese Aerospace Companies, *Aerospace Industry in Japan, 2000*, p. 6.

[13] U.S. industry officials, interview by USITC staff, United States, June 2000.

[14] Korea Aerospace Industries Association, *1997 Annual Report*, p. 10.

[15] The three participants share equally in 45 percent of the new company, with 25 percent held by the Korea Development Bank and other quasi-governmental interests and 30 percent reserved for additional Korean investors.

industry to take advantage of economies of scale and curtail LCA producers' ability to pit one company against another to obtain more favorable terms in supplier contract negotiations.[16] Further, the cooperation of the three in production, development, and marketing should eliminate duplications in investment across the aerospace sector and pool the industry's most talented personnel. Moreover, collective resources may help KAI shoulder a greater degree of risk-sharing responsibility and thus obtain contracts on the diminishing number of new aircraft programs. However, the new company is not all inclusive, as Korean Air Aerospace continues to operate independently; therefore, the potential remains for excess capacity among the nation's producers. Moreover, a long history of infighting among the four aerospace companies has hindered previous cooperative efforts on aerospace projects;[17] thus, it could prove difficult for KAI to act as a cohesive unit. The fact that the three participants in KAI will continue to trade under their respective company names[18] and can undertake certain contracts independently[19] may prove symbolic of a company that operates under a single title but continues to possess the characteristics of an industry divided by inefficiencies.

Foreign Direct Investment

While outside investment would boost the competitiveness of Asian firms through the infusion of foreign expertise and capital, state-ownership and restrictions on investment in military-related ventures essentially prevent foreign equity in Asian aerostructures firms. Moreover, the Korean aerostructures sector did not take advantage of a key investment opportunity to align with the United States and Europe's more successful and experienced aerostructures firms. Newly formed KAI was allowed to offer a 30-percent share to foreign investors following the Korean Government's decision to approve certain purchases of defense-related firms by foreign interests to help the industrial sector recover from the Asian economic crisis. Although several firms expressed interest in the new venture, most notably the teams of Aérospatiale/Lockheed Martin and Boeing/BAE Systems, talks were suspended in November 2000 following disagreement over the level of management control to be ceded to the foreign partner.[20] KAI now plans to raise its capital base in order to function without foreign investment;[21] however, the lack of foreign equity may compromise the company's success. Foreign participation would not only add to the credibility and technological foundation of the venture but would provide KAI with much needed funds to cover $600 million in debt contributed by the founding *chaebols*.

[16] Cho Myeong-Chin, "Korea Unveils New-look Aerospace Industry," p. 19.

[17] Paul Lewis, "S (sic) Koreans Discuss Link-up," *Flight International*, Jan. 29-Feb. 4, 1997, p. 20.

[18] Chris Jasper, "Reality Bites," *Flight International*, Feb. 15-21, 2000, p. 59.

[19] Andrzej Jeziorski, "Hyundai move sets back BAE's Korean Aerospace ambitions," *Flight International*, Feb. 8-14, 2000, p. 21.

[20] Andrzej Jeziorski, "KAI to Go it Alone After Deal with BAE/Boeing Collapses," *Flight International*, Nov. 21-27, 2000, p. 25.

[21] KAI will reportedly allow its creditors to acquire nonvoting shares of the company in exchange for additional loans. "KAI to Give Minority Stake to Creditors in Exchange for New Loans," *Flight International*, Jan. 2-8, 2001, p. 20.

Changes in the Relationship Between LCA Manufacturers and Aerostructures Manufacturers

Risk-sharing and R&D Arrangements

A key factor advancing the position of certain Asian aerostructures manufacturers vis-à-vis their global counterparts is the ability and desire to assume risk-sharing responsibilities, through which manufacturers can secure production work on a waning number of new aircraft programs and gain manufacturing and design experience via collaboration with LCA producers. Such arrangements are a concern to U.S. aerostructures producers, who indicate that global R&D cooperation and the associated technology transfer to Asian countries will heighten competition for the U.S. industry by providing Asian firms with the tools necessary to improve their capabilities.[22] Japanese aerostructures manufacturers, and to a lesser extent Korean firms, have heretofore assumed risk-sharing roles on LCA programs and will likely repeat as supplier-partners on future contracts. Financial and technical deficiencies may hinder China's ability to shoulder design and investment responsibilities[23] and as a result, restrict Chinese aerostructures firms' participation in such risk-sharing opportunities.

The strategic significance of Japan's risk-sharing capability is evident in the increasing number of collaborative agreements completed during the past several years and the progressive design and production responsibilities undertaken by Japanese suppliers. Following a 1978 risk-sharing arrangement in which Japanese firms absorbed $343 million in preproduction costs and infrastructure investments and assumed responsibility for producing 15 percent of a predetermined number of Boeing 767s, Japanese manufacturers agreed to the design, development, and production of 20 percent of the 777 airframe in a 1991 agreement spanning the life of the 777 program.[24] More recently, Japanese manufacturers committed to a risk-sharing role in the development of long-range versions of the 777-200/300,[25] and before its postponement, were set to assume responsibility for development and production of approximately 20 percent of the 747X, including the wing, at an estimated investment cost of $1 billion.[26] By comparison, Korean manufacturers have limited risk-sharing experience, predominately in cooperation with Boeing on the 717 program,[27] but have discussed additional risk-sharing arrangements for other aircraft programs.

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[22] U.S. producers also indicate that despite the need for capital for investment and interest from Asian producers to fund risk-sharing arrangements at the supplier level, they are averse to such arrangements because they would have to share technological expertise with Asian partners. U.S. industry officials, interview by USITC staff, United States, Aug. 2000. For more information, see ch. 3.

[23] In 1999, Airbus announced that Chinese firms would join in the development of the A318 (in a non risk-sharing capacity). Such an arrangement presents Chinese engineers with the opportunity to join the design, development, and certification phases of the aircraft program. Success on the program could theoretically open the door for similar work in risk-sharing arrangements.

[24] Susan MacKnight, "Japan's Commercial Aircraft Industry," Japan Economic Institute, May 6, 1995, found at Internet address *http://www.gwjapan.com/ftp/pub/policy/jei/1995/a-series/0506-95a.txt*, retrieved Sept. 3, 1998.

[25] "New 777's Work for Japan," *Aviation Week & Space Technology*, Mar. 13, 2000, p. 15.

[26] "Boeing, Shuyoku Seizou o Mitsubishi Juko ni," *Nikkei Business*, Dec. 11, 2000, p. 6; and Chris Jasper, "Boeing Chief Heads to Japan to Convince 747X Waivers," *Flight International*, Nov. 28-Dec. 4, 2000, p. 7. Japanese firms are likely to join Boeing's replacement program, involving the development of a high-speed passenger jet, in a design and manufacturing capacity.

[27] U.S. industry officials, interview by USITC staff, United States, June 2000.

Technology transfer through risk sharing and R&D collaboration is controlled by the contracting LCA producer; thus, fears on the part of the U.S. industry that such cooperation may nurture competition are somewhat overstated. Further, industry sources note that information shared with Asian firms is primarily obsolete, with key designs and manufacturing techniques, such as those for the wing and cockpit, kept in-house. With respect to Japan, leakage controls were in place on both the 767 and 777 programs, with information provided to the Japanese participants on a strict need-to-know basis.[28] Further, Japanese engineers working in Seattle on the 777 reportedly had limited access to Boeing's engineering facilities and computerized design system, and were provided with technologies characterized as dated.[29] Concerning Korean risk-sharing arrangements, the 717 is based on 30-year old designs, and thus will not provide Korean firms with state-of-the-art knowledge or manufacturing expertise. Nonetheless, Asian aerostructures firms have explicitly demonstrated a willingness to commit to risk-sharing roles on aircraft programs, and while technology transfer may not be extensive, Asian companies can secure production work and accumulate manufacturing experience and familiarity with design techniques through such agreements.

Contract Terms

While long-term agreements (LTAs) may be favorable to Asian manufacturers, which can secure a guaranteed volume of business and attain production efficiencies through multiyear contracts, exchange rate issues and a lack of understanding prevent Asian manufacturers from fully profiting from the trend toward LTAs. For example, according to industry sources, Chinese producers are averse to longer term contracts, as they do not see the benefit in committing themselves for long periods of time; industry sources report that this is typical of a novice supplier, who does not fully comprehend the potential cost benefits involved with longer production runs. In addition, LTAs create a competitive disadvantage for Asian suppliers, since the risk associated with exchange rate volatility is completely absorbed by the foreign firm. Japanese participation on the 767 program was reportedly a money-losing operation for Japanese aerostructures firms because of the steep appreciation of the yen over the course of the project.[30]

During the past several years, a greater number of exclusive contracts have been concluded with Asian manufacturers, indicative of the growing abilities of Asian aerostructures firms. When LCA manufacturers subcontract overseas, they often simultaneously source from an established backup producer until the foreign source is fully capable of manufacturing the part to the airframer's satisfaction, at which point the foreign firm may become "sole source" or the only supplier producing the part. An increase in the number of sole source agreements has characterized subcontracts placed in Asia. Japanese producers are sole source suppliers on a number of parts for Boeing aircraft, and Chinese producers, initially all dual source suppliers, have attained single source status on a few aircraft programs. Sole source production is prestigious in the aerostructures industry, and a firm that has attained sole source status can approach future contract negotiations with greater leverage based on the capabilities implied by exclusive supply.

[28] MacKnight, "Japan's Commercial Aircraft Industry."
[29] Ibid.
[30] Ibid.

Implications for the Competitiveness of the Asian Industry

Because of the nature of Asian firms' operations and the industry's reciprocal relationship with LCA manufacturers, Asian suppliers have established a notable presence in the global aerostructures industry. At the same time, most Asian manufacturers lack certain attributes essential to assuming a primary role in the industry. In general, industry sources note that Asian aerostructures manufacturers lag their North American and European counterparts in technical skill and experience, a factor that has thus far prevented Asian countries from becoming a strong competitive threat.[31] At present, complex aerostructures production is not taking place in Asian factories.[32] According to industry officials, without the ability to provide integrated structures with systems installed, Asian aerostructures will be relegated to build-to-print production.[33]

In addition, certain perceived strengths of the Asian industry may actually be competitive disadvantages. Recognized as an affordable labor source, the benefit of Asia's lower labor costs is diminished when training and manufacturing inefficiencies are considered. Likewise, the key businesses of Japanese and Korean conglomerates support aerostructures production and employment, yet the minor position of aerospace in such firms does not allow for bold business decisions or the huge amount of investment needed for such manufacturers to become global leaders in aerospace.

Nonetheless, because of the willingness of LCA producers to use the procurement process to gain access to Asia's large market for existing and proposed aircraft, the region's aerostructures manufacturers are able to secure substantial work without having to compete in the same way as other global aerostructures firms. Further, the apparent desire of one LCA producer to secure strong Asian ties at the expense of the other has led to generous agreements with Asian aerospace firms. For example, before deferring work on the 747X, Boeing awarded Mitsubishi responsibility for wing production and even discussed granting the company use of its facilities, as Mitsubishi does not have the proper infrastructure in place to build large and complex structures.[34] As a follow-up to a now defunct agreement with China to jointly develop and produce 100-seat aircraft, Airbus recently indicated that it will subcontract wing production to China, its largest potential market, within 7 years.[35]

Further, while Asian producers lag in technical skill, they are incrementally reducing their deficiencies, and the global aerostructures industry can expect growing competition, first from Japanese manufacturers, followed by Korean and Chinese firms. Japanese suppliers reportedly are acquiring the attributes of a top supplier through ascension up the production learning curve and achievements in qualification and certification.[36] Further, according to industry sources, Japanese firms have demonstrated the ability to absorb investment costs, more so than other smaller global manufacturers,[37] and the nation's aerostructures producers have a strong foundation in place upon which to assume a

[31] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.
[32] U.S. and European industry officials, interviews by USITC staff, United States, Aug. 2000, and Europe, Sept.-Oct. 2000.
[33] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.
[34] "「Cho・Seizougyou」e Kyusenkai," *Nikkei Business*, Sept. 18, 2000, p. 45.
[35] "Boeing Shows Off for Big Customer," *Seattle Times*, Nov. 7, 2000, found at Internet address *http://archives.seattletimes.nwsource.com/web/index.html*, retrieved Nov. 13, 2000.
[36] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.
[37] U.S. industry officials, interview by USITC staff, United States, June 2000.

larger role in the industry.[38] With respect to Korea and China, aerostructures manufacturers in these countries do not yet have the technological expertise necessary to be industry leaders, but industry sources indicate that they expect these countries to emerge as strong competitors over the next two decades as they build on the knowledge gained from Western firms.[39] Korean and Chinese firms reportedly are sharpening their process technologies and learning how to manufacture for the world market,[40] and while it is unlikely that they will pose a challenge to upper-tier global suppliers, comparative cost advantages combined with acceptable quality will create a competitive Asian presence in the lower levels of the supply chain.

[38] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.
[39] U.S. industry officials, interview by USITC staff, United States, Aug. 2000.
[40] European industry officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

CHAPTER 7
RESEARCH AND DEVELOPMENT FOR AEROSTRUCTURES

Introduction

Research and development (R&D) for the aerostructures industry encompasses a wide variety of activities carried out by businesses, academia, government entities, and national and international organizations. Most basic R&D involving aerostructures is conducted by governments or government-funded organizations in the United States, Europe, Asia, and Canada. The National Aeronautics and Space Administration (NASA) and the Department of Defense (DoD) are the principal U.S. Government entities charged with this responsibility, while ministries of defense in the other regions share this responsibility with designated R&D organizations such as Office National d'Études et de Recherches Aérospatiales (ONERA) in France, the Defense Evaluation and Research Agency (DERA) in the United Kingdom, and National Aerospace Laboratories (NAL) in Japan. On the other hand, development and testing that is related to specific products and processes is typically performed by aircraft and aerostructures producers, such as Boeing, Airbus, and their top-tier suppliers. Although the principal aerostructures manufacturers make substantial investments in R&D each year, government-sponsored R&D is widely recognized as vital to the industry and a source of spillover benefits for the rest of the economy.[1]

U.S. investment in R&D for aerostructures has decreased in recent years relative to other major aerostructures-producing countries. R&D spending by NASA for aeronautics and by DoD for aircraft decreased during 1995-99, as did total R&D spending by companies in the aerospace industry. Total R&D expenditures for aerospace increased in Europe and Asia during this period, as did comparable expenditures in Canada with the exception of 1999. Reduced investment in R&D infrastructure threatens to handicap future U.S. efforts because certain components of new or upgraded facilities often require long-term planning. European and Asian R&D facilities are generally newer and in some cases superior to their U.S. counterparts.

Increased competition between the two major large civil aircraft (LCA) producers and consolidation among top-tier suppliers has had a profound effect on the focus and sources of funding for R&D. Competition has resulted in cost pressures that have driven R&D providers to consider more radical cost-saving solutions and consolidation has enhanced the ability of top-tier suppliers to take on design and development responsibilities that were formerly undertaken by LCA manufacturers.

This chapter describes the R&D process and infrastructure, government involvement in R&D and the effect of military R&D on the civil sector. It then identifies and discusses the various government and industry entities conducting aerostructures R&D in the United States, Canada, the EU, and Asia. It concludes with an assessment of the implications of regional R&D funding trends.

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[1] European and U.S. R&D officials, interviews by USITC staff, Europe, Sept.-Oct. 2000, and United States, Feb. 2001.

R&D Elements

Definitions

R&D activities are defined differently by the various entities that perform them, often reflecting the mandate of a particular research organization or the laws that restrict the type of R&D that an organization may perform. Although there is consensus among the major R&D organizations concerning certain general classifications of R&D activities, narrower definitions are often unique to a particular organization. As such, direct comparisons between different R&D entities regarding research programs and funding can be difficult.[2] Unless otherwise noted, this chapter will discuss R&D based on the three broad classifications defined below by the U.S. National Science Foundation:[3]

- **Basic research**.–Research with the objective of gaining more complete knowledge or understanding of the subject under study, without specific applications in mind. In industry, basic research is defined as research that advances scientific knowledge but does not have specific immediate commercial objectives.

- **Applied Research**.–Research aimed at gaining knowledge or understanding to determine the means by which a specific, recognized need may be met. In industry, applied research includes investigations oriented to discovering new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

- **Development**.–Systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes.

Basic and applied research are predominantly funded by government. This funding supports advances in scientific knowledge and also provides much of the infrastructure that is required to translate this knowledge into specific applications that are commercially viable. Product development for LCA aerostructures is largely done by industry.

Process

The scope, time frame, and funding for an R&D project vary with the type of entity conducting the R&D and the project goals. The R&D process for NASA aerospace projects begins with a strategic plan based on government policy as well as input from individual NASA research centers, universities, and industry. The most promising ideas are assigned to one of seven programs conducted by NASA's Aerospace Technology Enterprise (ATE), which is responsible for its continuous basic research

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[2] For a description of the terms used by AECMA to define aerospace R&D, see Hans-Henrich Altfeld, ed., *Government Funding for Aerospace: A comparative analysis of government expenditures for aerospace in the EU and the US* (Brussels: European Association of Aerospace Industries, July 2000), p. 68. These definitions subdivide R&D activities differently from the National Science Foundation, i.e., activities defined by National Science Foundation as basic and applied research as well as certain development activities, would be included under the AECMA definition of "research."

[3] National Science Foundation, *Science and Engineering Indicators 2000* (Washington, DC: U.S. Government Printing Office, 2000), p. 2-30.

programs.[4] Successful basic research and technology (R&T) programs may, in turn, progress through an applied or "focused" research program. Industry takes over responsibility for promising technologies during later stages of development if it determines that a program has commercial potential.

The R&D process for an aerostructures manufacturer, however, is very different from that of most government research institutions and universities and is typically directed toward more specific production and market applications. The idea for a particular project may originate with a market study focusing on end-user needs, a production manager's suggestion for cost cutting, or an aircraft customer's request for a part matching certain specifications.

University research, on the other hand, typically involves basic research projects that result from discussions between universities and the government or industry entity that is providing the funding. Student involvement in each project is determined through consultations with academic advisors, and the duration of specific projects is often related to the academic program of the students carrying out the research.[5]

Boeing maintains responsibility for virtually all design and development of aerostructures for its LCA, whereas Airbus relies on its top-tier suppliers for a large share of these responsibilities. Therefore, suppliers to Boeing have not performed aeronautical R&D to the same extent as those supplying Airbus. As Boeing slowly divests itself of certain design responsibilities, it is likely that the demands for aeronautical R&D will increase for Boeing's top-tier U.S. suppliers.

Research contracts involving public and private research organizations may start with an invitation to tender issued by a government or industry entity. This invitation includes a set of specifications, some information on the scope of the project, and the "rules of engagement." The response to this invitation is usually followed by a series of meetings between the entity issuing the invitation and the research organization responding to discuss the type of test or methodology that will be used. The schedule for a typical R&D project includes staged deliverables and staged payments. The reports that result from government-sponsored research may be released to the public or remain confidential, depending on a number of factors, and the decision to withhold or release research findings is generally determined on a case-by-case basis. Research contracted by industry for specific applications and research used to enhance military capabilities very often remains proprietary, whereas the results of basic research that is likely to have benefits for civil aircraft are often released.[6]

Cost pressures are driving significant changes in the R&D sector. Growing competition in the airline industry has resulted in R&D expenditures for projects that are increasingly focused on cost reductions in manufacturing, fuel consumption, and maintenance. Commercial contracts are also more results-oriented with deliverables more clearly defined than a few years ago when compensation was commonly commensurate with hours worked. Although many government R&D organizations still

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[4] The seven ATE-based R&T programs are Aerospace Vehicles Systems Technology, Aerospace Propulsion and Power, Rotorcraft, Aerospace Operations Systems, Information Technology, Flight Research, and Space Transportation Launch Vehicles.

[5] Candidates for Master's degrees generally are assigned 2-year projects while Ph.D. candidates are typically involved for 3 or more years. U.S. and European university officials, telephone and in-person interviews by USITC staff, Europe, Sept. 2000 and United States, Mar. 2001.

[6] European R&D official, interview by USITC staff, Europe, Oct. 2000.

conduct basic research for purely scientific reasons, very little "blue sky" research is currently conducted by industry, and some projects have an application in sight.[7]

Most R&D advances are evolutionary, and the aviation system that can make use of a new product or technology may take years to develop. An advance in one system very often requires the redesign of other aircraft systems before it can be incorporated in an aircraft. Design changes are then followed by years of validation, testing and certification.[8] The development of a superior product or system does not necessarily ensure that the improvement will be incorporated into an aircraft.[9]

Infrastructure

The level of R&D necessary to develop and maintain global leadership in LCA aerostructures requires major long-term commitments by governments, academia, and industry in terms of money and planning. Substantial expenditures are required from governments and industry to fund the construction, maintenance, and operation of R&D facilities such as wind tunnels and structural testing laboratories and to purchase computers capable of processing vast amounts of data.

Wind tunnels are an integral component of most aeronautical testing and validation programs. The number, condition, and type of wind tunnel facility can be a reliable indicator of commitment to aerostructures R&D because they are expensive and require long-term planning. Construction costs alone for new facilities typically reach tens of millions of dollars[10] and the time required to develop and attain funding for a new wind tunnel may take 10 to 15 years.[11] Congress recognized the importance of wind tunnels in maintaining a strong aircraft industry after World War II by passing "The Unitary Wind Tunnel Act of 1949" which authorized the construction of wind tunnels and other R&D facilities at NASA sites and universities to support industry research in transonic and supersonic flight.[12]

This chapter presents some of the most commonly used indicators of wind tunnel capability such as test section dimensions, range of wind speed, and Reynolds number. Other important wind tunnel characteristics include airflow quality, productivity, and special features that allow testing under icing conditions and of grounded aircraft. Although computer models that simulate air flows under flight conditions were once regarded as a possible substitute for wind tunnels, they are still not capable of modeling all of the parameters that can be tested in a wind tunnel. Computational Fluid Dynamics (CFD) has proved to be an extremely useful tool that can supplement and complement, but not replace, wind tunnel testing. Wind tunnels remain an essential tool for aeronautical R&D.

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[7] Ibid.

[8] *Recent Trends in U.S. Aeronautics Research and Technology* (Washington, DC: National Academy of Sciences, 1999), p. 5.

[9] The cost of certification or retooling may be sufficiently high to prevent the introduction of an innovation, especially if the aircraft is already in production, even if it is in the design stage.

[10] For example, Korea built three new wind tunnels during 1998-99 that cost between $12 million and $20 million each. *Assessment of Asian Wind Tunnels*, paper prepared by Sverdrup Technology of Tullahoma TN, Inc. for ADF Corporation, June 1999, pp. 57-59.

[11] NASA official, telephone interview by USITC staff, United States, Mar. 2001.

[12] 50 USCS §§ 513.

Government Role

The governments of each of the major aerostructures-producing nations have determined that maintaining R&D capability for aircraft is important for their country's future for national security and other considerations. Government support is required to sustain this capability for a variety of reasons.[13] First, research activity for aerospace often takes a very long time to achieve commercial application, and capital markets may be averse to funding such projects when shorter-term alternatives are available. Second, other countries generally provide support for this sector; thus, a lack of government funding could put domestic industries at a competitive disadvantage. This disadvantage is exacerbated by increased globalization, which makes R&D programs and projects more mobile[14] and sensitive to the support provided by host nations. Third, aircraft-related research yields significant opportunities for technology transfer to other industrial sectors, especially in the area of advanced materials, electronics, and design techniques. Fourth, the long-term payoff for industry of government support has proven impressive; European government support for programs 20 years ago has contributed to gains in civil aircraft market share in recent years. Finally, government support can be used to foster collaborative efforts among firms, which benefit the industry by allowing cost-sharing.[15] However, many governments do recognize the potential for market distortion[16] if government-sponsored R&D replaces industry-funded R&D.

Impact of Military On Civil Aircraft

The amount of useable technology that flows from one sector to the other as well as the direction of the net flow is a matter of debate within the aerospace industry. Some industry officials argue that although there used to be a strong net flow of benefits from the military sector to the civil, this flow has diminished and possibly reversed in recent years. This change, it is argued, is due to decreasing R&D expenditures for military aircraft vis-à-vis civil aircraft and the diverging focus of military and civil programs. This group argues that greater competition in the airline industry has prompted civil R&D to concentrate on cost reduction through lower fuel consumption, reduced maintenance, and more efficient use of cabin space. Environmental issues such as the reduction of engine noise and emissions as well as improvements in aircraft safety have also claimed a significant share of civil R&D

[13] Direct government development support for new large civil aircraft programs is limited to a maximum of 33 percent of the total estimated or actual development cost under the 1992 agreement between the United States and the European Economic Community. Indirect government support is limited to 3 percent of the annual commercial turnover of the civil aircraft industry in the Party concerned, or 4 percent of the annual commercial turnover of any one firm in the Party concerned. See *Agreement between the Government of the United States of America and the European Community Concerning the Application of the GATT Agreement on Trade in Civil Aircraft on Trade in Large Civil Aircraft*.

[14] The infrastructure necessary to conduct aeronautical R&D, including wind tunnels, structural testing facilities, supercomputers, and qualified personnel, is available to some extent in at least 6 European countries, the United States, and in several Asian countries.

[15] CARAD, Annual Report 1999/2000 (London: Department of Trade and Industry, 2000).

[16] Government support may distort markets by inefficiently allocating resources in a number of different ways. For example, government support for a particular program might allow the production of an aircraft for which there is insufficient demand. In theory, this is less likely to happen if free-market forces are allowed to determine supply and demand.

expenditures in recent years. Military R&D concerns, on the other hand, remain concentrated on projects designed to achieve tactical superiority such as stealth and night-fighting.[17]

Proponents of the viewpoint that the net flow of R&D benefits continues to be from the military to the civil sector argue that the military sector has always been and will continue to be more innovative and willing to take risks on new technologies.[18] This innovative drive is fueled by the desire to maintain technological superiority over other countries. This group also points out that the greater demands on military aircraft in terms of speed, maneuverability, and survivability ensure that technological breakthroughs will first be achieved by the military sector.

Certain similarities between the needs of military and civil aircraft suggest that advances in one sector may be applied to the other. The design of a stronger, lighter, and more fuel-efficient aircraft is a common goal of both sectors. During the Cold War period, the drive to achieve numerical and tactical superiority in aircraft and missile technology prompted governments to spend lavishly on R&D for military aircraft that resulted in spillover benefits for civil aircraft, such as the development of supersonic transport and fly-by-wire control systems.[19] Although defense budgets in both Europe and the United States have been cut since the 1980s, R&D involving composite structures and advanced manufacturing techniques for both civil and military applications continue.[20]

Aerostructures R&D in the United States

The primary government sponsors of R&D for aerostructures in the United States are DoD, NASA, and, to a lesser extent, the Federal Aviation Administration (FAA). Each of these agencies conducts aeronautics and space research and develops technology in partnership with industry, academia, and other federal agencies.[21] NASA focuses on basic research; DoD, on the other hand, concentrates its resources on later stages of product development. Basic research accounted for 80 percent of NASA's R&D expenditures and less than 3 percent of DoD's total Research, Development, Test, and Evaluation (RDT&E) budget in 2000.[22] R&D that can be directly associated with LCA aerostructures includes certain aeronautics programs that account for less than 4.2 percent of the total NASA budget[23] (figure 7-1).

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[17] European industry officials, interviews by USITC staff, Europe, Sept.-Oct. 2000.

[18] DoD officials, in-person and telephone interviews by USITC staff, United States, Jan.-Feb. 2001.

[19] U.S. industry official, telephone interview by USITC staff, Mar. 2001. Although these advances were, to a large extent developed by NASA, European firms were the first to apply this technology to civil aircraft.

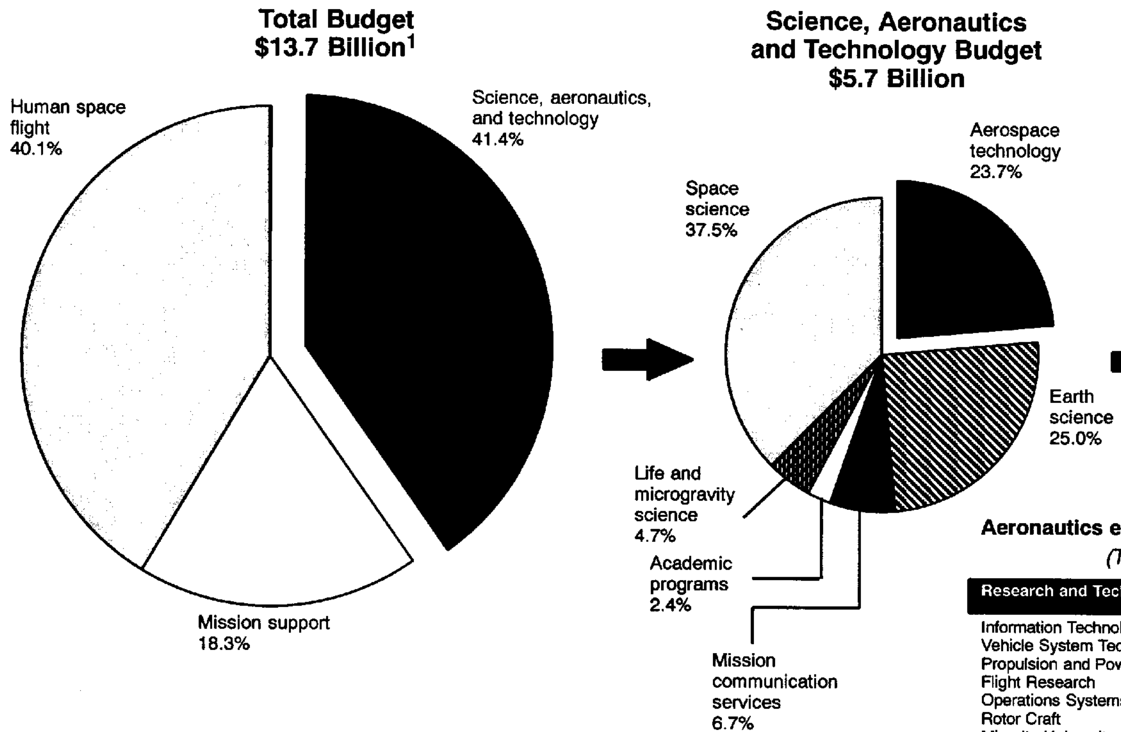
[20] NASA and DoD officials, interviews by USITC staff, United States, Jan.-Feb. 2001.

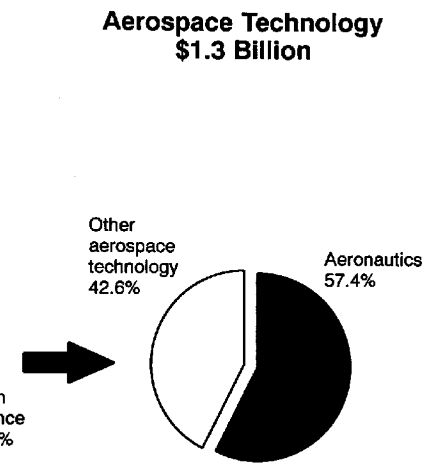
[21] *National Aeronautics and Space Administration Fiscal Year 2001 Budget Estimates*, found at Internet address *http://ifmp.nasa.gov/codeb/budget2001/HTML,* retrieved Nov. 1, 2000.

[22] DoD official, telephone interview by USITC staff, Feb. 2001.

[23] The share of the NASA budget that can be attributed to R&D for LCA aerostructures cannot be precisely determined because the NASA budget does not specifically address expenditures allocated to this type of R&D. Although programs such as high-speed research ($181 million) and advanced subsonic research ($90 million) focus largely on projects applicable to LCA aerostructures, other aeronautics programs, such as rotor craft, propulsion and power, operations systems, and aviation system capacity, are not applicable. The remaining programs may contain certain elements that are relevant to the R&D that is the focus of this study. See *National Aeronautics and Space Administration: Science, Aeronautics, and Technology, Fiscal year 2001 estimates, Budget Summary,* found at Internet address *http://ifmp.nasa.gov/codeb/budget2001/HTML/fy01_aeronaut.htm.,* retrieved Mar. 21, 2001.

Figure 7-1
NASA expenditures, by type, 1999





Aeronautics encompasses the following:
(Thousands of dollars)

Research and Technology Base programs	
Information Technology	66,592
Vehicle System Technology	138,493
Propulsion and Power	75,417
Flight Research	63,585
Operations Systems	43,353
Rotor Craft	27,201
Minority University Research and Education Programs	7,000
Construction of Facilities	2,500
Focused Programs	
High-Performance Computing and Communication	20,600
High-Speed Research	180,700
Advanced Subsonic Technology	89,620
Aviation System Capacity	53,888
TOTAL AERONAUTICS R&D	768,949

[1] The Office of the Inspector General accounts for 0.1 percent of the total.

Source: NASA.

Although the FAA's R&D budget is considerably less than those of NASA and DoD, it collaborates with these larger agencies to conduct R&D that focuses on aircraft safety. The FAA may also influence the choice of NASA projects.[24]

R&D objectives for U.S. suppliers generally differ from those of European suppliers, due to the dissimilar needs of their customer. In the United States, Boeing conducts most of the R&D related to the aerostructures for its aircraft, and suppliers manufacture these products according to Boeing-supplied specifications. Thus, U.S. suppliers conduct little aeronautical R&D; rather, they focus their R&D efforts on improving manufacturing efficiency, product quality, and on-time delivery. In Europe, the prime suppliers to Airbus are typically responsible for the design and integration of the parts that they supply. Consequently, suppliers use a broader suite of R&D services, not unlike those required by Boeing.

The U.S. government operates 20 major wind tunnel facilities at three NASA bases and at the U.S. Air Force's Arnold Engineering Development Center (AEDC); nine additional major facilities are operated by private firms in the U.S. aerospace industry (table 7-1).[25] U.S. wind tunnel facilities represent a broad range of capabilities. The NASA subsonic facility at Ames Research Center is the largest in the world, and NASA's cryogenic tunnel at Langley is capable of producing the highest Reynolds numbers in the world. Langley's focus is more research-oriented, while Ames concentrates more heavily on development.[26] The AEDC wind tunnel facilities primarily tests aerospace vehicles for the military and NASA, although the Center has recently begun testing civil aircraft.

During recent years, the general focus of NASA's R&D efforts involving aerostructures has changed from an incremental approach that encouraged small but steady technological improvements to a revolutionary approach that seeks larger technological leaps. During 1970-95, aeronautical research resulted in incremental advances in transport efficiency, measured by lift/drag, that averaged 1 percent per year. Recent research, however, has focused on revolutionary new designs such as strut-braced wing aircraft and blended-wing body aircraft that have the potential for increasing the lift/drag ratios by 20-100 percent.[27] In addition, there has been greater focus in recent years on reducing the environmental impact of aircraft by decreasing noise and emission levels and fuel consumption. NASA projects include not only new product and technology development, but may entail the development of manufacturing processes to facilitate implementation of a new technology. For example, the production process is integral to the successful manufacture of carbon fiber aerostructures and was the subject of NASA research pertaining to high speed aircraft during the 1990s.[28]

[24] FAA official, interview by USITC staff, Washington, DC, Jan. 2001.
[25] This study classifies a wind tunnel as a "major" facility if it is designated as such by NASA.
[26] NASA official, interview by USITC staff, United States, Feb. 2001.
[27] Ibid.
[28] Ibid.

Table 7-1
Major[1] U.S. subsonic, transonic, and supersonic wind tunnels

Type of ownership	Organization	Facility	Simulated speed range	Test section (feet)	Reynolds number (per ft. x 10^6)	Special characteristics
U.S. Government	NASA	Ames Research Center	2 subsonic 1 transonic 1 supersonic	11.3 x 11.3 80.0 x 120.0 11.0 x 11.0 9.0 x 7.0	0 - 1 0.1 - 12 0.3 - 9.6 0.8 - 6.5	Pressure tunnel
		Langley Research Center	3 subsonic 3 transonic 1 supersonic	14.5 x 21.8 7.5 x 3.0 20.0 diameter 15.5 x 15.5 1.1 x 1.1 16.0 x 16.0 4.0 x 4.0	2.1 0.1 - 15 0.6 1.2 - 4.2 100 2.8 air; 8.5 freon 0.5 - 12.2	Low-turbulence pressure tunnel Vertical spin tunnel Cryogenic tunnel Simulates unsteady flows
		Glenn Research Center	2 subsonic 1 transonic 1 supersonic	6.0 x 9.0 9.0 x 15.0 8.0 x 6.0 10.0 x 10.0	3.3 0 - 1.4 3.6 - 4.8 0.12 - 3.4	Icing research tunnel
	DoD	AEDC	2 transonic 3 supersonic	4.0 x 4.0 16.0 x 16.0 16.0 x 16.0 4.1 x 4.1 3.5 x 3.5	1.3 - 6.1 0.1 - 1.6 0.1 - 2.6 0.4 - 1.3 0.3 - 9.2	
U.S. aerospace industry	Boeing	Philadelphia, PA	1 subsonic	20.0 x 20.0	0 - 2.3	Vertical and short takeoff tests
		Seattle, WA	1 transonic	8.0 x 12.0	0 - 4	
		St. Louis, MO	1 supersonic	4.0 x 4.0	4 - 50	
	Lockheed	Smyrna, GA	1 subsonic	16.0 x 23.0	0 - 2	
		Dallas, TX	1 supersonic	4.0 x 4.0	4 - 34	
	Microcraft	San Diego, CA	1 subsonic	8.0 x 12.0	0.25 - 2.5	
		El Segundo, CA	1 transonic	7.0 x 7.0	2 - 14	
	Calspan	Buffalo, NY	1 transonic	8.0 x 8.0	0 - 12.5	
	Loral	Dallas, TX	1 supersonic	4.0 x 4.0	2 - 38	

[1] For purposes of this study, only wind tunnels identified by NASA as major facilities are included.

Source: Company websites and e-mail correspondence with U.S. Government officials.

Ongoing NASA research involving aerostructures includes the exploration of technologies designed to enhance performance and safety while reducing weight. These goals are being explored through a number of different projects including the Morphing Project, the Super Lightweight Multi-Functional Systems Technology (SLMFST) project, and the Inherently Reliable Systems (IRS) project. NASA's Morphing project includes the development and validation of smart material analysis tools and the solution of aeroelastic problems associated with new flexible structures. The SLMFST project focuses on the development of ultra-lightweight materials using nanotechnology, which manipulates material on an atomic or molecular scale. IRS focuses on increasing the safety and reliability of aircraft and includes the development of aircraft life extension methodologies such as accelerated test methods for cracks in corrosive environments and advanced environmental models for aircraft life prediction.

NASA's government partners in these projects include the Defense Advanced Research Projects Agency (DARPA), the Air Force, the Army, FAA, and the National Institute of Standards, while industry partners include aerostructures manufacturers Boeing, Raytheon, and Northrop Grumman, and independent research firms AS&M and Fraunhofer. At least 20 university partners from across the United States are also involved in these projects including the University of Washington, MIT, Texas A&M, Georgia Tech, and the Illinois Institute of Technology.[29]

The R&D conducted by DoD is principally directed toward military applications, although programs within each branch of the military concentrate on dual-use technologies that may benefit the civil aerostructure and other industries. For example, high strength, high stiffness composites developed by the military have found applications in civil aircraft and are even being used to create light-weight air tanks for firefighters.[30] DoD conducts a number of R&D programs in cooperation with universities and the U.S. industry that also focus on dual use technologies such as the Dual Use Science and Technology program and the Government/Industry Cooperative Research program.

The FAA is responsible for the safety of civil aviation in the United States, including the formulation and enforcement of regulations and standards related to the manufacture, operation, certification, and maintenance of aircraft.[31] As such, the FAA is required to carry out significant levels of R&D and develop and maintain test equipment and infrastructure necessary to fulfill its mandate. While the FAA conducts many short-term R&D projects that provide immediate solutions to aviation problems, it is also engaged in long-term research in cooperation with U.S. colleges and universities. This collaboration allows the FAA to expand its capabilities and leverage resources by sharing facilities and expertise.

The FAA is presently engaged in research involving advanced materials such as polymeric composites to ensure the safety of civil aircraft and "to advance U.S. civil aviation technology and expertise by encouraging the use of advanced materials in airframes and engines."[32] Other ongoing FAA research involves a crash worthiness program designed to eliminate structural design faults and the development of a computer code used in the analysis of airframe crash effects.

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[29] Most NASA R&D results are published, with the exception of proprietary projects that are undertaken in collaboration with industry. Propriety projects account for less than 5 percent of total NASA R&D–a level that has remained stable during recent years. Approximately 85 percent of NASA university grants for aerodynamics, aerothermodynamics, and acoustics result in published work.

[30] European industry official, interview by USITC staff, Europe, Sept.-Oct., 2000.

[31] *U.S. Department of Transportation: About DOT*, found at Internet address *http://www.dot.gov/about.htm.*, retrieved Jan. 10, 2000.

[32] *FAA William J. Hughes Technical Center: Advanced Materials Research Program*, found at Internet address *http://www.faa.gov/orgs.htm*, retrieved Nov. 2, 2000.

Government Funding

U.S. Government spending on aerospace R&D decreased during 1995-99 for each of the major government entities that conducts such research. NASA's total R&D expenditures decreased 2.4 percent during 1995-99, while its aeronautics R&D fluctuated between $824 million and $920 million during 1995-98 before decreasing, by 16 percent, to $769 million in 1999.[33] Although the aeronautics budget also encompasses programs that are not the subject of this study, it is the closest proxy for aerostructures R&D identified in the NASA budget.[34] The sharp decrease in aeronautics expenditures during 1998-99 is largely attributable to the termination of NASA's high speed aircraft research, which was canceled when Boeing determined that it was not "economically viable,"[35] and reductions in its advanced subsonic technology research.[36] NASA's expenditures on basic research have remained relatively stable since 1995 and are likely to hold at the same level through 2001.

Although total DoD spending on RDT&E increased 11 percent to $38.1 billion, spending on aircraft decreased by 23 percent during the same period (table 7-2).[37] Most of DoD's aircraft R&D expenditures–78 percent during 1999–were for tactical aircraft. DoD spent approximately $1.2 billion of its total budget on basic research, which could find applications in many different industries.

Table 7-2
U.S. Government R&D expenditures, 1995-99

Agency	1995	1996	1997	1998	1999
			(Million dollars)		
NASA total	13,996	13,884	13,709	13, 648	13, 665
Aeronautics	824	866	844	920	769
DoD total[1]	34,420	35,120	36,480	37,180	38,104
Aircraft	5,331	5,122	4,834	4,743	4,100
FAA total	259	186	208	199	219
Airframes	14	10	12	13	12

[1] Includes research, development, test, and evaluation.
Source: NASA, DoD, and the FAA.

During 1999, DoD spent $908 million on 13 programs such as the Dual Use Science and Technology Program, Small Business Innovative Research, and Industrial Preparedness Manufacturing Technology designed to support and foster collaboration with academia and industry.[38]

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[33] NASA official, e-mail communication to USITC staff, Feb. 22, 2001.

[34] None of the R&D entities discussed in this chapter were able to provide data for R&D expenditures on aerostructures as defined in this study. NASA R&D expenditures for aeronautics and DoD expenditures for aircraft include spending for R&D related to propulsion systems, helicopters, and small aircraft.

[35] "Boeing backs away from plans for supersonic jet," found at Internet address *http://archives.seatttletimes.nwsource.com*, retrieved Mar. 16, 2001.

[36] NASA official, interview by USITC staff, United States, Feb. 2001.

[37] *RDT&E Programs (R-1): Fiscal Year 2001*, Office of the Under Secretary of Defense (Comptroller), Feb. 2000.

[38] Compiled by DoD official from *RDT&E Programs (R-1): Fiscal Year 2001*, Office of the Under Secretary of Defense (Comptroller), Feb. 2000.

Industry Funding

Company R&D expenditures as a share of total aerospace industry sales steadily decreased from 5.1 percent to 2.8 percent during 1995-99 (table 7-3). This decrease is a function of the rise in industry sales during this period and a 27-percent drop in company R&D expenditures during 1996-99. R&D spending for LCA aerostructures is a subset of the total R&D expenditures by aerospace companies presented in tables 7-3 and 7-4. As such, R&D spending by aerospace companies, when used with the company-specific information presented in chapter 3, can be a useful proxy for aerostructures R&D spending, although trends in one do not necessarily parallel trends in the other. Reduced expenditures by the industry as a whole may be attributable to lower spending by major producers such as Boeing and Northrop Grumman (table 7-4).

R&D expenditures by companies in the aerospace industry are overwhelmingly concentrated in product development. During 1998, companies in the U.S. aerospace industry spent approximately $5.1 billion on R&D, of which over 90 percent was for development.[39] Basic research comprised only 4 percent of total aerospace company expenditures, with applied research accounting for the remaining 6 percent.

R&D funding for U.S. LCA and larger aerostructures producers usually comes from bank loans or internal company profits. R&D can also be shared by LCA manufacturers and larger aerostructures firms with potential suppliers in cooperative programs.[40] Increasingly, LCA manufacturers and larger aerostructures firms require their major suppliers to perform applied research and development work that relates to the aerostructures and systems for which they are responsible. Rather than providing actual R&D funding for a program, the suppliers often provide their own engineers, materials, and facilities for work with the potential customer on relevant parts of the program.

[39] *Aerospace Facts and Figures 2000/2001*, Aerospace Industries Association of America, Inc. (Washington DC: 2000), p. 102.

[40] U.S. industry officials, in-person and telephone interviews by USITC staff, United States, May-Sept. 2000.

Table 7-3
U.S. aerospace[1] industry R&D expenditures, 1990-99

Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
					(*Million dollars*)					
Company R&D expenditures[2]	5,387	5,533	6,871	5,684	5,466	5,489	5,710	5,677	5,108	4,159
Federal funds for industry R&D	15,248	11,096	10,287	9,372	8,794	11,462	10,515	10,619	9,341	8,656
Total R&D expenditures	20,635	16,629	17,158	15,056	14,260	16,951	16,224	16,296	14,449	12,815
Total industry sales	134,375	139,248	138,591	123,183	110,558	107,782	116,812	131,582	147,991	151,095
					(*Percent*)					
Company R&D expenditures/ total industry sales	4.0	4.0	5.0	4.8	4.9	5.1	4.9	4.3	3.5	2.8
Federal funds for industry R&D/ total industry sales	11.3	8.0	7.4	7.6	8.0	10.6	9.0	8.1	6.3	5.7
Total industry R&D expenditures/ total industry sales	15.4	11.9	12.3	12.2	12.9	15.7	13.9	12.4	9.8	8.5

[1] Companies classified in SIC codes 372 and 376, having as their principal activity the manufacture of aircraft, guided missiles, space vehicles, engines, and parts.

[2] Company funds include all funds for industrial R&D work performed within company facilities except funds provided by the Federal government. Excluded are company-financed R&D contracted to outside organizations such as research institutions, universities and colleges, or other nonprofit organizations.

Note.–The figures presented in this table reflect questionnaire responses by aerospace firms to the National Science Foundation's *Annual Survey of Industrial Research and Development* and adjustments to these responses by National Science Foundation staff to compensate for nonresponding firms. As such, there is significant overlap among the data presented in this table, the U.S. Government R&D expenditures presented in table 7-2, and the selected company R&D data presented in table 7-4.

Source: Aerospace Industries Association of America, National Science Foundation, and USITC staff estimates.

Table 7-4
R&D expenditures for selected major U.S. aerostructures manufacturers, 1995-99

Type	1995	1996	1997	1998	1999
			(Million dollars)		
R&D expenditures					
Boeing[1]	1,232	1,156	1,208	1,021	585
Northrop Grumman[2]	164	255	256	203	197
Goodrich[3]	86	108	148	177	194
Hexcel	8	17	18	24	25
ATP[4]	0.799	1.213	1.063	0.864	0.808
Net Sales					
Boeing[1]	17,511	19,916	26,929	35,545	38,105
Northrop Grumman[2]	7,272	8,607	9,153	8,902	8,995
Goodrich[3]	1,860	2,078	4,688	5,455	5,536
Hexcel	350	695	937	1089	909
ATP[4]	179	164	119	127	79
			(Percent)		
R&D expenditures/Net sales					
Boeing[1]	7.0	5.8	4.5	2.9	1.5
Northrop Grumman[2]	2.3	3.0	2.8	2.3	2.2
Goodrich[3]	4.6	5.2	3.2	3.2	3.5
Hexcel	2.3	2.5	1.9	2.2	2.8
ATP[4]	0.4	0.7	0.9	0.7	1.0

[1] R&D expenditures and net sales are for Boeing's Commercial Airplanes division only.
[2] Primarily develops military aircraft.
[3] Includes noncontract R&D only.
[4] Advanced Technology Products, Inc.

Source: Company 10-K forms.

Increased risk sharing is transforming the way industry R&D is being financed. Whereas LCA manufacturers formerly conducted most R&D, suppliers are increasingly conducting a greater share of R&D and collaborating with their customers in product design. As top-tier aerostructures producers are delivering increasingly more complex products and additional services to the aircraft manufacturers, their share of overall R&D expenditures has increased.

Boeing, the dominant U.S. industry producer and consumer of LCA aerostructures, cut its R&D expenditures for its commercial airplanes sector from $1.2 billion to $585 million (53 percent) during 1995-99 and attributed this reduction to the timing of major commercial aircraft development programs.[41] Boeing's R&D as a share of net sales fell even more dramatically during this period, from 7 percent to 1.5 percent.[42] R&D for commercial airplanes remained essentially unchanged during 1999-2000.[43] By comparison, R&D for Airbus has remained steady at approximately $1.0 to $1.2 billion annually and will likely climb to roughly $1.6 billion during 2001-03 as the A380 ramps up.[44] The changing levels of R&D expenditures by both companies are paralleled elsewhere in the industry. Industry aeronautics R&D

[41] The Boeing Company, 1999 Form 10-K, p. 32.
[42] The Boeing Company, 1999 Form 10-K.
[43] The Boeing Company, 2000 Form 10-K, p. 34.
[44] *Global Commercial Aerospace Monthly*, Feb. 18, 2000, Credit Suisse/ First Boston, p. 20.

spending in the United States as a percentage of sales has fallen by over 30 percent in the last decade, while European expenditures have risen.[45]

Boeing finances its R&D internally whereas Airbus relies on its former partners to obtain funding for its programs and has had limited exposure to international financial markets. Because of its lack of financial transparency under the previous G.I.E. structure, Airbus does not have the financial history to obtain funds at the same rates as Boeing on the open market.[46]

Other firms in the U.S. aerostructures industry, such as Goodrich, report increased levels of R&D. Many U.S. aerostructures suppliers report that they do not pursue basic research, but engage in applied research directly tied to specific products or process development for improved feasibility and technology demonstration.[47]

Aerostructures R&D in Canada

The Canadian aerospace industry contends that the Canadian Government is less involved in aerospace R&D funding than other countries, notably the United States and Europe.[48] R&D funding in Canada is a collaborative effort between aerospace companies and federal and local government institutions. R&D investment by the Canadian aerospace industry increased most years during 1992-98, reaching $668 million before decreasing 15 percent in 1999 (table 7-5). Bombardier—a producer of regional aircraft not covered by this investigation—accounted for much of this investment, and fluctuations in expenditures are largely tied to Bombardier's aircraft development cycle. Despite increased R&D expenditures during most of this period, R&D as a share of total sales steadily decreased from 9.1 percent to 5.0 percent during 1994-99, as the increase in total sales outpaced R&D investment.

Table 7-5
Canadian aerospace and defense industry R&D expenditures,[1] 1990-99

Type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
					(Million dollars)					
R&D	614	586	501	503	603	630	618	656	668	567
Total sales	5,953	6,457	6,190	5,844	6,610	7,218	8,387	9,020	10,315	11,325
					(*Percent*)					
R&D/total sales	10.3	9.1	8.1	8.6	9.1	8.7	7.4	7.3	6.5	5.0

[1] Does not include government expenditures.

Source: National Research Council Canada, Institute for Aerospace Research.

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[45] Aeronautics and Space Engineering Board, *Recent Trends in U.S. Aeronautics Research and Technology* (Washington, DC: National Academy of Sciences, 1999), pp. 1-24; and "What's at Stake in U.S. Aeronautics Decline," *Aviation Week & Space Technology*, Oct. 2, 2000, p. 82.

[46] Industry financial analyst, telephone interview with USITC staff, Jan. 19, 2001.

[47] U.S. industry officials, interviews by USITC staff, United States, June-Aug. 2000.

[48] PricewaterhouseCoopers LLP, *Canadian Aerospace Suppliers Base Strategy for Change*, June 25, 1999, p. 42; and Industry Canada, "Sector Competitiveness Series: Aircraft and Aircraft Parts," Aerospace and Defence Strategis, Sept. 11, 1996, found at Internet address *http://strategis.ic.gc.ca*, retrieved Sept. 18, 2000.

The Canadian aerostructures industry has access to government-financed aeronautical research facilities, including the National Research Council's (NRC) Institute for Aerospace Research (IAR) test laboratories, and research establishments of the Department of National Defence, which fund procurement programs and military R&D. The IAR performs R&D on both a client-funded (fee-for-service) and cost-shared (collaborative) basis, and operates wind tunnels, material testing facilities, engine test rigs, and acoustic test chambers.[49] The NRC estimates the value of these facilities at $337 million and maintains that they are comparable to facilities in other leading aerospace countries.[50]

Additional forms of Government assistance include financial partnerships through programs such as the NRC's Industrial Research Assistance Program (IRAP) and the Technology Partnerships Canada (TPC) program, a risk-sharing program supporting several high-technology sectors, including aerospace. IRAP supports the competitiveness and industrial development of small- and medium-sized enterprises through services provided by Industrial Technology Advisors located throughout Canada and repayable "concept to commercialization" funding assistance. TPC aerospace investments focus on technologies in aircraft structures, components, and materials. TPC investments in the aerospace industry include the following:

- Goodrich, Heroux-Devtek, and Messier-Dowty were awarded TPC repayable investments totaling $2.8 million in August-September 2000 for research and development of a joint Canadian-U.S. project involving the design and development of an alternative to hard-chrome plating in landing gear due to the health and environmental risks associated with the chrome plating process.[51]

- Bristol Aerospace received a TPC repayable investment of $1.4 million in April 1998 for the development of composite structures for aircraft.[52]

- Fleet Industries, a division of Magellan Aerospace Corp., obtained a $2.2 million repayable investment from TPC for the design and production of aircraft wing components.[53]

Aerostructures R&D in Europe

European governments have made a concerted effort in recent years to overcome redundancy and inefficiency in aerospace R&D. This effort includes a number of cooperative programs that allow the industry to make the most efficient use of existing R&D facilities and resources throughout Europe

[49] National Research Council Canada, Institute for Aerospace Research, "A Vision of the Future: The NRC Strategic Plan for Aerospace 1999-2004," undated, pp. 2-3.

[50] National Research Council Canada, Institute for Aerospace Research, "A Vision of the Future: The NRC Strategic Plan for Aerospace 1999-2004," undated, p. 3.

[51] Technology Partnerships Canada (TPC), press release, "Technology Partnerships Canada Invests in Third R&D Project Supporting Canada-US Aerospace Initiative," Sept. 15, 2000, found at Internet address *http://strategis.ic.gc.ca/SSG/tp00237e.html*, retrieved Oct. 24, 2000.

[52] TPC, press release, "Aerospace Sector Receives Boost from Federal and Provincial Funding," Apr. 6, 1998, found at Internet address *http://strategis.ic.gc.ca/SSG/tp00100e.html*, retrieved Oct. 24, 2000.

[53] TPC, press release, "Technology Partnerships Canada Investment Builds Ontario Aerospace Industry," Apr. 21, 1997, found at Internet address *http://strategis.ic.gc.ca/SSG/tp00016e.html*, retrieved Oct. 24, 2000.

(table 7-6). In addition, the European Commission (EC) has established a series of framework programs for R&D to foster "better exploitation of the industrial potential of policies of innovation, research and technology development." The current program (the Fifth Framework Program) has set priorities and a budget of $657 million for aeronautical R&D in the European Union (EU) during 1998-2002.[54]

European governments spent approximately $1.1 billion on civil aerospace[55] R&D during 1999, while European industry contributed approximately $2.9 billion (table 7-7).[56] Total R&D expenditures for the aerospace industry amounted to 14.5 percent of total sales during 1999, down from 16.1 percent in 1998.[57] R&D expenditures for aerospace are higher than that of any other European industry.[58] Industry analysts expect that these expenditures will increase during the next few years since development costs for the Airbus A380 program alone could reach $13 billion.[59]

Table 7-6
Selected organizations and programs that coordinate or fund European R&D for aerostructures, members, and major goals

Program	Members	Major goals
GARTEUR[1]	France, Germany, Italy, Netherlands, Spain, Sweden, United Kingdom	Promote collaboration in civil and military aeronautical research, eliminate duplication, exchange scientific information, and strengthen the competitiveness of the major European players.
Fifth Framework Program	EU-15	Promote better exploitation of the industrial potential of policies of innovation, research, and technology development. The program aims to achieve the following reductions for aircraft: production costs by 35 percent; development time by 15-20 percent; fuel consumption by 20 percent; NOx by 80 percent; CO^2 by 20 percent; external and cabin noise by 10dB; and maintenance costs by 25 percent.
AECMA[2]	EU-15	Promote the competitive development of the European aerospace industry and represent it in international cooperation programs that are coordinated with the EU.
EREA[3]	The national aeronautic research organizations of France, Germany, Italy, Netherlands, Spain, Sweden, United Kingdom	Provide European industry and authorities with a cost effective high quality aeronautics technology base by developing and executing joint research programs and through cost effective use of resources, facilities, and personnel. Coordinate the infrastructure requirements of all major European government-owned aeronautics research centers.

[1] Group for Aeronautical Research and Technology in Europe.
[2] European Association of Aerospace Industries.
[3] Association of European Research Establishments in Aeronautics.

Source: European R&D officials, interviews by USITC staff, Oct. 2000; BDLI Annual Report 1998/99.

[54] European R&D official, interview by USITC staff, Europe, Oct. 2000.

[55] Aerospace includes products such as propulsion systems, small aircraft, and helicopters that are not the subject of this investigation.

[56] *AECMA, 1999 Statistical Survey*, found at Internet address *http://www.aecma.org*, retrieved Nov. 1, 2000.

[57] Includes total government and industry spending on both civil and military aerospace R&D.

[58] Dee Dee Doke, "European melting pot," *Flight International*, July 11-17, 2000, p. 34.

[59] Chris Avery, *Industry Analysis: European Civil Aerospace Industry* (London: J.P. Morgan Securities Ltd. Equity Research, 2000), p. 61.

Table 7-7
EU aerospace[1] R&D expenditures

Type	1995	1996	1997	1998	1999
			(*Million dollars*)		
Company expenditures:					
Civil	[2] NA	[3]2,702	2,648	2,975	2,860
Military	[2] NA	[3]930	1,247	1,692	1,794
Total	[2] NA	[3]3,632	3,895	4,667	4,654
Government expenditures:					
Civil	[2] NA	[3]1,595	1,194	992	1,078
Military	[2] NA	[3]2,392	1,911	3,733	3,172
Total	[2] NA	[3]3,987	3,105	4,725	4,251
Total R&D expenditures	[2] NA	[3]7,620	7,000	9,371	8,904
Total sales	39,555	44,302	51,921	58,334	61,546
			(*Percent*)		
Company R&D expenditure/total sales	[2] NA	8.2	7.5	8.0	7.6
Government R&D expenditures/total sales	[2] NA	9.0	6.0	8.1	6.9
Total R&D expenditures/total sales	[2] NA	17.2	13.5	16.1	14.5

[1] Encompasses aircraft (including helicopters), missiles, and space.
[2] Not available. AECMA did not publish R&D data prior to 1996 and the EC did not publish complete R&D data after 1994.
[3] USITC estimates based on AECMA data.

Source: AECMA.

European government support for aerostructures R&D is provided directly and indirectly to manufacturers, research organizations, and universities. Several different ministries within a single country may provide funding, which flows in turn to national programs, national research organizations, international programs, academia, or industry.[60]

European National Organizations

Each of the seven countries[61] that comprise the bulk of the European aerospace industry have a government-sponsored R&D organization responsible for conducting aerospace R&D (table 7-8). These organizations own and operate the principal European R&D facilities and have responsibility for a major share of both the military and civil R&D involving aerostructures conducted by each country. The division of responsibilities for aerospace R&D varies from country to country and may involve many different government departments as well as private or semiprivate organizations, but the major R&D facilities, such as wind tunnels, are operated by a single entity within each country.

[60] For example, R&D funding for aerostructures in the United Kingdom may originate with the Ministry of Defence, the Department of Trade and Industry, the Office of Science and Technology, or the Department of Transportation.
[61] France, Germany, Italy, Netherlands, Spain, Sweden, and the United Kingdom.

Table 7-8
National organizations conducting aerostructures R&D in Europe

Country	Organization	Source of funding	Total 1999 budget (million dollars)	1999 aerospace budget (million dollars)	Total employment	Selected major customers
France	ONERA	Public/ private	190	[1] 57	1,989	French Government; Airbus
Germany	DLR	Public	720	336	4,500	German Government; industry
Italy	CIRA	Public	15	1	234	Italian Aerospace Research Center
Netherlands	NLR	Public/ private	72	72	950	Dutch Government
Spain	INTA	Public/ private	91	77	1,026	Spanish Ministry of Defense
Sweden	FFA	Public/ private	23	23	215	Swedish National Space Board
United Kingdom	DERA	Public/ private	1,618	[2] 16	12,000	Ministry of Defence

[1] R&D expenditures for aircraft.
[2] R&D expenditures for civil aeronautics.

Source: European industry officials interviewed by USITC staff and organization websites.

France

France's ONERA conducts R&D in aircraft, spacecraft, and missile technology for the French Ministry of Defense (MOD) as well as private industry. Forty-one percent of ONERA's budget in 1999 was funded through MOD grants, while an additional 41 percent came from government and industry contracts.[62] ONERA conducts basic and applied research; provides technical assistance to the government and industry; and designs, builds, and operates all facilities and equipment necessary to carry out R&D.

Germany

The German Aerospace Center (DLR) is the Federal Government's central agency for the organization and realization of projects within the framework of the German Aeronautics Research Program. DLR is supervised by a Senate composed of members of the government, industry, and the scientific community, and its mission is to serve public research needs in the areas of transport,

[62] *ONERA 1999 Annual Report*, p. 10.

communications, energy provision, environmental protection, and defense. DLR collaborates with the German Aerospace Industries Association (BDLI), which represents the leading German companies and organizations in the aerospace industry. During 1995-98, BDLI's Research and Technology Committee launched its first Civil Aeronautics research program which distributed approximately $280 million in research grants provided by the Federal Government and the German aerospace industry.[63] These grants funded 210 projects and involved 44 industrial enterprises, 6 DLR institutes, and 19 universities and colleges.

Italy

The Italian Aerospace Research Centre (CIRA) is a nonprofit research consortium that manages the National Aerospace Research Program. The Italian Space Agency (ISA) and the National Research Council are CIRA's majority shareholders. CIRA is responsible for noncompetitive applied research, the acquisition and development of technology, the evaluation and exploitation of scientific results, support to industry through applied R&D, and the development of basic research with the support of universities. Principal fields of research include aerodynamics, space vehicles and propulsion, ice protection, acoustics and vibration, structures and materials, structural dynamics, flight safety and human factors, flight dynamics, control and automation, and computer science. CIRA facilities include a crash test facility, a structure and materials lab, an acoustic and vibrations lab, and three wind tunnels.[64]

Netherlands

The Netherlands National Aerospace Laboratories (NLR) is a nonprofit organization that provides expert advice regarding aerospace and related fields to government departments, international agencies, aerospace industries, and aircraft operators.[65] Approximately 75 percent of NLR's total revenues involved R&D under contract in 1999.[66] NLR receives government funding for its basic research program and for the development of specialized research equipment. NLR jointly operates 7 major wind tunnels with DLR under the German-Dutch Wind Tunnel organization (DNW). Four of these facilities are in the Netherlands and the rest are in Germany (table 7-9).

Spain

The National Institute of Aerospace Technology (INTA) develops aeronautical and space technologies under the Spanish Secretary of State for Defense. INTA maintains many links with the domestic and foreign aerospace industry and conducts aerospace R&D that could not be financed exclusively by industry. Its primary goals are to raise the technological level of the Spanish

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[63] *BDLI Annual Report 1998/99*, p. 141.

[64] Italian Aerospace Research Centre-General Information, found at Internet address *http://www.cira.it/ciragen/index.html*, retrieved Feb. 26, 2001.

[65] NLR-Overview, found at Internet address *http://www.nlr.nl/public/about-nlr/index.html*, retrieved Feb. 25, 2001.

[66] *National Aerospace Laboratory Annual Report 1999: Executive Version*, p. 5.

Table 7-9
Major European government-owned subsonic, transonic, and supersonic wind tunnels[1]

Location	Operator	Facility	Simulated speed range	Cross-section (meters)	Reynolds number (per m x 10^6)	Special characteristics
France	ONERA	F1	subsonic	4.50 x 3.50	20.2	Pressurized
		S1MA	sub/transonic	8.00 diameter	11.5	4 test sections
		S2MA	trans/supersonic	1.75 x 1.77 - 1.93	21.8-30.7	2 test sections, pressurized
		S3MA	trans/supersonic	0.56 x 0.78 - 0.76 x 0.80	41.0-53.0	2 test sections, pressurized
Germany	DNW	NWB	subsonic	3.25 x 2.80	6.0	
		KKK	subsonic	2.40 x 2.40	39.6	Cryogenic
		TWG	supersonic	1.00 x 1.00	18.0	Pressurized
	ETW GmbH[2]	ETW	transonic	2.00 x 2.40	220.0	Cryogenic
Italy	CIRA	IWT	subsonic	2.35 x 1.50 - 3.60	0.2-22.4	Icing tunnel with 4 test sections
Netherlands	DNW	LST	subsonic	3.00 x 2.25	5.1	
		LLF	subsonic	6.00 x 6.00 - 9.50 x 9.50	4.1-10.0	3 test sections
		HST	transonic	2.00 x 1.80	47.4	
		SST	supersonic	1.20 x 1.20	125.0	
Sweden	FFA	LT1	subsonic	3.60 diameter	5.7	
		T1500	supersonic	4.00 x 1.50	80.0	
United Kingdom	DERA	5M PLS	subsonic	5.00 x 4.20	16.4	Pressurized
		13x9 ALS	subsonic	4.00 x 2.74	5.6	
		8x8 PHS	transonic	2.44 x 2.44	38.0	Pressurized
		4x3 SS	supersonic	1.22 x 0.91	42.0	Pressurized

[1] For purposes of this study, only wind tunnels identified by NASA as major facilities are included.
[2] ETW GmbH was established by an intergovernmental arrangement under which ONERA, DLR, and DERA each own capital shares of 31 percent and NLR, 7 percent.

Source: Research organization websites and e-mail correspondence with various European officials.

aerospace industry with special emphasis on small and medium-sized businesses; to maintain the capacity to develop the aeronautical and space programs determined by the Spanish government, especially the Ministry of Defense; and to provide services and test facilities that support the transfer of advanced technologies.[67] INTA tests and develops technology that has applications in both military and civil sectors such as the calibration of equipment and instruments, airworthiness certification, and the development of electronic systems.

Sweden

On January 1, 2001, the Defence Research Establishment and the Aeronautical Research Institute (FFA) merged to form the Swedish Defence Research Agency (FOI). The merger is intended to create a stronger international organization that is better equipped to deal with the transformation of the Swedish Armed Forces.[68] The principal activities of FOI are research, method and technology development, and studies on behalf of the National Total Defence. FOI's clients include the Swedish Armed Forces, the Ministry of Defence, the Defence Materiel Administration, and the Ministry for Foreign Affairs. FOI also uses its expertise to support the Swedish aerospace industry. Most of the results of FOI's R&D are unclassified and result in 150-200 publications each year. FOI also conducted research and investigative work on a contract basis, which is expected to total approximately $121 million in 2001.[69]

United Kingdom

DERA conducts different types of research for the British Ministry of Defence and contracts research from industry.[70] DERA's research is divided into three types of programs—corporate research, applied research, and project support. The goal of the corporate research program is to develop the defense technology base. Research in this program is not expected to reach fruition for at least 20 years. The applied research program provides support for defense equipment that might be required in service during the next 20 years. This research is aimed at systems with increasing emphasis on technology demonstrators. Technology demonstrators generally require constructing and testing prototypes. Project support is concerned with the procurement activities for specific military equipment and helps to meet immediate operational needs.

Total R&D expenditures by the British aerospace industry for civil aerospace totaled approximately $791 million in 1998.[71] British aerospace firms covered 74 percent of these

[67] Instituto Nacional de Tecnica: Organizacion, found at Internet address *http://www.inta.es/,* retrieved Mar. 16, 2001.

[68] FOI representative, e-mail communication to USITC staff, Feb. 2001.

[69] FOI-Welcome, found at Internet address *http://www.ffa.se/english/index.html*, retrieved Feb. 25, 2001.

[70] DERA, Contract Research and Development, found at Internet address *http://www.dra.hmg.gb/html/working_with_us/contract_research_and_development.htm,* retrieved Aug. 10, 2000.

[71] Includes government funding for industry R&D. Department of Trade and Industry and The Society of British Aerospace Companies, *U.K. Aerospace Statistics 1999: Key Points and Trends*, Apr. 2000,
p. 21.

expenditures through internal funding and contracts, and the government contributed the remainder through programs such as the Civil Aircraft Research and Technology Demonstration (CARAD) and defense contracts. DERA currently subcontracts about $275 million of its research of which approximately $49 million is spent with academia.[72] This spending level has remained relatively stable in recent years, while military aerospace spending has dropped by approximately 35 percent since 1990.

Aerostructures R&D in Asia

Aerostructures R&D in Asia has increased in intensity during the last few years as major economies such as Japan, China, and Korea seek to expand their role in the global aviation industry. Japan recently announced that it will continue to develop a long range supersonic transport despite the waning support for such programs in Europe and the United States. Korea is attempting to develop new capabilities that will allow it to provide a wider range of aircraft and aerostructures, and China is in the process of consolidating its aerospace R&D facilities and resources to increase its competitiveness. To accomplish these goals, each country will need well-trained researchers and world-class R&D facilities. Japan has a large established R&D infrastructure that includes experienced scientists and engineers engaged in aerostructures R&D using a wide range of facilities. Both China and Korea have made significant improvements to their R&D infrastructure during the 1990s and have the potential to expand both the scope and scale of their aerostructure operations significantly.

Japan

Japan has a long history of aircraft R&D. Its first wind tunnel was built in 1928, and it continues to operate world-class R&D facilities today. According to industry sources, Japan's major aircraft manufacturers are fully capable of design and development.[73] In addition, the Japanese Government provides significant amounts of assistance directly to industry for product development. For example, one Japanese aerostructures producer stated that it finances its own basic research, but that the Japanese Government provides more than half of its development expenditures.[74]

A number of government agencies are involved in R&D for aerostructures in Japan. The Ministry of Economy, Trade, and Industry determines national government policy affecting the industry through its Aircraft Industry Council, which coordinates the interests of the national government and private industry. NAL is charged with conducting experimental research on aeronautics and space technology and providing the facilities and equipment necessary for such research. The primary focus of NAL R&D in recent years has been the development of a large civil supersonic transport. NAL applied 71 percent of its $155 million budget for 2000 to aeronautics research and next generation supersonic transport technology[75] and recently announced that full scale development of a next generation supersonic transport aircraft would begin in 2002.[76]

[72] These figures include expenditures for both civil and military R&D.

[73] U.S. industry official, interview by USITC staff, United States, May-Aug. 2000.

[74] Japanese industry official, facsimile communication to USITC, Feb. 8, 2001.

[75] *Overview of NAL-Budget and Personnel*, found at Internet address *http://www.nal.go.jp/www-e/profile/b40c0001.html*, retrieved Jan. 24, 2001.

[76] "Japan to Build Supersonic Jet," *The Japan Times*, Feb. 20, 2001.

The Technical Research and Development Institute conducts research, development, test and evaluation of aircraft, military systems, and other equipment such as vehicles and ships. Its total R&D budget for 2000 was approximately $1.1 billion.[77] The Institute of Space and Aeronautical Science (ISAS) is Japan's principal institute for space and astronautical science. ISAS has a staff of approximately 300, and its budget for 1998 was approximately $261 million.[78]

Japan's R&D facilities for aerostructures include a number of major wind tunnels that are operated by government agencies and industry (table 7-10).

Table 7-10
Japanese wind tunnels[1] used for aerostructures

Operator	Year completed	Simulated speed range	Cross-section (meters)	Reynolds number (per m x 10^6)	Special Characteristics
Fuji Heavy Industries	1969	subsonic	2.00 x 2.00	5.0	
Kawasaki Heavy Industries	1938; 1969[2]	subsonic	3.50 x 3.50 2.50 x 3.00	2.3 4.0	2 test sections
	1988	transonic	1.00 x 1.00	70	
Mitsubishi Heavy Industries	1928; 1989[2]	subsonic	2.00 x 1.80	5.7	
	1968; 1989[2]	trisonic	0.60 x 0.60	65 max.	
National Aerospace Laboratory	1965	subsonic	6.50 x 5.50 5.60 x 4.60	4.0 4.8	2 test sections
	1960; 1985[2]	transonic	2.00 x 2.00	20	
	1961; 1988[2]	supersonic	1.00 x 1.00	(3)	
Technical Research and Development Institute	1972	subsonic	3.30 x 3.30 6.00 x 6.00 4.00 octagonal	4.6 max.	3 test sections
	1962	subsonic	2.50 x 3.50	4.0	
Institute of Space and Aeronautical Science	1989	transonic	0.60 x 0.60	70	

[1] For purposes of this study, only wind tunnels identified by NASA as major facilities are included.
[2] Year of latest upgrade.
[3] Not available.

Source: Sverdrup Technology, Inc.

Korea

The Korean Government has set a goal of becoming one of the top 10 aerospace countries in the world by the early 2000s. To achieve this, it must enhance its design, analysis, test, and evaluation

[77] *TRDI Homepage-Budget*, found at Internet address *http://www.jda-trdi.go.jp/english/resumee.html*, retrieved Feb. 18, 2001.

[78] *ISAS-Personnel and Budget*, found at Internet address *http://www.isas.ac.jp/e/about/pb/budget.html*, retrieved Feb. 18, 2001.

capabilities. The Korea Aerospace Research Institute (KARI) is the government entity primarily responsible for performing aerospace R&D and supporting expensive large scale testing and evaluation by industry, universities, research institutes, and the military.[79] KARI is one of 28 government-sponsored research institutes (GRIs) that have undergone a number of changes since their establishment in the 1960s. Most recently, these changes have been designed, among other things, to increase the productivity and accountability of the GRIs by funding research on a project basis rather than by providing an annual lump sum. KARI has a workforce of 252 employees, including 183 researchers.[80]

The Korean Government provides the country's dominant aerospace firm, Korea Aerospace Industries Ltd., with 100 percent of its R&D funding for military R&D projects and 50 percent of its funding for civil R&D projects.[81] Korea recently announced that it would triple its financial support for the aerospace industry to $15.1 million by 2003.[82]

KARI completed a low speed wind tunnel in 1999 and extended and upgraded its structural testing facilities for full-scale testing of medium-sized aircraft in 2000 (table 7-11).[83] The KARI facility accommodates three different test sections and produces air flow quality that, according to a recent study by Sverdrup Technology Inc., "is as good (or better than) any other in the world."[84] The same study reports that the Korean Air Force Academy (KAFA) facility achieves excellent flow quality through its two removable test sections. In addition to the KARI wind tunnel, Korea has completed two other low speed wind tunnels during 1998-99 which are operated by KAFA and the

Table 7-11
Korean wind tunnels used for aerostructures

Operator	Year completed	Simulated speed range	Cross-section (meters)	Reynolds number (per m x 10^6)	Special characteristics
Korea Aerospace Research Institute	1999	subsonic	4.00 x 3.00 6.00 x 4.50 4.00 x 3.00	7.4 3.5 6.2	3 test sections
Korean Air Force Academy	1998	subsonic	3.50 x 2.45 5.25 x 3.67	6.2 2.7	2 test sections
Agency for Defense and Development	1999	subsonic	3.00 x 2.25	8.0	2 lengths available

Source: Sverdrup Technology, Inc.

[79] Korea Aerospace Research Institute-About, found at Internet address *http://www.kari.kr/about_e/e_general.html*, retrieved Jan. 22, 2001.

[80] "Government-supported research institutes," found at Internet address *http://www.most.go.kr/govern-e/subs.html*, retrieved Jan. 22, 2001.

[81] USDOC, International Trade Administration, "Korea-Aerospace Consolidation Plans," Market Research Reports, July 2, 1999, found at Internet address *http:www.stat-usa.gov*, retrieved Jan. 25, 2001.

[82] "Korea to Triple Support for Aerospace Development, Paper Says," found at Internet address *http:www.bloomberg.com*, retrieved Mar. 23, 2001.

[83] "Korea Aerospace Research Institute-Research Facilities," found at Internet address *http://www.kari.re.kr/about_e/access/framefacility.htm*, retrieved Feb. 18, 2001.

[84] *Assessment of Asian Wind Tunnels*, p. 56.

Agency for Defense and Development. Total construction costs for the three facilities were approximately $47 million.[85]

China

China has recently undertaken steps to increase the competitiveness of its aircraft industry through corporate regrouping, alliances between research institutions, and the construction of new R&D facilities. Aviation Industries of China (AVIC) was split into AVIC I and AVIC II in 1999.[86] AVIC I, responsible for aerostructures production, maintains 31 research establishments that employ 45,000.[87] An effort is now underway to shift facilities and staff from the R&D divisions of various enterprises to AVIC's priority enterprises, which will take an estimated 5 years.[88] Chinese R&D efforts have also been enhanced in recent years by the construction of two new wind tunnels (table 7-12). China's primary wind tunnel facility, Chinese Aerodynamic Research and Development Center, began operation of a transonic wind tunnel in 1998 that has the highest Reynolds number capability of any noncryogenic facility in the world.[89] Northwestern Polytechnic University in Xi'an completed a low speed tunnel in 1995 that will be used for the development of commercial transport aircraft.

Table 7-12
Chinese wind tunnels used for aerostructures

Operator	Year completed	Simulated speed range	Cross-section (meters)	Reynolds number (per m x 10^6)	Special characteristics
Nanjing Aeronautical Institute	NA	subsonic	3.00 x 2.50 5.10 x 4.25	5.4 1.8	2 test sections
Northwestern Polytechnic University	1995	subsonic	3.00 x 1.60 3.50 x 2.50	7.0 5.0	3 test sections (includes section for propeller testing)
Beijing Institute of Aerodynamics	1966	subsonic	3.00 x 3.00	6.0	
	1962	trisonic	0.60 x 0.60	12.0 -30.0	
China Aerodynamic Research and Development Center	mid to late 70s	subsonic	4.00 x 3.00	6.0	
	1979	subsonic	12.00 x 16.00 8.00 x 6.00	1.7 6.9	2 test sections
	1998	transonic	2.40 x 2.40	40.0 - 70.0	
	1979	trisonic	1.20 x 1.20	35.0	

[1] Not available.

Source: Sverdrup Technology, Inc.

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[85] *Assessment of Asian Wind Tunnels*, pp. 57-59.

[86] USDOC, International Trade Administration, "China - Aviation Industry Corporation," International Market Insight Reports, Apr. 9, 1999, found at Internet address *http://www.stat-usa.gov*, retrieved Jan. 25, 2001.

[87] USDOC, International Trade Administration, "Aviation Industry Corporation I & II," International Market Insight, Nov. 30, 1999, found at Internet address *http://www.fas.org/nuke/guide/contractor/mark0025.htm*, retrieved Feb. 19, 2001.

[88] U.S. Department of Commerce "China -Aviation Industry Corporation."

[89] *Assessment of Asian Wind Tunnels*, p. 7.

Competitive Implications of Government R&D Funding Trends

The United States has led the world in R&D for LCA aerostructures since World War II because of the dominance of its LCA industry, massive spending on military aircraft, development of an unparalleled R&D infrastructure, and its fostering of an interdependent R&D network involving government, industry, and academia. This preeminence has been challenged in recent years by Europe and may soon face serious competition in Asia. Although the United States still maintains a number of world class R&D facilities–most notably those operated by NASA and DoD**S** Boeing has been increasingly using European facilities such as wind tunnels for development, testing, and evaluation as they tend to be newer than U.S. wind tunnels and offer a higher level of precision and productivity.[90]

In recent years, both Europe and the United States have attempted to eliminate surplus wind tunnel capacity and make more efficient use of their facilities. In Europe, this attempt has taken the form of bi- or multinational arrangements such as the DNW and the Association of European Research Establishments in Aeronautics, whereby countries jointly own and operate wind tunnel facilities. In the United States, DoD and NASA recently developed and signed the National Aeronautical Test Alliance (NATA) designed to integrate the management of aerodynamic, aerothermodynamic, and aeropropulsion facilities owned and operated by the U.S. government.[91]

Recent studies by Boeing, DoD/NASA, and others have found that the advanced age and state of maintenance of U.S. wind tunnels could have negative implications for future R&D efforts. The Boeing study found that, of the facilities evaluated, none were rated as satisfactory for the development of a new subsonic transport.[92] Other studies conclude that considerable investment is needed to maintain the unique capabilities of wind tunnel facilities and that such investment must be maintained to keep pace with the emerging technology base.[93] The study also points out that despite this need, neither NASA or DoD are building any new wind tunnels. Since wind tunnels typically require a 10- to 15-year period to develop and acquire funding,[94] this could have negative implications for U.S. R&D efforts in the long term. This neglect of the U.S. R&D infrastructure is of particular concern in recent years as the European aerospace industry is garnering support for a very large commitment to R&D programs and infrastructure by governments and industry. The European industry is currently planning how it will spend $100 billion over the next 20 years to fund its R&D programs for aeronautics and improve its R&D infrastructure.[95]

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[90] NASA official, interview by USITC staff, United States, Feb. 2001.

[91] Ibid.

[92] *A Technical Assessment of Wind Tunnels Considered by Boeing for Airplane Design*, The Boeing Company, Document No. D6-82213TN, May 7, 1999, p. 23.

[93] NASA official, interview by USITC staff, United States, Feb. 2001.

[94] NASA official, telephone interview by USITC staff, Mar. 2001

[95] *European Aeronautics: A Vision for 2020* (Luxembourg: Office for Official Publications of the European Communities, Jan. 2001), p. 26.

Although Asia, for the most part, is still significantly behind both the United States and Europe in terms of their R&D capabilities for LCA aerostructures, countries such as Korea and China have recently made large investments in their R&D infrastructure. Asian countries have spent more than $600 million on wind tunnels during the past 10 years and the cost of "potential future facilities that have already been designed or conceptualized" has been estimated at $1.3 billion.[96] If these commitments are realized, Asian R&D capabilities for large civil aerostructures are likely to be significantly enhanced.

[96] *Assessment of Asian Wind Tunnels*, p. 67.

CHAPTER 8
GOVERNMENT LAWS, POLICIES, AND OTHER PUBLIC SECTOR INVOLVEMENT AFFECTING COMPETITIVENESS IN THE GLOBAL LCA AEROSTRUCTURES INDUSTRY

Introduction

Although many different legal requirements affect the global aerostructures industry, only a few have a significant impact on competitiveness in this industry.[1] These regulations include tax laws, merger policies, export activities, and labor laws that confer benefits or drawbacks to the aerostructures industries in the United States, Europe, and Canada.[2] European industry officials suggest that U.S. aerostructures manufacturers benefit from the U.S. Foreign Sales Corporation program, which exempts companies from a portion of their tax on foreign income. U.S. and European competition authorities take dissimilar approaches to consolidation within the global aerostructures industry; U.S. policies concentrate on prevention of cartel facilitation and on general market responsiveness to consumer interests, whereas EU law centers more on market domination by a leading firm. Export promotion programs and export controls affect export activities of aerostructures producers in the global market. Productivity gains spurred by rigid EU labor regulations appear to balance the perceived advantage U.S. companies might receive from more flexible labor laws.

Tax Law

U.S. and European tax systems that affect aerostructures manufacturers are complex; moreover, direct comparisons between U.S. and foreign tax rates can be meaningless if not placed in the broader context of the global tax system.[3] Accordingly, this section is limited to a brief description of the key features of U.S., European, and Canadian tax law, with an emphasis on those provisions identified as being important to aerostructures manufacturers.

[1] Policies having an ancillary effect on the aerostructures industry include the U.S. Foreign Corrupt Practices Act (appendix G).

[2] A discussion of government laws and policies in Asia is not included due to insufficient information.

[3] 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 comparable rate on taxable income but fewer opportunities for deductions and credits. Similarly, a liberal system of deductions and credits directed at an industry may be of little or no benefit, and thus provide little incentive for additional investment if the industry tends to have low profits or taxable income.

U.S. Tax Benefits

Foreign Sales Corporations

The Foreign Sales Corporation (FSC) program provides a significant tax break to qualifying U.S. firms.[4] The tax laws of the United States generally apply to U.S.-based firms on a worldwide basis, making corporations organized under any state or the District of Columbia subject to U.S. taxes no matter where in the world they generate their income.[5] However, U.S. firms that qualify as an FSC are exempted from U.S. income tax liability on a portion of their foreign source income.[6] Furthermore, firms that manufactured in and exported from the United States qualified for income tax relief if they sold their goods through an offshore company.[7]

The FSC program replaced the Domestic International Sales Corporation (DISC) provision to conform with a 1981 "understanding" issued by the GATT Council after GATT panels found the DISC and certain European tax provisions to be prohibited export subsidies.[8] The United States maintained that the FSC law complies with the principles set forth in the GATT Council understanding.[9] In 1999, the European Union (EU) challenged the FSC program, ignoring a 1981 informal agreement that it would not challenge the territorial taxation systems of GATT members.[10] In February 2000, the WTO Appellate Body upheld a 1999 WTO Panel decision holding that the FSC program was a prohibited export subsidy.[11] In November 2000, to avoid retaliation from U.S. trading partners, Congress passed the FSC Repeal and Extraterritorial Income Exclusion Act of 2000, which repealed the FSC provisions and replaced them with a broad exemption for foreign-earned income.[12]

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[4] The Foreign Sales Corporation (FSC) program began first as the Domestic International Sales Corporation provision, which was devised by the Nixon administration in 1971. Office of the United States Trade Representative (USTR), press release, "U.S. Trade Representative Charlene Barshefsky Reacts to European Attacks on U.S. Tax Law," July 2, 1998, found at Internet address *http://www.ustr.gov,* retrieved May 23, 2000.

[5] "Foreign Sales Corporation Beneficiaries: A Profile," *Tax Notes International*, July 24, 2000.

[6] The legal requirements of an FSC are: (1) no more than 25 shareholders is permissible; (2) no preferred stock can be issued; (3) an office must be maintained outside the United States; (4) books must be maintained in the foreign office; (5) there must be at least one nonresident of the United States on the Board of Directors; and (6) the taxpayer must elect FSC status. Internal Revenue Code § 922(a).

[7] Only 7/23 of an FSC's foreign trade income is subject to taxation. Internal Revenue Code § 923(a).

[8] USTR, press release, "U.S. Disappointed with WTO FSC Ruling, Vows to Work With EU to Reach Solution," Feb. 24, 2000, found at Internet address *http://www.ustr.gov,* retrieved June 4, 2000.

[9] USTR, press release, "U.S. Trade Representative Charlene Barshefsky Reacts to European Attacks on U.S. Tax Law."

[10] *United States--Tax Treatment for "Foreign Sales Corporations,"* WTO Doc. WT/DS108/R (Oct. 8, 1999).

[11] *United States--Tax Treatment for "Foreign Sales Corporations,"* WTO Doc. WT/DS108/AB/R (Feb. 24, 2000).

[12] H.R. 4986, 106th Cong. (2000).

FSC Repeal and Extraterritorial Income Exclusion Act of 2000

The FSC Repeal and Extraterritorial Income Exclusion Act of 2000 (FSC Repeal Act) removes from the U.S. tax code those provisions (i.e., the FSC provisions) that the WTO Panel and Appellate Body determined to be an export subsidy program.[13] Essentially, the legislation replaces the FSC program with a rule exempting all extraterritorial income from U.S. taxes. Moreover, unlike under the FSC provisions, the FSC Repeal Act does not require that a firm establish a separate corporate structure.[14]

The FSC Repeal Act provides favorable tax treatment not only to goods manufactured in the United States, but also to goods manufactured by U.S.-owned firms operating overseas.[15] Thus, the United States maintains that the benefit is not contingent, in law or in fact, on exports and therefore cannot be challenged as an export benefit. The United States modeled this system of taxation on several territorial systems used in Europe. In particular, the United States points to the Dutch and French taxation systems, which exclude categories of foreign source income from domestic taxation completely–tax laws which greatly advantage European aerostructures manufacturers.[16] Therefore, any challenge to the FSC Repeal Act could also be made regarding the European systems. Nonetheless, the EU has claimed that the new system does not bring the United States into compliance with WTO rules because it will provide the same benefit to the same firms as the FSC provided.[17] The European Commission (EC) has stated its intention to challenge the FSC Repeal Act at the WTO.

Effects of the FSC Tax Exemption

Even though large civil aircraft (LCA) manufacturers on both sides of the Atlantic produce largely in their domestic markets, the major suppliers to this industry are rapidly adapting to the global economy by forming trans-Atlantic alliances to maximize market efficiencies. To this end, tax programs such as the FSC are viewed as business advantages to any companies that are able to take advantage of them. The aerostructures industry in particular has benefitted from the FSC exemption through the tax advantages offered to foreign sales of LCA. According to EC officials, Boeing has been the single largest beneficiary of the FSC program, receiving $686 million in FSC benefits during 1991-98, representing almost 10 percent of its cumulative net income for those years.[18] According to Boeing's 1999 annual report, its FSC benefits increased from $130 million in 1998 to $230 million in 1999.[19]

Although the FSC Repeal Act intends to bring the United States into compliance with WTO rules, it may provide even greater benefits for U.S. exporting firms than the FSC program.[20] The new

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[13] Ibid.

[14] "The Foreign Sales Corporation Tax Benefit for Exporting and the WTO," Congressional Research Service Report, published by The National Council for Science and the Environment, Oct. 11, 2000, found at Internet address *http://www.cnie.org/Nle/inter-61.html,* retrieved Mar. 10, 2001.

[15] H.R. 4986, 106th Cong. (2000).

[16] "Description of H.R. 4986 of the FSC Repeal and Extraterritorial Income Exclusion Act of 2000," House Committee on Ways and Means, Joint Committee on Taxation, July 27, 2000.

[17] European Commission government officials, interview by USITC staff, Europe, Sept. 2000.

[18] "Foreign Sales Corporation Beneficiaries: A Profile," p. 3.

[19] *Boeing Annual Report 1999*, Table: Federal Income Taxes and Benefits, p. 62.

[20] Adam Entous, "U.S. Leaders Press for Export Tax Overhaul," *Reuters News Service*, Oct. 4, 2000.

legislation is expected to result in a $4.5-billion revenue loss for the United States during 2001-10, largely because all extraterritorial income is tax exempt as opposed to a fraction of such income.[21] Moreover, under the new legislation, firms receiving the benefits will incur significantly less expense because they will no longer need to maintain a separate corporate structure.[22] For companies that had an FSC in place before September 30, 2000, the FSC Repeal Act also allows such firms to continue receiving FSC benefits during a transition period of up to 15 months.[23]

European Tax Benefits

European aerostructures manufacturers and EC officials claim that the countries of the EU do not offer tax exemptions specifically tailored to the aerospace sector.[24] However, the U.S. Government and U.S. manufacturers claim that EU member states offer tax incentives analogous to the FSC, as well as accelerated depreciation for R&D programs.[25] The lack of financial transparency by European companies prevents the calculation of actual tax benefits.

U.S. sources report that France, Germany, and Spain, the headquarter countries of the founding companies of the European Aeronautic, Defense, and Space Co. (EADS)–as well as the Netherlands, EADS's country of incorporation–have extensive tax and nontax incentive programs. For instance, EADS is allowed accelerated depreciation for fixed assets and R&D infrastructure, and France, Spain, and the Netherlands provide credits for research expenditures, deferral of tax for foreign subsidiaries, exemptions from business tax for depressed areas, and tax holidays in enterprise zones.[26]

Canadian Tax Benefits

Canadian industry officials indicate that the scientific research and experimental development (SR&ED) tax credit is one of several competitive advantages for aerospace companies performing research and development (R&D) in Canada.[27] The SR&ED program provides tax incentives for R&D in Canada. This program is intended to encourage businesses, particularly small and start-up firms, to conduct SR&ED that will lead to new, improved, or technologically advanced products or processes. Canada supports industrial research by offering immediate and full write-off of R&D capital and equipment; Federal Investment Tax Credits of 20 percent on most current and capital expenditures; tax credit increases up to 35 percent for small Canadian Controlled Private corporations

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[21] Greg Lubkin, "Extraterritorial Exclusions: Replacing the Foreign Sales Corporation," *Tax Management International Journal*, Nov. 10, 2000, pp. 611-628.

[22] H.R. 4986, 106th Cong. (2000).

[23] Ibid.

[24] European Commission government officials, interview by USITC staff, Europe, Sept. 2000.

[25] Sean D. Murphy, "U.S. Position on Foreign Sales Corporations," *American Journal of International Law*, July 2000; "FSC Replacement Update: Enacting Extraterritorial Exclusions," *Tax Management International Journal*, vol. 30, Jan. 12, 2001, pp. 33-35; and U.S. industry officials, interview by USITC staff, United States, July 2000.

[26] U.S. industry officials, interview by USITC staff, United States, July 2000.

[27] Canadian industry officials, interviews by USITC staff, Canada, Jan. 2001.

on the first C$2 million of qualifying R&D expenditures; and fully refundable tax credits for small businesses.[28]

Competition/Antitrust Enforcement

Competition policies, especially merger control, have important competitive implications for the industry. Rapid consolidation of the aerostructures industry in the United States and Europe, combined with heightened enforcement policies on both sides of the Atlantic, have made industry analysts and observers question how competitiveness and the pace of innovation can be maintained in a global industry with so few players and seemingly insurmountable barriers to entry. The U.S. and EU competition authorities have taken slightly different approaches to these recent developments, each with its own competitive implications.

EU merger law centers more on the prevention of market domination by a leading firm, whereas U.S. regulators concentrate more on prevention of cartel facilitation and on promotion of general market responsiveness to consumer interest. In other words, U.S. merger review law attempts to ensure a market structure that discourages collusion between competitors, whereas EU merger law seeks to prevent the leading firm from abusing its position in the market.[29]

U.S. industry representatives submit that the antitrust laws of the United States are an imperfect vehicle for regulation of the aerospace industry because this industry is characterized by global markets and competition. For instance, even though the 1984 National Cooperative Research Act allows for cooperation in joint research and development projects, the aerospace industry in the United States still experiences antitrust restrictions that potentially inhibit its members from entering into domestic cooperative arrangements to produce and market products resulting from joint development projects.[30] The U.S. aerostructures industry may be negatively 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 and its suppliers. 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.[31]

European manufacturers consider the merger review process to be slightly more business friendly in Europe, given the shorter and more strict statutory time lines for regulators to decide whether to block a merger.[32] The strict time table for decision-making can be a significant benefit in an industry characterized by rapid technological and business changes.[33] These differences, however, do not confer significant advantages to companies on either side of the Atlantic, since such mergers have to be approved by both U.S. and EC regulators.

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[28] Industry Canada, "Industrial Research," found at Internet address *http://strategis.ic.gc.ca/scdt/invest/presentations/infra/sld008.htm*, retrieved Feb. 6, 2001.

[29] European government official, interview by USITC staff, Europe, Sept. 2000; and Debra A. Valentine, "Building a Cooperative Framework for Oversight in Mergers–The Answer to Extraterritorial Issues in Merger Review," *George Mason Law Review*, vol. 6, 1998, pp. 525 and 528.

[30] Valentine, "Building a Cooperative Framework for Oversight in Mergers," pp. 525 and 528.

[31] 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).

[32] European industry official, interview by USITC staff, Europe, Sept.-Oct. 2000.

[33] Ibid.

Historically, differing legal philosophies regarding the purposes of merger control, combined with contrasting economic assumptions about the global marketplace, inevitably resulted in U.S. and EU antitrust authorities profoundly disagreeing on whether to permit a merger. For instance, in the case of the Boeing-McDonnell Douglas merger, the Federal Trade Commission (FTC) perceived a commercial aircraft market with only two significant competitors, and a transaction in which one of these competitors acquired a previously important but declining firm in the same line of business. Any doubts about the benefits of this transaction for the economy as a whole were likely allayed for the FTC by the likelihood of the creation of immense efficiencies in the commercial aircraft and defense industries, and likely prevention of significant losses and layoffs in the acquired company's commercial aircraft division.[34]

The EC, on the other hand, saw a commercial aircraft market that was increasingly characterized by long-term supply relationships with a leading firm that threatened to undermine the ability of its rivals to attract new customers. The EC perceived a transaction that threatened to contribute powerfully to this trend and to provide the leading firm with immense financial resources, new technical skills, and unearned market share.[35] The transaction would significantly increase the dominance of the leading commercial aircraft manufacturer, with undesirable economic and social repercussions for the global market.

European industry observers point out that the U.S. merger control regime, like its European counterpart, is not insulated from political pressure. The FTC is perceived by members of the European industry to be influenced by domestic political interests, because the Commissioners are appointed by the U.S. President and the agency is funded by the U.S. Congress.[36] Moreover, the EC posits that politicization of the U.S. merger control regime tends to be more concentrated and influential in the outcome of certain cases, because the strategic interests of industry are more easily defined than the disparate interests of the 15 EU member states.

U.S. industry sources openly criticized the vulnerability of the EC to political pressure and, in particular, lobbying from member states. Boeing underscored this point by referring to the EC's review of its merger with McDonnell Douglas even after receiving FTC approval in July 1997. Boeing asserted that intense pressure from member states with vested interests in the success of Airbus Industrie and its suppliers resulted in the EC's initial decision to unanimously reject the merger and levy heavy penalties against Boeing and McDonnell Douglas if they continued with the

[34] Eric J. Stock, "Explaining the Differing U.S. and E.U. Positions on the Boeing/McDonnell Douglas Merger: Avoiding Another Near-Miss," *University of Pennsylvania Journal of International Economic Law*, vol. 20, 1999, p. 825.

[35] Ibid.

[36] European government official, interview by USITC staff, Europe, Sept. 2000.

planned structure of the merger. The EC finally approved the merger of the companies after Boeing acceded to major concessions.[37]

Export Activities

Export Promotion

Export programs that affect competitiveness usually involve either high-level political or direct and indirect government supports, tax policies, and export financing (appendix F). Boeing asserts that the EU-member governments provide more consistent, high-level political support for aerospace exporters than the U.S. Government does.[38] European aerostructures companies, on the other hand, claim that the U.S. Government generally promoted the industry abroad and fiercely lobbied on behalf of the U.S. aerospace industry, specifically Boeing, by intervening in contract negotiations.[39]

Boeing asserts that European Governments that own their country's airlines arguably can influence the aircraft purchase decisions of those airlines.[40] U.S. industry sources also state that European Governments often use inducements such as landing rights, routes, regional economic assistance, trade agreements, subcontracting offsets, and low-interest financing assistance to win contracts for Airbus planes. Airbus, on the other hand, argues that major European carriers such as Air France are firmly committed to keeping a balanced fleet of aircraft to maintain competition,[41] and that there are many more large U.S. carriers with exclusive arrangements with Boeing than there are European carriers exclusively flying Airbus aircraft.

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[37] Boeing agreed to a number of conditions designed to prevent its use of Douglas Aviation Corp. (DAC), the civil aircraft division of McDonnell Douglas, to gain preferential access to its customers. Boeing agreed to maintain DAC as a separate legal entity for 10 years. Boeing also agreed not to enforce any of the three exclusive supply agreements that it signed with Delta, American, and Continental Airlines and not to enter into any further exclusive agreements with any purchaser until 2007. Boeing further agreed not to use its supply relationships against Airbus or other aircraft manufacturers and not to exert undue or improper influence on its suppliers to induce them to limit their relationships with alternative manufacturers such as Airbus. Lastly, Boeing entered into a variety of agreements designed to limit the advantages that Boeing would enjoy from government-related funding such as publicly funded R&D for McDonnell Douglas's military projects. Among these agreements, Boeing agreed to license any patents or "know-how" acquired through government funding to Airbus at reasonable rates upon request, and to file reports with the EC about unexpired patents for a period of 10 years. See *Commission Decision IV/M.877, OJ* No. L 336 (July 30, 1997), p. 2, and U.S. industry official, interview by USITC staff, United States, July 2000.

[38] "Peace in Our Time: Boeing v Airbus," *The Economist*, July 26, 1997, p. 59.

[39] EADS and the EC point out that President Clinton personally intervened to win sales for Boeing in Saudi Arabia, China, and Israel. European industry and government officials, interviews by USITC staff, Europe, Sept.-Oct. 2000. See Robert S. Greenberger & Ian Johnson, "U.S.-China Summit Brings Business," *Wall Street Journal*, Oct. 30, 1997; Paul Brustein, "U.S. Pressing Taiwan on Boeing's Behalf," *Washington Post*, Aug. 7, 1999, p. E9; Polly Lane, "Jet Sales Now as Much a Diplomatic Tool as Economic," *Seattle Times*, Jan. 4, 1998, p. F1; and "Peace in Our Time," p. 59.

[40] U.S. industry official, interview by USITC staff, United States, July 2000.

[41] Air France placed an order with Boeing in October 2000 for 10 long range 777s with an option to buy 10 more. According to the *Financial Times*, a spokeswoman for Air France said that "its long-term goal was to have its long-range fleet equally divided between Airbus and Boeing aircraft." "Air France Orders Long Range Boeings," *Financial Times*, Online Edition, Oct. 5, 2000.

Export Controls

Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies

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 the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Technologies (Wassenaar Arrangement),[42] which replaced the Coordinating Committee on Multilateral Export Controls (COCOM),[43] and those of other countries. Without multilateral imposition of export controls, U.S. industry sources claim that sales by U.S. manufacturers that are currently prohibited will go to their European competitors.[44] Aircraft require full-time support, and U.S. manufacturers that supply parts for Airbus and Boeing planes complain that U.S. export control laws prevent the timely shipment of parts, allowing manufacturers in other countries to fill the gap.[45] Moreover, many airline officials have informed Boeing that they cannot get proper support and services for the Boeing aircraft they purchased before certain export controls were put in place.[46]

The U.S. industry indicates that the U.S. system of export control laws and regulations developed for compliance with the Wassenaar Arrangement is so complicated, time consuming, and arcane that it is a major competitive disadvantage in the global market. Exporters claim that the patchwork system involving the U.S. Departments of Defense, Treasury, State, and Commerce often causes major delays in U.S. shipments and has earned the U.S. industry the reputation for being unreliable. The aerostructures manufacturing sector, like any part of the aerospace industry, is characterized by long-term, established supplier relationships in which goodwill between purchaser and supplier evolves slowly and incrementally over decades.[47] However, because certain aircraft components may be delayed by the bureaucratic tangle of the U.S. export control regime,[48] the entire assembly line of a certain type of aircraft may grind to a halt. European industry leaders state that potential U.S. suppliers are often not considered for new programs requiring high-technology products because of the uncertainty surrounding the export licensing process. This is especially true with so-

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[42] The Wassenaar Arrangement was approved by the United States and 33 countries in July 1996; subsequent U.S. regulations were effective January 15, 1998. 63 F.R. 2452-2555 (Jan. 15, 1998).

[43] U.S. industry official, interview by USITC staff, United States, Apr. 2000. COCOM was the result of an informal arrangement among all North Atlantic Treaty Organization (NATO) members. As such, COCOM, now the Wassenaar Arrangement, regulations are not legally binding, and member nations have the right to act independently to strengthen or weaken domestic implementing legislation. The three main functions of the Wassenaar Arrangement are to: (1) establish and maintain a list of embargoed technologies that may not be exported to controlled countries; (2) process requests by member nations to export controlled goods to proscribed nations; and (3) coordinate the export policies and enforcement efforts of its member nations.

[44] U.S. industry official, interview by USITC staff, United States, Apr. 2000.

[45] Ibid.

[46] Ibid.

[47] European industry official, interview by USITC staff, Europe, Sept.-Oct. 2000.

[48] In the United States, the Commodity Control List (CCL) is an important source of export control information, including validated license requirements for, among other things, avionics, materials, propulsion systems, and transportation equipment. Through its system of codes, the CCL specifies those commodities that are restricted from export under the Wassenaar Arrangement regulations, many of which are aircraft components and navigational equipment. For such products, validated licenses are required for export to most countries. 15 C.F.R. § 785.

called “dual-use” technology, that is, technology used in civil as well as military applications.[49] U.S. and European industry representatives agree that the European industry has a significant competitive advantage over its U.S. counterpart when it comes to dual-use technology, because it is able to compete in the United States, Europe, and third markets, whereas the U.S. industry is often limited to its domestic market.[50]

U.S. and European industry representatives also claim that the extraterritorial reach of U.S. export control laws affects trade on both sides of the Atlantic, specifically, U.S. re-export regulations control the movement of products containing components originating in the United States, incorporated into a final product in one foreign country, and then exported to an export-controlled country.[51] Airbus claims that the U.S. export control regime is especially sensitive to propulsion-related technology because it may be used to develop missile technology, meaning that Airbus planes which incorporate General Electric or Pratt & Whitney engines cannot be sold to any export- controlled countries.[52]

International Traffic in Arms Regulation

In the United States, the International Traffic in Arms Regulation (ITAR)[53] applies to temporary and permanent importation of defense articles as well as to exports of defense articles and defense services (and related technical data).[54] Such articles and services appear on the U.S. Munitions List, which is compiled by the U.S. Department of State, with concurrence from the U.S. Department of Defense. Furthermore, ITAR requires registration of all manufacturers and exporters, and export licenses for defense articles and technical data.

Canadian aerostructures producers, in addition to their LCA work, supplied the U.S. defense industry until the Canadian exemption to ITAR was revoked. Canadian industry officials indicate that ITAR had a significant impact on Canadian companies’ ability to do business with U.S. customers. ITAR eliminated significant portions of previous exemptions from export licensing requirements enjoyed by Canadian companies when purchasing a wide range of products and technologies from U.S. sources. Several Canadian companies reported reduced business with U.S. customers because some military and commercial technologies became protected.[55]

Canadian industry officials suggest that the dispute regarding ITAR is an example of protectionist attitudes in the United States, which contributed to Canadian aerostructures producers’ reluctance to rely on the U.S. market.[56] These companies subsequently decreased their reliance on U.S. Government contracts, and increased their commercial aerospace business vis-à-vis their military

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[49] European industry official, interview by USITC staff, Europe, Sept.-Oct. 2000.
[50] Ibid.
[51] The United States maintains export control on a U.S.-made component if it comprises as little as 25 percent of the value of the final product. U.S. industry official, interview by USITC staff, United States, July 2000. However, EADS representatives claim that the U.S. re-export control thresholds are as low as 10 percent of the value of the final product.
[52] European industry official, interview by USITC staff, Europe, Sept.-Oct. 2000.
[53] The ITAR (22 C.F.R. parts 120-130) is promulgated under the authority of the Arms Export Control Act. 22 U.S.C. §§ 2778-2994.
[54] 27 C.F.R. Part 47.
[55] Canadian industry officials, interviews by USITC staff, Canada, Jan. 2001.
[56] Ibid.

business.[57] However, on February 16, 2001, the U.S. Department of State promulgated certain amendments to ITAR, effectively reinstating the Canadian exemptions.[58]

Labor Laws

Airbus and EADS report that restrictive European labor laws put the European industry at a disadvantage because of the significant difficulties associated with increasing and decreasing employment levels in Europe in step with the LCA business cycle.[59] By comparison, U.S. manufacturers, they claim, benefit from having the freedom to enter into, as well as terminate, employment relationships at will. This gives U.S. companies more flexibility to adjust their workforce in an industry characterized by sharp cyclical patterns. Industry representatives state that when the industry is in a cyclical downturn, European manufacturers are burdened with an excessively large workforce, and in times of boom, manufacturers find themselves understaffed.[60]

To address this problem, Airbus has taken important steps toward minimizing the negative impact of excess employment during business downturns by investing heavily in automation, which has resulted in dramatic workforce reductions over the last decade. Automation has provided a spill-over benefit of significantly improving manufacturing efficiency and productivity. In fact, the workforce reductions at Airbus led a WTO review of EU policy in the aerospace sector to conclude that "Airbus' share of the large civil aircraft world market increased from around 30 percent in the early 1990s to 55 percent in 1999, largely as a result of greater productivity," noting that "Boeing has 216 workers for every aircraft, compared with 143 for Airbus**S**a 51-percent productivity difference."[61] Therefore, labor law differences between the United States and the EU may constitute a relatively important competitive difference. Although the U.S. workforce may be more flexible, according to one international study its European counterpart appears to be more productive.[62]

[57] U.S. Department of Defense spending cuts also contributed to the shift from military contracts to commercial aerospace business.

[58] 66 F.R. 10575 (Feb. 16, 2001).

[59] European industry official, interview by USITC staff, Europe, Sept.-Oct. 2000.

[60] European industry official, interview by USITC staff, Europe, Sept.-Oct. 2000.

[61] WTO Review of EU policy, Part E, Trade policy by sector, (iv) Aerospace, par. 60 (2000).

[62] Ibid.

CHAPTER 9
PRINCIPAL FINDINGS

The U.S. aerostructures industry became the world leader through its design and engineering expertise, skilled workforce, and long-term experience in supplying large civil aircraft (LCA) manufacturers Boeing, Lockheed, and McDonnell Douglas. Its competitive position appears to be deteriorating, however, as it confronts the dual challenges of supplying mature programs that typically do not employ or allow for cost-effective investment in state-of-the-art manufacturing processes, and operating under more aggressive contract terms. In addition, U.S. firms are facing increased competition from European and Asian producers and a declining U.S. aeronautical research and development (R&D) infrastructure. Whether the U.S. aerostructures industry can maintain a strong competitive position is directly related to its ability to overcome these challenges.

Boeing has historically been the world's largest supplier of LCA, relying on the U.S. aerostructures industry for nearly all of its assemblies not produced in-house. It is unlikely to significantly alter its dependence on U.S. producers of aerostructures in the short- to medium-term. However, U.S. aerostructures manufacturers face greater foreign competition as Boeing increasingly forms relationships with aerostructures suppliers worldwide, often for the purpose of market access. This is particularly true in Asia. For the most part, U.S. suppliers have not actively sought opportunities abroad or in other closely related product markets, such as supplying aerostructures for regional and general aviation aircraft, relying instead on the prospect of expanding demand for existing Boeing aircraft.

Most U.S. producers also appear to be increasingly disadvantaged vis-à-vis European and Asian producers as risk-sharing elements become more commonplace in contracts with LCA manufacturers. While the practice of shared risk has been a growing part of Asian and European contracts, it had not been used extensively over the last decade in the United States or Canada, where most suppliers are traditionally build-to-print producers. The use of public monies, either through direct support or preferential rates of interest on loans, has diminished the risk that some foreign companies must assume in risk-sharing agreements. While U.S. firms indicate that they can usually meet the challenge of a program's recurring costs, they find it difficult to meet nonrecurring costs, which may be mitigated by government assistance offered in other parts of the world. Moreover, U.S. firms appear to be disadvantaged by increasingly demanding contract terms. Suppliers are being forced into a new role requiring them to assume greater responsibility for supply chain management, and accept renegotiated or altered contract terms. Such challenges appear to be less prevalent in other countries, particularly those in Europe, where LTAs and collaborative relationships are upheld to a greater degree.

U.S. companies must consider how to meet the challenge of acquiring capital for risk-sharing agreements, new technologies, and advanced tooling. Some options U.S. aerostructures suppliers may consider include seeking capital on the open market, consolidation with other companies, or linking with companies in other countries that receive government support. In this respect, U.S. firms have a two-fold advantage in that they appear to be more independent than their foreign counterparts, allowing them to form alliances without the external influence that appears prevalent in foreign industries,[1] and their business operations tend to be more transparent, allowing them to access capital markets more readily.[2] Some U.S. companies have begun to exercise this flexibility; for example, Compass Aerospace and Ducommun are U.S. companies that integrated the assets of several smaller firms to compete more effectively in their changing market. Consolidation and linkups may provide the opportunity for U.S. suppliers to amass capital as well as expand technical skills and their customer base, although international linkups may be hindered by mandated security reviews conducted by the U.S. Departments of State, Defense, and Commerce.

The U.S. industry lags its foreign counterparts, particularly those in Europe, in the implementation of new manufacturing technology. A number of European industry manufacturing sites appear to be modern, highly automated, and capital-intensive, due in part to the fact that Airbus's programs are newer than most of Boeing's programs. As the only economical time to upgrade or add expensive tooling is at the inception of a new program, participation in newer Airbus programs has contributed to the ability of many European aerostructures suppliers to invest in the most current manufacturing equipment and processes that improves their manufacturing and technological skills base. Workforce limitations also encourage European firms to automate and computerize their operations so as to reduce labor inputs in their production operations, resulting in improved productivity and enhanced product quality and standardization. In addition, Europe's coordinated centers of excellence system has promoted production efficiencies via the development of highly specialized production sites for aerostructures manufacture. The U.S. industry does not utilize such an approach.

U.S. firms face additional competitive pressures from emerging manufacturers. Asian firms, for example, benefit from the willingness of LCA producers to use the procurement process to gain access to Asia's large existing and projected market for aircraft. Because of the use of offsets, Asian aerostructures producers are able to secure supply contracts without having to compete in the same manner as their U.S. counterparts. Asian firms also benefit from a corporate structure that supports aerostructures production through other profitable business ventures or government intervention. Sales of aerostructures account for only a small portion of total sales of Japanese and Korean conglomerates, and shortfalls may be offset by the firms' more profitable prime business ventures. Such support allows these firms to remain involved in aerostructures production despite fluctuations in the amount of work contracted or changes in other variables affecting aerostructures manufacturing. In China, government authorities determine which aerostructures firms receive subcontracting work regardless of the distinct capacity or cost of production, with the goal of improving local skills. China is able to support this mode of acquiring skills through both government support and LCA manufacturer offset agreements.

As U.S. firms grapple with challenges on the industry level, the U.S. R&D establishment is also at a competitive crossroads. NASA's relatively flat aeronautics budget, from which aerostructures R&D is funded, allots little for aerostructures programs. In the future, the U.S. industry may not be able to depend on NASA to expand its capabilities if current support levels are

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[1] Unlike in Europe, U.S. law regarding mergers and acquisitions does not include the element of industrial policy.

[2] The transparency of U.S. financial disclosures and accounting methods facilitates a potential investor's financial review of a company more easily than certain foreign companies, which may disclose less and use alternate methods of accounting. To compete in the capital markets, some foreign companies elect to prepare their financial statements in a form comparable to those in the United States, in part to facilitate data comparability for investors.

maintained. This is a concern given the trend of both Boeing and Airbus asking U.S. aerostructures companies to become more involved in the R&D phase of program development. With the exception of two of its wind tunnels, the capabilities of NASA's wind tunnel facilities have generally fallen behind the newer facilities found in Europe and Asia.[3] Asian and European officials have stated that they plan to allocate billions of dollars toward aerospace R&D that supports their domestic industry, and both regions have invested in new wind tunnels, learning from the shortcomings inherent in NASA's 50-year-old designs. Although a growing portion of NASA's research is done in partnership with industry around the world, with industry paying a predetermined portion of the overall cost, this income is not sufficient to significantly improve and address the long-term needs of the facilities.[4] Therefore, should Boeing continue its trend toward increasing R&D responsibilities for its suppliers, U.S. suppliers may find the domestic infrastructure inadequate for their needs and may be unable to utilize offshore facilities economically. U.S. companies would therefore be unable to fulfill the expanded role envisioned by LCA manufacturers and themselves.

Although a number of government laws and policies apply to the global aerostructures industry, competition laws and antitrust enforcement have the most notable effect on competitiveness. The U.S. and EU competition authorities have different approaches toward competition and antitrust enforcement. U.S. merger control law tries to ensure a market structure that discourages collusion between competitors, thus preserving competition, whereas EU merger law seeks to prevent the leading firm from abusing its position in the market. U.S. antitrust laws may sometimes have a negative effect on the competitiveness of the U.S. aerostructures industry, as they limit cooperation between competitors in research activities and inhibit intra-industry interaction and collaboration.

To retain their competitive position in the face of challenges presented by European and Asian firms, U.S. aerostructures producers must work toward adapting the current best-practices in the world, amassing the corporate size to fulfill the added demands of new contracts, and addressing the more intense competition for a shrinking number of LCA programs. Recognizing these challenges, the U.S. industry's ability to respond to evolving industry dynamics will be tested. U.S. firms unable to adjust will unlikely prosper as LCA aerostructures suppliers.

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[3] *A Technical Assessment of Wind Tunnels Considered by Boeing for Airplane Design (formerly Wind Tunnels Preferred by Boeing)*, The Boeing Company, Mar. 10, 1998.

[4] The NASA charging policy for use of its facilities is currently under reform. Commercial customers must now pay the approximate cost of the total direct costs if the data gathered are proprietary to the customer and not able to be shared with NASA as part of a joint research initiative. NASA official, interview by USITC staff, Feb. 2001.

APPENDIX A
REQUEST LETTER

COMMITTEE ON WAYS AND MEANS

U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, DC 20515-6348

March 8, 2000

The Honorable Lynn M. Bragg
Chairman
U.S. International Trade Commission
500 E Street, S.W.
Washington, D.C. 20436

Dear Chairman Bragg:

The Committee on Ways and Means requests the U.S. International Trade Commission to conduct an investigation on the civil aerostructures industry e.g., (fuselage, wings, and their landing gear), in its capacity as a major supplier to the large civil aircraft (LCA) industry, under Section 332(g) of the Tariff Act of 1930. The investigation should focus on the ability of the U.S. civil aerostructures industry and certain of its suppliers to compete over the short and long terms with those industries in Europe, Canada, and to the extent possible, Asia.

As a key participant in LCA manufacturing and a major consumer of a broad range of raw materials and ubassemblies, the global aerostructures industry is an area of considerable interest. The civil aerostructures industry has been affected by the rationalization of the LCA industry into two major players. The impact to the aerostructures industry has been a reduced customer base and increasing emphasis in government R&D funding at the supplier level. The nature of support for such activities is a factor to consider among the various trends affecting the industry and the resulting competitiveness of U.S. manufacturers.

The complexity of this matter and the evolving nature of support at the supplier level warrants closer examination. Elements of the investigation should include: 1) the composition of the industry and recent trends; 2) the process of new aerostructures development; 3) the means and trends in government supports and other financial assistance; and 4) the relative strengths and weaknesses of the aero-structures industries in the United States, Europe, Canada and to the extent possible, Asia.

The Commission is the logical venue for a study to determine the relative strengths and weaknesses of aerostructures industries in the United States, Europe, Canada, and Asia and the complex sources of support in the supplier industry. The commission has conducted two other major aerospacerelated studies in the last six years, and is well known for its objectivity in fact-finding investigations.

The Committee requests that the Commission transmit its report no later than fifteen months following the receipt of this request. It is the Committee's intent to make the Commission's report available to the public in its entirety. Therefore, the report should not contain any confidential business or national security confidential information.

Sincerely,

Bill Archer
Chairman

APPENDIX B
FEDERAL REGISTER NOTICE

Staff Report

The prehearing staff report in the final phase of this investigation will be placed in the nonpublic record on June 16, 2000, and a public version will be issued thereafter, pursuant to section 207.22 of the Commission's rules.

Hearing

The Commission will hold a hearing in connection with the final phase of this investigation beginning at 9:30 a.m. on June 29, 2000, at the U.S. International Trade Commission Building. Requests to appear at the hearing should be filed in writing with the Secretary to the Commission on or before June 23, 2000. A nonparty who has testimony that may aid the Commission's deliberations may request permission to present a short statement at the hearing. All parties and nonparties desiring to appear at the hearing and make oral presentations should attend a prehearing conference to be held at 9:30 a.m. on June 26, 2000, at the U.S. International Trade Commission Building. Oral testimony and written materials to be submitted at the public hearing are governed by sections 201.6(b)(2), 201.13(f), and 207.24 of the Commission's rules. Parties must submit any request to present a portion of their hearing testimony in *camera* no later than 7 days prior to the date of the hearing.

Written Submissions

Each party who is an interested party shall submit a prehearing brief to the Commission. Prehearing briefs must conform with the provisions of section 207.23 of the Commission's rules; the deadline for filing is June 23, 2000. Parties may also file written testimony in connection with their presentation at the hearing, as provided in section 207.24 of the Commission's rules, and posthearing briefs, which must conform with the provisions of section 207.25 of the Commission's rules. The deadline for filing posthearing briefs is July 7, 2000; witness testimony must be filed no later than three days before the hearing. In addition, any person who has not entered an appearance as a party to the investigation may submit a written statement of information pertinent to the subject of the investigation on or before July 7, 2000. On July 25, 2000, the Commission will make available to parties all information on which they have not had an opportunity to comment. Parties may submit final comments on this information on or before July 27, 2000, but such final comments must not contain new factual information and must otherwise comply with section 207.30 of the Commission's rules. All written submissions must conform with the provisions of section 201.8 of the Commission's rules; any submissions that contain BPI must also conform with the requirements of sections 201.6, 207.3, and 207.7 of the Commission's rules. The Commission's rules do not authorize filing of submissions with the Secretary by facsimile or electronic means.

In accordance with sections 201.16(c) and 207.3 of the Commission's rules, each document filed by a party to the investigation must be served on all other parties to the investigation (as identified by either the public or BPI service list), and a certificate of service must be timely filed. The Secretary will not accept a document for filing without a certificate of service.

Authority: This investigation is being conducted under authority of title VII of the Tariff Act of 1930; this notice is published pursuant to section 207.21 of the Commission's rules.

By order of the Commission.

Issued: April 17, 2000.

Donna R. Koehnke,

Secretary.

[FR Doc. 00–10075 Filed 4–21–00; 8:45 am]

BILLING CODE 7020–02–P

INTERNATIONAL TRADE COMMISSION

[Investigation No. 332–414]

Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry

AGENCY: United States International Trade Commission.

ACTION: Institution of investigation and scheduling of public hearing.

EFFECTIVE DATE: April 14, 2000.

SUMMARY: Following receipt of a request on March 13, 2000, from the Committee on Ways and Means of the U.S. House of Representatives, the Commission instituted investigation No. 332–414, Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry, under section 332(g) of the Tariff Act of 1930 (19 U.S.C. 1332(g)).

FOR FURTHER INFORMATION CONTACT: Industry-specific information may be obtained from Mr. Peder Andersen (202–205–3388), Office of Industries, U.S. International Trade Commission, Washington, DC 20436. For information on the legal aspects of this investigation contact Mr. William Gearhart of the Office of the General Counsel (202–205–3091). The media should contact Ms. Margaret O'Laughlin, Office of External Relations (202–205–1819). Hearing impaired individuals are advised that information on this matter can be obtained by contacting the TDD terminal on (202) 205–1810.

Background: As requested by the Committee, the Commission, pursuant to section 332(g) of the Tariff Act of 1930, has instituted an investigation and will prepare a report examining the civil aerostructures industry (e.g., fuselage, wings, and landing gear) in its capacity as a major supplier to the large civil aircraft (LCA) industry. This study will not include nonstructural components such as avionics and engines. The Commission will examine the composition of the industry and recent trends, the process of new aerostructures development, the means and trends in government supports and other financial assistance, and the relative strengths and weaknesses of the aerostructures industries in the United States, Europe, Canada, and to the extent possible, Asia. The report will focus on the ability of the U.S. civil aerostructures industry and certain of its suppliers to compete over the short and long terms with those industries in Europe, Canada, and to the extent possible, Asia.

Public Hearing: A public hearing in connection with the investigation will be held at the United States International Trade Commission Building, 500 E Street SW., Washington, DC, beginning at 9:30 a.m. on December 6, 2000. All persons will have the right to appear, by counsel or in person, to present information and to be heard. Requests to appear at the public hearing should be filed with the Secretary, United States International Trade Commission, 500 E Street SW., Washington, DC 20436, no later than 5:15 p.m., November 22, 2000. Any prehearing briefs (original and 14 copies) should be filed no later than 5:15 p.m., November 22, 2000; the deadline for filing post-hearing briefs or statements is 5:15 p.m., December 20, 2000. In the event that, as of the close of business on November 22, 2000, no witnesses are scheduled to appear at the hearing, the hearing will be canceled. Any person interested in attending the hearing as an observer or non-participant may call the Secretary of the Commission (202–205–1806) after November 22, 2000 to determine whether the hearing will be held.

Written Submissions: In lieu of or in addition to participating in the hearing, interested parties are invited to submit written statements concerning the matters to be addressed by the Commission in its report on this investigation. Commercial or financial information that a submitter desires the Commission to treat as confidential must be submitted on separate sheets of paper, each clearly marked "Confidential Business Information" at the top. All submissions requesting confidential treatment must conform with the requirements of section 201.6 of the Commission's Rules of Practice and Procedure (19 CFR 201.6). All written submissions, except for confidential business information, will be made available in the Office of the Secretary of the Commission for inspection by interested parties. To be assured of consideration by the Commission, written statements relating to the Commission's report should be submitted to the Commission at the earliest practical date and should be received no later than the close of business on December 20, 2000. All submissions should be addressed to the Secretary, United States International Trade Commission, 500 E Street SW., Washington, DC 20436. The Commission's rules do not authorize filing submissions with the Secretary by facsimile or electronic means.

Persons with mobility impairments who will need special assistance in gaining access to the Commission should contact the Office of the Secretary at (202) 205–2000. General information concerning the Commission may also be obtained by accessing its Internet server (http://www.usitc.gov).

By order of the Commission.

Issued: April 17, 2000.

Donna R. Koehnke,

Secretary.

[FR Doc. 00–10073 Filed 4–21–00; 8:45 am]

BILLING CODE 7020–02–P

NATIONAL SCIENCE FOUNDATION

Special Emphasis Panel in Astronomical Sciences: Notice of Meeting

In accordance with the Federal Advisory Committee Act (Pub. L. 92–463, as amended), the National Science Foundation announces the following:

Name: Special Emphasis Panel in Astronomical Sciences (1186).

Date/Time: May 10–11, 2000, 9 a.m.–5 p.m.

Place: National Science Foundation, 4201 Wilson Blvd., Room 130, Arlington, VA 22230.

Type of Meeting: Closed.

Contact Person: James Breckinridge, Program Director, Division of Astronomical Sciences, National Science Foundation, 4201 Wilson Blvd., Arlington, VA 22230. Telephone (703) 306–1820.

Purpose of Meeting: To provide advice and recommendations concerning proposals submitted to NSF for financial support.

Agenda: To review and evaluate proposals for facilities instrumentation submitted to the MRI Program within the Division of Astronomical Sciences.

Reason for Closing: The proposal being reviewed includes information of a proprietary or confidential nature, including technical information; financial data, such as salaries; and personal information concerning individuals associated with the proposals. These matters are exempt under 5 U.S.C. 552b(c), (4) and (6) of the Government in The Sunshine Act.

Dated: April 18, 2000.

Karen J. York,

Committee Management Officer.

[FR Doc. 00–10122 Filed 4–21–00; 8:45 am]

BILLING CODE 7555–01–M

NATIONAL SCIENCE FOUNDATION

Special Emphasis Panel in Civil and Mechanical Systems; Notice of Meeting

In accordance with the Federal Advisory Committee Act (Pub. L. 92–463, as amended), the National Science Foundation announces the following meeting:

Name: Special Emphasis Panel in Civil and Mechanical Systems (1205).

Date and Time: 12, 19, 20 and 21, June, 2000, 8 a.m. to 5 p.m.

Place: NSF, 4201 Wilson Boulevard, Rooms 360, 365, 330 and 380, Arlington, Virginia 22230.

Type of Meeting: Closed.

Contact Person: Drs. Ken P. Chong and Jorn Larsen-Basse, Program Directors Mechanics and Structures of Materials and Surface Engineering and Material Design, Division of Civil and Mechanical Systems, Room 545, (703) 306–1361.

Purpose of Meeting: To provide advice and recommendations concerning proposals submitted to NSF for financial support.

Agenda: To review and evaluate nominations for the FY'00 Mechanics and Structures of Materials and Surface Engineering and Material Design Review Panel proposals as part of the selection process for awards.

Reason for Closing: The proposals being reviewed include information of a proprietary or confidential nature, including technical information; financial data, such as salaries and personal information concerning individuals associated with the proposals. These matters are exempt under 5 U.S.C. 552b(c), (4) and (6) of the Government in the Sunshine Act.

Dated: April 19, 2000.

Karen J. York,

Committee Management Officer.

[FR Doc. 00–10124 Filed 4–21–00; 8:45 am]

BILLING CODE 7555–01–M

NATIONAL SCIENCE FOUNDATION

Special Emphasis Panel in Engineering Education and Centers; Notice of Meeting

In accordance with the Federal Advisory Committee Act (Pub. L. 92–463, as amended), the National Science Foundation announces the following meeting:

Name: Special Emphasis Panel in Engineering Education and Centers (173).

Date/Time: May 31–June 2, 2000, 8:30 a.m.–5:30 p.m.

Place: National Science Foundation, Rooms 360 & 380, 4201 Wilson Boulevard, Arlington, VA 22230.

Type of Meeting: Closed.

Contact Persons: Dr. Cheryl Cathey, Program Director, Engineering Education and Centers Division, National Science Foundation, Room 585, 4201 Wilson Blvd., Arlington, VA 22230. (703) 306–1380.

Purpose of Meeting: To provide advice and recommendations concerning proposals submitted to NSF for financial support.

Agenda: To review and evaluate proposals submitted to the Nanoscale Modeling and Simulation Program (Small Group Initiative) as part of the selection process for awards.

Reason for Closing: The proposals being reviewed include information of a proprietary or confidential nature, including technical information; financial data, such as salaries; and personal information concerning individuals associated with the proposals. These matters are exempt under 5 U.S.C. 552b(c), (4) and (6) of the Government in the Sunshine Act.

Dated: April 13, 2000.

Karen J. York,

Committee Management Officer.

[FR Doc. 00–10117 Filed 4–21–00; 8:45 am]

BILLING CODE 7555–01–M

NATIONAL SCIENCE FOUNDATION

Special Emphasis Panel in Human Resource Development; Notice of Meeting

In accordance with the Federal Advisory Committee Act (Pub. L. 92–463, as amended), the National Science Foundation announces the following meeting:

Name: Special Emphasis Panel in Human Resource Development (1199).

Date and Time: April 28, 2000, 8 a.m.–3:30 p.m.

Place: Room 330, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230.

Type of Meeting: Closed.

Contact Person: Dr. Victor A. Santiago, Program Director, Human Rsource Development Division, Room 815, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230. (703) 206–1633.

APPENDIX C
DEFINITION OF AEROSTRUCTURES

AEROSTRUCTURES

For the purposes of this investigation, aerostructures are structural assemblies that primarily house passengers, crew, and cargo of a large civil aircraft, dictate the aircraft attitude, and support the aircraft on the ground. Aerostructures are limited to the following 27 items:

Fuselages and components:
1. Completed fuselages
2. Barrel sections
3. Body panels
4. Frames and stringers
5. Cockpit structures
6. Keel beams

Tails and components:
7. Completed tails/empennages
8. Tailplanes
9. Tail panels
10. Fins
11. Rudders
12. Elevators/horizontal stabilizers

Wings and components:
13. Completed wings
14. Wing skins
15. Wing boxes
16. Wing-to-body fairings
17. Ailerons
18. Flaps
19. Flap hinge fairings
20. Flap support fairings
21. Flap track fairings
22. Leading and trailing edges
23. Wing tips
24. Winglets
25. Spoilers/speed brakes
26. Completed wing sections (wing sections with skins minus the aforementioned components)

Landing gear:
27. Completed landing gear assemblies

APPENDIX D
REGIONAL COMPARISON OF ACCOUNTING METHODS

REGIONAL COMPARISON OF ACCOUNTING METHODS

Accounting methods vary by country, are complex, and sometimes make direct comparisons difficult. While national accounting methods may not have been adopted with the broader intention of conferring a country or regional advantage, in effect they may do so. This appendix offers a discussion of how accounting methods might offer a competitive advantage for companies utilizing the methods generally employed in their own country.

United States[1]

Companies in the United States prepare their financial statements in accordance with generally accepted accounting principles (GAAP), which may differ from the financial statements prepared by foreign companies in accordance with their respective countries' accounting standards.[2]

Firms in the United States disclose items such as sales, profits, assets, and research and development (R&D) by line of business (e.g., military and commercial). By comparison, certain European firms may disclose only sales by line of business. As a result, U.S. companies may be at a competitive disadvantage, as viewed by their competitors, because less information on the competing companies is available. For example, some U.S. companies have expressed concern that segment disclosures may be sensitive or that information disclosed about a segment could affect contract negotiations with a customer, vendor, or employee union.[3] One U.S. aerostructures industry representative stated that "segmental information gives our competitors insights into our cost structure that could give them an advantage in the bidding process."[4]

Companies in the United States are required to expense R&D as incurred, thereby reducing earnings. This differs from several European firms, which may record R&D as an asset and amortize the balance against earnings over a period of years or record only the development cost as an asset.

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[1] Reference sources used for this section include Lee H. Radebaugh and Sidney J. Gray, *International Accounting and Multinational Enterprises*, 4th ed. (New York: John Wiley & Sons, Inc., 1997); Allen B. Afterman, *International Accounting, Financial Reporting, and Analysis: A U.S. Perspective* (New York: Warren, Gorham & Lamont, 2000); and annual reports of individual companies. Several differences in accounting methods and their effects on competition are discussed. Every effort was made to obtain the latest accounting methods by country in an ever changing accounting environment.

[2] One U.S. aerostructures industry representative stated that production efficiencies would be more likely to give a company a competitive advantage than differences in accounting methods. U.S. industry official, facsimile communication to USITC staff, Feb. 21, 2001. Another U.S. aerostructures industry representative stated that differences in accounting methods should have a limited effect on competition; they compete on a cost basis. U.S. industry official, facsimile communication to USITC staff, Feb. 27, 2001.

[3] Kenneth R. Bunce, "It's Time to Implement Segment Disclosures," *Journal of Accountancy*, Jan. 1999, p. 44. Furthermore, nonpublic and foreign enterprises, which are not required to provide segment disclosures, may gain a competitive advantage over U.S. public companies.

[4] U.S. industry official, facsimile communication to USITC staff, Feb. 21, 2001.

As a result, U.S. companies may be at a competitive disadvantage[5] as viewed by customers and investors because, all else being equal, their profits would be lower than the companies permitted to amortize all or a portion of R&D over a number of years.

When a firm in the United States buys another firm for a value in excess of its net asset value, the excess paid is referred to as goodwill. Goodwill is recorded as an asset and amortized against earnings over a number of years. This may put a U.S. firm at a disadvantage in international takeover bids when competing against other global firms who may charge the goodwill against the equity of the company, thereby avoiding a reduction in earnings.

Non-U.S. corporations listing securities on the exchanges under the jurisdiction of the U.S. Securities and Exchange Commission (SEC) are required to file a registration statement and annual report with the SEC. The reports must include financial statements prepared in accordance with U.S. GAAP, or companies may submit their financial statements prepared in accordance with some other basis of accounting (along with a reconciliation detailing the differences) to arrive at net income according to GAAP in the United States.[6] This reporting requirement would tend to minimize any competitive advantage or disadvantage due to differences in accounting standards between these specific European and U.S. companies.

Privately held aerostructures companies in the United States may have a significant competitive advantage over publicly held aerostructures companies in Europe, Canada, and the United States. The value of sales, profits, assets, debt, R&D, and other items of privately held companies are not available to competitors, whereas all or some of those disclosures would be available for publicly held companies.

Europe[7]

Firms in Europe may follow the accounting standards of their specific country or may use U.S. GAAP. Public companies in Europe plan to conform to international accounting standards promulgated by the International Accounting Standards Committee (IASC) by 2005. However, at present, there are still differences between the IASC standards and U.S. GAAP, which may still give a competitive advantage or disadvantage to specific companies. A recent survey of more than 700 companies in the 15 European Union countries and Switzerland found that businesses support the proposal to conform to International Accounting Standards (IAS) in order to have clarity and comparability in financial reporting under a single high quality international financial reporting

[5] One U.S. aerostructures industry representative indicated that there are enough disclosures in the footnotes to the financial statements of the other countries' firms that the method of accounting for R&D is not a disadvantage to a U.S. firm. U.S. industry official, telephone interview by USITC staff, June 21, 2000.

[6] Instructions for SEC form 20-F, found at Internet address *http://www.sec.gov/smbus/forms/20f.htm*, retrieved Oct. 19, 2000.

[7] Reference sources used for this section include Radebaugh and Gray, *International Accounting and Multinational Enterprises*, 4th ed.; Afterman, *International Accounting, Financial Reporting, and Analysis: A U.S. Perspective*; and annual reports of individual companies. Several differences in accounting methods and their effects on competition are discussed. Every effort was made to obtain the latest accounting methods by country in an ever changing accounting environment.

framework.[8] The companies suggest that the strategic advantages of moving to an international framework is more important than the finer points of the accounting framework itself. Other cited advantages of standard reporting for international accounting include improved marketability, facilitation of cross-border mergers and acquisitions, greater shareholder dialogue, and improved access to capital. Moreover, the high levels of reporting on the Internet make the need for global standards increasingly urgent. There is significant support across Europe for adopting IAS as the sole standard, or for having IAS as an alternative to national GAAP. A sizeable minority of companies would prefer the option to continue using U.S. GAAP. Investors want information that is comparable globally.

Firms in Belgium, France, the Netherlands, and Spain disclose sales by line of business while companies in Germany, Italy, and the United Kingdom, along with the United States, disclose profits and assets in addition to sales by line of business. As noted, this may give companies in countries that disclose less information a competitive advantage because they have access to more of their competitors' data.

Firms in Belgium, France,[9] Italy, the Netherlands, and Spain may record R&D expenditures as an asset and amortize the balance against earnings over a period of years. The United Kingdom and Italy may elect to record only development costs as an asset. Germany requires that R&D expenditures be expensed, therefore reducing earnings in the year incurred, and does not allow R&D to be recorded as an asset. All else being equal, a company that records R&D as an asset would have a higher net income than a company that is required to expense all R&D, which may be considered a competitive advantage to the more profitable company as viewed by customers and investors.

When a firm in Germany, Italy, and the Netherlands buys another firm and pays more than the value of the net assets of that firm and records goodwill, the goodwill may immediately be written-off against equity. Therefore, goodwill is not deducted from earnings. This may give the companies a competitive advantage in international takeover bids against firms in Belgium, France, Spain, Canada, the United Kingdom, and the United States, which are required to record goodwill as an asset and amortize it against earnings over a period of years.

The partners in Airbus, EADS and BAE, are expected to adopt different accounting treatment for launch aid, on the basis of existing standards. EADS is adopting IAS in most regards, with the exception that all development costs will be expensed as incurred (IAS allows capitalization). BAE offsets R&D against launch aid when it is provided. Launch aid is recorded under liabilities in the balance sheet and does not have an impact on earnings.[10] Using the accounting methods explained,

[8] New IAS Research, PriceWaterhouseCoopers, found at Internet address *http://www.pwcglobal.com/extweb/co...d*, retrieved Feb. 14, 2001.

[9] One aerostructures industry representative stated that, in France, the amount of R&D may not be disclosed. Response to USITC producer questionnaire in connection with Inv. No. 332-414, *Competitive Assessment of the Large Civil Aircraft Aerostructures Industry*. Commission staff reviewed one annual report from a French company that described the accounting method used for R&D but did not disclose the amount. Competing companies may be at a disadvantage because of the unavailability of the amount of R&D incurred. One Canadian aerostructures industry representative stated that a public company wants to show as much R&D as possible as shareholders and market analysts view these expenditures as having future benefits outside the scope of regular operations. Response to USITC producer questionnaire in connection with Inv. No. 332-414, *Competitive Assessment of the Large Civil Aircraft Aerostructures Industry*. From this viewpoint, the company disclosing its R&D would have a competitive advantage over a firm that does not disclose its R&D.

[10] *The Pilot*, Merrill Lynch, June 28, 2000.

BAE may have a competitive advantage because BAE would record higher earnings when compared to EADS and U.S. companies.

Canada[11]

Companies in Canada follow the accounting standards generally accepted in Canada, which are similar in many respects to the accounting methods used in the United States. For example, like U.S. companies, firms in Canada disclose sales, profits, and assets by line of business. As discussed, this may put Canadian companies at a disadvantage against firms in Belgium, France, the Netherlands, and Spain, which disclose sales by line of business but not profits and assets.

Canadian companies may capitalize the development portion of R&D. This may put Canadian firms at a disadvantage against companies that are allowed to capitalize and amortize R&D against earnings over a period of years; such firms have higher earnings and may have a competitive advantage as viewed by customers and investors. At the same time, firms in Canada or in countries that may capitalize all or a portion of R&D expenses may have a competitive advantage over U.S. and German firms, which must expense all R&D incurred. According to industry sources, however, the advantage of amortizing over the life of the contract/program is only short-term, and that in the long-term all will be equal.[12]

Canadian companies, as with firms in Belgium, France, Spain, the United Kingdom, and the United States, record goodwill as an asset and amortize its value against earnings over a number of years. The companies that record goodwill as an asset may be at a competitive disadvantage in international takeover bids against firms in Germany, Italy, and the Netherlands, which may record goodwill as a reduction of equity, thereby bypassing earnings.

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[11] Reference sources used for this section include Radebaugh and Gray, *International Accounting and Multinational Enterprises,* 4th ed.; Afterman, *International Accounting, Financial Reporting, and Analysis: A U.S. Perspective*; and annual reports of individual companies. Several differences in accounting methods and their effects on competition are discussed. Every effort was made to obtain the latest accounting methods by country in an ever changing accounting environment.

[12] Response to USITC producer questionnaire in connection with inv. No. 332-414, *Competitive Assessment of the Large Civil Aircraft Aerostructures Industry*.

APPENDIX E
EUROPEAN AERONAUTIC, DEFENSE, AND SPACE COMPANY (EADS) FORMATION

EUROPEAN AERONAUTIC, DEFENSE, AND SPACE COMPANY (EADS) FORMATION

EADS, the world's third-largest aerospace company,[1] was formed on July 10, 2000 from the activities of Aérospatiale Matra Airbus, DASA, and CASA, three of the Airbus partners.[2] EADS is incorporated in the Netherlands, where favorable taxation and labor regulations[3] exist, and has two chief executive officers (CEOs) headquartered in Paris and Munich. The formation of EADS brings together for the first time many of the critical European civil and military aerospace and other defense operations of these three firms under one management, providing the opportunity for long-term synergies and corporate planning. This merger may represent a European commitment to a more market-oriented outlook rather than the more prevalent state involvement in critical industries, and reflects recognition of the need to overcome national boundaries to reap the manufacturing and marketing advantages offered by larger, multinational corporations.

EADS partners anticipate greater operational efficiency, flexibility, and profitability—keys to shareholder value—to arise from the benefits of economies of scale, elimination of duplication, streamlining of corporate organization and industrial processes, and pooling of assets and purchasing power.[4] As a result, EADS expects to gain cost savings of approximately $450-475 million annually by 2004, at least one-half of which will be derived from the efficiencies gained as a result of the Airbus

[1] EADS is the world's second-largest commercial aircraft producer, with an 80-percent share of Airbus; the second-largest manufacturer of helicopters, with wholly-owned Eurocopter; the third-largest producer of military transport aircraft; and a world leader in commercial launcher systems, satellites, military aircraft, and defense technology. EADS reported pro forma revenues of €24.2 billion ($22.7 billion) for 2000, a 7-percent increase from 1999 pro forma revenues of €22.6 billion ($21.2 billion).

[2] After EADS's global offering, 30 percent of its shares are held by Ste. de Gestion de l'Aeronautique de la Defense et de l'Espace (SOGEADE), a French partnership held equally by SOGEPA for the French Government and Desirade (74 percent of which is held by Lagardère and 26 percent held by French financial institutions). DASA AG, an indirect subsidiary of DaimlerChrysler, also owns 30 percent of EADS. Thus, 60 percent of EADS shares are held equally by SOGEADE and DaimlerChrysler, who jointly control EADS through a Dutch law contractual partnership. SEPI holds another 5.48 percent of EADS for the Spanish Government. The public will directly hold 30.65 percent of EADS, and DaimlerChrysler and the French State will directly hold 2.73 percent and 1.14 percent, respectively, of these shares. "Western European Industry Ownership Jigsaw," *Defense Systems Daily,* Apr. 3, 2001, found at Internet address *http://defence-data.com/current/pagerip1.htm,* retrieved Apr. 12, 2001.

[3] With its incorporation in the Netherlands, EADS will pay taxes for only 20 percent of its earnings under certain circumstances. The remaining 80 percent of its earnings would be subject to a 10-percent tax rate. In addition, holding companies such as EADS are not subject to corporation income tax on its capital yield and dividends. Norbert Burgner, "EADS: Will It Succeed?" Dec. 1999, found at Internet address *http://www.flug-revue.rotor.com/FRHeft/FRH9912/FR9912b.htm,* retrieved Mar. 15, 2000. EADS and its relevant labor unions formed a European Workers Council under Dutch law that promotes "cross-border understanding and mutual cooperation." Pierre Sparaco, "EADS Completes Europe's Long-Awaited Restructuring," *Aviation Week & Space Technology*, July 24, 2000, p. 109.

[4] EADS will likely revamp its procurement process, which handles €15 billion in purchases annually. Roughly 70 percent of these purchases are made with the same suppliers, but most of these purchases are covered by contracts negotiated separately by the three partners that formed EADS. Jens Flottau, "EADS Integration Team Targets Suppliers," *Aviation Week & Space Technology*, Dec. 4, 2000, p. 45.

reorganization.[5] EADS intends to reach a balanced mix of civil and military operations by acquiring or partnering with international defense businesses and divesting businesses that do not fit the target portfolio, as well as diversifying its customer base, with a particular focus on the U.S. market.[6] With this strategy, EADS will gain added political weight and the critical mass and product diversity to better compete with Boeing and other competitors. As a publicly traded company, EADS will also have access to capital markets to provide funding for its aerospace projects.

Although significant advantages are anticipated with the formation of EADS, several challenges remain. As a publicly traded company, EADS is subject to both market forces and shareholder influence, which could redirect focus from long-term corporate interests to more short-term, profit-oriented motives. However, the French[7] and Spanish State holdings in EADS raise questions about the firm's ability to best respond to market forces and make sound business decisions in the interest of the company. The government holdings may also hinder Pentagon approval of potential alliances with U.S. defense firms and thus impact EADS's ability to access the U.S. defense market and balance its business mix.[8] Moreover, three different corporate cultures must be integrated and politically sensitive merger decisions resolved. The dual management organization already hints at unresolved internal differences and could subject the company to an unnecessarily cumbersome reporting structure that could hamper swift response to competitors and slow the integration of the merged assets. However, these companies have demonstrated an ability to work together over the years despite their differences, and any difficulties that arise will likely be resolved over time.

EADS has actively pursued linkages with other European aerospace firms to further consolidate the European industry and expand its market and product reach. Alenia, Italy's leading aerostructures manufacturer, agreed in April 2000 to form a 50-50 joint venture with EADS, referred to as the European Military Aircraft Company (EMAC).[9] As part of the deal, Alenia was offered a 5-percent shareholder position in the newly-formed Airbus Company (valid for a 3-year period), and participation of no more than 10 percent in the A380 program.[10]

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[5] Sparaco, "EADS Completes Europe's Long-Awaited Restructuring." p. 109.

[6] "EADS Faces Serious Cutbacks and Change," Aerotech News and Review, Dec. 29, 2000, found at Internet address *http://aerotechnews.com,* retrieved Jan. 2, 2001; and untitled article found at Internet address *http://www.flug-revue.rotor.com/FRweek1.htm,* retrieved Jan. 2, 2001.

[7] The Government of France agreed to certain limitations on its ownership rights, including only limited input on major acquisitions and business strategy and no veto power over plant closures and employment cutbacks. DaimlerChrysler has reserved the right to sell its entire share to Lagardère if major policy disputes with the French Government arise. John Rossant, "Birth of a Giant," *Business Week*, July 10, 2000, p. 171.

[8] EADS is heavily reliant on Airbus sales, which accounted for 61 percent of revenues in 2000.

[9] EMAC will encompass the military and civil activities of Alenia Aeronautica, the combat aircraft operations of DASA and CASA, and DASA's military aircraft aerostructures facilities. Martial Tardy, "Alenia Links with EADS, Spurns BAE, in 50-50 Venture," Apr. 14, 2000, found at Internet address *http://www.aviationnow.com,* retrieved Apr. 17, 2000.

[10] "Joint Press Release: Head of Agreement with EADS," press release, Apr. 14, 2000, found at Internet address *http://www.finmeccanica.net/eng/news/14apr2000.htm*, retrieved Aug. 22, 2000.

BAE Systems is notably absent from the EADS group[11] and appears to be positioning itself as an independent defense-related aerospace concern bridging both the United States and Europe. BAE Systems has emerged as the world's second-largest defense contractor and third-largest aerospace electronics firm with the continued expansion of its defense and electronics portfolio, most notably with its acquisitions of Lockheed Martin's Control Systems and Aerospace Electronics Systems businesses in 2000. BAE Systems has also indicated interest in increasing its aerostructures work for Boeing, citing excess capacity at some of its U.S. facilities and lower U.S. labor rates.[12]

Although the two European aerospace giants would at first appear to be rivals, their current product portfolios and geographic markets are strikingly different. BAE Systems is primarily a systems integrator, with the majority of its business in the defense arena. Conversely, EADS's current business is centered on the commercial aircraft sector, with emphasis on airframing and aerostructures manufacturing. BAE Systems's sales are also more globally spread than those of EADS, with 32 percent coming from Europe compared to 50 percent for EADS. European industry sources indicate that the co-existence of these two companies will likely keep them competitive.[13]

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[11] BAE Systems views the shareholding and management structures of EADS as inherent weaknesses that contributed to its decision to not participate in the venture. "Inside Track: Pilot Through Turbulent Times: Profile Richard Evans, BAE Systems: After 30 Years in an Industry Convulsed by Change, the Chairman is Focused on Global Ambitions," *Financial Times*, July 31, 2000, found at Internet address *http://today.newscast.com*, retrieved Aug. 1, 2000. BAE Systems also prefers to manage fully its businesses, which hinders joint-venture development. Graham Warwick, "BAE Tests US Resolve," *Flight International*, July 25-31, 2000, p. 48.

[12] John D. Morrocco, "BAE Systems Focuses on U.S. Connection," *Aviation Week & Space Technology*, July 24, 2000, p. 114.

[13] European industry association officials, interview by USITC staff, Europe, Sept.-Oct. 2000.

APPENDIX F
EXPORT PROMOTION PROGRAMS

EXPORT PROMOTION PROGRAMS

U.S. Export-Import Bank

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.[1] The purpose of the Eximbank is to "facilitate export financing of U.S. goods and services by neutralizing the effect of export credit subsidies from other governments and by absorbing reasonable credit risks that are beyond the current reach of the private sector."[2] However, compared to its counterparts in other industrialized nations, Eximbank suffers from structural weaknesses that directly affect U.S. competitiveness in the global economy. This is particularly true in the aerospace industry where new European initiatives such as market windows and untied aid have given European companies a significant competitive edge over their U.S. competitors.[3] A recent paper assessing Eximbank's ability to provide genuine value to U.S. exporters concluded that:

> Ex-Im Bank has changed and innovated over the years. However, it has not done so at a rate of change that enables it to remain competitive. The combination of administrative burden, legislative requirements, the residue of threats to its existence in recent Congressional efforts to end "corporate welfare," and bureaucratic inertia have all combined to weaken the ability of Ex-Im Bank to stay current with the needs of the exporting community. The result is a long list of policies, procedures and requirements that no other export credit agency imposes on its customers.[4]

Boeing and other U.S. aerostructures companies echo these conclusions about Eximbank's long-term viability.[5] The following are the most important impediments to effective operation of Eximbank, according to members of the U.S. industry and trade analysts:

- Eximbank financed exports are required to be shipped on U.S. flag vessels. Given the small size of the U.S. fleet, most transactions require complicated waivers from the Maritime Administration to use foreign flag vessels. According to the U.S. Trade Deficit Review Commission, "U.S. exporters have reported sourcing from foreign factories (using foreign export financing assistance) to avoid the added cost and inconvenience of U.S. flag shipping."[6]

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[1] Remarks of Chairman Jim Harmon, 65th Anniversary of the U.S. Export-Import Bank, Washington, DC, May 15, 2000.

[2] The Eximbank was chartered by the Congress with the Export-Import Bank Act of 1945. 12 U.S.C. § 635 (1988). However, the Eximbank was originally organized in 1934 under Exec. Order No. 6581, Feb. 2, 1934, as a District of Columbia banking corporation. Through a series of Acts of Congress it was continued until the passage of the Export-Import Bank Act of 1945.

[3] Remarks of Chairman Jim Harmon.

[4] Statement of Allan I. Mendelowitz, Director, Trade, Energy and Finance Issues, National Security and International Affairs Division, General Accounting Office--U.S. Trade Deficit Review Commission, "Responding to the New Competitive World of Government Supported International Transactions."

[5] U.S. industry official, interview by USITC staff, United States, July 2000.

[6] Statement of Allan I. Mendelowitz, p. 7.

- Eximbank will finance only the U.S. content embodied in U.S. exports. This is a core policy requirement that is more stringent than the domestic content requirements imposed by other export credit agencies. As such, because a maximum percentage of a transaction that Eximbank may finance is 85 percent, it permits up to 15 percent of a financed export to consist of foreign content without affecting the amount of Eximbank financing that is available. However, every individual contract line item of a large project is analyzed as to its content to insure that the 85 percent requirement is met. Higher U.S. content in one line item for a specific project cannot offset lower U.S. content in another line item. "In other words, not only must the entire transaction be 85 percent U.S. content to qualify for the maximum available financing, each separate line item must also meet the same requirement."[7]

Boeing asserts that European export credit agencies are able to support exports of aerostructures and civil aircraft with a greater degree of flexibility than Eximbank.[8] In part, this reflects the fundamental difference between the role of European export credit agencies and Eximbank.[9] European agencies are not viewed as lenders of last resort, and consequently, applicants do not have to prove that there is no alternative source of funding to qualify for financing. In addition, European agencies do not require that exports be carried on a national flag carrier, and the required level of domestic content in a financed export may be significantly lower than that required in an Eximbank financed export.

Market Windows

Although market windows do not exist in the United States, they are most akin to the quasi-governmental financial institution, Fannie-Mae. One of the most successful market windows in the world, and the one most pertinent to the aerospace industry, is the German Kreditanstalt fur Weideraufbau (KfW). KfW is a powerful player in the world trade finance market because of its successful operating culture and considerable government support and benefits. Like Fannie-Mae, KfW does not receive an annual government appropriation, and its business is making money. Although it does not receive an annual appropriation, KfW does receive significant benefits from the German Government. For example:

- KfW's initial capitalization of DM1 billion came from the federal German government (80 percent) and from the German state governments (20 percent).

- KfW borrows with the full faith and credit of the German Government. Therefore, its cost of funds is lower than that of any private financial institution. This benefit lowers the cost of borrowed funds to a rate that is close to the German federal government's borrowing cost. Access to liquidity and the interest rate paid on its borrowings will be the same irrespective of the risk in its portfolio or the level of accounting profit. In theory, KfW could be insolvent and still be able to borrow at the same rate.

[7] Ibid., p. 9.
[8] U.S. industry official, interview by USITC staff, United States, Apr. 2000.
[9] Ibid.

- KfW does not pay dividends to its shareholders, which is forbidden by German law. It can only retain its profits, accumulate them, and lend them out. Hence, the annual accumulation of retained earnings is the equivalent of an annual infusion of public support for KfW.[10]

- German law exempts KfW from paying any taxes. This tax-free status provides the equivalent of an annual tax expenditure subsidy to KfW.

- KfW has a lower and more flexible German-content requirement to export financing than do other export credit agencies, especially Eximbank. This makes it particularly adept at financing projects in the global aerospace industry. For example, KfW participated in the financing of sales of the Boeing 717 aircraft to Air Tran, something Eximbank could not do because of its strict U.S. content requirements. KfW participated in the transaction because BMW/Rolls-Royce engines powered the aircraft in question.

Governments that offer market window financing claim they do not have to abide by the terms of the Organization for Economic Cooperation and Development Agreement, because they are not subsidizing deals explicitly or rigidly tying them to exports. U.S. companies, such as Boeing, that rarely can take advantage of KfW financing because most of their manufacturing operations are in the United States, complain that market windows confer a significant competitive advantage to their competitors and that Eximbank is woefully unprepared to compete with the flexible, market-oriented, user-friendly market windows like KfW.

Canadian Commercial Corporation and Technology Partnership Canada

U.S. aerostructures manufacturers claim that the Canadian Commercial Corporation (CCC) provides a competitive advantage to Canadian companies by guaranteeing the performance of Canadian companies.[11] The CCC promotes export growth for Canadian companies in a variety of sectors through government-backed contract performance guarantees. CCC uses its governmental status to sign sales contracts on behalf of Canadian exporters, thus providing buyers with a guarantee with respect to price, quality, and terms.[12] In effect, the CCC signs contracts on behalf of exporters, thus accepting responsibility for the contract. In addition, the CCC assists Canadian exporters with a range of export sales and contracting services, which enhance access to market opportunities and promotes export sales on improved terms.[13] Eighty percent of CCC exporters in 1999-2000 were small- and medium-sized companies.

[10] In 1999, net income was DM528 million, which represented an infusion of DM528 million from public funds. From its creation in 1948 through 1999, KfW has accumulated DM10.6 billion in capital, reserves, and retained earnings. Consequently, KfW has available for its financings DM10.6 billion on which it pays no interest or dividends. The cost of capital is essentially zero. Statement of Allan I. Mendelowitz.

[11] Response to USITC producer questionnaire in connection with inv. No. 332-414, *Competitive Assessment of the U.S. Large Civil Aircraft Aerostructures Industry*.

[12] Canadian Commercial Corporation, *Annual Report 1999-2000*, p. 4.

[13] Canadian Commercial Corporation, "Home Page," found at Internet address *http://www.ccc.ca*, retrieved Feb. 8, 2001.

Although not originally intended as an export promotion program, Technology Partnership Canada (TPC)[14] was found to violate WTO rules on export promotion.[15] A WTO Dispute Settlement Body decided in 1999 that Canada's TPC investment program was a prohibited subsidy and recommended that Canada withdraw the subsidy within 90 days. Canada complied and withdrew approvals-in-principle for two new TPC projects, closed all TPC files in the aircraft sector, and restructured the TPC program to eliminate subsidies that appeared dependent on export performance.[16]

[14] The TPC replaced the Defence Industry Productivity Program (DIPP) which had provided conditionally repayable funding for product development. The Canadian government withdrew further funding for new initiatives under DIPP in 1995 pending a review of government R&D support. DIPP was discontinued in 1996.

[15] The PRO EX program of Brazil was also found to be in violation of WTO rules on export promotion.

[16] "Brazil Fails to Withdraw Aircraft Subsidies, Says WTO Panel," *Aviation Week's Aviation Now*, July 24, 2000, found at Internet address *http://aviationnow.com*, retrieved July 25, 2000, pp. 1-2.

APPENDIX G
FOREIGN CORRUPT PRACTICES ACT

FOREIGN CORRUPT PRACTICES ACT

In a survey of aerospace companies, respondents reported that the Foreign Corrupt Practices Act of 1977 (FCPA) has adversely affected the overseas business of the U.S. aircraft industry.[1] Additionally, of the companies surveyed, over 60 percent responded that, assuming all other conditions were similar, U.S. companies could not successfully compete with foreign companies that were engaged in bribery.[2]

In the United States, the FCPA (15 U.S.C. §§ 78dd-1 & 78dd-2 et seq.) imposes criminal penalties on individuals and corporations that engage in the bribery of foreign officials. Bribery, as defined by FCPA, constitutes the offer of a payment for the purpose of influencing any act or decision of the foreign recipient acting in his official capacity in violation of his lawful duty.[3] Criminal penalties under the FCPA can reach up to 5 years imprisonment, and fines up to $2,000,000 for corporations and $100,000 for individuals.[4] There are two exceptions and affirmative defenses to the FCPA. The first defense covers foreign payments that are considered lawful in the jurisdiction and written law of the foreign recipient.[5] The second defense applies to reasonable bona-fide expenditures that have a direct link to the execution of contracts and promotional activities.[6]

There has been sharp criticism of the extraterritorial effects of the FCPA, consisting of claims that its provisions place U.S. businesses at a disadvantage in countries where bribery is a routine business practice.[7] Amendments to the FCPA by title V of the Omnibus Trade and Competitiveness Act of 1988 alleviate some of these concerns. In addition to establishing the affirmative defenses to the FCPA, the amendment lifted some of the restrictions that previously, in effect, discouraged the use of foreign agents to promote business.[8] Further, the FCPA was again amended by the International Anti-Bribery and Fair Competition Act of 1998.[9] The aim of this amendment was to integrate the 1997 convention negotiated at the Organization for Economic Co-operation and Development (OECD),[10] which evinced the success of the FCPA in influencing the anti-corruption movement at the global level. The agreement, which came into force on February 15, 1999, requires that the 29 members of the OECD and the 5 nonsignatory members institute and ratify their own national laws prohibiting bribery of foreign government officials.[11] In turn, implementation of the convention by other countries may help alleviate the concerns of U.S. businesses that they are being placed at a competitive disadvantage by the FCPA.

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[1] Barton Fisher, *International Trade and Investment* (Boston: Little, Brown & Co., 1986), pp. 571-572.

[2] Fisher, p. 571.

[3] *See* 15 U.S.C. §§ 78dd-1(a), 78dd-2(a)(2), 78dd-3(a).

[4] *See* 15 U.S.C. §§ 78dd-2(g)(1)(A), 78dd-2(g)(2), 78ff-(c)(1), 78ff(c)(2)(A), (B).

[5] *See* 15 U.S.C. §§ 78dd-1(c)(1), 78dd-2(c)(1).

[6] *See* 15 U.S.C. §§ 78dd-1(c)(2), 78dd-2(c)(2).

[7] Fisher, pp. 571-572.

[8] Thomas F. Clasen, *Foreign Trade and Investment: A Legal Guide* (Salem, NH: Butterworth Legal Publishers, 1990), sec. 11.08.

[9] Alejandro Posadas, *Combating Corruption Under International Law* (Duke Journal of Comparative and International Law, 2000), 10 Duke J. Comp. & Int'l L. 345, p. 359.

[10] Posadas, p. 359.

[11] Andrea D. Bontrager Unzicker, *From Corruption to Cooperation: Globalization Brings Multilateral Agreement Against Foreign Bribery*, Indiana Journal of Global Legal Studies, vol. 7, pp. 655-656, 2000.