Apogee and Perigee:

Analysis of the U.S. Aerospace Industry

Office of Aerospace and Automotive Industries
International Trade Administration
U.S. Department of Commerce
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Dear Reader,

This is the inaugural edition of the Aerospace Team's annual publication *Apogee and Perigee.* Designed to provide the reader with the status of the aerospace industry in the United States, topics include financial analysis of major aerospace firms, trading partners, and industry leaders. *Apogee and Perigee* is not designed to cover every aspect of industry in detail. Rather, it provides an overview of salient issues, which the reader can then research for additional information. This paper is based upon contributions and information from multiple government agencies and numerous private sector entities.

Published by the Office of Aerospace and Automotive Industries, this report was written by members of the Aerospace Team. A group effort, it provides insight to major aerospace industry topics such as unmanned aircraft systems, large commercial aircraft, regional jets, general aviation, and workforce issues. We welcome your comments, criticisms, and suggestions for improvement. I also suggest you view our website at: http://www.ita.doc.gov/td/aerospace/ for additional information on the U.S. aerospace industry.

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Table of Contents

Chapter		page
1.	Introduction	2
2.	Executive Summary	4
3.	Large Commercial Aircraft	6
4.	Regional Jets	12
5.	Rotorcraft	19
6.	Commercial Space	25
7.	General Aviation	36
8.	Engines/Powerplants	42
9.	Workforce	52
10.	Unmanned Aircraft Systems	55
11.	Maintenance, Repair, and Overhaul	68
12.	Airport Infrastructure/Aviation Security	72
13.	Country Analysis: India	79
14.	Country Analysis: China	81
15.	Country Analysis: Japan	84
16.	Country Analysis: Europe	86
17.	Country Analysis: Russia	91

EXECUTIVE SUMMARY

Overall, 2005 was exceptional for the aerospace industry in terms of change, product offerings, orders placed, and increased manufacturing activities. Civil aerospace exports from the United States totaled over $56.6 billion. This figure is expected to grow in the near to medium term as orders are filled and aircraft prove themselves airworthy. Boeing and Airbus, the two largest airframe manufacturers, set a record number of new aircraft orders.

Each company has offered new and competing products that revolutionize how large civil aircraft are viewed. The products support different theories of civil air transport in that the Boeing aircraft is designed for long distance point-to-point transportation that avoids use of the hub and spoke system. The competing Airbus product features the largest civil transport in history that depends on the hub system. These two competing products offer international civil transport systems greater flexibility for operators to design their fleets for the greatest efficiency.

An important element in this competition are the current WTO cases over government subsidies. In May of 2005, the United States filed a request for the establishment of a dispute settlement panel to resolve the issue of subsidies being paid to Airbus for the development costs of new aircraft. This request was filed as the EU was preparing to commit $1.7 billion in new subsidies for the development of Airbus' A350, the direct competitor to Boeing's 787. Indeed, since that initial request, the EU is discussing providing additional multi-billion dollar subsidies.

The trade cases cast a pall over the entire aerospace industry as they have the potential to affect the numerous suppliers to both manufacturers. Never-the-less, suppliers to both manufacturers have had a very good year with new plants and equipment under construction/ fabrication. Recent investments in Charleston, South Carolina by Vought and Alenia are excellent examples.

In addition to the "boom" in large civil aircraft, general aviation manufacturing has benefited from a strong upturn in business. Shipments in 2005 are the highest since 1982 with a 27 percent increase in sales dollars from only one year ago. Much of this increase is due to the sale of business jets, especially exports of general aviation aircraft to the People's Republic of China. As more airspace is decontrolled by the military, general aviation sales in the PRC will continue to rise.

Outlook: LCA sales will likely remain robust for the foreseeable future, but probably not as strong as the past twelve months. Companies will continue to book additional orders for future deliveries, but production slots are generally filled for the next few years. News reports suggest that Airbus is considering a redesign of the A350 but so far have no announced a final decision. If true, this will likely adversely affect scheduled deliveries of this aircraft and perhaps double development costs. Their new flagship aircraft, the jumbo A380, has been delayed a second time. These delays are having a negative impact on Airbus and will most likely result in penalties assessed and orders cancelled by airlines.

Conversely, general aviation manufacturing and sales are expected to continue climbing and reach record levels. This industry segment is poised to produce new and relatively inexpensive very light jet aircraft. Initially envisioned as a new jet taxi service, over 2,875 of these aircraft are already on order. Deliveries of full size business jets are also expected to reach new levels as demand increases for fractional ownership of these aircraft. These factors in addition to the expected increase in sales to China and India indicate that the general aviation industry segment will have a record year. While sales to the PRC will remain small for the next year, sales of aircraft to flight academies are expected to increase as China continues to open their sky to general aviation. The Indian market is also one of great opportunity as they develop their internal aviation infrastructure. Pilot training is a major component of this effort , increasing the demand for simulators, instructors, and training craft.

Another significant development is the announcement BAE Systems to sell its 20 percent ownership in Airbus. Negotiations are presently underway between BAE and EADS over price. While BAE is prohibited from selling its stake to anyone other than EADS, unsolicited offers are still possible. One factor could be Russian desire to reassert their presence in the LCA industry segment. Russia has recently reorganized its conglomeration of design bureaus and production facilities into one holding company named OAK. Russia could submit a bid for the 20 percent stake in Airbus as a means of improving its own aircraft manufacturing abilities. Indeed, considering the enormous need for new aircraft by the various Russian airlines, this is a strategic possibility. The same argument could be applied to the Chinese, as they want to develop an indigenous LCA operation.

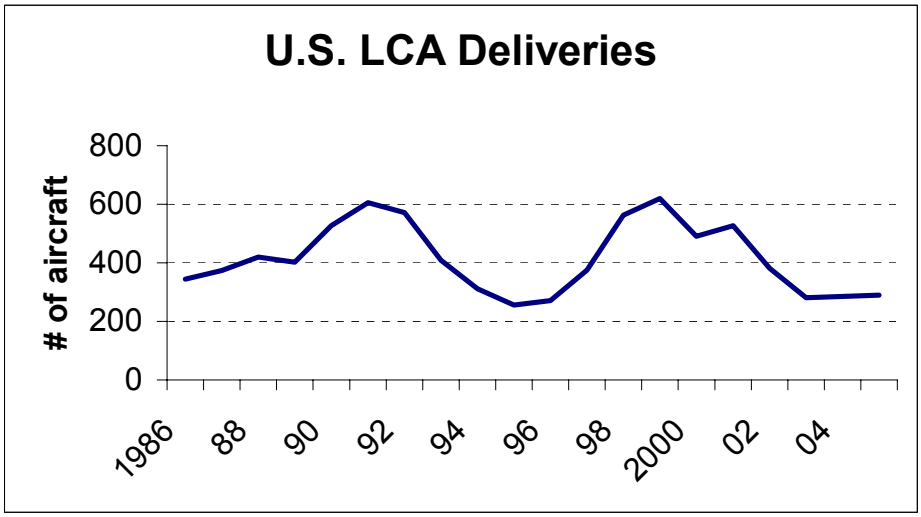
The outlook for the aerospace industry is very good for the next few years. India and China's infrastructure will continue to develop and with it the need for additional civil aircraft of all types. The market in these two nations demands everything from fire trucks to simulators in order to improve their basic airport infrastructure. These are just a few of the numerous opportunities that will further stimulate international trade.

Large Civil Aircraft

Following its acquisition of McDonnell Douglas in 1997, Boeing is the only U.S. manufacturer today of large civil aircraft (LCA), that is, aircraft of more than 100 seats or an equivalent cargo capacity. Boeing's LCA revenues in 2005, at $22.7 billion, accounted for 58 percent of the total non-government, civil output of the U.S. aerospace industry.

Market trends

U.S. (and global) LCA production is cyclical, experiencing peaks about every ten years in the number of aircraft delivered (with "valleys" about every other ten years).[1]



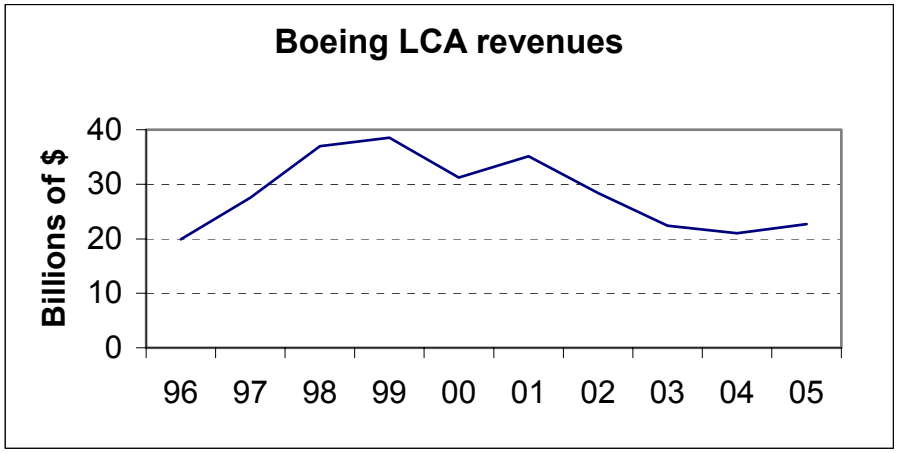
The terrorist attacks of September 11, 2001 economically shocked the civil aircraft industry. As demand for air travel plummeted sharply, airlines' demand for new transport aircraft also plunged. By mid-October, airlines cancelled orders for 50 Boeing aircraft. At year's end, Boeing said that the net number of new Boeing aircraft ordered in 2001 (number of new orders less the number of existing orders that were cancelled) was 314 airplanes. This was about half the figure from the previous year (net orders in 2000 of 598 aircraft). With demand stagnant in the immediate aftermath of 9/11, Boeing's sales continued to slump. The number of orders fell again in 2002, and bottomed out in 2003 with 249 net orders.

Boeing's investors suffered accordingly. On the day before 9/11, Boeing's stock closed with a value of over $43 a share. Three weeks later it traded at $33. Although the price rebounded somewhat in late 2001, Boeing stock declined steadily throughout 2002 and early 2003, reaching a low in March 2003 at $25 a share.

[1] The source for this, and other data in this report regarding aircraft orders, deliveries, and sales volumes for Boeing and Airbus are the companies themselves. Although widely accepted by aerospace industry analysts, the data has not been independently verified.

The U.S. LCA industry turned a corner in 2004. After hitting an eight-year low in 2003 of 281 aircraft delivered, Boeing posted a slight increase – to 285 – of aircraft delivered in 2004. The number of Boeing aircraft ordered in 2004 also increased from the previous year, marking an end to the market slide precipitated by 9/11. Market conditions continued to improve in 2005, with the apparent demand last year for LCA stunning many analysts. Boeing announced orders of 1,029 aircraft, an increase of over 370 percent from the 2004 order figure of 277 aircraft.

While Boeing appears to be on the rebound in terms of numbers of aircraft ordered, it may be some years before the company regains previous sales levels when measured in dollars. The highest revenues Boeing received from large civil aircraft sales, about $38.5 billion, was in 1999, when it delivered a record 620 aircraft. This is a significant difference from Boeing's LCA revenues in 2005, of about $22.7 billion.



Access to foreign markets is crucial to Boeing. Over the next ten years, Boeing predicts that 73 percent of the large civil aircraft market will be outside of the United States. Key foreign markets include China, Japan, and India.

Competition

As a practical matter, Airbus (Europe) is Boeing's only competitor. Other civil aircraft manufacturers do not produce aircraft comparable to those of Boeing and Airbus.

Antonov, Ilyushin and Tupolev (Russian) manufacture noisy, unreliable, fuel-guzzling large civil aircraft that attract few customers. Embraer (Brazil) manufactures regional aircraft. Its largest models, the Embraer 190 (94-106 passengers) and the Embraer 195 (106-118 passengers) could compete marginally with Boeing's smallest model, the 737-600 (110-132 passengers), but only in short-range applications. The maximum range of the various types of Embraer 190 and 195 models varies between 1,800 and 2,300 nautical miles, while the maximum range of the Boeing 737-600 is 3,050 miles. Bombardier (Canada) manufacturers regional aircraft, the largest of which, the CRJ900, seats a maximum of 86 passengers. Bombardier's plans to produce a 110-130 seat "C-Series" aircraft were postponed, if not cancelled, in early 2006.

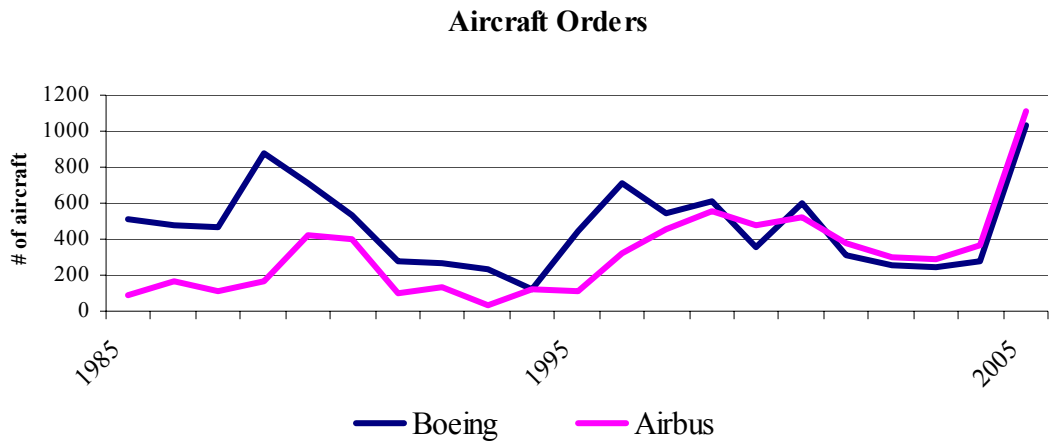
Created in 1970, Airbus was a consortium of four government-supported companies. In 2001, it was transformed into a single corporate entity, Airbus S.A.S. Today, Airbus is owned by European Aeronautic Defense Systems (EADS) with 80 percent equity, and by UK-based BAE Systems with 20 percent equity. The French government owns 15 percent of EADS.

Throughout its history, Airbus has received substantial financial and other support from the governments of France, Germany, the United Kingdom and Spain. These governments have provided over $15 billion in "launch aid" to develop new models of Airbus aircraft. Airbus has benefited from government equity infusions, debt forgiveness, aircraft production support, and infrastructure development. Senior economic officials from the four Airbus governments coordinate pan-European aerospace industry policy in their informal capacity as "Airbus Ministers".

Boeing and McDonnell Douglas dominated the global LCA market in 1970s and 80s. In the 1990s Airbus became a serious competitor, as it remains today. For every year since 2001, Airbus announced that it received more orders for civil aircraft than Boeing. Airbus makes the same claim concerning aircraft deliveries for every year since 2003.

As calculated by various measurements, Airbus' share of the LCA market in 2005 was:

- 56.6 percent, measured by number of aircraft delivered (378 vs. Boeing's 290);
- 51.9 percent, measured by number of new aircraft orders (1,111 vs. Boeing's 1,029); and
- 54.6percent, measured by LCA sales revenues ($27.3 billion vs. Boeing's $22.7).



Boeing's orders before 1997 (when it acquired McDonnell Douglas) include aircraft ordered from McDonnell Douglas.

<u>A difference in market projections</u>

Airbus and Boeing differ starkly in their projection for the future market of large civil aircraft. In Airbus' view, the future of the LCA market lies with huge aircraft capable of long flights that will fill a growing demand for "hub-and-spoke" airline operations. Airbus says that larger

aircraft will be increasingly required to mitigate congestion at the finite number of gates airports have available.

In keeping with this market view, Airbus developed the A380 "super-jumbo" aircraft in the early 200's. Several versions are planned, with seating capacity ranging from 555 to 850 passengers. (By comparison, the latest version of the largest civil aircraft now flown, the Boeing 747-400, typically is configured for a maximum passenger capacity of 416.)

In contrast, Boeing believes that the future of civil aviation lies with so-called "point-to-point" airline operations. In Boeing's view, passengers' demand for non-stop service will trump their interest in the lower fares that can be achieved with one or more intermediate stops. Consequently, Boeing says, airline fleets will be composed of large numbers of aircraft with relatively small passenger capacities. The mix of particular aircraft models should be capable of meeting short-, mid- and long-range operations.

In keeping with its market projection, Boeing developed its latest jetliner, the 787 "Dreamliner", with many fewer seats than the Airbus A380, and somewhat fewer than the last aircraft Boeing developed, the 777. Boeing anticipates entry into service in 2008 of two versions of the 787. The 787-3 will have a maximum seating capacity of 289 passengers and a range of 3,500 nautical miles. The 787-8 will seat a maximum of 217 passengers with a range of 8,500 nautical miles.

While the two LCA manufacturers have different views of the future market, neither Boeing nor Airbus has put all of its eggs in one basket. In October 2005, Airbus announced it would develop an aircraft, the A350, aimed at competing against the Boeing 787. Boeing plans to produce a stretched version of its existing 747, to be called the 747-8, that will add room for 34 more seats in a typical configuration of three passenger classes.

Which manufacturer's market projection is correct? Based on recent demand, it appears Boeing's forecast may be more accurate than Airbus'. In 2005, airlines placed orders for a total of 2,140 aircraft to be produced by Boeing and Airbus. The very largest aircraft, the A380 and the Boeing 747, accounted for a minute fraction – one percent and two percent, respectively. Small, single-aisle aircraft, *i.e.*, the Airbus 320 family and the Boeing 737 "New Generation" family, dominated the market, accounting for 70 percent of all orders. Aircraft of a size in between the very largest and the small, single aisle aircraft accounted for 27 percent of the new orders.

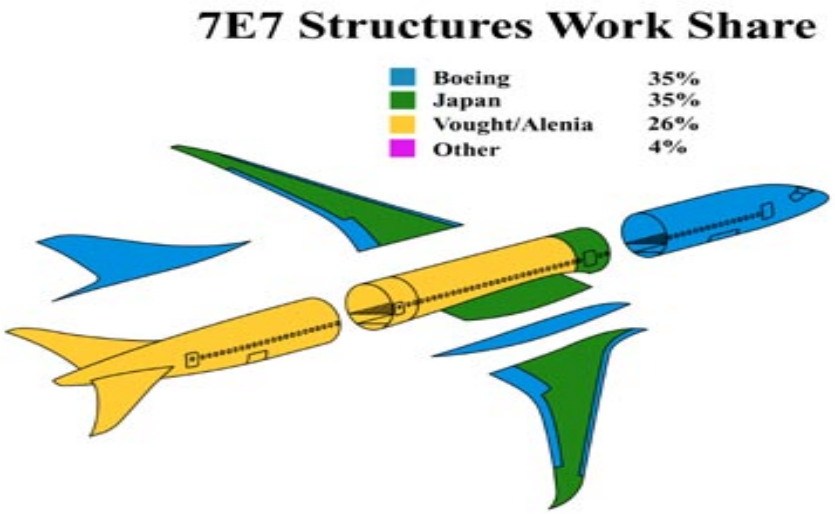
These figures should be read with caution for several reasons. First, the number of aircraft ordered in 2005 was far higher than anticipated based on airlines' historic demand. If the experience with previous spikes in demand holds true, many of the 2005 orders could be cancelled. Second, factors other than the hub-and-spoke vs. point-to-point debate may be at play. Chief among these is aircraft fuel economy. With oil prices climbing dramatically throughout 2005, Boeing's offer of a 20 percent fuel savings with its 787 may have been more important than its smaller size. Finally, technical production snags in 2005 caused Airbus to delay the dates (in 2006) of the first deliveries of the A380 "super-jumbo". This did nothing to attract orders from airlines for which timely delivery of new aircraft is important.

New U.S. manufacturing process

In a departure from its traditional way of manufacturing aircraft, Boeing will be using an assembly technique for the 787 that has been used by Airbus for decades. In this new, "systems integration" approach, instead of receiving parts from tens of thousands of suppliers, Boeing is working with a small number of companies to provide major sub-assemblies for the 787. Boeing requires that these suppliers assume the cost of integrating the sub-assemblies. Final assembly of 787 at Boeing facilities near Seattle will take three days, Boeing says, instead of the two-four weeks now required for final assembly of similar aircraft.

In another departure from its traditional business model, Boeing is relying to a great extent on the participation of foreign companies to help develop and manufacture 787 components.

· A partnership between Alenia (Italy) and Vought (Texas) will design and manufacture center and rear fuselage sections, representing 26 percent of the 787 "structures". Some fuselage sections will be assembled in Italy.
· The Japanese Aircraft Development Corporation (JADC), a consortium of the three largest Japanese aerospace manufacturers, will design and manufacture both wings, representing 35 percent of the 787 structures.



Boeing seeks to minimize its role in producing aircraft parts. Its future vision emphasizes the company's skills in designing and integrating large, complex aircraft.

Future market

Boeing's sales in the coming year are likely to be dominated by three models of aircraft: the single-aisle 737, the wide-body 777, and the new 787 with a body fabricated from carbon composite materials.

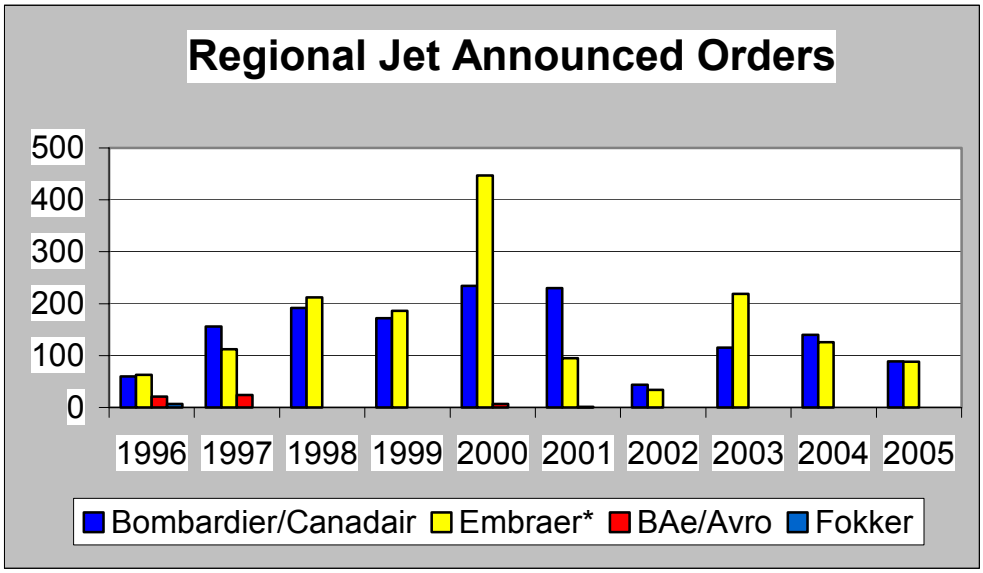
While aircraft orders typically decline following a boom year, as 2005 was, the market experienced an opposite trend in early 2006. Boeing received net orders for 176 aircraft in the first quarter of 2006, an increase of 171 percent from the first quarter 2005 figure (65 orders). Boeing's deliveries in the first quarter of 2006, 98 aircraft, was an increase of 40 percent from the number of aircraft Boeing delivered in the first quarter of 2005 (70 aircraft). Boeing reported an increase in profit of 29 percent in the first quarter of 2006 over the year before.

As of late April 2006, Boeing forecasted that it would deliver a total of 395 aircraft in 2006, an increase of 36 percent over its 2005 deliveries. Much of the demand for Boeing aircraft may be led by three sources: low-cost carriers, Asia-Pacific airlines and leasing companies.

Regional Jets

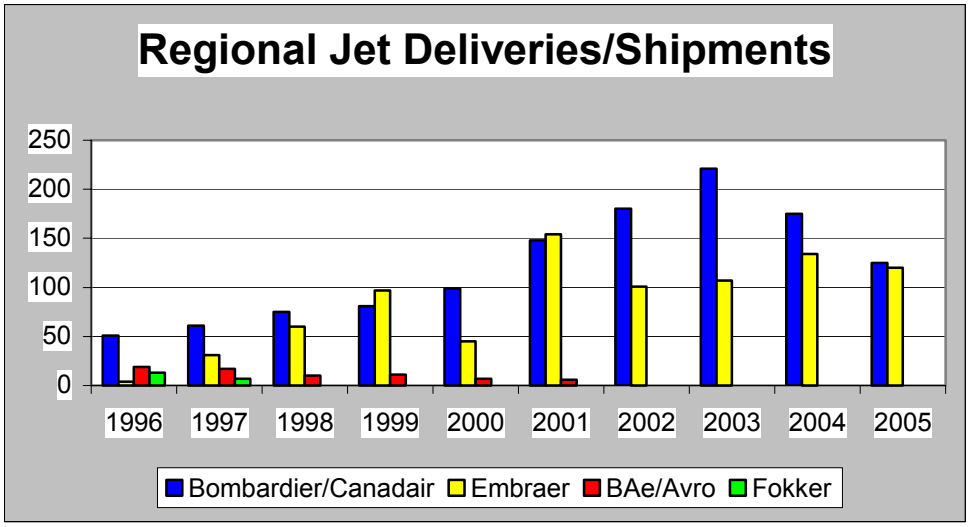
Similar to the large civil aircraft sector, global production of regional jets is dominated by two manufacturers — Bombardier (Canada) and Embraer (Brazil). Regional jets are typically considered to be commercial jet transport aircraft with fewer than 100 seats. However, this traditional defining line is becoming blurred as large RJs are competing with the smallest product offerings from Boeing and Airbus. Orders and deliveries of regional jets have grown rapidly over the last ten years in particular as airlines look use them to fill a unique market niche. Production of current generation regional jets has jumped from 2 RJs delivered in 1992 to well over 300 delivered in 2003.[2] The aerospace subsidiary of Bombardier is the third-largest civil aircraft producer behind Boeing and Airbus, and the foremost global producer of regional aircraft, accounting for two-thirds of global deliveries in 2003.

Together, Bombardier and Embraer have completely displaced European RJ manufacturers in the global market. Other producers of regional jets in recent years have exited the market. German company Fairchild/Dornier entered into bankruptcy, and sold the rights to its different aircraft programs to various investors in early 2003.[3] The only Fairchild/Dornier program to survive was the 32-passenger 328JET program purchased by AvCraft Aviation. The last BAE Systems regional jet rolled off the assembly line in 2001.



Source: *Speednews*

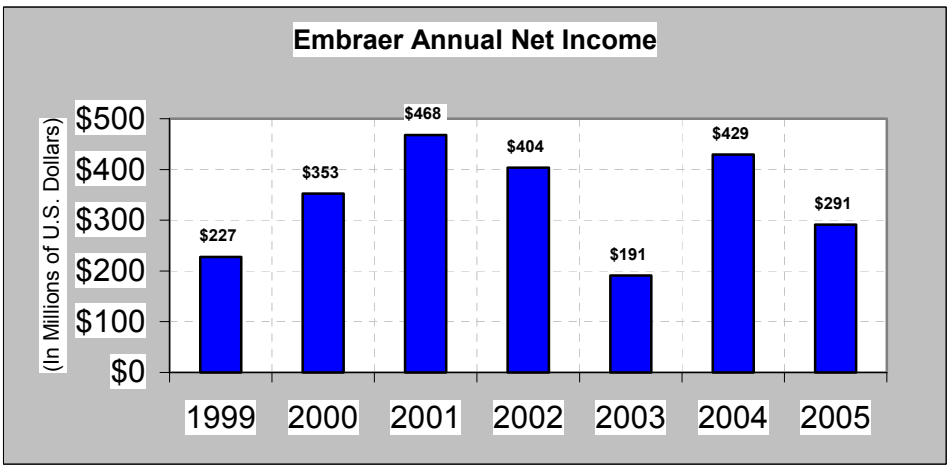
[2] U.S. Department of Commerce analysis of RJ data from *Speednews*.
[3] "New Owner Expects To Begin Delivering 328Jets Within 60 Days", *The Weekly of Business Aviation*, March 31, 2003.



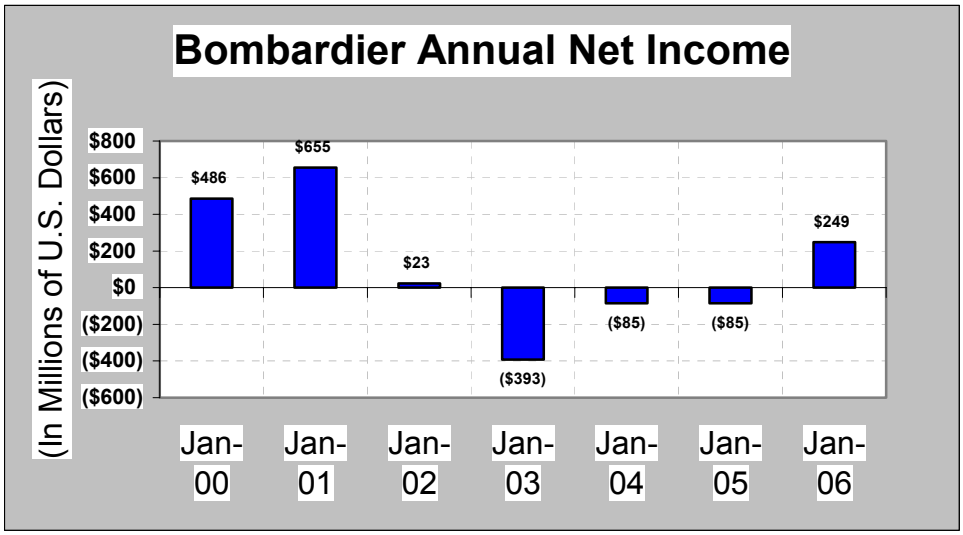
Source: *Speednews*

Bombardier has consistently increased annual deliveries of current generation RJs from two jets in 1992 to 221 jets in 2003, but has not dominated the market. Embraer delivered more RJs in 1999 (97 vs. 81 aircraft) and again in 2001 (154 vs, 148 aircraft), and announced more orders for new aircraft than Bombardier in four of the last six years. Perhaps more importantly, Embraer had a production backlog for RJs 20 percent greater than that of Bombardier at the end of 2003 (426 aircraft vs. 274 aircraft.)

The financial performance of the regional jet manufacturers has been mixed. Embraer and Bombardier both experienced rising net income in the late 1990s as deliveries of regional jets grew, peaking in 2001. Embraer has successfully weathered the post-September 11 downturn with positive net earnings. In contrast, Bombardier net income plunged into negative territory for the three consecutive years ending January 2003, 2004, and 2004, but this negative streak with net income of $249 million in January 2006.



Source: *Bloomberg Professional*



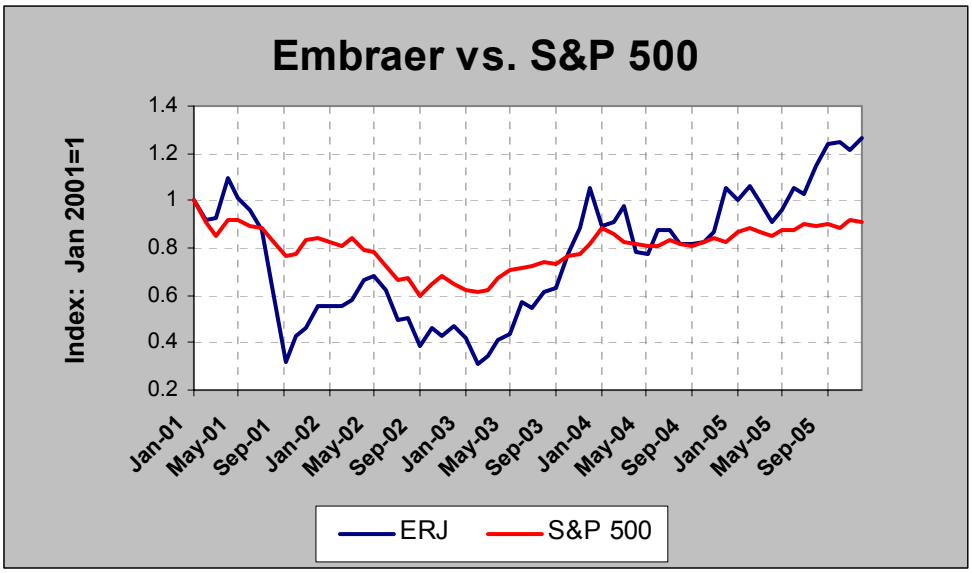
Source: *Bloomberg Professional*

This performance is shadowed in the stock market. Embraer stock has mostly outperformed the S&P 500 over the last three years, whereas Bombardier's stock has performed increasingly poorly since mid-2001 in comparison with the Toronto Composite (S&P TSX Index). In 2004, Bombardier's credit rating was downgraded to "junk" status, thereby making it more expensive for the company to borrow money.

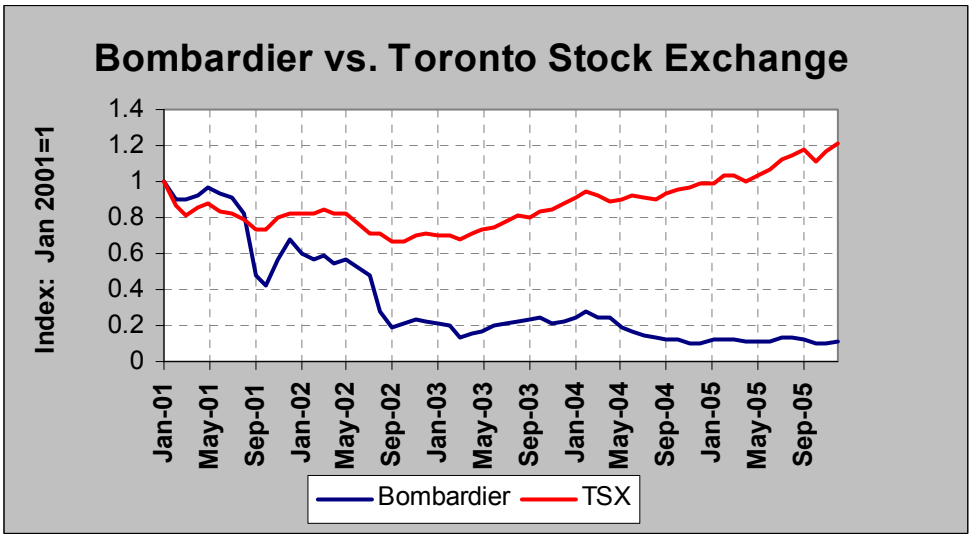
The financial problems of United States-based RJ customers are having a direct financial impact on Embraer and Bombardier. For example, after US Airways filed for bankruptcy a second time in September 2004, Embraer announced that it was suspending deliveries of RJs to that carrier until it could determine US Airways' ability to pay for the airplanes. Press reports indicated that US Airways at the time was committed to nearly $1.5 billion worth of future deliveries from Embraer, calling into question the viability of Embraer's future production targets.[4]

The impact on Bombardier of poorly performing airlines has been even greater. Concerns about order delays and declining production, due in part to bankruptcy concerns about two key Bombardier RJ customers – Delta Airlines and US Airways – led credit rating agencies to downgrade Bombardier stock in late summer 2004.[5]

[4] "Embraer halts US Airways delivery", Reuters, September 16, 2004.
[5] "Bombardier likely headed to junk by Moody's," Reuters, August 30, 2004.



Source: *Yahoo Finance*



Embraer

Embraer's existing production and assembly facilities are concentrated in a large complex outside of São José dos Campos, Brazil, where it employs a significant portion of Embraer's 12,000-person Brazilian workforce. Like Boeing and Airbus, Embraer is not widely diversified outside of the aerospace sector, although it manufactures both civil and military aircraft and produces sub-assemblies and parts for other aircraft manufacturers.

Embraer's presence in the United States is thus far limited to support and engineering facilities with a handful of direct employees. As of 2003, Embraer maintained the following U.S. operations[6]:

- Ft. Lauderdale, Fla. (support center)
- West Palm Beach, Fla. (engineering offices)
- Dallas, Texas (administrative offices)
- Nashville, Tenn. (aircraft maintenance and support center)

Embraer takes a systems integration approach to manufacturing, relying on a broad (non-Brazilian) supplier base for aircraft parts. Embraer claims that up to 70 percent of the hardware on their RJs (citing the ERJ 145 as an example) comes from United States suppliers.[7] As with Boeing and Airbus, Embraer is now utilizing risk-sharing partners in the development and production of their newest program, the Embraer 170/190 E-Jet family. Five U.S. companies are primary risk-sharing partners in this program, including:

- General Electric (turbofan engines)
- Honeywell (avionics systems)
- Hamilton Sundstrand (aircraft tail core, auxiliary power unit, electrical systems and the air management system)
- C&D Aerospace (aircraft interior)
- Grimes Aerospace Company (exterior and cockpit lighting)

Embraer also relies almost entirely on non-Brazilian markets for regional jet sales, and is Brazil's largest single exporter. The Americas (primarily North America and excluding Brazil) account for 74 percent of the company's sales. Many of these customers are regional airlines, low-cost carriers and even legacy airlines that seek to use RJs to transition away from traditional business models. U.S.-based airlines are some of Embraer's largest customers[8]:

- American Eagle
- Continental Express
- GE Capital
- Mesa Air
- US Airways
- Jet Blue Airways

Embraer is starting to blur the traditional line between large civil aircraft and regional jets as it introduces two new models with more than 100 seats that are roughly the same size as Boeing's smallest aircraft. Embraer began deliveries of the 100-seat Embraer 190 in 2005, and is expected to deliver 108-116-seat Embraer 195 in 2006.[9]

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[6] Embraer SEC Form 20-F; June 30, 2003
[7] Presentations to U.S. Department of Commerce
[8] Hoover's Inc.
[9] "JetBlue Spices Up Its Fleet, Ordering 200 Embraer Jets," *Wall Street Journal*, June 10, 2003.

Embraer has secured big orders for their new aircraft. JetBlue Airways, whose fleet currently comprises 156-seat Airbus A320s, has ordered up to 200 of the new Embraer 190s.[10] Air Canada has also agreed to purchase forty-five 190s, subject to the airline finding financing as it emerges from bankruptcy protection.[11]

Embraer is moving away from the traditional model of domestic ownership. The company began as a government-owned entity in 1969, began privatization in 1991, and was listed on the NYSE in 2000. In 2006, the company announced a capital-restructuring plan that extends voting rights to all shareholders, thereby adding increased transparency[12].

Embraer also is diverging from the traditional model of domestically based production. In December 2002, Embraer entered into a joint venture with Harbin Aircraft Industry Co., Ltd. and Hafai Aviation Industry Co., Ltd., subsidiaries of China Aviation Industry Corporations II (AVIC II). The agreement provides for the manufacture, sale and after-sale support of the ERJ 145 regional jet family. Embraer owns 51 percent of the joint venture.[13]

In September 2004, Embraer took a first step toward a U.S. production presence by breaking ground for a new facility in Jacksonville, Florida, to assemble ERJ 145 aircraft as part of a Defense Department contract to supply the new Aerial Combat System (ACS). The ERJ 145 aircraft were meant to as the ACS platform as part of a system assembled by a Lockheed Martin-led team. However, in January of 2006, the Army cancelled ACS program, claiming that the ERJ 145 was in fact too small to meet their requirements[14].

Embraer is teaming with a number of European companies on military projects as well. In March 2002, Embraer formed a consortium with Dassault, Thales, and SNECMA to bid on the development and manufacture of up to 24 fighter jets for the Brazilian Air Force. In 2002, Embraer formed a $50 million joint venture with China Aviation Industry Corporation to build the ERJ 145 jet.

Bombardier

Bombardier's aerospace manufacturing and production facilities are located in Canada, the United States and Northern Ireland. Bombardier (including all business segments) employed a total of 59,550 people at the end of fiscal year 2005.[15] Bombardier's production facilities include the following:

- Quebec (Saint-Laurent, Dorval, Mirabel)
- Ontario (Downsview, North Bay)
- Northern Ireland (Belfast)
- Kansas (Wichita)

[10] NYTimes.com article: Bombardier Considering a New Line of Jets; June 2, 2004.
[11] *Airline Business*; May 1, 2004
[12] *Aviation Week and Space Technology*; April 17, 2006
[13] Embraer SEC Form 20-F; June 30, 2003
[14] *The Seattle Times*; January 25, 2006
[15] Hoover's Inc Report on Bombardier

- Arizona (Tucson)
- West Virginia (Bridgeport)

Unlike the other prime aircraft manufacturers, Bombardier is widely diversified outside of the aerospace sector. Aerospace accounted for 53 percent of Bombardier's corporate sales in fiscal year 2004, with $8.498 billion in revenue.[16] Bombardier's other business units include Transportation Products (primarily rail operations, for which Bombardier is the world's largest manufacturer) and Bombardier Capital.

Although Bombardier is a publicly listed company on the Toronto Stock Exchange, the Bombardier family owns more than 50 percent of the company. Much of the content in Bombardier regional jets comes from a broad supplier base across Canada and the United States.[17] General Electric Aircraft Engines is the sole engine supplier for Bombardier RJs.

International customers (and predominately United States airlines) make up almost the entire order book for Bombardier regional jets. Their customer base includes regional airlines, LCCs and even legacy airlines that seek to use RJs to transition away from traditional business models. Bombardier is not actively marketing RJs configured for military purposes.

Bombardier sought to match Embraer's move into the 100-plus-seat market by proposing a new series of aircraft consisting of three models with a capacity of 100 to 130 passengers, known as the C-Series. Currently, Bombardier does not produce an aircraft with more than 86 seats, and technical limitations prevent them from enlarging existing aircraft with simple modifications.[18] Bombardier started the process with an $18 million feasibility study in 2004. In 2005, the company's board approved the C-Series, but deferred its final decision until 2006. The company ultimately decided not to move ahead with the C-Series and instead decided to focus on the 80-100-seat market.

[16] Hoover's Inc.
[17] Bombardier presentation to U.S. Department of Commerce
[18] Hoover's Inc.

Rotorcraft

Overview

The rotorcraft industry produces aircraft which are capable of performing vertical take-off and landing (VTOL) operations and are powered by either turbo shaft or reciprocating engines. The rotorcraft sector includes helicopters, gyrocopters, and tiltrotor aircraft. Helicopters, which employ a horizontal rotor for both lift and propulsion, are the mainstay of the industry. Gyrocopters are produced in much smaller quantities, primarily for use in recreational flying. Tiltrotor aircraft can take off vertically and fly horizontally as an airplane.

Rotorcraft are produced in most industrialized countries, either of indigenous design, in collaboration with, or under license from, other manufacturers. U.S. manufacturers of civilian helicopters include Bell, Enstrom, Kaman, MD Helicopters, Robinson, Schweizer, and Sikorsky. European producers include Agusta, Eurocopter, PZL Swidnik, Westland. Russian manufacturers of Mil and Kamov helicopters have been consolidated within OAO OPK Oboronprom (United Industrial Corporation). Asian producers include Harbin Aircraft, Hindustan Aeronautics, Indonesian Aerospace, Kawasaki, Mitsubishi, and Korean Aerospace.

Most U.S. helicopter manufacturers produce for both the civil and military markets. Boeing, however, currently produces only for the military market. Bell moved its civilian helicopter production to Canada, with the last U.S. product completed in 1993. Bell is building the BA-609 civilian tiltrotor, with Agusta, in Texas.

U.S. Manufacturers

Bell Helicopter

Bell Helicopter, a wholly owned subsidiary of Textron, was founded in 1935 as Bell Aircraft Corporation. The company is the leading provider of vertical take-off and landing aircraft. With more than 34,000 helicopters delivered to customers around the globe, it is teaming with Boeing to introduce tiltrotor technology into aviation via the military V-22 Osprey, the Bell Eagle Eye UAV (Unmanned Aerial Vehicle), and civil BA609. In addition to these platforms, Bell manufactures eight models of civil and military helicopters. The civil models are in the single, and light and intermediate turbine weight classes. As mentioned above, the transfer of civil helicopter production to its Quebec plant was completed in 1993.

Enstrom Helicopter

The R.J. Enstrom Corporation was established in 1959 (renamed the Enstrom Helicopter Corporation in 1971) and began building and selling the F-28 light helicopter. Enstrom produces light turbine and piston-powered helicopters. The company shipped 29 units in 2006 compared with 23 in 2005.

Robinson Helicopter

Robinson Helicopter Company was founded in 1973 to design and manufacture a light, inexpensive helicopter for the general aviation market. The company currently produces light piston-powered helicopters. Its R44 and R22 are the world's best and second best-selling civil helicopters. The company shipped 806 units in 2006 compared with 690 in 2005.

Schweizer Aircraft

Schweizer began operations in 1939 producing gliders. It produces fixed-wing aircraft and airframe components for other manufacturers, as well as both manned and unmanned helicopters. Schweizer became a wholly owned subsidiary of Sikorsky in September 2004, after acting as a subcontractor to Sikorsky for almost 25 years. The company produces light turbine and piston-powered helicopters.

Sikorsky Aircraft

Sikorsky, a subsidiary of United Technologies, is a world leader in the design and manufacture of advanced helicopters for commercial, industrial and military uses. The company was formed in 1923 to produce the S-29A (all-metal, twin-engine passenger plane). After the success of his flying boats and amphibians, Igor Sikorsky returned to the helicopter, which he had been developing since 1909. In 1931, he patented a design with the now-familiar helicopter layout - a single large main rotor and small anti-torque tail rotor. Sikorsky helicopters occupy a prominent position in the intermediate to heavy turbine range of 5,300 to 33,000 kilograms gross weight. They are used by all five branches of the United States armed forces, along with military services and commercial operators in 40 nations.

MD Helicopters

MD Helicopters (MDHI) produces helicopters designed while the company was owned by McDonnell Douglas. MD helicopters feature the NOTAR® (no tail rotor) anti-torque system, which is standard equipment on the MD Explorer® MD 600N® and the MD 520N® NOTAR® system-equipped aircraft are quieter and safer than helicopters with conventional tail rotors. Patriarch Partners, LLC took a controlling interest in MDHI in July 2005, after the company ran into financial difficulties. The new CEO wants to reverse an industry trend and move production of fuselages and most component parts in house to insure reliability of the supply of those products.

<u>Foreign Competitors</u>

Eurocopter

The Eurocopter group was born in 1992 from the merger between the helicopter divisions of Aerospatiale-Matra (France) and DaimlerChrysler Aerospace (Germany). The group is now a subsidiary owned 100percent by EADS (European Aeronautic, Defense and Space Company). The company produces civil turbine-powered helicopters in all four categories (single engine,

light twin, intermediate, and large multiple engine). Eurocopter delivered a total of 334 helicopters of all types (civil and military) in 2005 compared with 279 in 2004.

Joint Ventures

AgustaWestland

Agusta and Westland first collaborated in the 1960s, when Westland started license production of the Agusta AB47, which was renamed as Westland-Agusta/Bell 47G, better known as the "Sioux". Starting in 1964, Westland built 250 of this small helicopter at Yeovil, England. Agusta's relationship with Westland has evolved for over 20 years which has included collaboration on the development and production of the 15-ton multi-role EH101, the largest European helicopter program ever undertaken.

AgustaWestland produce rotorcraft in both commercial and military categories that encompass all the principal weight categories and missions. The company offers a range from the 2.5-ton light single-engine A119 Koala to the 15-ton three-engine multi-role EH101. Other products include the light twin A109 Power and Grand, the A129 combat helicopter, the multi-role Super Lynx 300, AW139 and BA609 Tiltrotor, the NH90 and the Apache AH Mk1

Bell/Agusta Aerospace

Bell/Agusta Aerospace Company (BAAC) is a partnership for the purpose of producing the BA609 Civil Tiltrotor. Headquarters for the joint venture is located at Alliance Airport in Fort Worth, Texas. BAAC is a joint venture formed in 1998 by Bell Helicopter, a Textron company, and Agusta, an AgustaWestland company owned by Finmeccanica, who have collaborated on a variety of notable products dating back to 1952. In the medium-twin engine segment, Bell and Agusta have delivered and supported more than 35,000 helicopters.

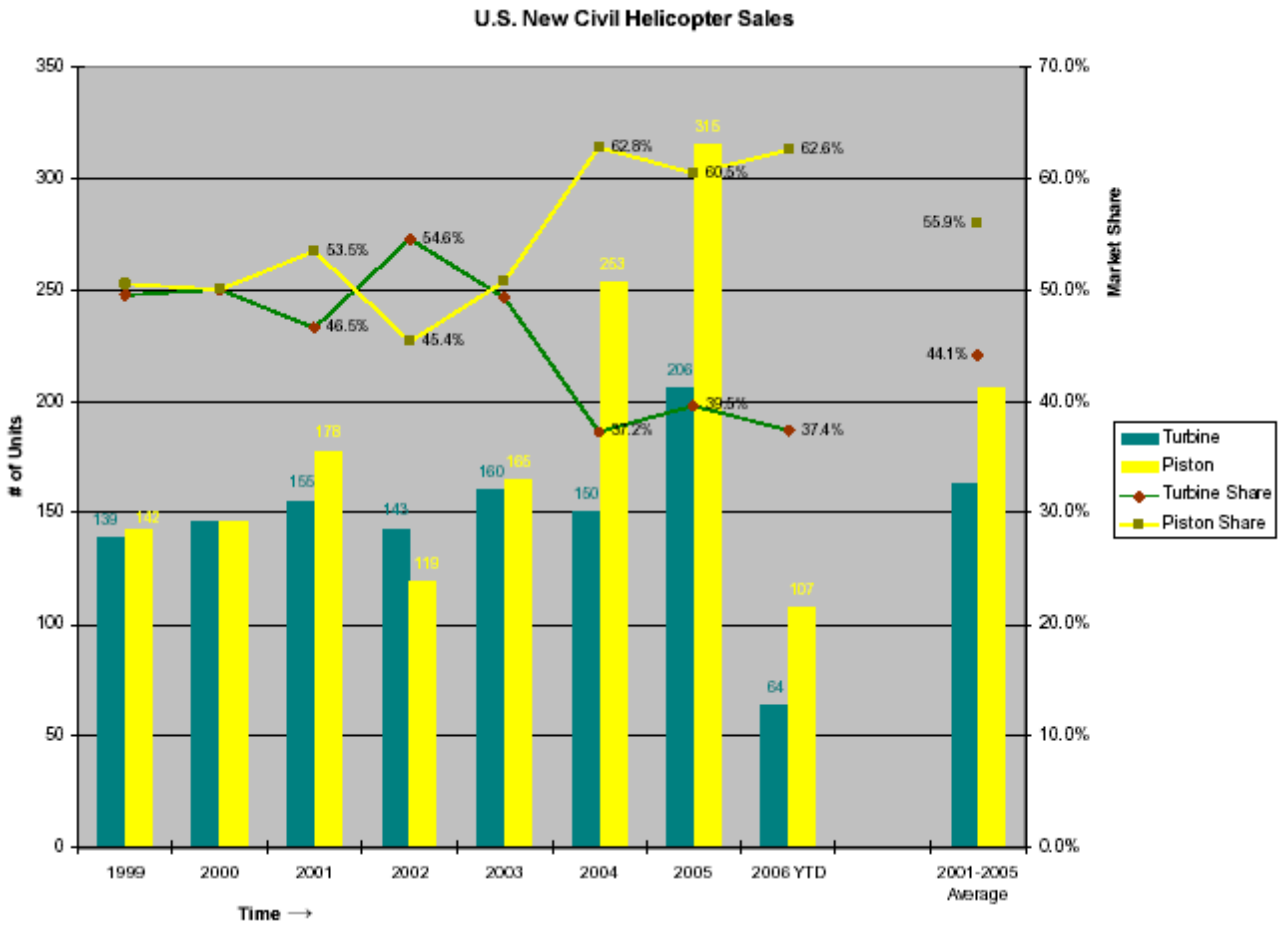
In November 2005, the partners announced that effective upon regulatory and other necessary approvals, Bell is selling its 25 percent interest in the AB139 medium twin helicopter program to AgustaWestland. AgustaWestland will assume 100 percent ownership of all aspects of the AB139 program going forward. In return for its 25 percent interest, Bell will receive payments to reflect its value in the program. Specific terms of this transaction are undisclosed.

In addition, the realignment allows AgustaWestland to confirm the ability to increase its economic interests in the BA609 civil tiltrotor aircraft, which will remain within BAAC, from the original 25 percent to a maximum of 40 percent by increasing its investments during the development phase.

NH Industries

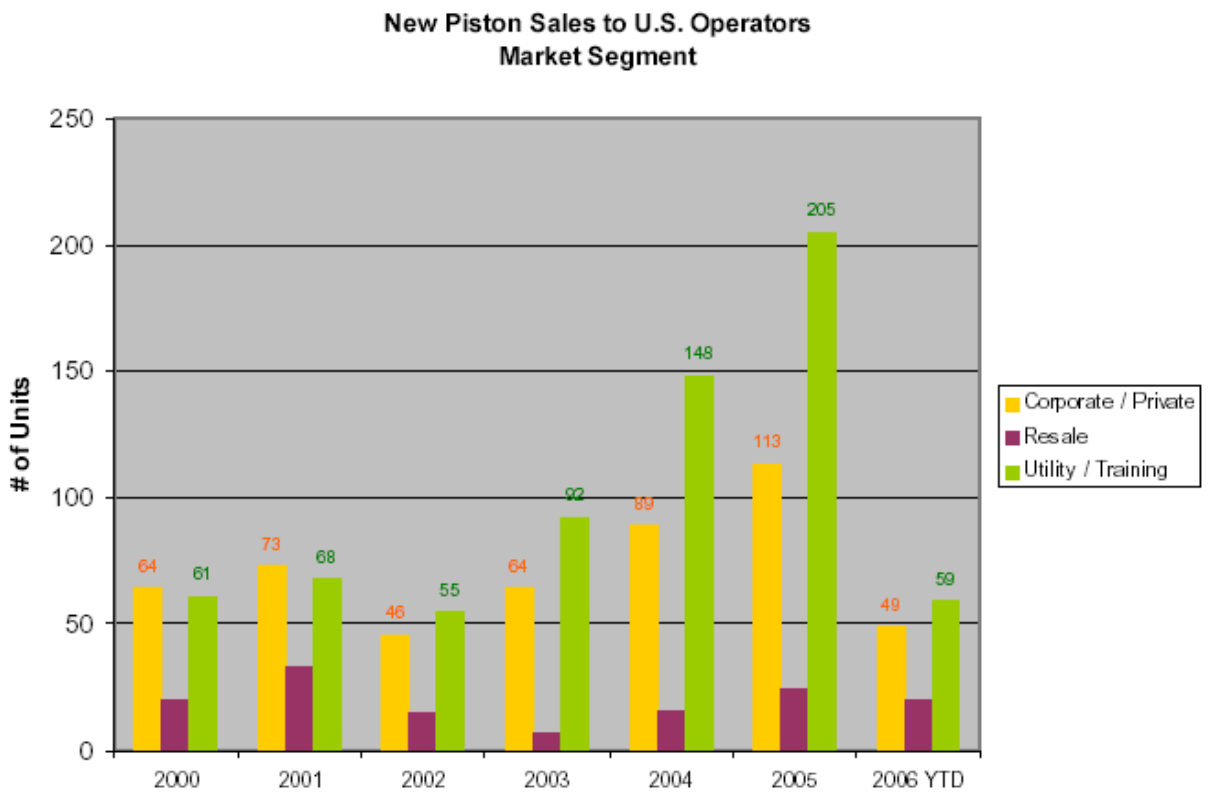
NH Industries (NHI) was formed by Agusta, Eurocopter and Stork Fokker AESP to manage the production of the NH90, which is a twin engine, 10.6 ton multi-role helicopter, developed to meet naval and tactical transport helicopter requirements of Italy, Germany, France and the Netherlands. The NH90 is now in production and will soon enter service.

Trends

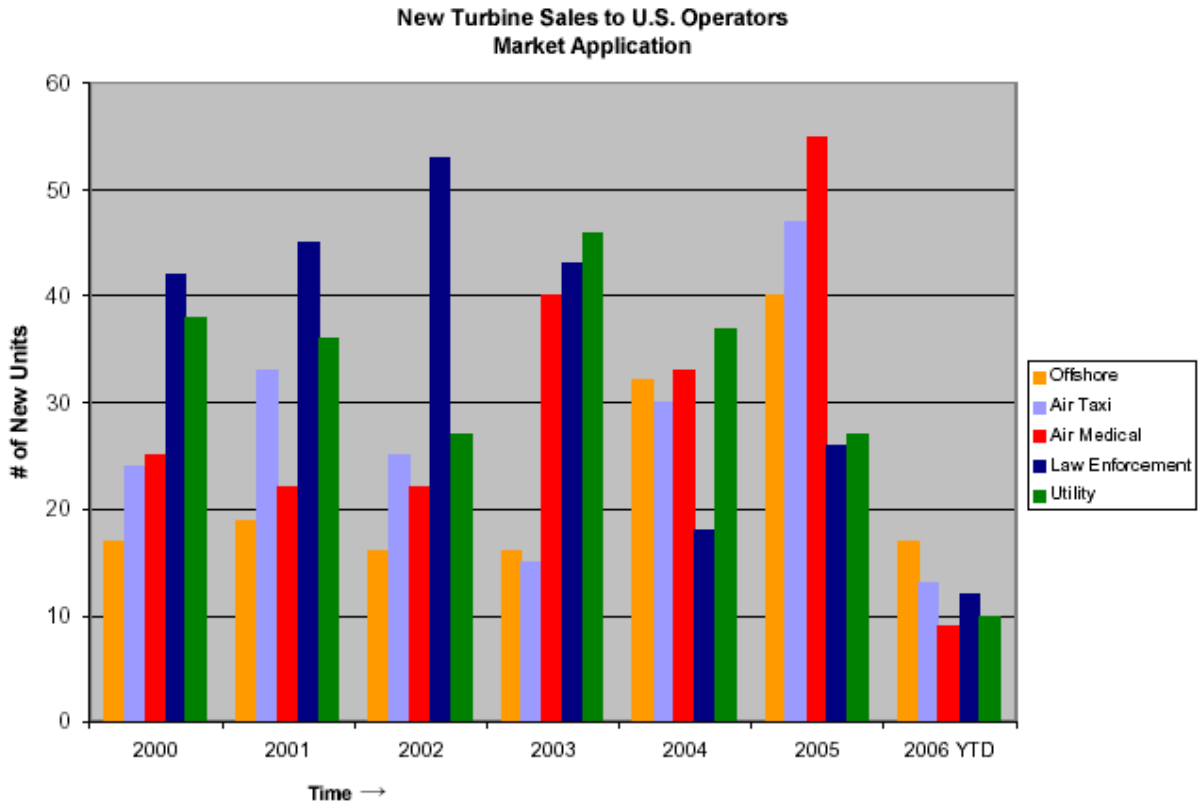


Source: Helicopter Association International, *The Helicopter Market Newsletter, Turbine,* April 2006.

The upsurge in the shipments of piston-powered helicopters to the global, as well as the U.S., market has been primarily due to Robinson's sales of its R22 model, which has the lowest acquisition and operating cost of any production helicopter.

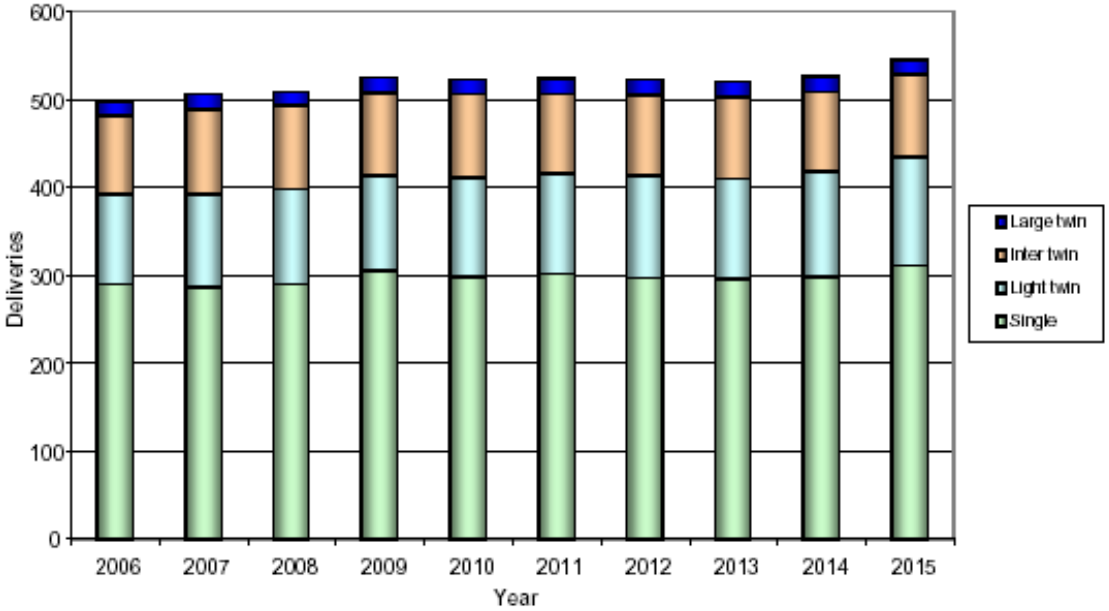


Source: Helicopter Association International, *The Helicopter Market Newsletter, Piston,* April 2006.



Source: Helicopter Association International, *The Helicopter Market Newsletter, Turbine,* April 2006.

Turbine helicopter forecast 2006-2015: Civil market phasing



Source: Rolls-Royce/Teal Group 10-Year Turbine Helicopter Forecast 2006-2015.

Rolls-Royce and the Teal Group forecast about 5,190 new turbine-powered civil helicopters to be delivered during the ten-year period 2006-2015 (519 per year). Included in the forecast are aircraft for the non-armed services paramilitary market.

Honeywell projects about 6,000 for the 11-year period 2006-2016 (545 per year). Civil helicopter deliveries were up 24 percent in 2005 and are likely to rise again in 2006, as helicopter OEMs increase production to satisfy strong demand for new aircraft. North America will constitute 40 percent of those helicopter deliveries.

There is some good news for U.S. helicopter manufacturers on the research and development front. Some funds have been returned to NASA's budget for aeronautics research, while the Aerospace Industries Association and the American Helicopter Society (AHS) International are still trying to have more funds put back into that budget. The budget had been cut from $1.5 billion to about $700 million. NASA's new associate administrator for the Aeronautics Research Mission Directorate has introduced a more science-oriented program, focusing on developing tools and applications that are science-based. Under the new manager, $42.6 million has been budgeted for helicopter research. Funds have also been spent to revitalize the National Full-scale Aerodynamics Complex (NFAC) at the NASA Ames Research Center in California, which had been closed in 2005 due to lack of funding.

Source: Rolls-Royce/Teal Group 10-Year Turbine Helicopter Forecast 2006-2015.

Commercial Space

Overview

The commercial space market is dominated by a small number of large companies that provide launch services and manufacture commercial communications satellites. Commercial remote sensing satellites are emerging within this market, but have seen limited growth internationally. The companies comprising this market are also major suppliers to U.S. Government launch and satellite programs, where demand has remained stable during the commercial downturn.

Three major companies dominate the launch market: Boeing, Lockheed Martin and Arianespace (Europe). The U.S. companies provide launches through joint ventures that were established to take advantage of Russian launch technology. Boeing's Sea Launch uses Russian engines, Ukrainian launch vehicles, and a Norwegian ship and launch platform. Sea Launch transports the rocket and satellite from California to an ocean-based location on the equator for launch. Lockheed Martin's International Launch Services is a joint venture with Russia's Khrunichev that co-markets Lockheed Martin's Atlas launch vehicle and Russia's Proton launch vehicle. Arianespace, a European consortium of more than 23 companies provides launch services on the Ariane 5 rocket, which is launched from a site near the equator in French Guiana. In addition to these three, Orbital Sciences manufactures smaller satellites and provides lightweight-class launch services on the Pegasus and Taurus launch vehicles. Orbital Sciences is not involved in an international joint venture, and mainly provides launches for the U.S. Government.

In 2005, 55 total orbital launches took place globally, of which 18 were commercial launches.[19] Nine of the commercial launches were completed by U.S. ventures—ILS conducted one Atlas 5 launch and four Proton launches, while Boeing's Sea Launch conducted four. Arianespace launched 10 satellites on 5 commercial launches.[20] These figures demonstrate the stiff competition between European- and Russian-manufactured rockets in the commercial market and the return to a focus on government launches for U.S.-built rockets. Commercial launch revenues totaled nearly $1.2 billion in 2005, an increase of $200 million over 2004.[21]

The 55 total global launches carried 75 spacecraft into orbit in 2005. Of those 75 spacecraft, 20 provide commercial broadcast and communications services, while the remaining spacecraft perform other scientific or government functions.[22]

In the commercial communications satellites sector, U.S. companies have regularly maintained approximately 70 percent of the commercial market over the past 5 years, with European

[19] "2005 Year in Review", Federal Aviation Administration, Office of Commercial Space Transportation, January, 2006.
[20] "2005 Year in Review", Federal Aviation Administration, Office of Commercial Space Transportation, January, 2006.
[21] "2005 Year in Review", Federal Aviation Administration, Office of Commercial Space Transportation, January, 2006.
[22] "2005 Year in Review", Federal Aviation Administration, Office of Commercial Space Transportation, January, 2006.

companies striving to gain market share.[23] Boeing, Lockheed Martin, Orbital Sciences, Alcatel Espace, Astrium, and Loral Space and Communications dominate the market. Several factors will impact the demand for telecommunications services over the next 5-10 years including the overall economic conditions, new market applications, competition with other non-space-based services (such as cable television), data compression technology, regulatory barriers, emerging competitors and the new trend towards investment firms' ownership of services companies.[24]

In the commercial remote sensing satellite sector, the major communications satellite manufacturers listed above as well as Ball Aerospace and Northrop Grumman have the capability to build state-of-the-art imaging satellites. No U.S. company has sold one of these satellites to an international customer, even though the 2004 national policy on remote sensing encourages trade in this sector. Export control concerns and indecision and/or lack of funding from foreign customers are the main reasons for the slow emergence of this market.

Domestically, two U.S. companies—GeoEye and Digital Globe—own and operate imaging satellite systems and sell the data commercially. The companies' success still hinges on purchases from their main customer, the U.S. Government. This government-customer focus will not change in the near term, but will slowly diminish as new applications are developed for commercial use, such as commercial mapping, mineral exploration, insurance appraisals, journalism/news media, and agriculture.

Competitors

Boeing

Boeing Launch Services Inc. (BLS), based in Huntington Beach, California, combines strategic planning, marketing and sales for government and commercial launch service customers on the U.S. built Delta launch vehicles and through the international Sea Launch venture. The Delta family of launch vehicles has the best reliability among U.S. vehicles and can launch satellites up to 13,100 kilograms to Geosynchronous Transfer Orbit (GTO). The Delta II, widely used by NASA and the U.S. Air Force, has demonstrated more than 98 percent reliability in more than 100 launches since 1989. Boeing has launch service contracts in place for Delta II through 2010, and will determine whether to continue using the Delta II based upon the needs of U.S. Government customers. Boeing Launch Services earned $290 million in 2005 revenues.[25]

Starting in 2002, the newly developed Delta IV launch vehicle has flown successfully in its first three flights, and its capabilities include launch pads on the East and West coasts of the United States, heavy lift capability and a U.S. designed and built engine, the RS-68 (Pratt & Whitney/Rocketdyne).[26] The Delta IV launch vehicle is currently only being offered for U.S. government launches, but could re-enter the commercial market if the demand for launches rose and prices increased.

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[23] Satellite Industry Association.
[24] "2005 Year in Review," Federal Aviation Administration, Office of Commercial Space Transportation, January, 2006.
[25] http://www.boeing.com/defense-space/space/bls/why_bls.html
[26] http://www.boeing.com/defense-space/space/bls/why_bls.html

In addition to the Delta family, Boeing launches commercial satellites through its Sea Launch venture, a joint venture involving Russia and Ukrainian rocket technology and a Norwegian transport ship and mobile sea-based launch platform. Based in Long Beach, California, Sea Launch transports its launch vehicle and spacecraft to a sea-based launch site near the equator, which provides additional launch power or extended spacecraft life, due to the Earth's increased gravitational pull there. Sea Launch remains in a highly competitive pricing war with Europe's Arianespace and ILS' Proton rocket, but recent contracts demonstrate that prices on all of these launch vehicles may be rising.

Boeing is also exploring another venture called "Land Launch". Land Launch would use a modified version of the Zenit Sea Launch rocket, but would launch from Baikonur Cosmodrome, Russia's land-based launch site in Kazakhstan. No contracts have yet been signed for Land Launch, though they are participating in several ongoing competitions.[27]

(Note: For financial data on The Boeing Company, please refer to chapter 2a, on Large Civil Aircraft).

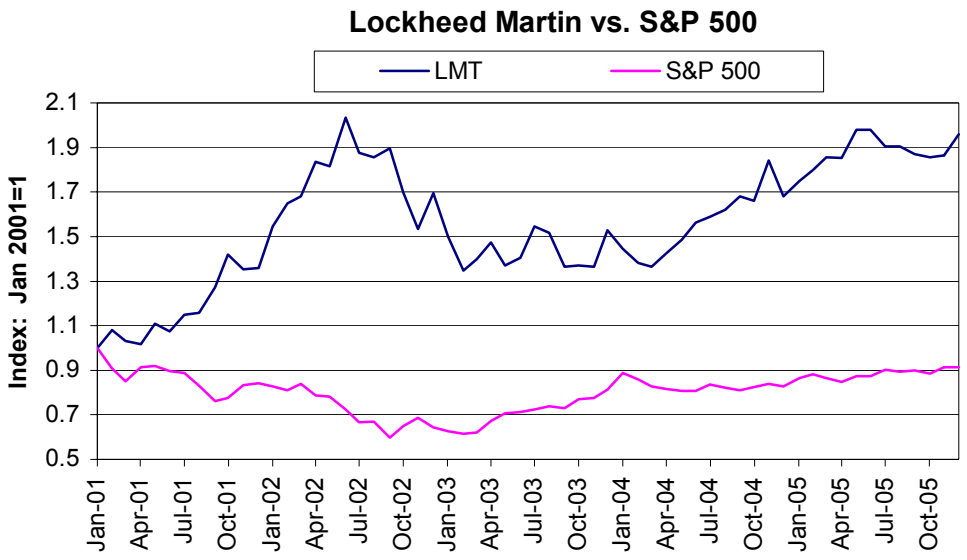
Lockheed Martin

International Launch Services was established in 1995 by Lockheed Martin and the Khrunichev State Research and Production Space Center to jointly market and launch the U.S.-built Atlas family of rockets and the Russian-built Proton rocket. The launch vehicles are not only marketed separately but are also offered as back-ups to each other in order to ensure timely launch schedules. Since 1995, ILS has signed contracts for more than 100 launches, valued at more than $8 billion (LMC). Having the two launch vehicles allows ILS to launch spacecraft of all weight classes.[28] The Atlas family launches both medium- and heavy-lift spacecraft, and can be launched from either the east or west coast of the United States, depending on the required orbit. The Proton targets heavier-class satellites and only launches from the Russian Spaceport, Baikonur, located in Kazakhstan. The vast range of capabilities and launch sites has allowed ILS to average one launch per month since the venture's inception (LMC)

FY	2005	2004	2003
Revenue (in million USD)	37,213	35,526	31,824
Operating Profit (in million USD)	2,986	2,089	2,019

Source: Lockheed Martin 2005 Financial Statements

[27] http://www.sea-launch.com/land-launch/index.html
[28] http://www.ilslaunch.com/whoweare/



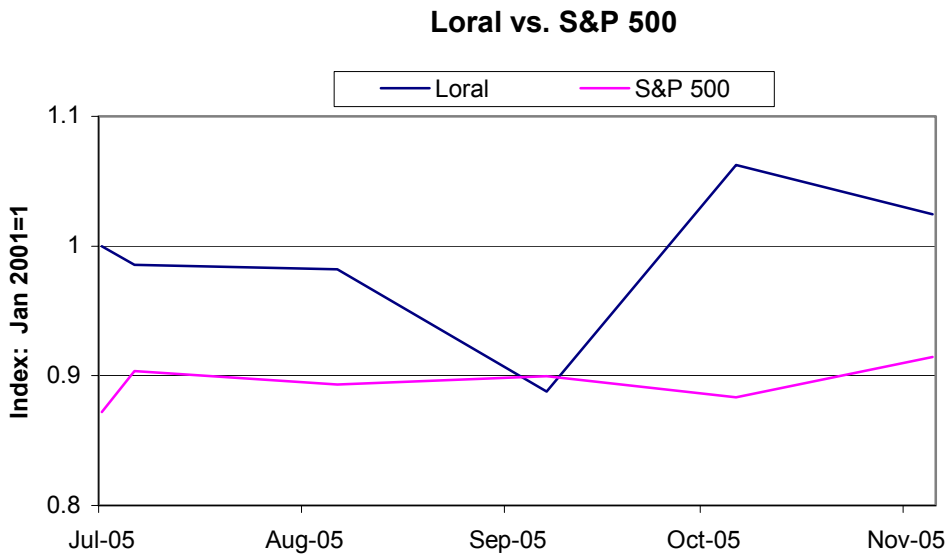
Source: *Wall Street Journal*

Loral

Loral Space and Communications designs and manufactures communications satellites for commercial and government customers. These satellites address such applications as direct-to-home television, broadband communications, wireless telephony, weather monitoring and air traffic management. Loral also owns and operates a fleet of communications satellites for broadcasting, Internet access and other communications services. Loral emerged from Chapter 11 of the federal bankruptcy code on November 21, 2005 and began "fresh start" accounting as of October 1, 2005. Therefore, financial information previous to the "fresh start" date is irrelevant to the new company's financial situation. Since reorganizing its business and operations under the bankruptcy filing, Loral has begun to attract new investors for its Globalstar telecommunications system and new customers for its satellites. Loral's leaner organization will also make it more competitive internationally.

FY	2005	2004	2003
Revenue (in million USD)	626.4	522.1	392.0
Operating Loss (in million USD)	(40.8)	(183.9)	(363.6)

Source: Loral 2005 10K



Source: *Wall Street Journal*

Europe: Arianespace, Alcatel SA and Astrium

Based in Evry, France, Arianespace is a group of 23 European aerospace companies that build the Ariane 5 launch vehicle.[29] Arianespace produces the Ariane 5 launch vehicle, which can launch up to 39,600 pounds to Low Earth Orbit (LEO).[30] In addition to Ariane 5 launches, Arianespace will soon offer launches of the Russian Soyuz rocket and the Vega rocket from its Spaceport in French Guiana.[31] Arianespace will remain extremely competitive in the commercial launch services sector, due to competitive pricing and a reliable launch vehicle. Arianespace conducted 5 commercial launches in 2005 and introduced a new variant (the Ariane 5 ECA) with improved technology and capability. Arianespace's launch schedule is sold out through 2006 and 2007, with only a few slots remaining for 2008.[32]

Arianespace, Inc.

FY	2005	2004	2003
Revenue (in million Euros)	1,068	657	559

Source: Clayton Mowry, President, Arianespace U.S.

Europe's key satellite manufacturers, Alcatal SA and EADS Astrium, develop, produce, and distribute telecommunications equipment and services. These companies will continue to close the gap technologically vis-à-vis U.S. manufacturers. While the U.S. seems to still maintain a cost advantage (aided partly by the weakness of the dollar), this advantage has also been

[29] http://www.arianespace.com/site/about/about_index.html
[30] http://www.arianespace.com/site/about/arianespace_today_sub_index.htm l
[31] http://www.arianespace.com/site/about/arianespace_today_sub_index.html
[32] "2005 Year in Review", Federal Aviation Administration, Office of Commercial Space Transportation, January 2006

shrinking as Europe produces a greater number of satellites and gains more technological expertise. In May 2006, EADS announced that it would merge its launcher and satellite activities into one entity "EADS Astrium" instead of "EADS Space". (Financial data for the EADS Astrium subsidiary was unavailable).

Alcatel SA

FY	2005	2004	2003
Revenue (in million Euros)	13,135	12,244	12,513
Operating income (loss)	1,189	1,179	(246)

Source: Bloomberg L.P., 2006.

Orbital Sciences

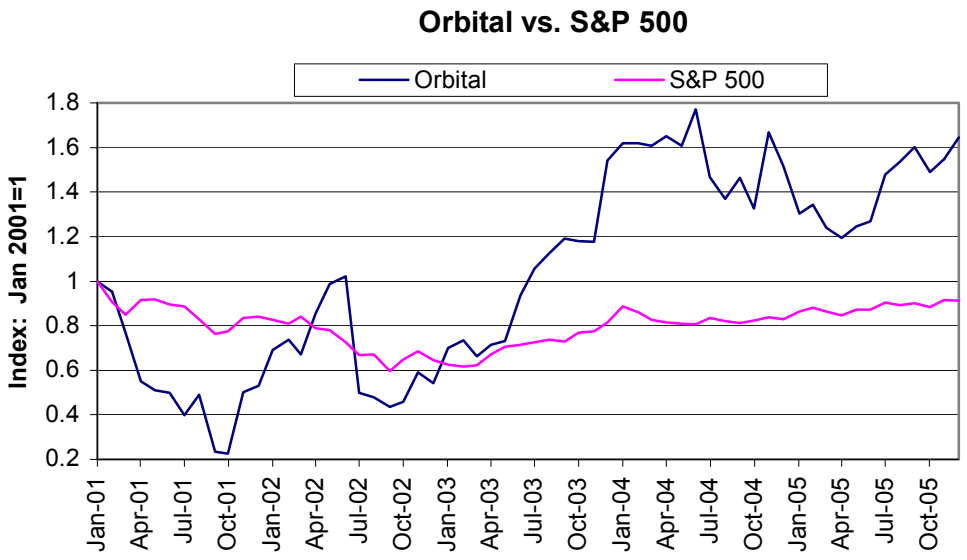
Founded in 1982, Orbital Sciences develops and manufactures smaller satellite and launch vehicles, which are generally less expensive than their competitors' larger, more powerful products. Orbital manufactures small geosynchronous (GEO) communications and broadcasting satellites, low Earth orbit (LEO) remote sensing and scientific satellites, lightweight launch vehicles, target rockets, and interceptor booster vehicles. The company performs space engineering services and also develops advanced space-based transportation management systems. Orbital Sciences has carved out a niche in the small- to medium-sized communications satellite sector, and attracts mid-range customers who do not require the power and capability of a large, state-of-the-art satellite. Orbital Sciences estimates that only 30 percent of its 2006 revenues will come from commercial and international customers, with nearly all of the remaining revenue generated by sales to the U.S. Government.[33] Communications satellites and launch vehicles will account for approximately 30 percent and 11 percent, respectively.[34]

Orbital Sciences Corporation

FY	2005	2004	2003
Revenue (in million USD)	703.5	675.9	581.5
Operating Profit (in million USD)	52.9	55.3	35.6

Source: Orbital 2005 Financial Statements

[33] http://www.orbital.com/About/
[34] http://www.orbital.com/About/



Source: *Wall Street Journal*

SpaceX

SpaceX is an entrepreneurial firm that is privately developing the Falcon family of launch vehicles. The company's goal is to reduce the cost of launch by a factor of 10 while increasing the reliability of those launches.[35] The company is located in Los Angeles, California and has test facilities in Central Texas. On its first test flight in January 2006, the Falcon 1 rocket exploded seconds after launch, causing a setback to the development of the larger launch vehicles in the Falcon family. While the Falcon 1 will provide lightweight launches, the Falcon 5 and Falcon 9 rockets will expand the company's capabilities into the medium- and heavy-lift classes to compete with Atlas, Proton, Ariane and Sea Launch.[36] Though the Falcon 1 has a reusable first stage, the Falcons 5 and 9 are planned to be fully reusable. SpaceX can launch from Cape Canaveral, Florida; Vandenburg Air Force Base, California; and Kwajalein Atoll in the Marshall Islands. SpaceX currently has contracts for up to seven additional launches, five of which are for commercial customers.[37] The recent failure could cause some of these customers to explore other launch options due to reliability or scheduling concerns. SpaceX is financed solely through private investment and development costs are confidential.[38]

China

China has had the ability to launch commercial satellites since the late 1980's, but has not conducted a commercial launch since 1999, mainly due to difficulties with export controls. Due to Tiananmen Square sanctions that remain in place, U.S. satellites being shipped to China for

[35] http://www.spacex.com/
[36] http://www.spacex.com/
[37] http://www.spacex.com/
[38] http://www.spacex.com/

launch must receive a waiver from the President before shipment. When faced with such a difficult requirement, satellite customers have chosen other launch providers instead.

Even in the face of a lagging commercial business, China continued to develop its launch program and safely launched humans into space for a second time in 2005. In fact, China launched 5 non-commercial spacecraft in 2005.[39] China has also worked with Brazil and Europe to develop advanced satellite technology and will likely begin offering low-cost, mid-size satellites on the international market within five years. With the appearance of these satellites, China likely will link low-cost launches with its satellite sales in Asia, and a re-emergence of China's commercial launch industry may occur over the next 5-10 years. Given the continued oversupply in the satellite market and China's lagging technology, China will only win these contracts with extremely low prices, negatively impacting U.S. manufacturers.

India

India has stated a strong interest in entering the commercial launch services market. In 2005, India performed one launch for the Indian Government, which was its ninth launch of the Indian PSLV rocket.[40] India's larger GSLV rocket did not launch in 2005, but has performed successfully in the past. In the commercial market, India is likely to win an average of one launch per year for a few years, mainly through promotional pricing, package deals, partnership programs with Europe, etc.[41] Because of India's launch vehicles' limited capabilities and size, India likely will not gain a significant portion of the market in the short term.

India intends to enter the commercial communications satellite market. India has already manufactured several communications and remote sensing satellites for the Indian Government, and is now actively seeking international customers. India has also explored joint ventures with U.S. and European companies to build communications satellites. The U.S.-India High Technology Cooperation Group (HTCG) is exploring areas in which cooperation in the space sector can be increased between the two countries. Areas likely to be considered are space research and development, joint satellite production and the ability to launch U.S. satellites and/or components on Indian rockets.[42]

Other Emerging Providers

In 2005, Japan conducted two orbital launches on its H-2A launch vehicle, but neither of them was for a commercial customer. While Japan has indicated an interest in commercial launches, recent problems with the H-2A rocket and high costs of production have kept Japan from being competitive in this market to date.

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[39] "2005 Year in Review," Federal Aviation Administration, Office of Commercial Space Transportation, January 2006.
[40] "2005 Year in Review," Federal Aviation Administration, Office of Commercial Space Transportation, January 2006.
[41] "2005 Year in Review," Federal Aviation Administration, Office of Commercial Space Transportation, January 2006.
[42] http://www.bis.doc.gov/InternationalPrograms/IndiaCooperation.htm

Several entrepreneurial companies, such as Transformational Space and Bigelow Aerospace, are developing new launch vehicles and satellites that are intended to lower launch costs and support the Vision for Space Exploration. The majority have minimal financing, and have not moved beyond the initial program design stage. It is likely that many of these companies will not survive on their own, but they may consolidate with other companies or participate in cooperative technology programs with other larger, more established companies.

A few U.S. states are also exploring building commercial "spaceports", for launching commercial launches and space tourism flights. FAA regulations are currently reviewing safety factors impacting such facilities, and the proposed spaceports will be reviewed on a case-by-case basis. The states that are interested include New Mexico, California, Florida, Virginia and Oklahoma, among others.

Analysis

Trends

Telecommunications satellites are being built larger and heavier in order to provide greater amounts of service and longer satellite lifetime. In turn, these satellites require larger, heavier launch vehicles. Greater size reduces the likelihood of launching two satellites on one launch vehicle, a practice that was more common in the 1990s. On the other hand, Orbital Sciences has carved out a small niche market providing medium-sized satellites to customers requiring a smaller amount of capacity. Orbital Sciences contracts to build a few of these satellites every year, mainly to mid-size customers.

USG purchases will remain and may become even more important for U.S. companies as the commercial market remains flat. However, the unreliable schedule associated with government launches and the move from "lot buy" purchases to annual awards for launches will negatively impact second and third-tier suppliers. The result is that the overall price associated with those launch vehicles will be higher because of the inability to take full advantage of rate and quantity discounts from critical suppliers. Additionally, the merger between Pratt & Whitney and Rocketdyne, the country's major suppliers of rocket engines, limits the ability of U.S. launch vehicle manufacturers to negotiate better prices for propulsion.

There are several factors that may stimulate growth in the launch market. For instance, if NASA decides to rely mainly upon the use of commercial suppliers to deliver cargo and supplies to the International Space Station, the market could get a significant annual boost. Additionally, the development and stabilization of the space tourism market could encourage growth in the sector, though this could take 10 or more years.

During the 1990's, the telecommunications boom encouraged a large number of entities around the globe to enter the market with new launch vehicles or to increase their production rates. Unfortunately, the telecommunications crash left an oversupply in the launch sector of approximately 5:1, and an estimated oversupply in the telecommunications satellite sector of 4:1, which simply eliminated normal profit margins.[43] This oversupply resulted in a reduction of

[43] U.S. Department of Commerce, Office of Aerospace and Automotive Industries.

launch prices that stabilized nearly 40 percent below mid-1990's prices.[44] Those prices have risen slightly over the past year for all launch providers. This may be due to a slight rationalization of the oversupply for these vehicles, or a late attempt by the major launch suppliers to regain profitability.

The oversupply and extremely low launch prices have essentially pushed the U.S. manufactured launch vehicles out of the commercial launch business, forcing the U.S.-international joint ventures to market their foreign launch vehicles for commercial launches and the U.S.-manufactured launch vehicles for U.S. Government launches. Within the joint ventures, U.S.-manufactured launch vehicles are really only being offered as backup launches to the foreign partner launch vehicles in case a failure would delay a customer's launch. To highlight this point, in 2006, Lockheed Martin's Atlas launch vehicle will be the only U.S. manufactured launch vehicle to launch a commercial satellite.

The then-projected launch demand has never materialized, and the launch market has remained flat, with many proposed telecommunications projects disappearing. With most communications programs solely focusing on system maintenance and not the creation of new systems, the market is expected to remain flat for at least another 5-7 years.[45] Investors generally remain leery of space, due to the sector's high risk and slow returns on investment. However, investments in telecommunications satellite systems in May 2006 may be pointing towards a return in investor confidence in this sector, and investment in some telecommunications systems may increase. Even with a possible small upturn, the launch and satellite markets will not be able to fully resolve the oversupply problem, since India, China and a few small, entrepreneurial ventures continue to strive to enter the launch and satellite markets.

Another trend having a small impact on the market is the increased interest from entrepreneurial manufacturers to develop low-cost alternatives to the established launch providers. With the successful flight of Space Ship One, and the ongoing competitions sponsored by the Federal Aviation Administration to develop new technologies, this sector has seen been reenergized. However, to turn these demonstration launches into successful suborbital and/or orbital space tourism operations will require huge investments, the development of new safety and operational guidelines, and the ability to use new technologies regularly and at a reasonable cost. With short space tourism flights currently predicted to cost approximately $200,000 per person per flight, space tourism remains only in the grasp of millionaires.[46] Until this cost can be reduced, the market will not flourish. This market will remain immature for at least 10 years, but the advances in innovation will spur further research and development in the meantime.

The more stringent enforcement of U.S. export control policies in the late 1990's and the international perception that U.S. export licensing laws would negatively impact a customer's ability to acquire a U.S. satellite hurt the ability of U.S. satellite manufacturers to compete internationally. Even though larger companies have learned to manage these requirements, they remain a heavy burden for smaller companies and entrepreneurial ventures that lack expertise in this area. Europe's response to the U.S. export control policies has been to develop

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[44] U.S. Department of Commerce, Office of Aerospace and Automotive Industries.
[45] U.S. Department of Commerce, Office of Aerospace and Automotive Industries.
[46] http://www.virgingalactic.com/en/when.asp

communications satellites that do not contain any U.S. components. A small number of these satellites have been sold, highlighting international concern about buying from the United States. Europe's response has probably had the greatest impact on second- and third-tier suppliers who are no longer supplying to European customers while simultaneously watching U.S. market share decline.

A smaller trend is the desire for national security spacecraft to have the ability to be launched "on demand". The Department of Defense and the commercial industry are working together to develop guidelines that would encourage "operationally responsive launch". Given that manufacturing a launch vehicle and/or a satellite requires 12-18 months, this goal won't be achieved for at least 10 years and will take substantial investments in inventories and production lines, which is unlikely given the current limited investment climate.

Following the telecommunications crash, several major companies sought ways to consolidate with others in order to survive. As a result, the satellite services sector has seen a fundamental consolidation, with the ultimate owners often being financial or investment entities, rather than traditional aerospace firms. The two remaining behemoths include SES Astra-GE Americom-New Skies and Intelsat-PanAmSat-Loral Satellite Services. This consolidation was unthinkable in the 1990s during the telecommunications boom, but is necessary in the current economic climate. Moreover, this sector continues to compete with non-space based solutions which can meet the same high-technology needs, such as cellular phones, cable television and other information technologies.

Policy issues

Since 2004, the President has signed four new policies supporting the space sector, and the Administration is still working to conclude an overarching National Space Policy that would provide guidance to all space sectors on functional issues such as acquisition. The President's policies address the remote sensing; space-based positioning, navigation and timing (also known as GPS); and space transportation industries. The Vision for Space Exploration directs NASA to return humans to the Moon by 2020 as a stepping-stone to explore Mars. Each of these policies states that the USG will not develop systems that will directly compete with the commercial industry and that the USG should seek to rely upon commercial solutions when possible. The policies also state that USG satellites and spacecraft should be launched upon U.S. launch vehicles, except under specific international cooperation situations. Enforcement of these and other similar policy guidelines will be essential to promoting the health and growth of this industry, especially while the commercial market remains flat.

Key Competitions

Due to the limited size of the launch market, and the small nature of contracts, there are no ongoing competitions that would have a fundamental impact upon the international commercial market. Depending upon how NASA decides to work with U.S. and foreign industry partners on the Vision for Space Exploration programs, U.S. companies could receive a large amount of USG work, which would have a substantial impact on the health of the sector, though not the "commercial" market.

General Aviation

Overview

U. S. general aviation manufacturers shipped 2,857 units in 2005, marking the best year for general aviation since 1982.[47] Exports represented 19.5 percent of total production and nearly 30 percent of total billings. Worldwide, estimated billings were up 27 percent over 2004 to $15.14 billion, mostly due to significant gains in business jets.

Growth is expected to continue in 2006, in part due to continued demand from fractional ownership companies and to the introduction of very light jets. Both the Honeywell Five-Year Forecast[48] and the Roll-Royce Outlook[49], reliable industry forecasting tools, predict that manufacturers will deliver over 800 business jets for the first time in history. Although North America is expected to remain the top market for aircraft sales, manufacturers are also turning increased attention to potential high-growth markets such as China and India.

General Aviation Manufacturers

Adam Aircraft
Airbus
American Champion
AvCraft Aviation
Aviat Aircraft
Boeing Business Jets
Bombardier
Cessna Aircraft Company
Columbia Aircraft
Cirrus Design Corporation
Dassault Falcon Jet
Diamond Aircraft

Analysis

General aviation encompasses a wide variety of planes, from very large corporate jets such as the Gulfstream GV or the Boeing Business Jet to experimental aircraft built in a garage. Most available data, however, centers on the turboprop, piston, and jet aircraft built by 24 manufacturers worldwide. This analysis will focus on these manufacturers.

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[47] Unless otherwise noted, all statistics and figures are taken from the General Aviation Manufacturers Association's General Aviation Statistical Databook, 2005.
[48] Honeywell Five-Year Forecasts. *World Aircraft Sales Magazine.* December 2005. p. 58. Available on the web at http://www.avbuyer.com/PDFs/HoneywellDEC05.pdf .
[49] "The Outlook, March 2006 Update." Rolls-Royce. Available on the web at http://www.rolls-royce.com/civil_aerospace/overview/market/outlook/downloads/outlook0306.pdf .

The year 2005 saw the recovery of the general aviation market, with both shipments and billings surpassing pre-September 11 levels. By number of units, the largest segment of the market was piston airplanes, which accounted for 68 percent of airplanes shipped. Piston aircraft are the smallest and least expensive on the market and thus traditionally make up the largest segment of GA deliveries. Due to their size and relative low-cost these planes are often marketed as personal aircraft, though they are used as business aircraft. Over half of last year's piston airplane deliveries were by two U.S.-based manufacturers, Cessna Aircraft (822 units), a division of Textron Corporation, and Cirrus Design (600 units). Piston airplanes accounted for 5 percent of total billings for 2005.

Turboprop aircraft represented the smallest segment of the market by units and is the one segment of the general aviation market not to have recovered to pre-September 11 levels. Despite this, however, the turboprop market accounted for nearly 8 percent of billings in 2005, placing it a head of piston aircraft. Turboprop airplanes have begun to incorporate some of the technological innovations typically found in business aircraft[50] and generally cost more than piston aircraft. Raytheon is the largest seller in this market segment, accounting for nearly one-third of the market in 2005 (114 units).

Turbojets/turbofans (usually referred to as business jets) represent the most profitable and most widely tracked segment of the general aviation market, accounting for nearly 87 percent of total billings in 2005. Once again, Cessna is the largest seller in this category with 247 units shipped in 2005, followed by Bombardier (188 units) and Raytheon (141 units). Due to their price, business jets are traditionally not used as personal aircraft. Advances in aviation technology are quickly adopted by business jets manufacturers motivated by consumer demand and a constant quest to improve safety.

A significant factor in the demand for business jets has been the rise of fractional ownership companies (sometimes called "fractionals"). Fractional ownership companies own fleets of business aircraft and sell shares of the aircraft to consumers, who thus avoid the cost of maintaining their own planes. The smallest shares allow for 25 hours of flying. The fractional customers buy shares in a specific type of aircraft owned by the fractional ownership company, with the expectation that the plane will be provided when requested. In order to meet that obligation, the fractionals maintain large fleets and are sometimes forced to charter additional aircraft when the requested model is unavailable. According to Honeywell's Five-Year Forecasts, fractionals are expected to take delivery of 80-100 aircraft per year over the next 5 years.[51]

The business jet market stands to expand even further in 2006 with the introduction of very light jets (VLJs).[52] VLJs are classified as single-pilot aircraft that weight less than 10,000 lbs and with a range of about 1,000 miles. VLJs are currently being developed by about a dozen manufacturers, and including Cessna, Adam Aircraft, and Honda Motors, the automobile manufacturer. The first entry in this market is likely to be Eclipse 500, which should be certified

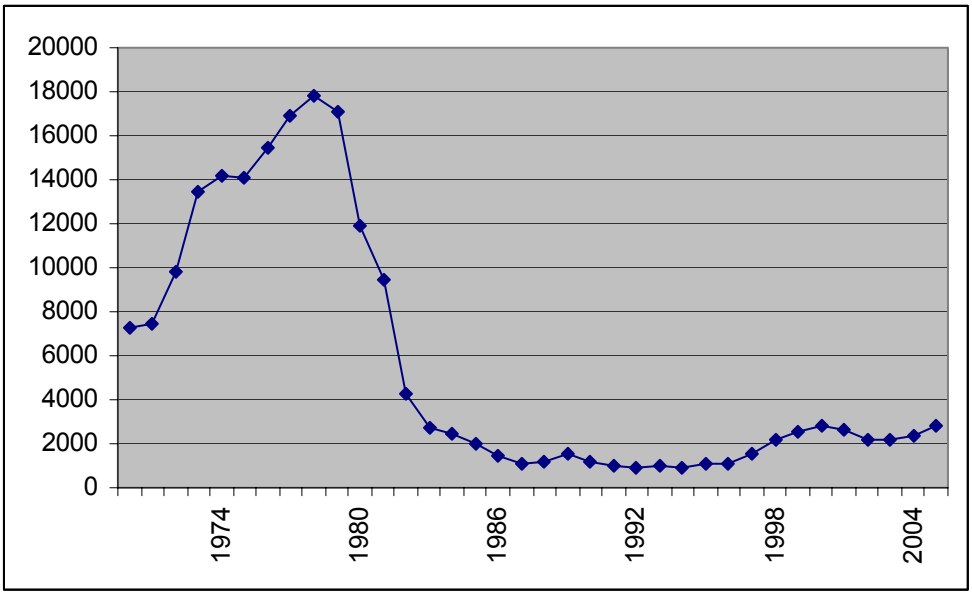
[50] GAMA Annual Industry Review and 2006 Market Outlook. p.4.
[51] Honeywell Five-Year Forecasts. p. 62.
[52] Very light Jets are called Ultra Light/Personal Jets in Honeywell's Five-Year Forecasts

by the Federal Aviation Administration in the summer of 2006. These jets could play a great role in the air taxi and charter business, which has expanded significantly in the post-September 11 security environment.[53] In addition, some VLJs priced between $1-$2 million may also be marketed as personal aircraft

Trends

In 1994, Congress passed General Aviation Revitalization Act, which placed a time limit on the legal liability of manufacturers and effectively ended the dramatic decline in shipments that had persisted throughout the 1980s and early 1990s. Since that time, general aviation shipments are up over 200 percent, from 928 aircraft in 1994 to 2,857 aircraft in 2005. While neither the piston nor turboprop markets have approached their earlier levels, the business jet market has actually surpassed previous sales records to become the most lucrative segment of the market.

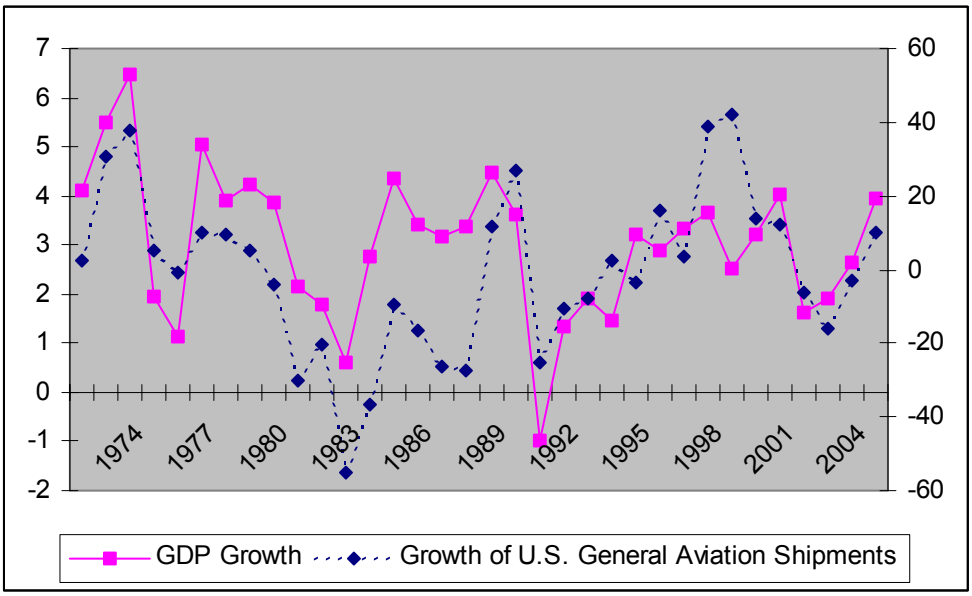
Chart 1: Shipments of general aviation aircraft produced in the United States, 1970-2005[54]



As with large aircraft sales, gross domestic product growth in a good indicator for the health of the general aviation market. Since business aircraft are generally viewed as a luxury item, businesses tend to purchase a new plane or replace an old one when the economy is strong and profits are up. The chart below indicates that changes in the general aviation market tend to lag GDP growth by one year. General aviation shipments thus suffered during the recessions in the early 1990s and 2000s, and rosy GDP predictions for 2006

[53] Davis, Tom. "For some travelers, it's the only way to fly; but critics question air taxis' security." *The Record,* April 2, 2006.
[54] Data from the General Aviation Manufacturers Association's General Aviation Statistical Databook, both the 2002 and 2005 editions.

Chart 2: Global GDP Growth and U.S. General Aviation Shipment Growth, 1971-2004[55]



Competitors

About 80 percent of all general aviation aircraft shipped in 2005 were made in the U.S. By number of units, the biggest international competitor is Diamond Aircraft, which manufactures piston engine planes in Austria and Canada. In 2005, Diamond Aircraft shipped 329 planes, placing it behind only Cessna and Cirrus Design in the piston airplane category. Diamond's market share in deliveries has grown from 9 percent in 2002 to 13 percent in 2005. This growth can be attributed to the new plane it introduced in 2005 and to several other manufacturers exiting the market.

In billings, the biggest international competitor is Bombardier; by that measure, Bombardier is actually the largest general aviation manufacturer in the world. However, a significant portion of Bombardier's billings comes from Learjet, which are manufactured in Wichita, Kansas. Likewise, Gulfstream, the second largest general, aviation manufacturer by billings, manufactures some aircraft in Israel.

Bombardier's success in the business jet market has helped offset problems with its regional jet business. Seventy percent of the market of the market for regional jets is in the United States,[56] and the poor financial position of many American airlines has resulted in poor sales for Bombardier and its main competitor, Embraer. Hoping to take advantage of the growing business jet market, Embraer delivered its first business jet in 2002, and should introduce two more models in 2006. Embraer exited the piston airplane market in 2001.

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[55] Data points represent percent changes over the previous year. GDP data downloaded from the National Accounts Main Aggregates Database, United Nations Statistical Division. (Search terms World, GDP, Annual Average Rate of Growth – Percentage, and ALL years). Available on the web at http://unstats.un.org/unsd/snaama/selectionbasicFast.asp

[56] Bloomberg.com. "Bombardier 4th-Qtr Profit Rises on Private-Jet Demand." March 29, 2006.

Airbus, like Boeing, is only a minor player in the business jet field. Both companies' business jets are modified versions of their popular commercial aircraft (the A319 for Airbus and the 737 for Boeing). Both are also relatively new entrants to the business jet market, delivering their first planes in 2001 and 1998 respectively.

Market

North America remains the largest market for business aircraft, thanks in part to the strengthening stock market and the growth of fractional ownership companies. Indeed, Richard Santulli, CEO of NetJets, noted in June, 2005 that he'd like to have 20 more planes but he "just can't find them."[57] FAA estimates that the 2005 turbojet fleet totaled 8,628 aircraft in 2005 and projects it will reach 17,270 by 2017.[58]

According to Honeywell's Five-Year Forecast, however, the purchase expectations for North America are expected to decline in 2006, as many operators have already ordered or received new planes.[59] Purchase expectations for the rest of the world, however, are expected to increase, with those areas with the smallest number of operators (Asia, Africa, and the Middle East) growing the fastest.

Figure 1: Fixed-wing Turbine Business Aircraft Operators by Region, 2003[60]

Region	Number of Operators
North America	10,982
Europe	1,255
South America	979
Central America	485
Africa	379
Asia and Middle East	332
Oceania	143

Figure 2: Fixed-wing Turbine Business Aircraft Fleet by Region, 2003[61]

Region	Number of Planes
North America	16,650
Europe	2,378
South America	1,255
Rest of World	2,560

[57] Bloomberg.com. "Buffett's NetJets Soars as Wall Street Bonuses Buy Flight Time." June 22, 2005.
[58] Federal Aviation Administration. Table 27. *FAA Aerospace Forecasts FY 2006-2017.* Available on the web at http://www.faa.gov/data_statistics/aviation/aerospace_forecasts/2006-2017/media/Tables%201%20-%2034.pdf .
[59] Purchase expectations refers to the number of planes fleet operators plan to replace or expand by, according to Honeywell survey respondents. Honeywell Five-Year Forecast. p. 60.
[60] National Business Aviation Association. NBAA Factbook 2004, p. 21.
[61] National Business Aviation Association. NBAA Factbook 2004, p. 21.

The emergence of a strong business aviation community in Asia has been hampered by regulation and by an aversion to what are perceived to be ostentatious luxury items. Japan, an OECD member, has turbine fleet of 90 planes and only 20 of these are owned by the private sector. China has slowly been opening its doors to business aviation in 2005 a Chinese company sold the first Chinese-made small aircraft to the Flight College of the General Administration of Civil Aviation of China. Many barriers remain, however, the most significant being the continued military control over 90 percent of China's airspace. China has a total business aviation fleet of 42 planes, and of these only 2 are owned by companies.[62] India is also trying to encourage domestic production of small aircraft in partnership with some European companies. Like China, India has fewer than 50 business aircraft.[63]

[62] Jan Kot. "Aviation players zero in on China." *Business Travel News*. September/October 2005. Available on the web at http://www.btnap.com/bt/btn-200509/briefing/index.shtml .
[63] Joseph C. Anselmo. "Maybe Tomorrow." *Aviation Week and Space Technology.* March 6, 2006.

Engines/Powerplants

Overview

The large civil aircraft jet engine market is dominated by a few individual manufacturers and a few joint ventures comprised of one or more of these players along with a smaller company or companies. With one exception, the major engine manufacturers are a part of diversified corporations[64] producing engines for both civil and military aircraft, either alone or as part of one or more joint ventures.

Three major manufacturers dominate the large commercial jet engine market. Of the three, General Electric Aircraft Engines (GEAE) and Pratt & Whitney are the two largest U.S. manufacturers, with Rolls-Royce PLC (United Kingdom) being the largest non-U.S. producer.

The dominant engine manufacturers also participate in various joint ventures. These ventures are formed to capitalize on emerging market demand for engines, while at the same time allowing partners to share development and production costs along with risk. CFM International, a joint venture of GEAE and Snecma Moteurs of France, produces the CFM56, which is used in various Boeing and Airbus aircraft and is the sole engine option for the Boeing 737. International Aero Engines AG, a consortium comprised of Pratt & Whitney, Rolls-Royce, German engine manufacturer MTU Aero Engines GmbH and the Japanese Aero Engines Corporation, produces the V2500 engine for use in the Airbus A319/A320/A321. Finally, the Engine Alliance, a 50/50 joint venture between GEAE and Pratt & Whitney, was formed to produce an engine for the Airbus 380.

In addition to their jet engine production for LCA aircraft manufacturers Boeing and Airbus, GEAE, Pratt & Whitney and Rolls-Royce produce engines for regional jet manufacturers Bombardier and Embraer and also manufacture a variety of turboshaft and turboprop engines for both military and civil applications.

Competitors

General Electric Aircraft Engines

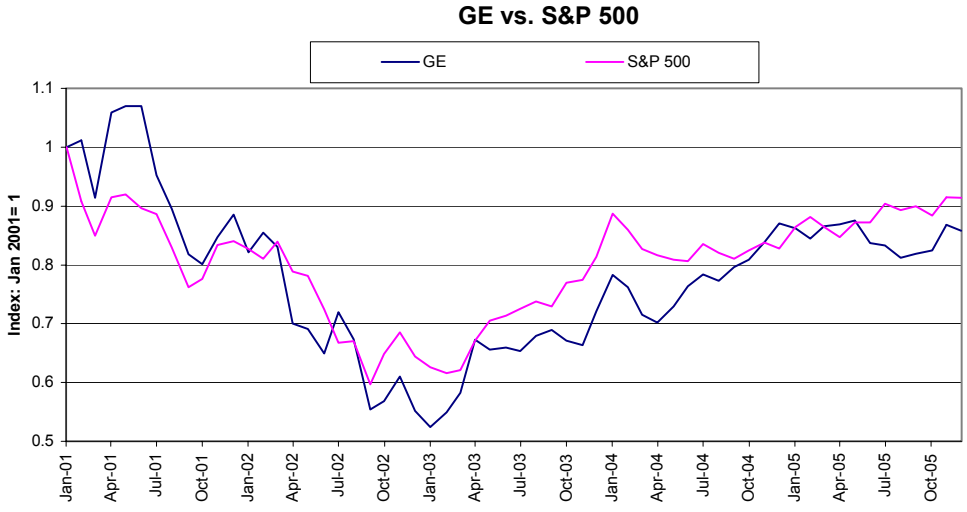
General Electric Aircraft Engines (GEAE) is currently the world's largest producer of engines for commercial and military aircraft, with FY 2005 sales of $11.9 billion and an operating profit of $2.57 billion. GEAE is a division of GE's Infrastructure operating segment, which is itself a subsidiary of GE, the most diverse of the parent companies of the top three engine manufacturers. In FY 2005, GEAE accounted for about 8 percent of GE's total sales and about 11 percent of the company's operating profits.[65] GEAE manufactures turbojet, turboprop and turboshaft engines for both military and commercial applications to include wide body cargo and passenger jets, regional jet and turboprop aircraft, bombers and helicopters. In addition, GEAE

[64] In FY 2005, Rolls Royce civil and defense aerospace segments comprised a combined 74 per cent of the company's total revenues. See Rolls Royce PLC 2005 Financial Report Review of Operations.
[65] GE 2005 Annual Report "Summary of Operating Segments." In FY 2005, Aviation revenues were $11,904,000,000 and segment profit was $2,573,000,000.

also produces aircraft engine derivatives for marine propulsion and industrial power sources.[66] For after sales service, GEAE's OnPoint program offers a portfolio of engine maintenance, repair, exchange programs and availability of new and used parts for GE-produced engines.[67] GEAE's primary manufacturing facilities are located in nine U.S. states, and the company has overhaul, on-wing support and component repair in facilities around the world.[68] As of 2005, the company had 26,500 employees worldwide.[69] In addition to GE's participation in joint ventures the Engine Alliance and CFM International (see below), the company has also formed GE Honda Aero Engines LLC, a joint venture with Honda Aero, Inc. to develop, manufacture and support engines for use in light business jets.[70]

FY	2005	2004	2003
Revenue (in million USD)	11,904	11,094	9,808
Operating Profit (in million USD)	2,573	2,238	1,809

Source: GE 2005 Annual Report; 10K



Source: *Wall Street Journal*

Rolls-Royce PLC

Rolls-Royce PLC (Rolls-Royce) is the second-largest aircraft engine maker in the world behind GEAE. Rolls-Royce manufactures commercial and military jet engines for military, airline, and corporate aircraft customers worldwide. Through its wholly owned subsidiary Rolls-Royce North America; the company manufactures engines in the United States for regional and corporate jets, helicopters, and turboprop aircraft. Rolls-Royce also constructs and installs power generation systems and is one of the world's largest makers of marine propulsion systems.

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66 Hoover's Company Records – In-depth Records GE Aircraft Engines.
67 http://www.geae.com/services/onpoint_getonpoint.html .
68 http://www.geae.com/aboutgeae/facilities/index.html .
69 http://www.geae.com/aboutgeae/factsheet.html .
70 http://www.gehonda.com/index.html; http://www.gehonda.com/company/index.html .

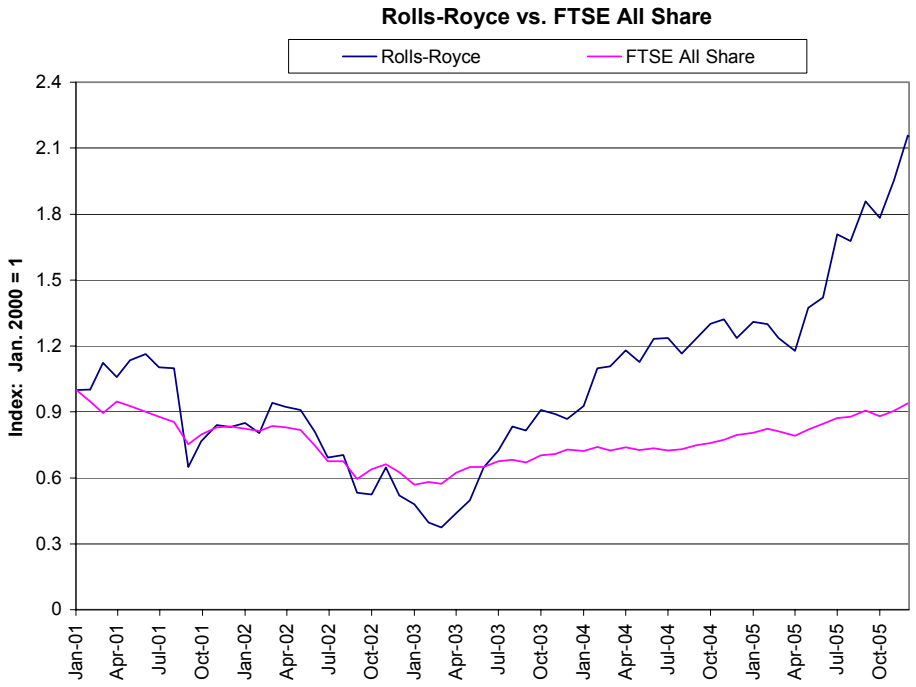
Via the company's Services business segment, Rolls-Royce offers aftercare and service support for its engine products.[71] In FY 2005, Rolls-Royce realized combined revenue of 4.92 billion pounds sterling and an operating profit of 634 million pounds sterling in its Civil and Defense Aerospace segments. These segments accounted for about 75 percent of Rolls-Royce's total revenue and about 72 percent of the company's operating profits.[72] As of 2005, Rolls-Royce had approximately 36,000 employees worldwide, with almost 8,000 of that total based on North America.[73]

In addition to its North American subsidiary, Rolls-Royce also uses joint ventures to increase its global presence and spread risk, most notably with their 32.5 percent share in the International Aero Engines consortium described in the joint ventures section below.[74] Rolls-Royce has operations in about 15 different countries and sells its products around the world.[75]

FY	2005	2004	2003
Revenue (in million £)	4,923	4,414	4,092
Operating Profit (in million £)	634	373	278

Source: Rolls-Royce PLC 2005 Annual Report

[71] Hoover's Company Records – In-depth Records Rolls-Royce PLC.
[72] Rolls-Royce 2005 Annual Report Consolidated Income Statement and Review of Operations for Civil Aerospace and Defense Aerospace.
[73] Rolls-Royce 2005 Annual Report Consolidated Income Statement and Review of Operations for Civil Aerospace and Defense Aerospace. In FY 2005, Rolls-Royce PLC realized total revenue of 6.60B £ and an operating profit of 879M £. Civil Aerospace realized 3.51B £ in revenue and 454M £ in operating profit. Defense Aerospace realized 1.41B£ in revenue and 180M£ in operating profit.
[74] http://www.i-a-e.com/company/facts.shtm .
[75] See Hoover's Company Records – In-depth Records Rolls-Royce PLC.



Source: *Wall Street Journal*

Pratt & Whitney

Pratt & Whiney is the world's third-largest producer of aircraft engines and second-largest in the United States with FY 2005 sales of $9.3 billion and an operating profit of $1.45 billion.[76] Pratt & Whitney is a subsidiary of United Technologies Corporation (UTC), a diversified company whose products include heating and air conditioning, aerospace systems and industrial products, elevators and escalators, aircraft engines, fire/security systems and fuel cells.[77] In FY 2005, Pratt & Whitney accounted for about 22 percent of UTC's total sales and about 27 percent of its operating profits.[78] Pratt & Whitney manufactures and services commercial and military aircraft engines and produces space propulsion systems. Pratt & Whitney has facilities in 13 U.S. states and various other worldwide locations. In addition, Pratt & Whitney Canada manufactures fixed-wing and helicopter aviation engines for business, general aviation, military, regional, utility, and agricultural applications.[79] As of 2005, Pratt & Whitney had approximately 40,000 employees worldwide.[80] Pratt & Whitney is also a 50/50 joint venture partner in the Engine Alliance, which will produce the GP7000 turbofan engine for use in the Airbus A380.[81]

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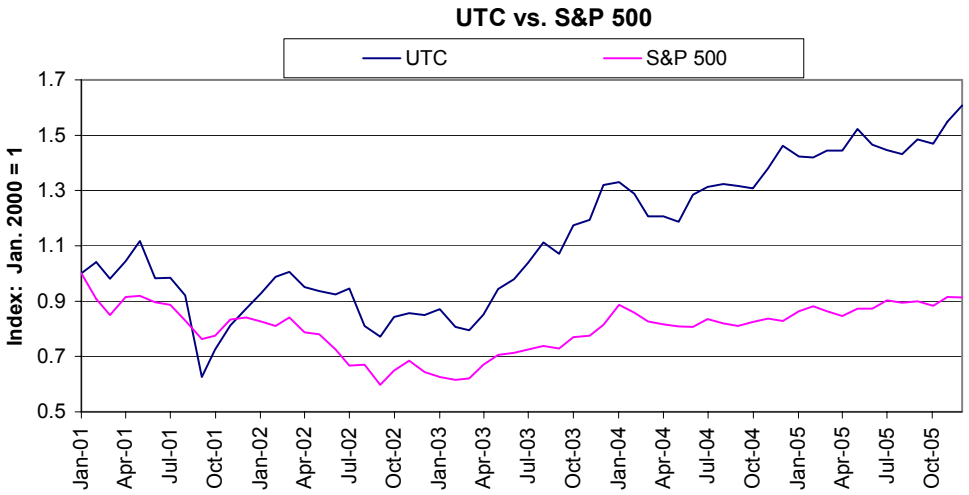
[76] http://www.utc.com/profile/facts/index.htm
[77] Hoover's Company Records – In-depth Records Pratt & Whitney.
[78] UTC 2005 Annual Report "Segment Review." In FY 2005, Pratt & Whitney revenues were $9,295,000,000 and segment operating profit was $1,449,000,000.
[79] Hoover's Company Records – In-depth Records Pratt & Whitney Canada .
[80] http://www.pratt-whitney.com/about_facts.asp .
[81] http://www.enginealliance.com/aboutintro.html .

FY	2005	2004	2003
Revenue (in million USD)	9,295	8,281	7,484
Operating Profit (in million USD)	1,449	1,083	1,063

Source: UTC 2005 Annual Report



Source: *Wall Street Journal*

Joint Ventures

The Engine Alliance

The Engine Alliance is a 50/50 joint venture between General Electric and Pratt & Whitney. The venture was formed in 1996 initially for the purpose of developing a new turbofan engine in the 70,000– 85,000 lb. range for use on Boeing's announced "growth" version of its 747. As neither company had an existing engine in its inventory in the necessary thrust range, GE and Pratt & Whitney decided to form an alliance to combine the core competencies of both companies in the production of such an engine and to share the approximately $1 billion associated development costs. When Boeing eventually declined to develop the growth 747 model variant due to a lack of demand, the Engine Alliance refocused development of their engine toward use on the Airbus A380.[82] The GP7200 engine is now the market leader in engine orders for the A380 with a total of 72 firm orders, which constitutes 55 per cent of the total market.[83] The Engine Alliance's sole competitor for the Airbus 380 powerplant is the Rolls-Royce Trent 900 engine, which has been selected as the launch engine for the A380 and which is planned to go into service in late 2006.[84]

[82] http://www.enginealliance.com/aboutintro.html .
[83] http://www.enginealliance.com/aboutmrkt.html .
[84] http://www.rolls-royce.com/civil_aerospace/products/airlines/trent900/default_flash.jsp .

CFM International

CFM International (CFM) is a joint venture of General Electric and France's Snecma Moteurs, a member of the SAFRAN Group of defense security, aerospace equipment, propulsion, and communication companies. As a joint venture, all CFM employees are actually fact employed by the joint venture partners. Similarly, CFM's engine and service sales go to the bottom line of its parent companies.[85] CFM manufactures its CFM56 series of engines for more than 400 commercial and military customers worldwide. The company's name stems from a combination of CF6 and M56, designations for commercial aircraft engines manufactured by GE and Snecma. GE manufactures CFM International's engine cores and assembles roughly half of its engines; Snecma makes the fans and rotors and assembles the rest of the engines. CFM International's CFM56-3 is the sole engine option for Boeing's 737-300/400/500 models, and the company also manufactures engines for the DC-8, Airbus A319/320/321/340s, and the Boeing KC-135 and E-3 AWACS.[86]

International Aero Engines AG (IAE)

International Aero Engines AG (IAE) is a joint venture consisting of shareholders Rolls-Royce (32.5 percent), Pratt & Whitney (32.5 percent), the Japanese Aero Engines Corporation[87] (23 percent) and MTU Aero Engines (12 percent). IAE manufactures the 22,000-33,000 pound thrust V2500 engine, which is used in a number of Boeing and Airbus aircraft. Each IAE partner contributes an individual module to the V2500 engine, and the engines are assembled and tested at Pratt & Whitney and Rolls-Royce's respective facilities in East Hartford, Connecticut and Derby, UK. IAE's V2500 engine applications include the Airbus A319/ 320/321, the Airbus Corporate Jetliner and the Boeing MD-90. IAE has more than 100 customers from 35 countries for the V2500 engine.[88]

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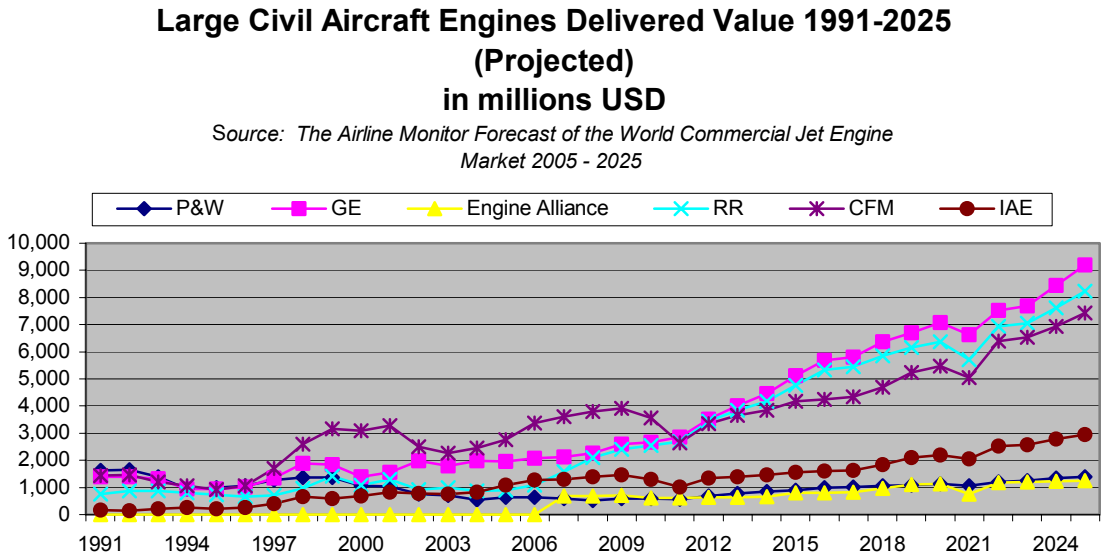
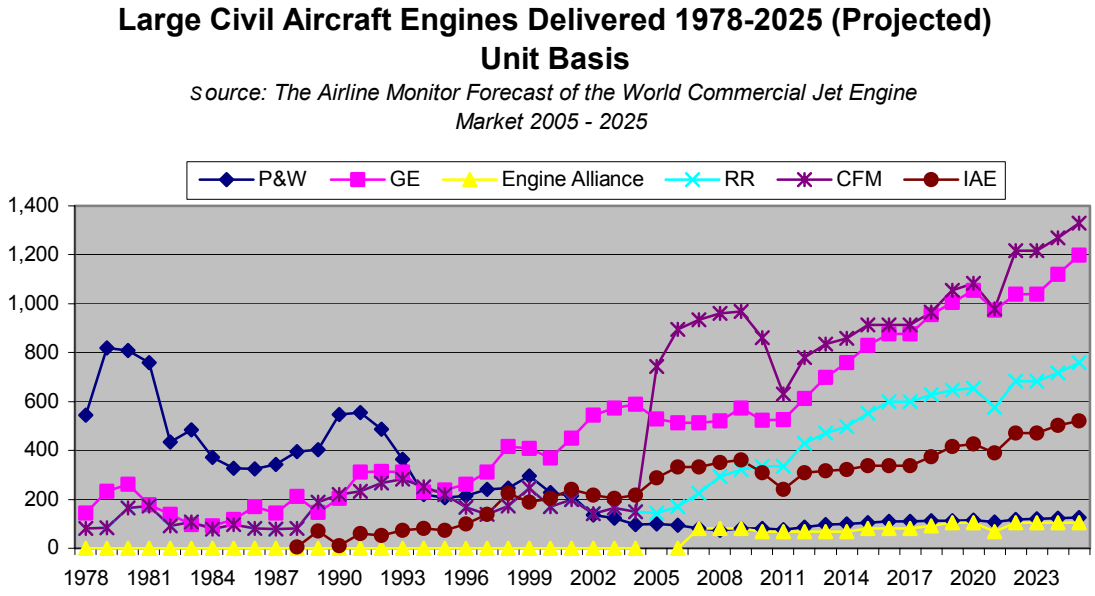
[85] Hoover's Company Records – In-depth Records CFM International and SAFRAN Group.
[86] http://www.cfm56.com/engines/index.html .
[87] Ishikawajima Harima Heavy Industries, Mitsubishi Heavy Industries, and Kawasaki Heavy Industries.
[88] http://www.i-a-e.com/company/facts.shtm .

Analysis

Trends



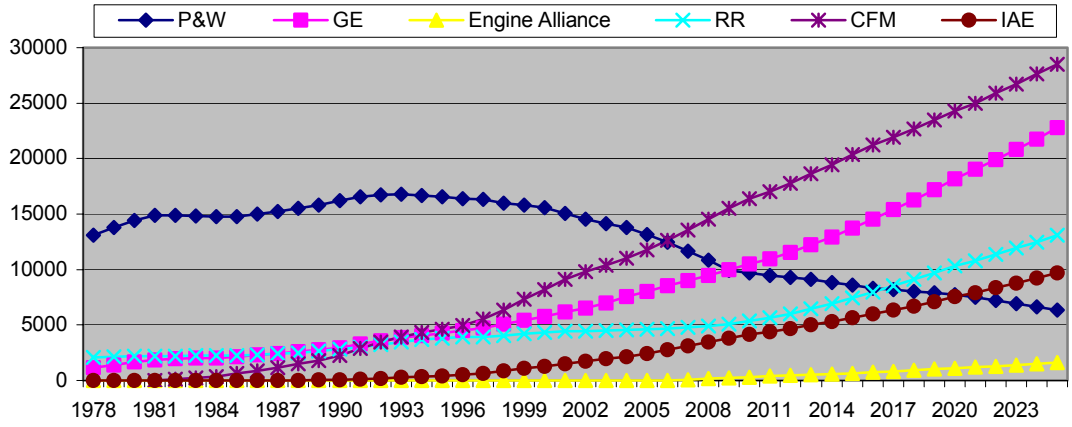


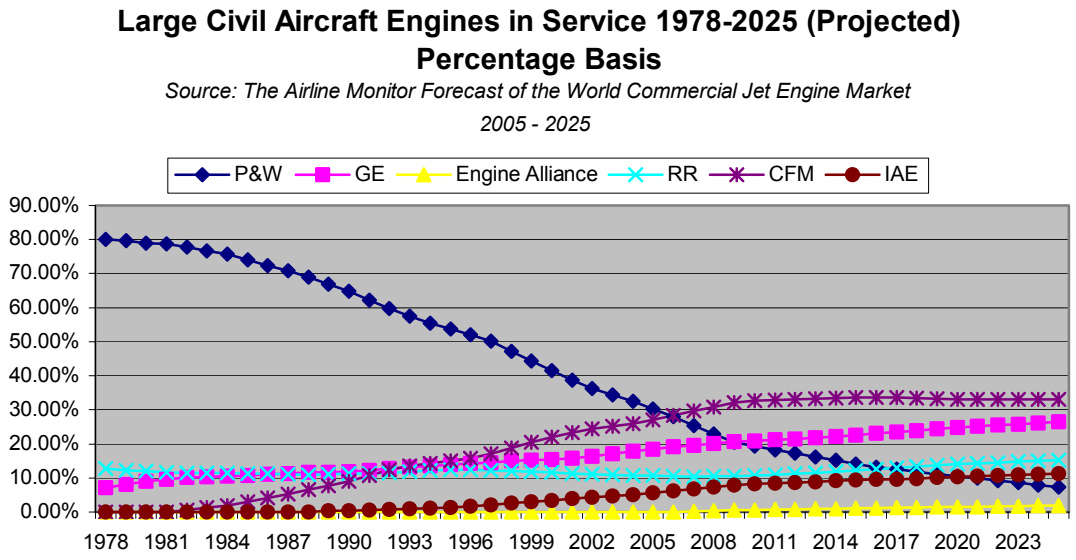
In the delivery segment, GEAE, Rolls-Royce and CFM[89] currently lead the LCA jet engines market on both a unit and total value basis. CFM's strength in the market is driven by current and projected high unit sales of the CFM 56 engine. As the CFM 56 is the sole engine choice for the entire Boeing 737 series and is also used in a number of Airbus aircraft, deliveries of the

[89] For purposes of this analysis, CFM deliveries are counted separately from those of GEAE, which owns 50 per cent of CFM. However, revenue from CFM deliveries is shared on a 50/50 basis by GEAE and Snecma Moteurs.

engine should remain high for the foreseeable future. GEAE and Rolls-Royce's current strength and projected growth, on the other hand, is predicated upon higher per unit engine prices. GEAE's market share is built on deliveries of its CF6 and GE90 engines, which power the Boeing 747, 767, and 777 and multiple Airbus aircraft. Rolls-Royce's market position is based upon sales of the company's Trent series engines, which are used in the Boeing 747,757,777 and 787 Dreamliner and Airbus 330, 340, 350 and 380. Pratt & Whitney's position as the second-largest aircraft engine manufacturer in the United States is increasingly based on its revenue from military sales and commercial aftermarket services. The company has experienced lower sales of commercial engines and commercial engine spare parts, most notably its non-selection as one of the two companies (GEAE and Rolls-Royce) that will build engines for the Boeing 787 Dreamliner.

Large Civil Aircraft Engines in Service 1978-2025 (Projected)
Unit Basis
Source: The Airline Monitor Forecast of the World Commercial Jet Engine Market 2005 - 2025





Regarding the number of engines in service, Pratt & Whitney is currently the market leader, but the company's lead is projected to give way to competitors as new engine models begin service and older model aircraft are retired. As a partner in both the Engine Alliance and IAE, however, Pratt & Whitney still stands to benefit from the introduction of new aircraft and engines. As the only engine suppliers for the Boeing 787 Dreamliner, GEAE and Rolls-Royce have an opportunity to capitalize on their position if their respective engines and accompanying technology can be utilized in future aircraft models.

Global Competitors: EU and Beyond

As discussed above, the global market for LCA jet engines is dominated by a few large manufacturers and several multinational joint ventures. Although Russia and China do have domestic markets consisting of both large and small aircraft parts manufacturers, none of these manufacturers have a measurable impact on the world LCA jet engine market.

EU and Japanese engine manufacturers compete mainly through their holdings in joint ventures. Most notably, as a 50/50 partner with GEAE in CFM International, Snecma Moteurs of France maintains a significant market presence. In addition, MTU Aero Engines GmbH of Germany, along with the Japanese Aero Engines Corporation, maintains a presence via their equity holdings in IAE.

With regard to Russian engine aircraft manufacturers, since no Russian engine manufacturers produce engines for use on Boeing or Airbus aircraft, the impact of Russian jet engines on the LCA jet engine market is negligible.[90]

[90] Industry Analysis of Aircraft and Aircraft Parts Sector in Russia, U. S. Department of Commerce October, 2002, available at http://www.bisnis.doc.gov/bisnis/isa/021001RusAir.htm .

China possesses a growing market of small domestic aircraft parts manufacturers, along with a number of established major manufacturing entities. However, since only a small percentage of Chinese aircraft parts manufacturers are capable of manufacturing parts that meet international aviation quality standards, at this time Chinese manufacturers have no measurable impact on the LCA jet engine market.[91]

[91] Aerospace Industry Market Brief 2005 – China, U.S. Department of Commerce, November 29, 2005, available at http://www.buyusainfo.net/docs/x_7566162.pdf .

Workforce

In 2002, the Commission on the Future of the U.S. Aerospace Industry reported that the U.S. aerospace workforce is in jeopardy. It pointed to a significant reduction in the number of U.S. workers, a lack of young workers who are attracted to the aerospace industry, loss of U.S. jobs through offsets, and the need for more mathematics and science education in the United States. These concerns continue today.

Reduction in U.S. aerospace workforce

Various sources report different figures on the number of workers employed in the U.S. aerospace manufacturing industry.

- The Aerospace Industries Association's (AIA) figures appear to overstate employment. They include a significant group of employees who manufacture products – "search, detection and navigation instruments" – that may or may not be used in aerospace applications.

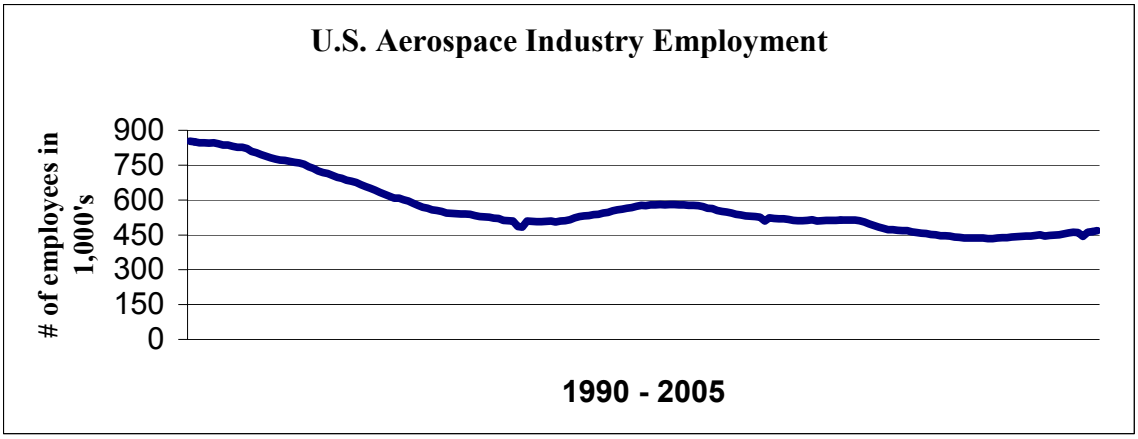
- The Census Bureau's data is not current. Its most recent data, covering the year 2004, is based on a sampling of a survey originally conducted before 2002.

- The Bureau of Labor Statistics' (BLS) data may be preferable, among these three sources, because it cannot be questioned with having an industry bias (as is the case with AIA) and is not outdated (as is the case with Census data). Moreover, BLS data is based on monthly sampling, as opposed to Census' annual survey.

According to the BLS, the number of U.S. workers employed in the aerospace industry fell by almost half from 1990 (when there were 853 thousand workers) to its nadir in February 2004 (with 434 thousand workers).

Among the reasons for the decline are increases in manufacturing productivity, the elimination of jobs associated with mergers and acquisitions, cutbacks in defense procurement following the end of the Cold War, and increased offshore sourcing of components.

Since bottoming-out in early 2004, U.S. aerospace employment has slowly rebounded. The number of workers in March 2006, 466 thousand, was up 7 percent from the February 2004 figure.



While their numbers have declined over the last 15 years, American aerospace workers are well paid. In the most recent year for which data is available, 2004, the average annual salary of all aerospace workers, at about $63,800, was one and a half times higher than the average annual salary of U.S. manufacturing workers in general. Production workers in the U.S. aerospace industry had an average salary ($54,400) that was 53 percent higher than manufacturing production workers in general (whose average salary was $35,500).

Graying workforce

Several observers have noted difficulties the aerospace industry has in attracting and retaining younger workers. According to the Commission on the Future of the U.S. Aerospace Industry, 26-27 percent of aerospace workers will be eligible to retire by 2008. The average age of production workers in the civil aerospace sector is 44 and, at the National Aeronautical and Space Administration (NASA), 51. According to the BLS, the proportion of workers in the aerospace industry 34 years old or younger declined from 32 percent in 1992 to 16 percent in 2003.

The long-term contraction in the number of workers is a central reason younger workers have been dissuaded from entering the industry. Compounding this is the "boom-bust" cyclicality of aerospace manufacturing. Anecdotal evidence points to many workers who have been hired during good times, fired during lean times, and rehired, by the same company, when business conditions improved. According to the Aerospace Industries Association, in a survey of 500 U.S. aerospace workers, 80 percent said they would not recommend their children pursue an aerospace career due to workplace instability.

Offsets

An "offset" is industrial compensation required of suppliers as a condition for selling to a government-owned or -controlled entity. Offsets may involve subcontracting, co-production, and technology transfer. U.S. civil aircraft trade policy opposes offsets because of the adverse effects they may have on the U.S. economy. Among these adverse effects is the movement of U.S. jobs overseas. This occurs when a U.S. manufacturer transfers the acquisition of aircraft parts from a U.S. supplier to a foreign supplier, as mandated by a foreign government.

Unlike defense offsets, the magnitude of which is analyzed annually by the Bureau of Industry and Security, there are no studies that quantify civil offsets. However, from anecdotal evidence it appears that offsets in civil aircraft trade are increasing. Even when no offset is formally required, U.S. civil aerospace manufacturers may feel pressured to source components from overseas in order to win sales. In some cases, governments play Airbus and Boeing against each other to gain the most favorable offsets concessions possible.

Offsets can have ripple effects on the supply chain. Prime manufacturers, such as Boeing, may require that their major component suppliers, such as engine manufacturers, share in the offset requirement. These major component suppliers, in turn, may pass the requirement further down the supply chain to *their* suppliers.

Not all aerospace offsets reduce employment opportunities for U.S. aerospace workers. Some offsets can be satisfied through unrelated activities. These may include, for example, a requirement that the U.S. aerospace supplier promote the export of some agricultural product in which the aircraft-purchasing country specializes.

Mathematics and science education

A well-educated workforce grounded in engineering, the physical sciences, and mathematics is critical for the future of aerospace manufacturing in the United States. Unfortunately, there are a number of troubling indications about U.S. preparedness, especially when U.S. educational performance is measured against other countries.

U.S. 12th-grade students performed below the average of 21 countries in a recent test of general knowledge of mathematics and science. In an assessment of students' advanced mathematics skills, 11 nations—out of 15—outperformed the United States. Foreign-owned companies and foreign-born inventors now account for about half of all U.S. patents.

According to the National Science Foundation (NSF), the U.S. aerospace industry employed almost 145,000 engineers and scientists in 1986. By 2004, this figure had fallen to just over 40,000. NSF figures indicate that the aerospace industry employed 20 percent of all U.S. R&D scientists in 1979 – and just 3.5 percent in 2004.

Possible solutions to workforce concerns

The President's American Competitiveness Initiative recognizes the importance of intellectual capital as an ingredient to economic well-being. This initiative is aimed at boosting federally funded R&D and at strengthening U.S. education of mathematics and science.

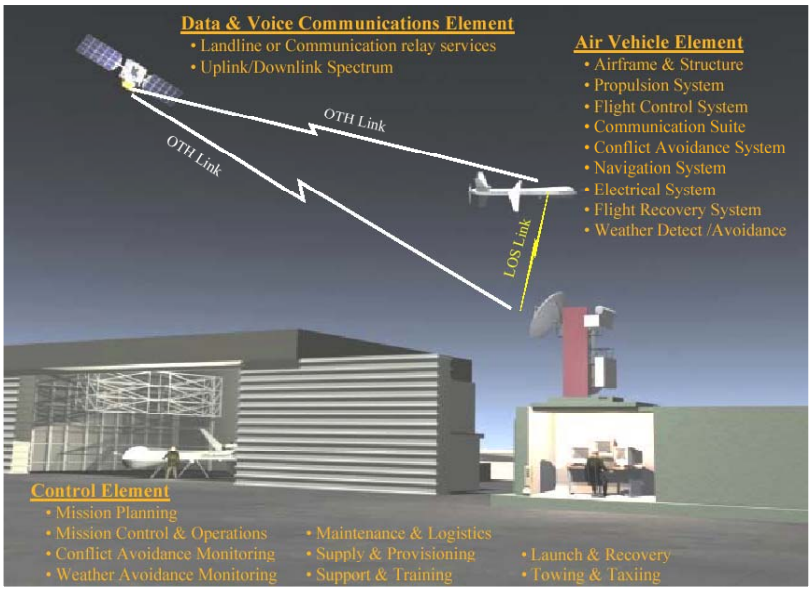
In October 2005, the House of Representatives approved a bill (H.R. 758) aimed at developing a national strategy for aerospace workforce recruitment and training. The legislation calls for an "Interagency Aerospace Revitalization Task Force", headed by the Labor Department. The task force would develop policies and increase interagency cooperation to promote the development of skills, such as science, engineering, and mathematics, to promote the U.S. aerospace workforce. As of May 2006, the Senate had not acted on the legislation.

Unmanned Aircraft Systems (UAS)

Overview

Unmanned Aircraft Systems (UASs) are air vehicles that do not carry a human operator, but instead fly autonomously, or are remotely piloted. UASs must be considered in a systems context (Figure 1). A UAS "system" includes the remote human operator(s), a command, control and communications (C3) system as well as the UAS, or multiple UASs.

Figure 1. Conceptual UAS System



There currently is no widely accepted common classification system for UAS vehicles or systems due to the wide variety of capabilities, size, and operating characteristics of different systems. Most UASs are described in terms of weight, endurance, purpose of use, and altitude of operation. For the purposes of this report, broad categories and uses are as follows[92]:

High altitude: High altitude UASs fly above 60,000 feet (above the current Class A airspace used by most long-range commercial and military air traffic). High altitude UASs likely will be used for surveillance or to relay communications. Many high altitude UASs are designed for long endurance (high altitude long endurance or HALE) to reduce cost and operational risk. These UASs may be similar to existing jet aircraft or lighter-than-air ships (balloons, blimps, etc).

Medium altitude: Medium altitude UASs will fly in Class A airspace (18,000 ft - 60,000 ft) with other commercial and military air traffic. UASs in this range may be used for a wide variety of applications ranging from surveillance and information gathering to cargo transportation. These UASs may resemble manned aircraft or airships, and some may have a vertical take-off and landing (VTOL) capability. Medium altitude long endurance (MALE) UASs may operate for days without landing.

[92] Descriptions drawn from "The Impact of Unmanned Aerial Vehicles on the Next Generation Air Transportation System: Preliminary Assessment", Unmanned Aerial Vehicle National Task Force, October 22, 2004

Low altitude: Low altitude UASs will operate up to 18,000 feet (primarily in today's Class E airspace). These UASs will fly at less than 150 knots for many hours, and perhaps as long as two days. Many will provide sustained surveillance or carry out targeted missions. Low altitude UASs will also operate in the same airspace used by manned helicopters and other general aviation aircraft, including those operating under visual flight rules (VFR), and will have a wide variety of operating characteristics (fixed wing jet or propeller, VTOL, lighter-than-air, etc).

Very low altitude: Very low altitude UASs will be relatively small and generally weigh less than 100 pounds. They typically will fly below 1000 feet for a few hours, performing various types of reconnaissance, inspection, or surveillance missions. These UASs will fly low enough that they will not operate in U.S. controlled airspace. They may be small enough to operate from a pickup truck; some will be so small they can be launched by hand. Most of these UASs will be VTOL or powered by propellers.

Analysis

Since UASs were first developed in World War I, they have been used in small numbers, primarily during military conflicts. Improved technology and evolving military mission needs stimulated greater investment in UASs in the mid-1990s. Today there are 32 nations developing or manufacturing more than 250 models of UASs, many of them countries with established aerospace manufacturing sectors such as the United States, Israel, Australia, Japan and multiple European countries.[93]

Although certain types of civil UAS operations are commonplace in Japan, and emerging in Australia, the United States and across Europe, almost all UAS operations and vehicles around the world today are for military purposes. The absence of standards, regulations and procedures to govern the safe integration of civil-use UASs into civilian air space are key factors limiting growth in the non-military UAS sector. Existing military UAS manufacturers likely will dominate civil-use UAS markets in the near-term if they are able to leverage their capabilities and technologies in the adaptation of existing platforms or development of new systems for civil purposes. However, they may face stiff competition from new entrants to the market in the long run.

Trends

The U.S. Department of Defense (DOD) leads in development, ownership, operation of UASs globally. The DOD "Unmanned Aircraft Systems Roadmap 2005 – 2030", released in August of 2005, describes this market in detail. The DOD executive responsible for coordinating UAS activities at the Pentagon has stated that UASs are now the preferred platform for most information, surveillance and reconnaissance needs (especially for video).

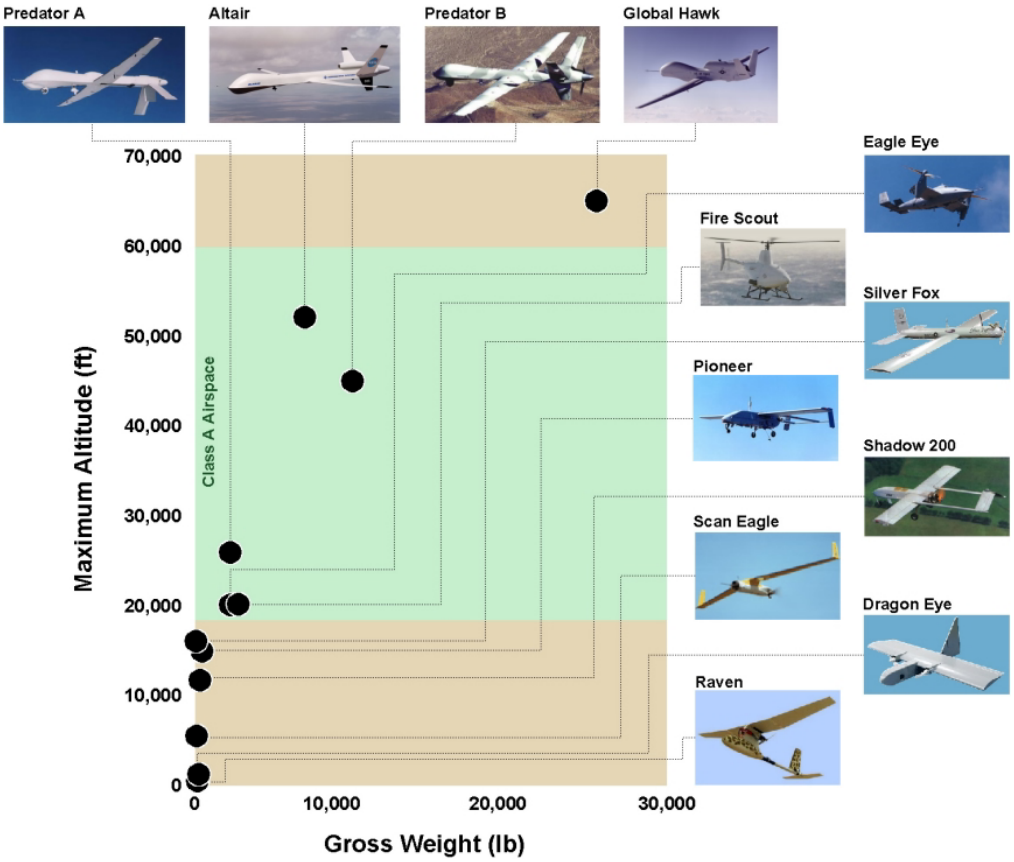
The current and projected DOD UAS inventory and investments reflects the growing interest of the Pentagon in UASs. Not including micro/mini UASs, there are 250 UASs in use today by the Pentagon. DOD predicts more than doubling this number to 675 by 2010, and then jumping to 1400 by 2015. Between 1991 and 2002, the Pentagon invested roughly $250-$350 million per

[93] Unmanned Aircraft Systems Roadmap 2005-2030, U.S. Department of Defense, August 4, 2005.

year in UAS development, procurement, and operation. In 2003, this number jumped to $1.5 billion. In 2005, it spent $2.1 billion.[94]

Figure 2. Current U.S. Operational UAVs

Today's operational military UASs encompass a wide range of sizes, gross weights, speeds, and operating altitudes (Figure 2). The smallest operational UAS described in Figure 2 is the four-pound Raven that flies for about an hour at 50 knots and normally below 1000 feet. The largest is the Global Hawk, which weighs 25,600 pounds, and flies at 400 knots for over 30 hours at 65,000 feet.



The Global Hawk had logged 240 combat missions, totaling more than 5,000 hours in support of the War on Terror, as of February 2006. Those missions included providing about 55 percent of the images of military targets during the initial Iraq campaign by American troops and their allies in 2003. The Predator had logged more than 150,000 flight hours, with over two-thirds of that time logged in combat. Smaller, shorter range UASs have seen dramatic usage increases in Iraq. For example, the Army reported a doubling of UAS usage over the last six months of 2005.[95]

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[94] Ibid.

[95] Presentation by LTC Jeff Gabbert, U.S. Army UAS Program Office, AUFSI Unmanned Systems Program Review, February 6, 2006.

The DOD Quadrennial Defense Review released in February 2006, call for increased reliance on UASs by nearly doubling the DOD UAS capacity, and tasking a rationalization of UAS development and use among the armed services. The QDR calls for 45 percent of future Air Force long-range strike capability to be met by unmanned systems. In addition, the QDR calls for establishment of a UAS squadron under the U.S. Special Operations Command (SOCOM) in Fiscal Year 2007.

Civil UAS markets

In spite of military dominance of the UAS sector to date, there is large potential for civil applications by private and public entities in future years. In fact, the Defense Department is encouraging the use of UASs for civil applications, since a growth in the civil-use industrial base would shift some of the burden of UAS development from the armed services to other markets.

There are three key market drivers for civil-use UASs – unique flight performance, such HALE capabilities; suitability to carry out "dull, dirty and dangerous" missions; and cost – when they are cheaper or more flexible than manned aircraft or space assets. Some applications will be modified from military uses, such as observation, surveillance and reconnaissance. Federal agencies such as the Customs and Border Protection Service, the Drug Enforcement Agency, the Federal Bureau of Investigation, the Transportation Security Administration and the Federal Emergency Management Agency, as well as state and local law enforcement agencies, are interested in using UASs in the national air space (NAS). Public uses include border security, port security, surveillance, drug interdiction, search and rescue, fire fighting, and other law enforcement and homeland security initiatives. The Department of Homeland Security Customs and Border Patrol initiated trials of UASs to monitor the U.S.-Mexico on September 29, 2005.

Some uses will be a variation on traditional observation/reconnaissance of people or locations, including scientific experimentation and data gathering. For example, Commerce's National Oceanic and Atmospheric Administration has conducted test flights for environmental data gathering and fisheries management, and used a UAS to gather data by flying through Hurricane Ophelia. The Department of Energy is considering UASs outfitted with radiation sensors to detect potential nuclear reactor accidents. Similarly, NASA has conducted environmental science experiments for years. UAS science experiments will become more numerous as UASs gain more access to U.S. civil managed airspace, become more reliable, and are less expensive than other alternatives. Even so, the science community may be able to afford relatively few scientific UAS operations compared to other civil government agencies.

Other applications will be modified from manned aircraft. For example, there are over 2,500 UAS helicopters in use today in Japan for crop dusting, a task usually left to manned aircraft in the United States and other places. Although these operations have been limited to line-of-sight flying and a 50 meter maximum ceiling, even these boundaries are being pushed by operators. As another example, the U.S. Forest Service and NASA have been investigating the use of UASs for wildfire mapping. A California company announced in 2005 a $2.5 million purchase of fourteen UAS rotorcraft to be used for special effects in movies.

Some experts estimate that thousands of small UASs have been operating in the United States national air space in recent years, ranging from agricultural data gathering and monitoring to law enforcement/security to information collection (such as for real estate). Many of these operations have been conducted without regulation or insurance.[96]

Experimental Airworthiness Certification

In response to the growing number of unregulated UAS operations, the FAA has imposed strict limitations on UAS operations in the NAS until sufficient standards and regulations can be developed to safely integrate them into civilian air space. Currently, access to civil air space in the United States is limited through special Certificates of Authorization or COAs granted by the FAA. Even under a COA, UAS operations are granted only for specific times, locations and operations. The FAA has stated that current restrictions on operation of UASs in the NAS will remain until appropriate standards are developed.

In the meantime, the FAA is developing domestic certification regulations that will address all relevant technology, policy, regulatory and infrastructure issues. This includes certification not only of the air vehicle and system, but also the operators, as well as maintenance. Starting in late 2005, the FAA began issuing experimental airworthiness certificates for UASs operating in the NAS. The FAA reportedly has received fourteen program letters from companies seeking experimental certification for UASs. To date, two UAS systems have received experimental certification from the FAA, and the FAA is expecting to grant two more by the end of 2006.[97]

Competitors

United States

The U.S. UAS industry is undergoing a major transition. Unlike a decade ago, all major U.S. aerospace prime contractors are now involved in UAS programs and expected to remain working on UASs for the foreseeable future. Numerous small and mid-sized companies also entered the market in the 1990s. Some small companies failed or withdrew from the UAS market, others were acquired (part of the industry consolidation), and a few new companies entered the market. Industry consolidation is expected to continue for the next several years.

U.S. UAS manufacturers are a mix of public and privately owned companies. Three of the nine U.S. manufacturers of UASs currently operated in Operation Iraqi Freedom are part of publicly traded corporations. For each of these companies, UAS development, manufacture and operation make up a relatively small percentage of overall corporate revenues. Most have outperformed the overall S&P 500 over the last five years. Most privately held U.S. UAS

[96] Testimony of Robert Owen, Embry-Riddle Aeronautical University, to Aviation Subcommittee of the House Committee on Transportation and Infrastructure, March 27, 2006.
[97] Testimony of Nicholas Sabatini, Associate Administrator fo rAviation Safety, FAA, to Aviation Subcommittee of the House Committee on Transportation and Infrastructure, March 27, 2006. http://www.faa.gov/news/testimony/news_story.cfm?newsKey=4029 .

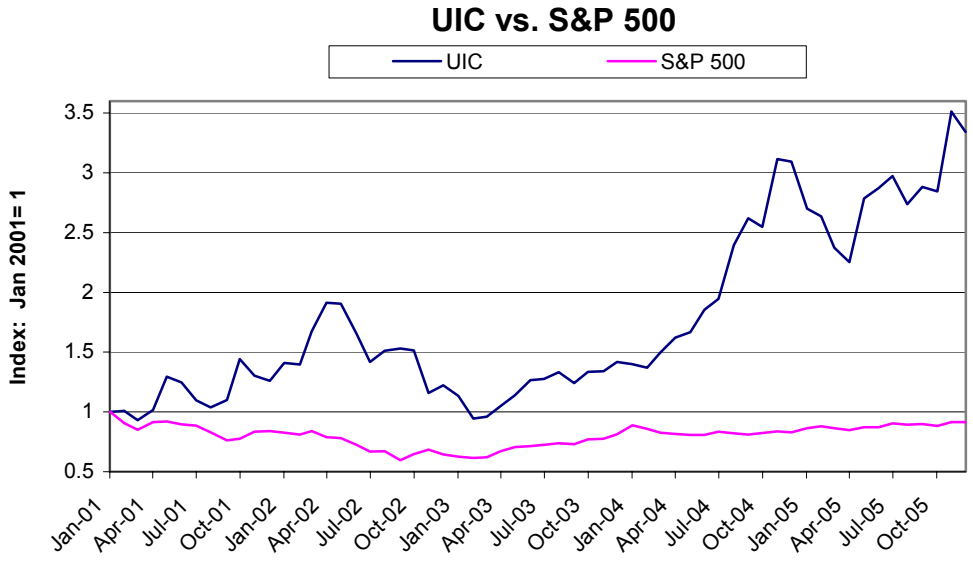
manufacturers are not widely diversified out of this market segment, although they may produce a variety of UASs. A number of U.S. manufacturers have established partnerships with non-U.S. companies to strengthen their market presence and to supply UASs to the U.S. military. In addition, some foreign companies have established subsidiaries in the United States.

Given the wide range of UAS companies in the United States and abroad, the absence of a measurable civil-use UAS market today, and the prevalence of international partnerships to develop, manufacture and operate UASs, a comprehensive assessment of competitors in the civil-use UAS market is extremely difficult. There are a number of publicly available, authoritative studies by other federal agencies and private organizations about the military UAS manufacturing industry, which provide details about the military UAS market structure and competition.

Accordingly, the following listing of companies is intended only to provide a representative snapshot of the UAS industry in early 2006. The following U.S. companies manufacture UASs currently in use in Operation Iraqi Freedom (excluding very small "micro/mini" UASs) and/or have been granted experimental airworthiness certification by the FAA.

AAI

FY	2005	2004	2003
Revenue (in million USD)	517.1	385.1	311.0
Operating Profit (in million USD)	40.4	26.1	15.1



AAI Corporation designs, manufactures, tests, and supports a family of advanced Tactical Unmanned Aerial Vehicles (TUAVs) for an array of customers around the world as a subsidiary of publicly traded United Industrial Corporation (UIC). In 1991, AAI Corporation and Israel Aircraft Industries, Ltd., the original developers of the Pioneer system, formed a jointly owned corporation called Pioneer UAV, Inc. Pioneer UAV, Inc., was created in order to manage the program and function as the prime contractor to the U.S. Government for all Pioneer-related activities. [98] AAI has improved on the Pioneer platform since 1991through a series of new Shadow UASs, a MALE system used extensively by the U.S. Army (132 in the DOD inventory as of January 1, 2006.)

Advanced Ceramics Research

Advanced Ceramics Research (ACR) is a privately held company founded in 1989 to develop state-of-the-art high temperature, high strength ceramic materials and processes. ACR manufactures the Silver Fox, a small UAS developed with U.S. Office of Naval Research funding to function primarily as an "expendable over the horizon surveillance tool" that could be launched from ships and/or from land. It is controlled via line of sight communication and has an effective operating range of 20 plus nautical miles. Originally designed to monitor whales in the ocean, ACR UASs (Silver Fox and Manta) are in development and testing projects with the U.S. Marines and SOCOM for military operations. The DOD has 20 Silver Fox UASs in their inventory as of January 1, 2006. The U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) is evaluating uses of ACR UASs for marine research.

Aerovironment

AeroVironment (AV) designs, develops, and produces high-efficiency, unmanned aircraft for communications relay, remote sensing, and research applications. AV develops both small and HALE UASs. Since 1986, AV has been developing small UASs for use in military surveillance, law enforcement, and civilian rescue efforts. Privately held AV currently is the most prolific supplier of UASs to the U.S. military. As of January 1, 2006, the U.S. military had over 1200 Ravens, 356 DragonEyes and 125 Pointers manufactured by AV in their inventory.

AV also has an active civil UAS program. In the mid 1990s, AV developed the Pathfinder HALE UAV with NASA. Pathfinder was the world's first unmanned solar-powered airplane. Successors to Pathfinder include Helios and Pathfinder Plus. Global Observer is AV's next-generation HALE UAV now under development. AeroVironment has a subsidiary, SkyTower, that markets solar UAV-based telecommunication platforms as an alternative to satellite, land, blimp, or conventional UAV (non-solar) systems.

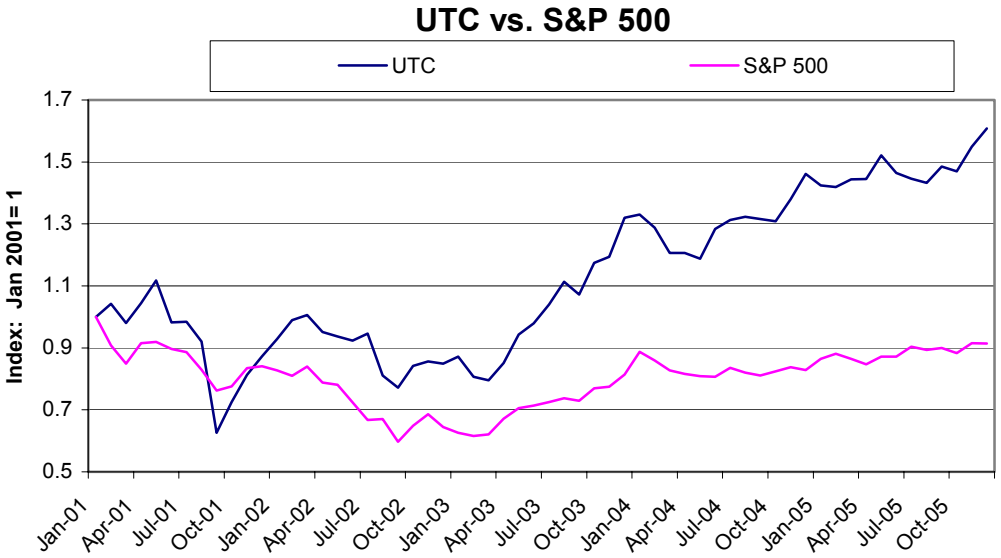
Bell Helicopter Textron

Bell Helicopter, a subsidiary of United Technologies Corporation, is developing the Eagle Eye TR918 vertical lift, tiltrotor UAS. The Eagle Eye is the first vertical lift UAS (and second UAS overall) to receive FAA experimental certification, granted in December 5, 2005. The U.S. Coast Guard has ordered 45 Eagle Eyes to be based aboard its ships for long-range surveillance

[98] http://www.puav.com/home.asp, http://www.aaicorp.com/

as part of the Deepwater program. With the tiltrotor technology Bell developed for the V-22 Osprey, the Eagle Eye will be capable of faster and longer flights than unmanned helicopter-type vehicles now being developed.

Bell Helicopter began flight tests of the full scale UAS in January 2006. The aircraft was developed and built entirely with Bell funding after the Coast Guard program was delayed because of budget cuts. Bell Helicopter has stated plans to begin demonstrations to potential U.S. and foreign buyers in 2007 and 2008 of the Eagle Eye for border patrol, military and civilian missions.



FY	2005	2004	2003
Revenue (in million USD)	9,295	8,281	7,484
Operating Profit (in million USD)	1,449	1,083	1,063

Source: UTC 2005 Annual Report

General Atomics Aeronautical Systems

As a privately held international company formed in 1993, General Atomics Aeronautical Systems, Inc. (GA-ASI) is focused on the design and production of remotely operated aircraft. GA-ASI systems are in extensive use by the U.S. Government, including the U.S. Air Force, NASA, Department of Energy, U.S. Army, and the U.S. Navy as well as by overseas customers. The MQ-1 Predator has a broad range of systems packaged to meet a variety of customer requirements.

The FAA's first experimental airworthiness certificate for a UAS was issued August 17, 2005, for the General Atomics Altair. A high-altitude version of Predator B, the Altair was specifically designed for scientific and commercial research missions that require high-altitude endurance,

reliability and increased payload capacity. Altair was build in partnership with NASA's Dryden Flight Research Center for its Environmental Research Aircraft and Sensor Technology (ERAST) Program, and has been operational since 2003.[99] Altair can fly above 52,000 feet and remain airborne for over 30 hours.

GA-ASI collaborated with NASA and NOAA to demonstrate with the Altair the operational capabilities of remotely piloted aircraft systems for science missions related to oceanic and atmospheric research, climate research, marine sanctuary mapping and enforcement, nautical charting, and fisheries assessment and enforcement.

Insitu

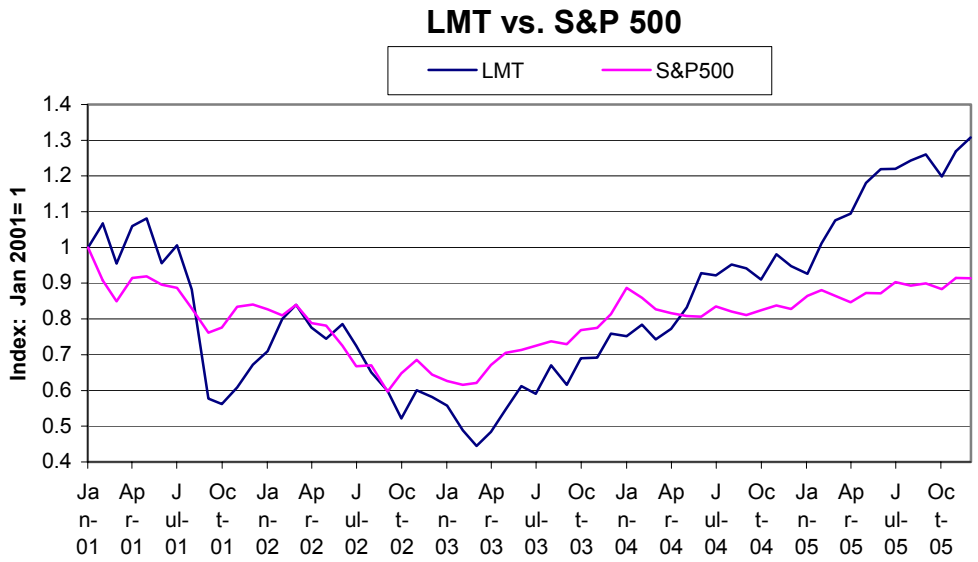
Insitu is a small, privately held company focused on the design, development, and production of MALE UASs for environmental resource monitoring and intelligence, surveillance and reconnaissance (ISR) missions. Insitu's ScanEagle is currently deployed in Iraq with the U.S. military, with 18 aircraft under contract with the DOD as of January 1, 2006. The ScanEagle is produced in partnership with Boeing.

Insitu entered the UAS market in 1992 by licensing Australian UAS producer Aerosonde's core technology. Insitu developed the SeaScan UAS prototype in 2001 for the commercial fishing fleet, outfitted with a digital video camera for fisheries and marine studies. In 2004, Insitu announced a partnership with Fugro Airborne Surveys to develop the Georanger sensor package to collect geotechnical information related to building of mines, oil pipelines, bridges and other remote engineering studies. Fugro Airborne Surveys is using the Georanger to conduct airborne mining surveys in Ghana as well as in Northern Manitoba, Canada.

Lockheed Martin

FY	2005	2004	2003
Revenue (in million USD)	37,213	35,526	31,824
Operating Profit (in million USD)	2,986	2,089	2,019

[99] "FAA Issues First Commercial UAS Airworthiness Certificate to General Atomics Aeronautical Systems", General Atomotics Aeronautical Systems Press Release, September 28, 2005



Lockheed Martin produces the Desert Hawk, a small UAS system that is part of the US Air Force's Force Protection Airborne Surveillance System, or FPASS. Twenty Desert Hawk systems (out of 48 ordered) are used in Afghanistan by the U.S. Air Force as of January 1, 2006.[100] The United Kingdom's Defense Procurement Agency awarded Lockheed Martin a $2.65 million contract in February 2006 to enhance the British Army's current fleet of Desert Hawks and supply additional units. Lockheed Martin also is pursuing a number of UAS concepts under military research programs.

Northrop Grumman

Northrop Grumman produces a range of unmanned aircraft systems for military use. The multirole U.S. Army RQ-5 Hunter, produced in partnership between Northrop Grumman and Israeli Aircraft Industries (IAI), was the Army's first fielded UAS (first flight in 1991). Although most Hunters are no longer in active duty, they were used extensively in early stages of Operation Iraqi Freedom.

Northrop Grumman also produces the Air Force RQ-4 Global Hawk HALE UAS. Although the Air Force did not take first delivery of production Global Hawks until January 2006, these UASs delivered more than 15,000 images to Air Force and joint war fighting commanders and flew more than 5,000 combat hours while still in the advanced concept technology demonstration stage.[101] Northrop Grumman is seeking to expand their global presence by establishing a partnership with European aerospace manufacturer EADS to develop the EuroHawk based on the Global Hawk platform.[102] A mixed fleet of Global Hawks and Airbus A321s will make up the core of the NATO Alliance Ground Surveillance (AGS) system, developed in partnership with a number of European and North American aerospace companies.

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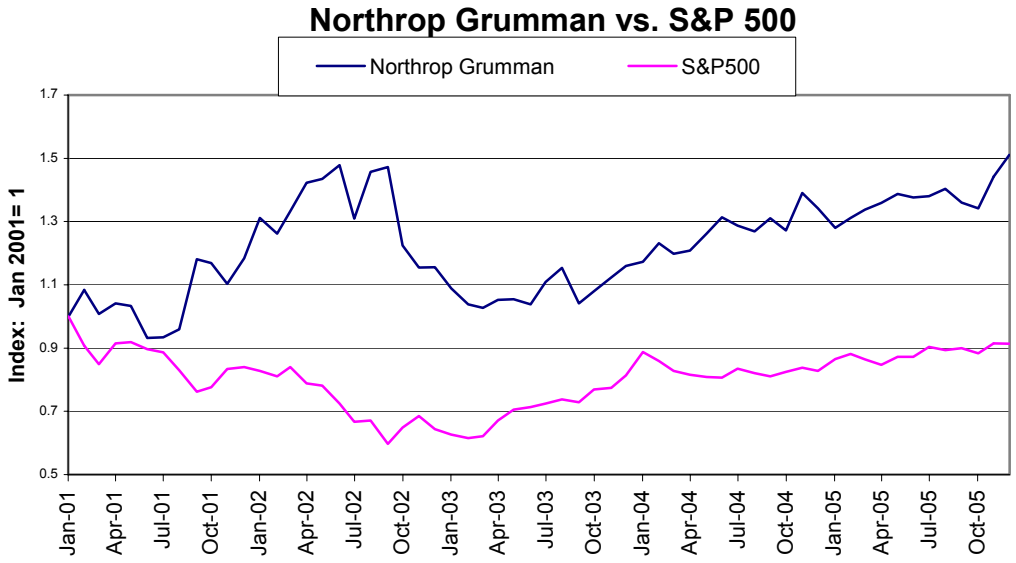
[100] http://www.defense-update.com/products/d/deserthawk.htm
[101] "Air Force Takes Delivery Of First Production Global Hawks," January 22, 2006, http://www.aero-news.net/index.cfm?ContentBlockID=30673120-240a-4fbb-b80d-f7402656bdf6#d
[102] http://www.northropgrumman.com/unmanned/index.html

The Northrop Grumman RQ-8 Fire Scout vertical take-off and landing tactical unmanned aerial vehicle currently is in low-rate initial production for the U.S. Navy and for U.S. Army Future Combat Systems Class IV unmanned air vehicle program. Northrop Grumman also is developing the X-47 Joint Unmanned Combat Air Systems for the Defense Advanced Research Projects Agency, Air Force and Navy.

Northrop Grumman also is exploring alternatives for civil and scientific applications for their existing and future UAS platforms.

FY	2005	2004	2003
Revenue (in million USD)	30,721	29,853	26,396
Operating Profit (in million USD)	1,383	1,093	758



Isreal

The Israeli Defense Forces (IDF) started using domestically produced UASs in combat in the early 1970s. As a result, Israeli UAS manufacturers have a wide-ranging capability to address most civil and military UAS applications. In addition, they have influenced UAS development programs around the world, entering into industrial partnerships and international marketing and co-production agreements around the world, in part to offset limited national market opportunities within Israel. Elbit Systems' Silver Arrow subsidiary is currently the IDF's principal supplier of UASs with the Hermes family of vehicles, and has business relationships around the world. Israel Aircraft Industries' Malat division (IAI-Malat) has produced a broad range of UASs including the Searcher, Heron and Hunter lines.

Japan

The leading manufacturers of civil-use UASs are in Japan, based largely on the widespread use of unmanned rotorcraft for agricultural uses (primarily spraying). Yamaha Motors Company began unmanned helicopter development in 1982 for agricultural applications. In 1990, Yamaha released the R-50 single-rotor UAS for agricultural spraying, with flight controls similar to those of radio-controlled aircraft. Yamaha has continued to upgrade the capabilities of their UAS rotorcraft, introducing autopilot and advanced sensors on new RMAX models, but still enables a pilot to control the UAS from the ground within line-of-sight. Yamaha has entered into numerous partnerships with organizations in Europe, North America and across Asia for further UAS development and sales.

Yamaha currently supplies over 60 percent of the Japanese market for unmanned agricultural spraying applications. In 2005, there were an estimated 2,000 unmanned helicopters and over 8,000 certified UAS operators in Japan, compared to a total of 730 non-government-operated manned helicopters and 3,600 professional helicopter pilots. Yanmar Agricultural Equipment Co., Kawada Industries, Inc. and Fuji Heavy Industries share the rest of the market.[103]

Market

Given the rapid growth of UAS operations for military purposes, there appears to be tremendous potential for U.S. industry in the evolving civil UAS sector. However, it is extremely difficult to determine actual civil market size in light of the many regulatory and technological obstacles to be overcome before UASs can be integrated into civilian air space. This is complicated by the absence of common terminology, market segment definition and widely varying vehicle capabilities.

Various studies have been conducted regarding the future market opportunities for civil UAS sales worldwide. Many analysts are bullish on market growth, although there is wide variance in views about the actual market size, ranging from a healthy 10-15 percent per year to order of magnitude growth in civil market opportunities. One market assessment conducted by a series of UAS manufacturers concluded that the civil market for UASs might be between $3 billion and $10 billion by 2015.

Many governments are funding UAS initiatives -- almost every European country, the European Commission through their Framework Programs, Canada, Australia, and Japan. They are building incubators, forming advisory groups, and researching how to make technical and operational improvements to UAS operations.

Many multinational organizations are looking at policy issues related to Unmanned Vehicle Systems, including NATO, the International Civil Aviation Organization (ICAO), and even the International Air Transport Association (IATA).

[103] "UAV Systems: The Global Perspective 2005", UVS International

Future needs/uses

The U.S. military is seeking new UAS capabilities to enable new war fighting doctrines and operations. DOD is seeking improved payload capabilities, adding the number and types of sensors available on different platforms. They are pursuing new operational capabilities such as autonomous mission operations, multi-vehicle systems and aerial refueling, as well as increased modularity to enable "plug-and-play" systems and maintenance. They also are evaluating options for weaponized unmanned combat air vehicles (UCAV) as force multipliers for fighter and bomber aircraft.

These new requirements will drive innovation across a broad range of UAS systems and technologies, which in turn may assist with integration of UASs into civil air space.

U.S. and foreign military organizations are expected to continue expanding procurement and operation of UASs in the coming years. Some countries, such as Australia, have developed UAS "roadmaps" outlining how and when they plan to integrate UASs into their operations.

Maintenance, Repair, and Overhaul

Overview

In terms of value, the global maintenance, repair, and overhaul (MRO) industry has not recovered to pre- 9/11 levels, as pressure from struggling airlines force MRO firms to become more cost efficient. According to the Annual MRO forecast produced by TeamSAI and BACK Aviation Solutions, the unit cost of MRO has been declining and is expected to decline through 2015.[104] Thus, although airline fleets are actually increasing, the market value is not expected to recover for several years. North America remains the largest consumer of MRO services, but labor cost advantages are causing some airlines to outsource to offshore MRO providers. The foreign market share for MRO will likely increase as fleets expand overseas, particularly in Asia.

Major MRO Providers in North America[105]

Airlines		OEMs
Air Canada Technical Services American M&E Delta Tech		EADS GE Goodrich Hamilton Sunstrand Honeywell Middle River Nordham Pratt & Whitney Rockwell Collins Rolls Royce

Analysis and Trends

MRO firms fall into three main categories: the Original Equipment Manufacturers (OEMs), the airlines, and the independent contractors. For years, a majority of maintenance work was completed by the first two categories of firms—OEMs would negotiate maintenance and overhaul arrangements as part of sales packages, and the airlines kept a large number of staff on hand to take care of other maintenance needs. Today, the rise of low-cost carriers and general industry pressure to decrease costs has led to the rise of maintenance outsourcing. According to

[104] Team SAI and BACK Aviation Solutions produce an annual MRO World Market Forecast that provides widely used benchmarks for the MRO industry. David Marcontell. Executitve Vice President and CFO, TeamSAI. "Engine MRO Industry Growth." Presentation at the Aero-Engine Cost Management Conference, Hollywood, FL. February 6, 2006. Available on the web at http://www.teamsai.com/pdf/Future%20of%20MRO%20for%20Aero-Eng%20FLL%20020806.pdf

[105] Jonathan M. Berger, Vice President-Technical Services, SH&E International Air Transport Consultancy. "MRO Facilities for the Americas Region." Presentation at the 5th Annual Aircraft Maintenance Outsourcing Conference for the Americas, Las Vegas, NV. November 9, 2005. Available on the web at http://www.sh-e.com/presentations/Berger_MRO_Speech_11-05.pdf

Team SAI and BACK Aviation Solutions, approximately 50 percent of MRO activity was outsourced in 2000, a figure that they expect will increase to 65 percent by 2010.[106] While a significant amount of maintenance work is still performed in the United States, these same cost pressures have led some airlines to contract work out to foreign sources.

The MRO market is divided into four main segments: line maintenance, heavy maintenance of airframes, engine overhaul, and component maintenance. Maintenance length is measured both in man-hours and in days. Line maintenance comprises the routine daily inspections performed on an aircraft between flights to maintain its airworthiness. Heavy maintenance refers to what are colloquially called "C" and "D" Checks—scheduled examinations of the aircraft performed every 12-18 months ("C" Checks) or every 4-5 years ("D" Checks). For both sets of examinations, the aircraft is taken to a hanger and subjected to strict inspections for wear, cracks, and corrosion that are not visible in daily maintenance. For a "C" Check, parts of the aircraft may be removed, inspected, or repaired. For a "D" Check, the entire aircraft is completely overhauled, with meticulous testing done on aircraft part and systems and some parts being replaced or upgraded. Time for these checks depends on the size of the aircraft and the nature of necessary repairs, but thousands of man-hours are involved.

Engines also undergo periodic overhaul, where the entire engine is broken down, cleaned, and reassembled. Engines undergo more frequent maintenance than does the entire airframe, so engine purchase agreements may also include the cost of a temporary engine to run the plane. Component maintenance covers a wide range of service for various aircraft parts and systems. According to Aerostrategy, maintenance for wheels and brakes, avionics, and the auxiliary power unit (APU) accounts for about 50 percent of the demand in components.[107]

The global market value of MRO services has been slowly growing since 2004 but it has still not recovered to pre-9/11 levels (see graph below). Changes in fleet composition, changes to labor costs, and changes to customer demand have led to a general decrease in the cost of maintenance services and the time it takes to perform maintenance. For example, although the global fleet size has increased, the introduction of new aircraft with more composite parts has decreased the amount of maintenance work required. This, combined with the retirement of older aircraft, has helped lower the overall cost of maintenance.[108]

In addition, industry pressure to increase efficiency in the MRO process has led firms to make organizational changes that have reduced the time for and cost of repairs. Finally, the international market, and particularly pressures to reduce labor cost to remain competitive have contributed to decreased labor cost in the United States. All of these factors have led to the general decrease in the value of the MRO market. Industry forecasts do not expect the MRO to reach pre-9/11 levels for several years.

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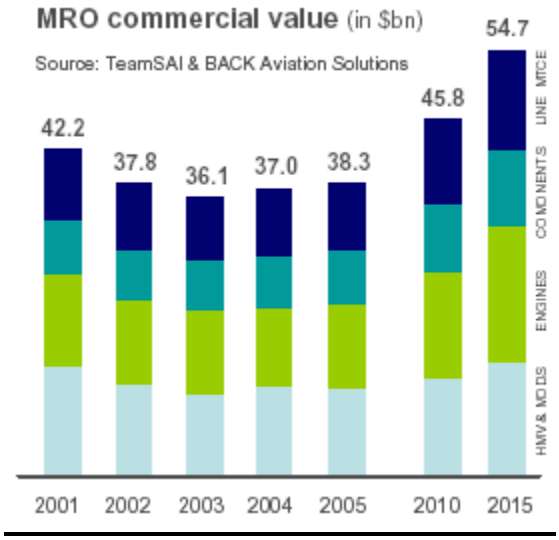
[106]David Marcontell. Executitve Vice President and CFO, TeamSAI. "Future of MRO for the Americas." Presentation at the Renaissance Hotel in Las Vegas, NV. November, 2005. Available on the web at http://www.teamsai.com/pdf/Future%20of%20MRO%20for%20Americas%20LAS%20110805.pdf .

[107] Kevin Michaels. Aerostrategy. "Forging Ahead: MRO Market Outlook." Presentation at Aviation Week's 2006 MRO Conference and Exhibition, Phoenix, AZ. April 26, 2006.

[108] David Marcontell. Executitve Vice President and CFO, TeamSAI. "Engine MRO Industry Growth." Presentation at the Aero-Engine Cost Management Conference, Hollywood, FL. February 6, 2006. Available on the web at http://www.teamsai.com/pdf/Future%20of%20MRO%20for%20Aero-Eng%20FLL%20020806.pdf

Figure 3: MRO market value by market segment[109]



The only exception to these trends is in the engine MRO segment, where new engine technologies are actually increasing the cost of maintaining the engine. Also, unlike airframe maintenance, most of the cost of engine overhaul comes from parts rather than labor, and thus is not as affected by the labor cost reductions the industry has been able to achieve.[110] Industry analysts predict that engine MRO will be the highest growth segment of the market over the next several years.

Market

Over the next decade, North America is expected to lose market share in MRO demand and experience a lower rate of growth than other regions. According to TeamSAI and BACK Aviation Solutions, the ten-year compound annual growth rate for South America and the Asia/Pacific (excluding China and India) is expected to be around 6 percent while the rate for North America will be less than 3 percent.[111] In China and India, growth rates are expected to be even higher, around 13 and 9.5 percent, respectively. These projections reflect the overall expansion of the aviation industry in both of these countries—Boeing expects India to acquire 380 new planes by 2025[112] and China to acquire about 2,600 new planes in that timeframe.[113]

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[109] Peter van de Pas. Senior Vice President for Engineering and Maintenance, KLM. "MRO as a Profit Centre." Available on the web at http://www.nivr.nl/Download/Presentatie_vd%20Pas.pdf .

[110] Fraank Jackoman. "MRO Market Up Modestly As Efficiencies Take Hold." *Overhaul and Maintenance.* April 12, 2006. Available on the web at http://www.aviationnow.com/avnow/news/channel_om_story.jsp?id=news/om406cvr.xml .

[111] Doan, Christopher. President and CEO, TeamSAI. "A New MRO World; A Look Forward." Presentation at the North American MRO Conference, Phoenix, AZ, April 2006. Available on the web at http://www.teamsai.com/pdf/2006MROForecastPresentation041706R12%20Printable.pdf

[112] U.S. Commercial Service. "Air and Air Parts." Market Research Report. August 31, 2005. Available on the web at http://www.buyusainfo.net/docs/x_4342293.pdf .

[113] The Boeing Company. "2005 Current Market Outlook." p. 28. Available on the web at http://www.boeing.com/commercial/cmo/index.shtml .

On the supply side, Europe is currently a net exporter of MRO services, while North America and Asia are net importers.[114] This is despite the fact that Europe has higher labor costs than either of the other two regions. For Asia, at least, this is probably a capacity issue—as new MRO facilities are built in Asia over the next few years, the balance may change. Already, there are three Asian MRO companies amongst the global top ten providers of airframe maintenance (including Taikoo Xiamen Aircraft Engineering Co., Hong Kong Aircraft Engineering Co, and the overall world leader, Singapore Technologies Aerospace).[115] When looking at just third-party (i.e. outsourced) MRO, AMECO Beijing can also be added to the list.

Latin America and Asia are expected to be two of the highest growth areas for MRO and are likely to compete for shares of the outsourced market. Proximity may grant Latin America an advantage to snagging business from North America; however, more investment is necessary to increase capacity before the industry can truly take off.[116]

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[114] Kevin Michaels. Aerostrategy. "Forging Ahead: MRO Market Outlook." Presentation at Aviation Week's 2006 MRO Conference and Exhibition, Phoenix, AZ. April 26, 2006.
[115] Lee Ann Tegtmeier. "Top 10 Airframe MRO Companies." *Overhaul and Maintenance.* May 2005.
[116] David Marcontell. Executitve Vice President and CFO, TeamSAI. "Future of MRO for the Americas." Presentation at the Renaissance Hotel in Las Vegas, NV. November, 2005. Available on the web at http://www.teamsai.com/pdf/Future%20of%20MRO%20for%20Americas%20LAS%20110805.pdf .

Airport Infrastructure/Aviation Security

Overview

The Airport Infrastructure and Aviation Security markets are in a state of rapid growth due to a number of reasons. Steady air traffic growth across all regions, post-9/11 security concerns, and expected growth in the next 20 years are major contributors to this surge. Worldwide airport capital expenditures grew from $31 billion in 2004 to $36 billion in 2005.[117] Although constrained by local, state, and federal regulations, U.S. airports will need to expand capacity to meet future demand. Moreover, the evolving security paradigm both within the U.S. and throughout the world will ensure long-term viability of the market for aviation security technologies.

U.S. Infrastructure Manufacturers

Airport Infrastructure		Aviation Security	
ARINC	Parsons Transportation Group	Battelle	SRA International/Galaxy Security
Daktronics, Inc.	ESRI	SRS Technologies, Inc.	SecureScan
Magnetic Automation Corp.	ThyssenKrupp Airport Systems	Raytheon/McNeil Security	ARINC (Verified Identity Pass/Clear)
Penta Corporation	NEC Display Systems		Matrix Systems, Inc.
Trident Computer Corp.	Unimark, Inc.	URS Corporation	Zortek Systems
Vidtronix	Unisys	Honeywell Aerospace	UTC
FMC Technologies, Inc.	Zortek Systems	MITRE/CAASD	TransSecure, Inc.
Airports Seating Alliance			

Analysis and Trends

Both industry and government predict and are preparing for significant increases in demands on the commercial air transportation system. Through the auspices of the Joint Planning and Development Office (JPDO)[118], the U.S. government is working, on a multi-agency basis, to develop policy and technology roadmaps that will support a doubling or tripling of air traffic by 2025. Privately owned airports and aviation infrastructure manufacturers are participating in this effort both on their own and in partnership with the JPDO through the NGATS Institute.

Airport Infrastructure

Large numbers of new airports throughout Europe and Asia are "either planned or under construction to accommodate global air traffic, which is expected to double by 2020."[119] Some analysts expect China alone to build up to 50 new airports in the next decade.[120] Furthermore,

[117] Airports Council International. "Airports invest to meet surging traffic demand." Press Release. January 24, 2006.
[118] The JPDO was established through the enactment of the 2003 VISION 100 — Century of Aviation Reauthorization Act [P.L. 108-176] in order to oversee the development of the Next Generation Air Transportation System.
[119] Kevin Brass. "Dubai turns focus to airports." *International Herald Tribune*. March 29, 2006.
[120] *Ibid.*

existing airports continue to renovate and expand to handle future increases in passengers and cargo traffic as well as larger jets (such as the Airbus A380). In the United States, construction of new airports and expansions of existing airports must take into account local, state, and federal regulations (managed by entities such as the Federal Aviation Administration, the Environmental Protection Agency, and the Transportation Security Agency) as well as standards and strictures issued by the International Civil Aviation Organization (ICAO). That being said, the JPDO and U.S. airports continue to develop plans for new construction, airport expansions, and modernization initiatives that will in turn create numerous opportunities for manufacturers of airport infrastructure equipment and technologies. From landside passenger services (e.g., check-in and baggage handling) to cargo operations (such as inter-modal transfers and just-in-time delivery to runways) to basic infrastructure (as in passenger terminal facilities, access control, information displays, and boarding bridges), the global business of building and maintaining airports could potentially be worth $400 billion a year.[121] This business is projected to grow at a rate of 9 percent a year over the next 10 years.[122]

The need for new and/or expanded airport capacity is further underlined by the current and potential job growth that has been spurred by the surge in passenger traffic and cargo volumes over the past two years.[123] According to Airports Council International and the Air Transport Action Group, 4.5 million persons were employed on airport sites worldwide in 2005.[124] This effect is further multiplied by the evolution of the "aerotropolis" in which international airports increasingly serve as magnets for commercial development and combine office, retail, entertainment facilities, and even some housing with airports to create "airport cities".[125] In fact, many of the largest airports derive up to 50 percent of their revenue from non-aviation sources, such as shopping areas and restaurants.[126]

Given this new status as economic catalysts, existing airports (or "aerotropoli") will need to build new capacity both to meet the expected growth in passenger and cargo traffic and to maintain economic momentum. To do so, airports, airport infrastructure manufacturers, and government entities such as the JPDO are working to remove regulatory and political obstacles to building new capacity. This effort is necessary to avoid severe congestion that could restrict the economic dynamism of airports by suppressing trade, investment, and traffic flows.[127]

Figures 1-3 illustrate the continuing upward trend of passenger and freight traffic from January 1999 to the present and beyond.

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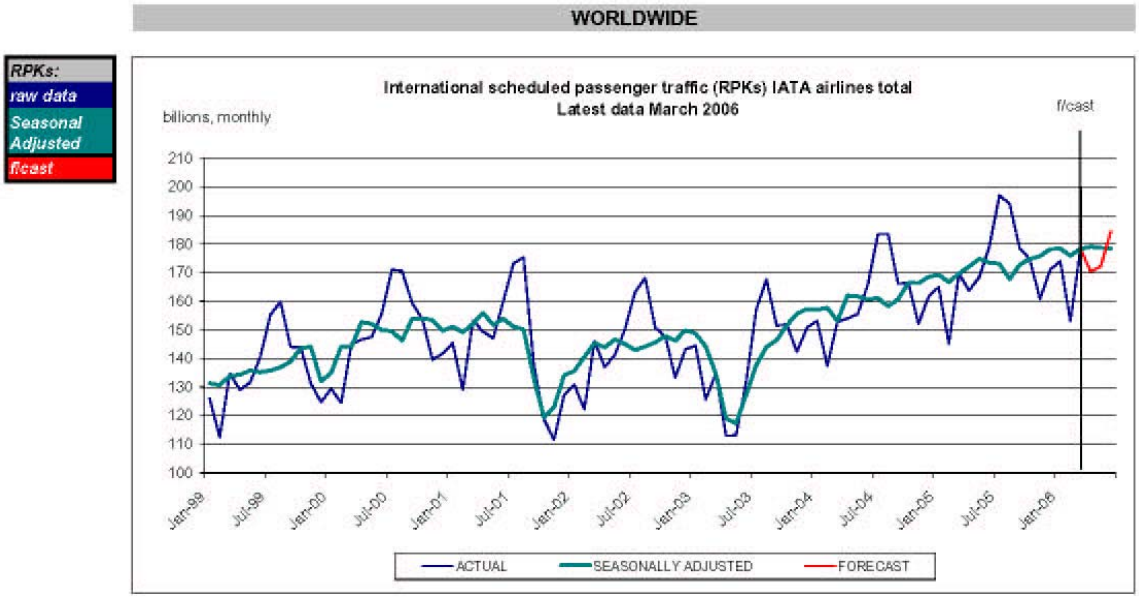
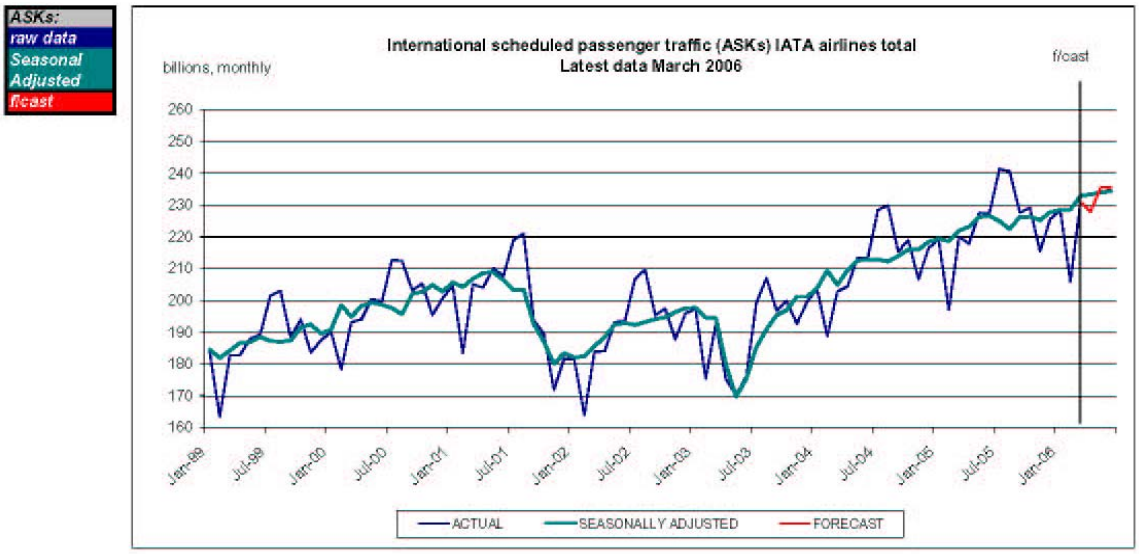
[121] *Ibid.*
[122] *Ibid.*
[123] Airports Council International. "Airports Stimulate Employment and Economic Growth." Press Release. April 11, 2006.
[124] *Ibid.*
[125] Urban Land Institute. "Will the 'Aerotropolis' Replace the Metropolis? In Today's Real Estate Environment, Easy In-Easy Out is Key Factor." November 7, 2002. Available on web at http://www.uli.org/AM/Template.cfm?Section=Home&CONTENTID=21387&TEMPLATE=/CM/ContentDisplay.cfm
[126] Kevin Brass. "Dubai turns focus to airports." *International Herald Tribune*. March 29, 2006.
[127] Airports Council International. "Airports Stimulate Employment and Economic Growth." Press Release. April 11, 2006.

Figure 1: Worldwide Passenger Data (RPKs) and Forecast[128]



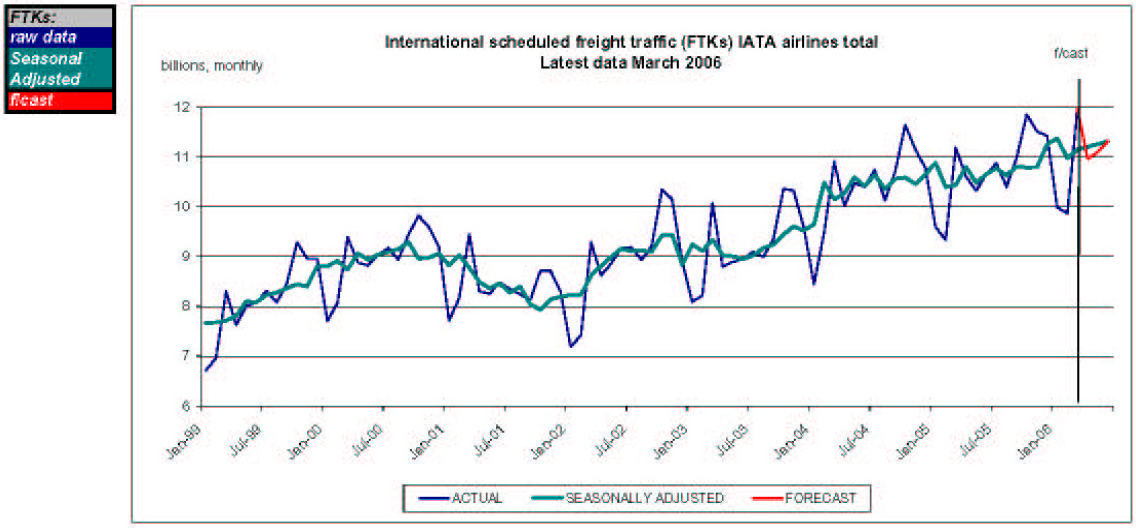
RPKs: Revenue Passenger Kilometers
ASKs: Available Seat Kilometers
FTKs: Freight Tonne Kilometers

Figure 2: Worldwide Passenger Data (ASKs) and Forecast[129]



[128] International Air Transport Association. "International Scheduled Operations Traffic Analysis." *IATA Economics 2006*. March 2006.
[129] *Ibid.*

Figure 3: Worldwide Cargo Data and Forecast[130]



RPKs: Revenue Passenger Kilometers
ASKs: Available Seat Kilometers
FTKs: Freight Tonne Kilometers

[130] *Ibid*

Aviation Security

In the post-9/11 air transportation system, the aviation security paradigm continues to evolve. In fact, security concerns, though hardly an afterthought in the past, have become an essential part of airport and aviation operations that cannot be relegated to the background. As demonstrated by Figure 4, airport security technologies were deployed throughout the world in 1995, yet the United States (Column 7) had not deployed any of the listed baggage screening/explosives detection devices, despite the fact that these systems were considered state-of-the-art. The 1988 terrorist bombing of Pan Am Flight 103 and the explosion of TWA Flight 800 in 1996 contributed to the creation of the White House Commission on Aviation Safety and Security headed by Vice President Gore (the Gore Commission).[131] The Gore Commission presented a number of recommendations to enhance security at U.S. airports in its initial report to President Clinton in September 1996 as well as in its final report in February 1997.[132] As well, the evolution of threats that face aviation have forced airports and governments to place greater and greater emphasis on security.

Figure 4: Report to the FAA Research and Development Advisory Committee

Etter Report August 1995

Deployed Airport Security Technology

Countries: 1.Germany, 2.UK, 3.Italy, 4.Belgium, 5.Israel, 6.Saudi Arabia, 7.USA, 8.China, 9.Japan, 10.Sweden, 11. Spain, 12. Holland, 13. Gulf States, 14.Malaysia, 15.Hong Kong, 16. Singapore, 17. Korea, 18.Canada, 19.Taiwan, 20. India, 21. Austria, 22.Indonesia, 23. France, 24. Switzerland

Technology: 1. EGIS, 2. CTX, 3. VIVID, 4. EG&G

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	45	18	1	2					1			1	1		2							3		7
2	+	11	+	1	7	+		1	1	+	+	+	+	+		+	+		+	+	+		+	+
3		57		2								2						2					2	5
4		11																						

The Bush Administration has produced a number of plans, including the Transportation Security Operational Plan, the National Infrastructure Protection Plan, and the National Strategy for

[131] Statement of Keith O.Fultz, Assistant Comptroller General, GAO, before the House Committee on Science. "AVIATION SECURITY—Technology's Role in Addressing Vulnerabilities." September 19, 1996. Available on the web at http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=gao&docid=f:rc96262t.pdf

[132] White House Commission on Aviation Safety and Security. "Final Report to President Clinton." February 12, 1997. Available on the web at http://www.fas.org/irp/threat/212fin~1.html

Transportation Security, to address various aspects transportation security. At present, the Administration is in the process of drafting a National Strategy for Aviation Security (NSAS). Within the NSAS, a supporting plan regarding the Aviation Transportation Security System is being created to help manage the development and implementation of new and improved security measures throughout U.S. airports and the National Air Space (NAS). Moreover, the Airports and Security Integrated Product Teams of the JPDO have partnered with industry and are working with the governmental agencies involved in drafting the NSAS. This partnership is meant to ensure that costs, efficiencies, economic impact, and the fluid and changing nature of air transportation (e.g., the expected increases in air traffic) are considered and reflected in the Strategy.

In conjunction with the drafting of the Strategy and Plans, the Aviation Security industry has moved forward with a number of possible solutions and technologies. These new technologies will address both security concerns and the need to reduce congestion (and thus not interfere with the business of airports and aviation transportation). For instance, a number of U.S. airports are participating in pilot "Registered Traveler" (RT) programs. RT programs grant frequent air travelers, who have subscribed to the program and submitted to background checks, the opportunity to use expedited check-in and security services.[133] These pilot programs provide airports and security technology manufacturers with a means of testing various identification and screening technologies, such as biometrics, radio frequency identification (RFID), and prototype explosives/baggage screening devices. Ideally, sufficient use of RT programs would reduce the burden on non-RT screening positions within airports and thus reduce congestion. The goal, of course, of RT and other initiatives, is to minimize the security impact on the stream of safe commerce while developing and maintaining a layered and adaptive aviation security system.

Market

The market for airport infrastructure and aviation security products will continue to expand in the foreseeable future as plans for implementing the Next Generation Air Transportation system and the National Strategy for Aviation Security go forward. Moreover, the expected growth in air traffic, the economic catalyst affect of large airports, and the demands of air travelers will pressure airports and vendors of infrastructure and security technologies to pursue greater efficiency.

While throughout much of the world airports have been government-owned enterprises, this paradigm is shifting towards commercially operated businesses (as is the case in the United States).[134] As such, the current and planned new airports and expansion projects will provide numerous opportunities for providers of airport infrastructure products. Granted, government-owned airports will continue to favor local or regional providers. That being said, the paradigm shift towards commercial operation as well as current government-to-government negotiations regarding procurement indicate that opportunities will arise and continue to improve.

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[133] ARINC. "Clearing the Way Through Airport Security." *ARINC Airport News*. Pg. 2. Issue Number 4. January 2006. Available on the web at http://www.arinc.com/news/newsletters/airportnews04.pdf

[134] Kevin Brass. "Dubai turns focus to airports." *International Herald Tribune*. March 29, 2006.

U.S. providers of aviation security technology hold a leading position in the market. Almost all U.S. aviation security technologies are used internationally. Over the past 15 years, international visitors seeking security technology have averaged over 30 visits per year to the FAA/TSA/DHS Security Laboratory near Atlantic City, New Jersey. These visits have yielded many purchases of state-of-the-art U.S. security technology. The next generation of technologies will be smaller, faster, cheaper, and lighter and will be able to detect a greater array of threats. These new systems will be more user-friendly and have less impact on civil liberties. Further, these new systems and technologies will be more adaptable to the airports in which they will be placed. In addition, harmonized security requirements will allow cohesive systems of passenger management, baggage handling, and cargo shipments to be built around available and future technologies (rather than jerry-rigged, as is the case in many airports today).

Again, given the dynamic nature of airports economies and the demand that expected growth in air traffic will engender, the airport infrastructure and aviation security markets will continue to grow and expand as new airports and expansion projects are planned and implemented.

Country Studies: India

India has stated a strong interest in entering the development of space technologies. The Indian Space Research Organization (ISRO) is the primary (government) vehicle for technology research and development, procurement and the provision of space-related services. ISRO built and operates the INSAT satellite system to provide television, meteorological, and telecommunications services. ISRO's Indian Remote Sensing (IRS) Satellite System provides satellite-imaging data for resource monitoring, infrastructure development, and exploration.

India has also developed two launch vehicles, the smaller PSLV rocket and the larger GSLV rocket, which have both launched satellites for the Government of India. In 2005, India performed one launch for the Indian Government, which was its ninth launch of the Indian PSLV rocket. India's larger GSLV rocket did not launch in 2005, but has performed successfully in the past. Once India enters the commercial market, India is likely to win an average of one launch per year for a few years, mainly through promotional pricing, package deals, partnership programs with Europe, etc. (FAA 2005 Year in Review) Because of India's launch vehicles' limited capabilities and size, India likely will not gain a significant portion of the market in the short term. India will be able to enter the commercial market once it has signed two Memorandums of Understanding with the United States: one that oversees technology transfer and a commercial space launch trade agreement.

India intends to expand its communications satellite production capabilities to capture some of the commercial market. India has already manufactured several communications and remote sensing satellites for the Indian Government, and is now actively seeking international customers. India is exploring joint ventures with U.S. and European companies to build communications satellites. The U.S.-India High Technology Cooperation Group (HTCG) is exploring areas in which cooperation in the space sector can be increased between the two countries. President Bush and Indian Prime Minister Vajpayee agreed in 2001 to develop the HTCG to spur cooperation in this sector and to address ways to increase trade in dual-use goods and technologies. Some areas likely to be considered are space research and development, joint satellite production and the ability to launch U.S. satellites and/or components on Indian rockets.

In aviation, India is expected to experience major growth over the next several decades, taking delivery of around 380 new aircraft.[135] Domestic passenger traffic is expected to grow at 12.5 percent per year as the growing Indian middle class starts to spend more money on air travel. To feed this growth, several new domestic airlines have been started in India over the past several years, most following the low-cost business model. These airlines helped fuel a buying binge in 2005, with Indian carriers ordering 327 new aircraft. The expected growth in the Indian market has generated considerable competition amongst foreign firms.

Overall, India imports a majority of aerospace products, with about 80 percent of aircraft and parts coming from foreign sources. Domestic production in India has largely centered on military aircraft, with the state-owned Hindustan Aeronautics Limited (HAL) anchoring the aerospace hub in Bangalore. In recent years, many of India's aircraft have been derived from

[135] Fleet estimate from Boeing. U.S. Commercial Service Market Research http://www.buyusainfo.net/docs/x_4342293.pdf .

foreign technology, particularly from the Soviet Union; the Light Combat Aircraft (LCA), which had its first flight in 2001, was the first indigenous fighter produced in India in nearly 40 years.[136] As it did in the IT sector, India is attempting to grow its domestic industry by promoting it as a low-cost outsourcing site. In addition, the Indian government imposes a 30 percent offset requirement on defense purchases valued over $70 million. Thus, while market opportunities in India are significant, capitalizing on them require millions of dollars of investment by foreign companies.

One factor that could limit growth of the domestic aviation industry is infrastructure, as the current infrastructure is inadequate to address the needs of the growing system. Problems persist across the system—air traffic control equipment is old and unreliable, there is not enough space to park airplanes or store cargo, and there are not enough area control centers to provide complete coverage of the airspace. Indian government officials have launched several multibillion programs over the last several years to address problems throughout the country. One of these programs, announced in 2004, would include $4 billion to upgrade the facilities at India's two main hubs, Mumbai and New Delhi along with $5 billion for 23 other non-metro airports.[137] A second program, announced in 2006, would invest $12.5 billion in regional airports through 2009.[138]

[136] Sukumar R. Iyer. "LCA: Impact on Indian Defense." Bharat Rakshak Monitor. Vol 3(5) March-April 2001. http://www.bharat-rakshak.com/MONITOR/ISSUE3-5/sukumar.html
[137] U.S. Commercial Service Market Research. http://www.buyusainfo.net/docs/x_866852.pdf
[138] "India Pushes $12.5 billion Overhaul of Secondary Airports." *Aviation Daily.* February 24, 2006.

Country Studies: China

The People's Republic of China is likely to be the single largest customer–and possibly an emerging competitor–of the U.S. aerospace industry in the future. Today, China's aviation industry consists of more than 200 enterprises that produce and manufacture products such as aircraft, turboprop engines, aircraft components and subsystems, helicopters, industrial gas turbines, and various electromechanical products. Military products produced in China include fighters (F7, F8, and their derivatives), fighter-bombers (FBC-1), bombers (H5 and H6 series), transports, trainers (FT6, FT7, HJ5), and reconnaissance aircraft.[139] China's first successful manned space launch in late 2003 makes it the third country in the world (after the United States and Russia) to put a human in space on its own rocket.

In 1999, China established 10 new state-owned enterprises (SOEs), and all of China's large aerospace-related institutes were operationally merged with enterprises in their area of specialty. The two industry leaders for aircraft are China Aviation Industry Corporations I (AVIC I), which focuses on large- and medium-sized aircraft, leasing and general aviation aircraft, and China Aviation Industry Corporations II (AVIC II), which produces small aircraft, feeder aircraft, and helicopters. AVIC I and AVIC II and their subsidiaries have about 491,000 employees[140] and have total combined assets of approximately $8 billion.[141]

Technological advancement of China's aviation industry has moved hand in hand with cooperation and investment from international firms. Chinese companies have a long history of industrial cooperation with Russian aerospace companies, although such programs have been negatively affected by the troubles facing the Russian industry. Boeing has sourced various parts from Chinese factories for years, including horizontal stabilizers, vertical fins, tail fins, nose cones, and aircraft doors. In November 2005, Boeing received a U.S. export license to manufacture the rudder for the 787 in Chengdu. Chinese companies also supply components to some Airbus models and have entered into cooperative ventures with Eurocopter to produce helicopters. Canadian company Bombardier has sourced parts from China for some of its aircraft beginning in the 1980s.

Cooperative efforts extend beyond the supply of aircraft components. In 2006, Boeing plans to partner with Shanghai Airlines and the Shanghai Airports Authority to build a maintenance, repair, and overhaul (MRO) center in Shanghai.[142] This will be the first MRO facility in China in which a foreign company has a controlling share. U.S. companies also have partnered with Chinese companies to incorporate U.S. engines and components on Chinese aircraft. Starting in the late 1980s and into the early 1990s, Pratt & Whitney established joint ventures with Chinese firms to manufacture turboprop engines for several of China's Y-series transport aircraft.

Programs based on large commercial aircraft co-production have had mixed results. One of the most extensive U.S.–Chinese civil manufacturing partnerships was a program started in 1985 with McDonnell Douglas to assemble MD-82 aircraft in China. Thirty-five of these aircraft were

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[139] www.avic1.com.cn/English/index.htm
[140] NTI Research Library http://www.nti.org/db/china/avic1.htm
[141] *China Civil Aviation Sector Summary for 2001*, British Embassy, Beijing.
[142] William Dennis. "Boeing Leads Charge in new Chinese MRO Joint Ventures." *Aviation Daily.* April 20, 2006.

produced, five of which were sold in the U.S. market.[143] In 1994, McDonnell Douglas finalized an agreement to coproduce MD-90s in China, but only two of the planned 40 aircraft were ever assembled, and the project was cancelled in 1998.[144] Plans announced in 1996 by Chinese and Airbus officials to jointly build a 100-seat "Asian Express" aircraft that would be added to the Airbus product line similarly stayed on the drawing board and never came to fruition.[145] Despite this history, in 2005 Airbus announced that it was studying possible sites for assembling A320 aircraft in China, with production designed to serve the Chinese market. The study should be completed in mid-2006 with 2008 targeted as the date for the first delivery date.

For coproduction of regional jets, Chinese companies have found a willing international partner in Embraer. AVIC II owns 49 percent of a joint venture with Embraer to manufacture, assemble, sell, and provide after-sales support for the ERJ 135/140/145 family aircraft in Harbin, China.[146] Embraer launched the venture in 2002, in response to a Chinese government ban on regional jet imports established the year before.[147] The enterprise delivered its first plane in 2004; slow orders, however, place some doubt on the long-term longevity of the project.[148]

U.S. and European manufacturers continue to press hard to expand partnerships with Chinese aerospace companies. Boeing is expanding its relationship with China through plans to double its annual purchases from Chinese companies over the next six years to more than $1 billion per year by 2010.[149] EADS officials have publicly announced a number of joint initiatives they are pursuing with Chinese companies ranging from subcontracts on Airbus aircraft programs to establishment of engineering and training centers.[150]

China has big plans for its future indigenous civil aircraft manufacturing sector. China's first business aircraft, the Little Eagle 500 developed by AVIC II, flew its maiden flight in October 2003 and was originally scheduled to enter service in late 2004.[151] AVIC I is developing China's first indigenous regional jet, the ARJ21, albeit with significant contributions from U.S., European and Russian aerospace manufacturers. Ten U.S. aerospace companies supply major components on the ARJ21, and Ukrainian manufacturer Antonov is designing the ARJ21 wings.[152] AVIC I hopes to sell 500 regional jets in 20 years, and is seeking FAA certification to facilitate exports of the aircraft. Targeting 80 percent of Chinese passenger flights that carry fewer than 100 passengers, AVIC I already has launch orders for 35 aircraft from three Chinese

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[143] *The Changing Structure of the Global Large Civil Aircraft Industry and Market: Implications for the Competitiveness of the U.S. Industry*, ITC Publication 3143, Investigation No 332-384, November 1998.
[144] Ibid.
[145] "Believing in a jet plane," *South China Morning Post*, September 24, 2002.
[146] *Commercial Aviation Today*, December 2, 2002.
[147] Gregory Polek. "Order book stalls for Sino ERJ-145." Aviation International News. Feb. 2004. http://www.ainonline.com/Publications/asian/asian_04/d1_erj-145p2.html
[148] Nicholas Ionides. "ERJ-145 deal earns reprieve for Chinese assembly line." *Flight International.* Jan 24-30, 2006.
[149] "Boeing Seeks Higher-Level Cooperation with Chinese Suppliers," *Business Daily Update,* http://mutex.gmu.edu:2056/universe/printdoc
[150] "*The Chinese aerospace industry is and will be the permanent partner of EADS,*" EADS news release, November 2, 2004.
[151] Xinhua News Agency, October 27, 2003.
[152] "AVIC I Commercial Aircraft," *Aviation International News*, January 2005. www.ainonline.com/Features/regionalbusaircraft/arj21a.html

airlines.[153] AVIC I is seeking to establish a role for itself as a developer and systems integrator on this new program, perhaps with an eye to future–and larger–aircraft programs. Finally, in March 2006, China released its 11th 5-Year plan, which included the goal of developing an indigenous large passenger aircraft. The goal is to produce the plane by 2015.

China's transition to a viable prime producer of commercial jet aircraft and engines will be aided by its large and growing domestic aviation market, providing a ready market for new indigenous aircraft. China's aviation industry is arguably the fastest growing aviation industry worldwide. Air traffic in China has increased threefold between 1980 and 2004.[154] AVIC I predicts that passenger traffic alone is expected to grow 8.5 percent annually over the next two decades.[155] Given that there are only about 1,100 registered aviation aircraft operating in China (compared to roughly 219,000 in the United States[156]), industry analysts predict that Chinese airlines will add nearly 2000[157] large- and medium-sized aircraft to their fleets over the next two decades. Boeing currently enjoys a dominant market position in China with around 70 percent of the current operating fleet. Boeing sold its first commercial jet to China in 1972 following President Nixon's trip to China. The first Airbus delivery to China occurred in 1994.

Not surprisingly, Boeing and Airbus have identified China as the single most important market for new sales over the next 20 years, and both companies are working hard to win new orders from Chinese airlines. In 2005, Chinese carriers ordered 339 aircraft in 2005, 219 from Airbus and 120 from Boeing. Traditionally, the Chinese government (through the China Aviation Supplies Corporation [CASC]) directs the purchase and distribution of imported aircraft among the various Chinese airlines. This practice is changing as Chinese airlines become more independent.

Future U.S. and European export prospects may be dampened to the extent that Chinese companies are able to satisfy at least some of this growing demand with indigenously produced aircraft. U.S. and European companies also may face new competition domestically and in other countries as Chinese manufacturers seek to expand their share of the global aircraft market.

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[153] "ARJ21 structural design nearly done," *Aviation International News,* January 2005. http://www.ainonline.com/issues/01_05/01_05_arj21_67.html

[154] "China's aviation industry to soar, Boeing predicts," *Business Report*, November 1, 2004. http://www.businessreport.co.za/index.php?fArticleId=2282356; "China's aviation industry to retain robust growth," *China's People's Daily Online*, March 26, 2000. http://english.people.com.cn/200407/14/eng20040714_149522.html

[155] "Forecast Summary by Market and International Cooperation Department of AVIC I," *China Aviation News*, November 17, 2000.

[156] Speech by CAAC Vice Minister Li Jun, China–U.S. Aviation Symposium, Beijing, April 2004.

[157] Consolidated estimate from Boeing, Airbus, CAAC, and industry analysts.

Country Studies: Japan

Japan was the top market for U.S. aerospace products in 2005, the $6.6 billion dollars in sales representing 9.9 percent of total aerospace exports.[158] This figure reflects the close relationship between the U.S. and Japanese aerospace industries in both the civilian and military arenas. Japanese companies serve not only as a major customer for U.S. manufacturers, but also as a major supplier as well.

Figure 4: U.S. Aerospace Exports to Japan, 1996-2005[159]

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Value of Exports (million USD)	$3,772	$5,071	$6,057	$5,401	$4,257	$3,795	$5,071	$5,966	$6,285	$6,648
% Total	10.1%	10.1%	9.5%	8.6%	7.8%	6.5%	8.9%	11.2%	11.1%	9.9%
Market Rank	1	2	2	2	4	6	2	1	1	1

Japanese aerospace companies have established themselves in the global aerospace industry as important manufacturers of a wide range of civil, military and corporate aerospace products. They supply components and structures for a wide range of commercial aircraft (especially Boeing and Airbus jet transports) and aircraft engines.

In spite of their diverse and longstanding manufacturing programs, individual Japanese companies lag in size behind leading firms in the United States and Europe. The overall Japanese aerospace manufacturing industry is about half the size of the industries in the United Kingdom or France, and one tenth the size of the U.S. aerospace industry.[160] Nonetheless, aerospace production is ten times greater than it was in 1980.[161]

The Japanese aerospace industry is dominated by the four "heavies": Mitsubishi Heavy Industries (MHI), Kawasaki Heavy Industries (KHI), Ishikawajima-Harima Heavy Industries (IHI), and Fuji Heavy Industries (FHI). These four companies, together with a wide range of smaller Japanese companies, employ around 29,488 aerospace workers.[162] Aerospace products make up only about 20 percent of total sales (in fiscal year 2002) of the individual largest companies, which are widely diversified among strategic businesses such as industrial machinery, shipbuilding, electrical machinery, and automobiles.[163]

The expansion into new civil markets has been aided significantly through financial support from the Japanese government, such as through the International Aircraft Development Fund (IADF) made up of the four heavies and the Ministry of Economy, Trade and Industry (METI).[164] For

[158] "Top Twenty Aerospace Export Markets." Office of Aerospace and Automotive Industries, U.S. Department of Commerce. http://www.ita.doc.gov/td/aerospace/inform/top20exp.xls .
[159] Ibid.
[160] "Aerospace Industry in Japan." The Society of Japanese Aerospace Companies (SJAC), 2005. http://www.sjac.or.jp/hp_english/aerospace_industry.pdf .
[161] Ibid.
[162] Ibid.
[163] The Society of Japanese Aerospace Companies (SJAC), http://www.sjac.or.jp/english/003.html. November 18, 2003.
[164] The Japanese Ministry of International Trade and Industry (MITI) was the Japanese Government agency responsible for this activity prior to being reorganized into METI in 2001.

example, in 1996 the Japanese government provided ¥2.9 billion ($24 million USD) to assist with Japanese participation in the Boeing 777 program, and ¥1.6 billion ($13 million USD) for the International Aero Engines V2500 engine project.[165]

More than 91 Japanese companies, including the four heavies, are program partners, subcontractors, or suppliers to Boeing across its commercial-airplane product lines.[166] Japanese-manufactured parts and components make up significant portions of the Boeing 777,[167] and Japanese companies have been identified as significant risk-sharing partners in Boeing's new 787 program.[168] Boeing also has extensive relationships with Japanese airlines. "Through June 2005, Japan has ordered 796 Boeing airplanes worth approximately $70 billion (in 2004 dollars). In the past decade, 80 percent of the airplanes ordered by Japanese customers have been Boeing products, and Japan is the largest customer for Boeing twin-aisle airplanes."[169]

Airbus has actively pursued partnerships with Japanese companies on new aircraft programs such as the A380, possibly in hopes of capturing a larger share of Japan's large jet transport market. Seven Japanese suppliers, including MHI, FHI, and the Japan Aircraft Manufacturing Company, have been signed up to manufacture parts for the A380 over a period of 20 years, for a total of $850 million in components including cargo doors and parts of the tail.[170]

The Japanese aerospace industrial base is not limited to supplying other manufacturers, however. Japanese companies also produce complete small jet and turboprop aircraft and helicopters, military aircraft and trainers, and space launch vehicles. Almost two-thirds of total Japanese aircraft production historically has consisted of military aircraft sold to the Japanese Defense Agency.[171] Often these aircraft were manufactured under technical license or in coordination with non-Japanese (mostly U.S.) companies.[172] Many indigenous military aircraft programs have had relatively small production runs, in large part due to a 1967 Japanese government ban on military product exports. This continuing ban and shrinking domestic defense budgets have led Japanese companies to seek out new opportunities to participate in civil aircraft programs.

Analysts have speculated about the potential for Japanese companies to develop and produce a wholly indigenous large civil jet transport, given their extensive aerospace manufacturing capabilities. However, Japanese investments in new major Boeing and Airbus aircraft programs such as the 787 and, to a lesser extent the A380, may be indications that they are for now focusing their efforts as partners in global programs.

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[165] The Society of Japanese Aerospace Companies (SJAC), 1998. www.sjac.or.jp/english/01_a.htm
[166] "The Boeing Company and Japan," May 5, 2006. www.boeing.com/companyoffices/aboutus/boejapan.html
[167] http://www.sjac.or.jp/english/008.html
[168] "Groups move closer to Boeing 7E7 deal," *Financial Times*, October 20, 2004.
[169] "The Boeing Company and Japan," May 5, 2006. www.boeing.com/companyoffices/aboutus/boejapan.html
[170] "Airbus Picks Three More Suppliers from Japan for Its A380 Jet," *Wall Street Journal*, June 2002.
[171] http://www.sjac.or.jp/english/003.html
[172] "Aerospace Industry in Japan." The Society of Japanese Aerospace Companies (SJAC), 2005. http://www.sjac.or.jp/hp_english/aerospace_industry.pdf .

Europe

Overview

The European Union (EU) is the largest export market for the United States aerospace industry. Although Japan was the largest single country export market for the U.S. aerospace industry in 2005, combined exports of the U.S. aerospace industry to the United Kingdom, France and Germany, the EU's three largest aerospace markets, clearly illustrate the importance of the region for both the U.S. and EU aerospace markets.[173]

As is the case in the United States, large and small European aerospace companies supply the full range of aerospace products and services. The European Aeronautic and Defence Company N.V. (EADS) is the largest aerospace company in Europe. Formed in 2000 by the merger of DaimlerChrysler Aerospace AG of Germany, Aerospatiale Matra of France and CASA of Spain, EADS is a global leader in aerospace, defense and related services. EADS includes aircraft manufacturer Airbus, helicopter manufacturer Eurocopter and the joint venture MBDA Missile Systems.[174] In additon, EADS is the major partner in the Eurofighter consortium[175], is the prime contractor for the Ariane launcher, is developing the A400M military transport aircraft, and is the largest industrial partner for the European satellite navigation system Galileo. The company employs about 113,000 people at more than 70 production sites in France, Germany, Great Britain and Spain as well as in the United States and Australia.[176]

Aside from EADS, the six companies listed below are the leading European suppliers to large commercial transport aircraft programs. Like their U.S. counterparts, they too manufacture large structures or subassemblies, such as fuselages or landing gear, or components such as avionics or communications equipment. Again, there are thousands of other companies across the EU that are suppliers to commercial and military aircraft programs, and some are even prime producers of complete military aerospace products.

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[173] "Top Twenty Aerospace Export Markets." Office of Aerospace and Automotive Industries, U.S. Department of Commerce available at http://www.ita.doc.gov/td/aerospace/inform/top20exp.xls

[174] http://www.eads.com/web/lang/en/1024/content/OF00000000400004/6/03/31000036.html .

[175] EADS holds a 46 per cent share in the Eurofighter consortium, making it the major shareholder. http://www.eurofighter.com/Organisation/EADS/ .

[176] http://www.eads.com/web/lang/en/1024/content/OF00000000400004/6/03/31000036.html .

European Major Suppliers

BAE Systems PLC
Avionics and other commercial aerospace operations

Finmeccanica SpA
Air traffic management, avionics, and fuselage components

Kohlberg Kravis Roberts & Company
(parent: U.S.-based private equity firm)
MTU Aero Engines
Develops/produces aircraft engines

Smiths Group PLC
Advanced avionics and mechanical and electrical equipment

Thales Group
(Government of France owns 31%)
Air traffic management, avionics, computer hardware and software

Volvo Aero
Develops and produces aircraft engines and space propulsion subsystems

All of the European companies listed above supply parts and components used in U.S. aircraft and engines or partner with U.S. manufacturers in aerospace joint ventures. There is significant variety in the ownership structure of European major suppliers. Some European manufacturers are partially government-owned. For example, the government of France holds a 31 percent share of the Thales Group.[177] On the other hand, MTU Aero Engines is owned by a U.S.-based private equity firm. In addition, there are significant cross-holdings of shares amongst many European aerospace companies. Most significantly, BAE holds a 20 percent equity share of Airbus, which is itself a division of EADS.[178]

European Union Aerospace Policy

As a union founded to enhance political, economic and social cooperation amongst member nations, the individual member states of the European Union are free to shape their own aerospace policies. Recognizing the advantage of a regional unified aerospace policy that would facilitate enhanced competition, particularly with the United States, the EU has taken steps to strengthen the coherence of its regional aerospace market. In 2002, the European Advisory Group on Aerospace was convened to identify shortcomings and suggest remedies. The Group issued its findings in a July 2002 report, entitled "Strategic Aerospace Review for the 21st Century" (STAR 21) and made a number of policy recommendations. The STAR 21 Report's recommendations include (1) coordinated efforts to increase access to world aerospace markets, particularly through advocacy for changes to "Buy America" practices and convergence in export control policies; (2) mobilization of region-wide public and private research funds to launch a coordinated, long-term civil aerospace research strategy; (3) a shift from authority of

[177] http://www.thalesgroup.com/ir/shareholders/about/shareholding/shareholding.htm .
[178] Hoover's Company Records – Basic Record BAE Systems PLC.

individual member state specific aerospace policy makers to a more unified structure, including wider roles for the European Aviation Safety Agency and advocating for membership of the EU in the International Civil Aviation Organization (ICAO) alongside member states; and (4) consolidation of aerospace defense research and acquisition policies among member states.

Member Countries

The following is a brief summary of the five largest aerospace country markets in the European Union.

United Kingdom

The UK aerospace industry is the largest in Europe, with 2005 exports of $110 billion.[179] The UK aerospace sector is forecast to grow by 8 pe cent annually from 2003 to 2008, due primarily to growth in the maintenance, repair and overhaul (MRO) market, which is driven by increasing demands for air travel.[180] The UK is home to several of the world's leading aerospace companies to include BAE Systems PLC and Rolls-Royce PLC. In addition, U.S. aerospace companies such as Boeing,[181] Honeywell,[182] Raytheon,[183] Rockwell Collins,[184] and Lockheed Martin[185] also maintain a presence in the UK. According to the Society of British Aerospace Companies (SBAC), UK aerospace companies directly employ over 114,000 people, and over 30,000 people in the United States.[186]

France

The French aerospace industry is the second largest in Europe, with 2005 exports of $38.9 billion.[187] The French aerospace industry employed approximately 118,000 people in 2004.[188] The outlook for the French aerospace industry remains generally positive, with the primary trend being the increasing percentage contribution of the civil aviation sector to total revenues.[189] Within the civil aerospace sector, Airbus France and Dassault Falcon continue to increase production of civil aircraft in response to demand.[190] In addition, Eurocopter's rotary wing sales

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[179] H.M Customs and Excise data for Harmonized Tariff System (HTS) 88 "Aircraft, Spacecraft." This data is also available from the World Trade Atlas, published by Global Trade Information Services, Inc. (WTA), which is a secondary electronic source based upon the H.M. Customs and Excise data. See http://www.gtis.com/wta.htm .

[180] United Kingdom: An Overview of the Aerospace Market, U. S. Department of Commerce, April, 2006, available at http://www.buyusainfo.net/docs/x_7389140.pdf .

[181] Hoover's Company Records – Basic Company Record Boeing UK Ltd.

[182] http://www.honeywell.com/sites/uk/aerospace.htm .

[183] http://www.raytheon.co.uk .

[184] http://www.rockwellcollins.com/about/locations/rcuk/index.html .

[185] http://www.lockheedmartin.co.uk/aboutus/aboutus.html .

[186] SABC UK Aerospace Industry Survey 2005 available at http://www.sbac.co.uk/pages/33314013.asp#aGroup_1.

[187] Eurostat data for HTS 88 "Aircraft, Spacecraft." This data is also available from the World Trade Atlas, published by Global Trade Information Services, Inc. (WTA), which is a secondary electronic source based upon the Eurostat data. See http://www.gtis.com/wta.htm .

[188] UK Investment & Trade: The Aerospace Industry in France available at http://www.fco.gov.uk/Files/kfile/Aerospace%20Industry%20cm%2070605.pdf .

[189] Ibid.

[190] Ibid. Airbus France is responsible for final assembly of the Airbus A300, A320, A330/A340 and the A380, and the manufacture of engine pylons, central fuselage and cockpit sections.

are a strong contributor to the health of the aerospace market, as the company remained the world's largest helicopter manufacturer on a volume basis in 2005.[191] Finally, ATR (turboprop regional commercial aircraft), Socata (turboprop and piston light aircraft and LCA sub-assemblies) and Reims Aviation Industries (turboprop light aircraft and LCA sub-assemblies) are all at or near the top of their respective markets worldwide.[192] In the military aviation sector, production of the Airbus A400M tactical airlifter, increased production of the Eurofighter and the Tiger and NH90 military helicopters are all driving export sales growth. With the exception of Reims Aviation, France's leading aerospace companies are all owned in whole or part by EADS. EADS claims to contribute more than $4 billion annually to the United States economy and directly employ over 4,000 people through its many subsidiaries and suppliers in France.[193]

Germany

The German aerospace industry is the third largest in Europe, with 2005 exports of $20.9 billion.[194] Germany accounts for approximately one-fifth of the total revenue generated by the European aerospace industry.[195] In general, the outlook for the German aerospace industry remains positive, with gains in the civil and military aviation sectors driving growth. Specifically, continued production of the Airbus A350 and future production of the A380, coupled with Eurocopter's fixed wing sales, are driving strong civil aviation sales. Similar to France, in the military aviation sector, production of the Airbus A400M tactical airlifter, increased production of the Eurofighter and the Tiger and NH90 military helicopters are driving export sales growth. By extension, aerospace revenue gains are sustained by Germany's continued emphasis on research and development expenditures, which are greater on a percentage of sales basis than in other EU member countries.[196]

Italy

The Italian aerospace industry is the fourth largest in Europe, with 2005 worldwide exports of $3.4 billion.[197] The Italian aerospace industry, which employed approximately 40,000 people in

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[191] EADS: Business Year 2005 Brings Considerably Expanded Order Book for Eurocopter January 20, 2006, available at http://webbolt.ecnext.com/coms2/news_58670_IND

[192] Civilian Aircraft Industry Manufacturers in France (2004), May 2005 available at http://www.buyusainfo.net/docs/x_6629815.pdf

[193] Civilian Aircraft Industry Manufacturers in France (2004), May 2005 available at http://www.buyusainfo.net/docs/x_6629815.pdf

[194] Eurostat data for HTS 88 "Aircraft, Spacecraft." This data is also available from the World Trade Atlas, published by Global Trade Information Services, Inc. (WTA), which is a secondary electronic source based upon the Eurostat data. See http://www.gtis.com/wta.htm .

[195] The German Aerospace Industry Maintains Its Ascent: U S. Department of Commerce, September 2005, available at http://www.buyusainfo.net/docs/x_4638399.pdf .

[196] German Aerospace Industries Association (BLDI) Press Report "German Aerospace Industry Remains in the Ascendant" April 6, 2005 available at http://www.bdli.de/index.php/component/option,com_docman/task,view_category/subcat,1/catid,35/limitstart,0/limit,12/Itemid,111/lang,en/ .

[197] Eurostat data for HTS 88 "Aircraft, Spacecraft." This data is also available from the World Trade Atlas, published by Global Trade Information Services, Inc. (WTA), which is a secondary electronic source based upon the Eurostat data. See http://www.gtis.com/wta.htm .

2004, is generally open to cooperation with the U.S. aerospace industry.[198] Major players in the Italian aerospace industry include Finmeccanica, the country's largest engineering and aerospace/defense group. Finmeccanica manufactures helicopters, military aircraft, defense systems, satellites, and is also an energy producer and builder of generation and transmission components, boilers, turbines, cogeneration plants, desalination plants, and nuclear power plants.[199] Telespazio, a Finmeccanica joint venture, is involved in satellite management and navigation, and broadband multimedia telecommunications.[200] Fiat Avio SpA is the country's major manufacturer of aircraft propulsion systems. Fiat Avio has partnerships with Pratt & Whitney, GE Aviation and Rolls-Royce for the production of aircraft engines.[201]

Spain

Spain's aerospace industry is the fifth largest in Europe, with 2005 exports of $2.79 billion.[202] The Spanish aerospace industry, which employed 26,200 people in 2004, is dominated by three manufacturers.[203] EADS CASA is Spain's largest aerospace company and is a world leader in light and medium-size military aircraft. EADS CASA is also responsible for final assembly of the Airbus A400M and is a supplier of aerodynamic surface components for the Boeing 737, 757 and 777.[204] Gamesa Aeronautica designs, develops, and manufactures major subassembly structures for a number of large civil aircraft. [205] Indra Sistemas S.A. is Spain's leading producer of electronic defense equipment.[206] Industria de Turbo Propulsores S.A. (ITP) designs, produces and provides maintenance repair and overhaul services for a variety of aircraft engines and gas turbine compressors.[207] Again, similar to the other member countries of the EU, the outlook for Spain's aerospace industry remains positive, as continued sales growth by EADS affiliated aerospace companies carries over to the industry in general.

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198 http://www.european-defence.co.uk/examples/natoeu_defence_report.pdf
199 Hoover's Company Records – In Depth Company Record Finmeccanica SpA.
200 http://www.telespazio.it/profile.html
201 Outline of the Italian Aerospace Industry, U.S. Department of Commerce, available at http://www.buyusainfo.net/docs/x_9518011.pdf .
202 Eurostat data for HTS 88 "Aircraft, Spacecraft." This data is also available from the World Trade Atlas, published by Global Trade Information Services, Inc. (WTA), which is a secondary electronic source based upon the Eurostat data. See http://www.gtis.com/wta.htm .
203 http://www.atecma.org .
204 http://www.eads.net/web/lang/en/1024/content/OF00000000400004/4/41/529414.html .
205 http://www.gamesa.es/gamesa/index.html .
206 Hoover's Company Records – In Depth Company Record Indra Sistemas S.A.
207 http://www.itp.es/ingles/acercade.htm.

Country Studies: Russia

Although Russian aerospace companies have essentially lost their position as prime manufacturers of large civil aircraft, they have been somewhat successful in supplying materials, parts, and engineering services for Western commercial aircraft and engines.[208] Boeing plans to invest has reportedly invested more than $1.3 billion[209] into Russian joint ventures since the early 1990s and plans to bring that total to $2.5-$3 billion by 2010.[210] This investment has enabled Boeing to tap into the vastly underutilized expertise of Russian aerospace experts who have extensive experience as well as different approaches to engineering and manufacturing than their Western-trained counterparts. Boeing operates the Boeing Design Center in Moscow, employing Russian engineers to work in research, materials, design, information technology, and modification work on the 777, the 787, and other commercial aircraft models. Russia is a key supplier of raw materials–especially titanium–used in Western aerospace production.

European industry also has pursued this approach. In July 2001, Airbus's parent company EADS signed a cooperation agreement with the Russian Aerospace Agency and agreed to invest more than $2 billion in the Russian aerospace industry over a ten-year period.[211] The agreement calls for a broad range of cooperative projects, including Russian participation in the A320, A380, and other Airbus projects.

Sometimes these investments appear to have been tied to increasing market presence in Russia of Western-manufactured equipment. The EADS joint venture was followed soon after by the acquisition of 18 new Airbus aircraft by the Russian flag carrier Aeroflot. However, purchases and leases of Boeing and Airbus aircraft by Russian airlines remain limited due to a number of factors, including Russian government policies such as high import taxes intended to promote procurement of Russian-produced aircraft and the inability of Russian airlines to secure sufficient financing.

Russian aircraft manufacturers have sought to make their domestically produced aircraft competitive and attractive to Russian and foreign carriers by upgrading them with Western avionics and engines to bring them into compliance with international noise, emissions, navigation, and other requirements. Several large U.S. aerospace companies are engaged in joint production projects and supply equipment used on Russian aircraft platforms. GEAE, Honeywell, and Pratt & Whitney supply engines for various Russian-built aircraft and helicopters. Hamilton Sundstrand provides propellers. Honeywell also provides power units and avionics, and its Traffic Collision Avoidance System (TCAS) is installed on about 300 Russian-built aircraft.

Russian manufacturers also have sought partnerships and cooperative ventures with Western manufacturers to help them develop new aircraft. For example, Pratt & Whitney entered into a

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[208] http://www.boeing.com/commercial/777family/pf/pf_background.html
[209] http://www.boeing.com/news/releases/2002/q3/nr_020805a.html
[210] "Boeing to invest $2.5-$3 billion in Russian Aircraft Industry." Russian News and Information Agency. http://en.rian.ru/business/20050427/39749807.html April 27, 2005.
[211] "Negotiations between EADS and Russian Aerospace Agency Rosaviakosmos Finalised," EADS press archives, July 2, 2001, http://www.eads.net

strategic partnership with Perm Motors Joint Stock Company, which is developing an internationally compliant upgrade to the widely used PS-90A engine in Russia.[212] In 2004, Boeing entered into a contract with Russian manufacturer Sukhoi to help develop and market the Russian Regional Jet (RRJ), which is designed to replace aging Russian airplanes and intended to compete worldwide with those made by Bombardier and Embraer.[213] SNECMA Group of France is developing the engine, in cooperation with NPO Saturn, with French government assistance worth €250 million.[214] The RRJ should undergo its first test flight in 2007 and enter service in 2008.[215] Aeroflot, Sibir, and Concord Aviation are among the airlines that have placed orders for the first variant, called the RRJ-95.

Nonetheless, significant additional hurdles must be overcome before Russian aircraft production rates will increase. Upgraded Russian aircraft typically are not economically and operationally competitive with Boeing and Airbus aircraft. New aircraft programs are unproven, and continued financial and production obstacles present challenges to Russian manufacturers. The absence of global support networks, and limited opportunities for resale of used aircraft are additional disincentives for Western airlines to purchase Russian aircraft.

In spite of these joint ventures, Russia has not given up on independently establishing a viable domestic prime-manufacturing sector again. The government of Russia announced plans in February 2004 to consolidate the existing Russian major aerospace companies (Sukhoi, MIG Irkut, Ilyushin, and Tupolev) into a consortium. In February 2006, President Putin signed a decree calling for an action plan to be created for this consortium, called United Aircraft-Building Company.[216] This is the most recent of a long series of plans to revitalize the Russian aerospace manufacturing industry and recapture its position as a global prime producer of large civil aircraft and engines. Without recovery of the traditional customers of Russian aircraft manufacturers or the manufacturers themselves, however, it is difficult to predict when this might actually happen. To meet this challenge head on, the Russian government has even proposed underwriting a new Russian aircraft leasing company to be the buyer of newly produced Russian aircraft.[217]

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[212] "Pratt & Whitney in Russian Gas Turbine Accord," *Dow Jones Newswires*, August 9, 2000.
[213] "Sukhoi picks up pace on RRJ," *Concise B2B Aerospace*, June 17, 2003.
[214] "Paris Breathes New Life into Jet Project", *The Moscow Times*, September 20, 2004.
[215] "Sukhoi Russian Regional Jet." http://www.aerospace-technology.com/projects/sukhoi/ May 17, 2006.
[216] Aviaok International, LLC. "United Aircraft Building Company Begins." http://www.aviaok.com/index.php?page=news&id=1383&npage=15 May 5, 2006.
[217] "Industry Ministry: Aircraft Construction Sector Needs USD 2.5 billion State's Support", *ISI-Intellinews*, September 20, 2004.