Flight Plan 2011

Analysis of the U.S. Aerospace Industry

INTERNATIONAL
TRADE
ADMINISTRATION

Office of Transportation and Machinery
International Trade Administration
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PREFACE

Flight Plan 2011 is being released in stages. Chapter 1, an industry summary, was released in March 2011. As additional chapters are released, the Table of Contents will be updated accordingly.

This report was prepared by aerospace industry specialists on the staff of the Aerospace Team of the International Trade Administration, U.S. Department of Commerce. Questions and comments may be directed to each chapter's primary author, identified at the chapter's end.

We would appreciate attribution when this report is cited, such as "*Flight Plan 2011*, U.S. Department of Commerce, International Trade Administration, March 2011."

Summary

Introduction

The purpose of *Flight Plan 2011* is to report on the state of the U.S. aerospace manufacturing industry from the standpoint of business trends and developments. In this report, we emphasize issues related to U.S. interests in international trade and investment.

Aerospace manufacturers are generally considered to be companies that produce civil[1] and military aircraft, missiles, satellites and other space vehicles, and parts for all of the foregoing.[2] Census Bureau data on industry output, used in this report, include in the aerospace manufacturing industry companies engaged in aircraft conversion (that is, major modifications to aircraft systems) and aircraft overhaul and rebuilding. For the purposes of this report, we have included also manufacturers of products used at airports or in aviation security.

With the exception of aircraft conversion, overhaul and rebuilding, our report does not cover services related to aerospace manufacturing. These non-covered services include the provision of air transportation (such as by airlines); aircraft repair and maintenance services; aircraft parts distribution; and consultancy services.

Aerospace manufacturing is critical to the President's National Export Initiative (NEI) goal of creating jobs for American workers through a doubling of U.S. exports over five years. U.S. aerospace manufacturers are internationally competitive, accounting for the highest trade surplus of all U.S. manufacturing industries. For the last year in which data in available (2008), more jobs in the United States were supported by exports of U.S. aerospace products than of any other manufacturing or service industry.

The analysis in *Flight Plan* contributed to the development of an NEI aerospace strategy by the Commerce Department's Aerospace Team.

Snapshot of aerospace industry output

We estimate that the value of total U.S. aerospace industry shipments in 2010 was $171 billion, a decrease of 4.5 percent from the 2009 figure of $179 billion.

Measured by value, shipments of civil aircraft[3] and aircraft parts in 2010, at $85 billion, constituted one-half of the total 2010 aerospace industry output. The value of civil aircraft and aircraft parts shipped in 2010 was a decrease of almost 13 percent from the 2009 figure ($97 billion). While shipments of civil aircraft and aircraft parts were down in 2010, orders for these products rose sharply, increasing by 66 percent in 2010 from the 2009 order value of $55 billion.

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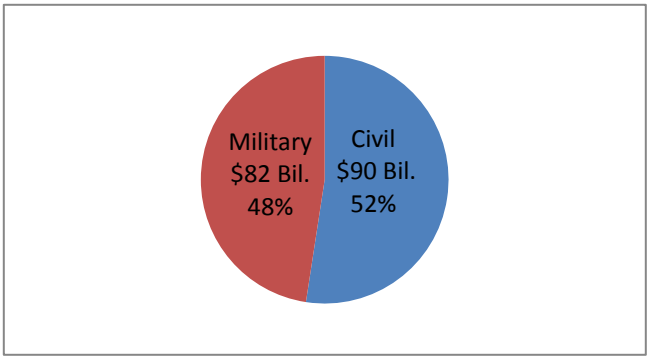
[1] We use the term "civil", rather than "commercial", because the former refers to *all* non-defense aircraft. "Commercial" refers to *only a portion* of non-defense aircraft, i.e., those that are used in commerce (such as by airlines and charter operators).

[2] North American Industry Classification System (NAICS) code 3364, "Aerospace Product and Parts Manufacturing."

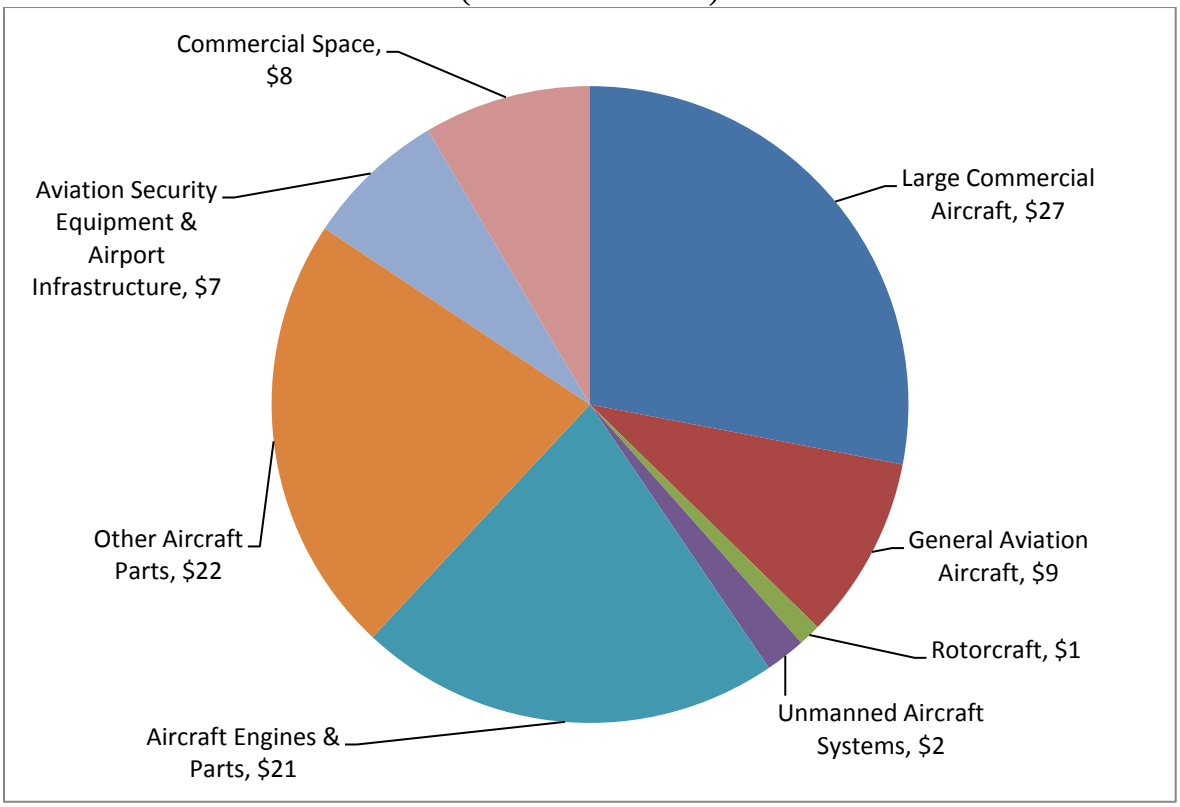
[3] This includes all large civil aircraft, fixed-wing general aviation aircraft, and helicopters.



Estimated total U.S. aerospace industry shipments in 2010 were roughly half and half, military and civil, with the value of civil shipments ($90 billion) slightly exceeding that of military shipments ($82 billion). U.S. Government sources of aerospace manufacturing activity did not provide details on specific sectors, e.g., aircraft engines, at the time this summary section was prepared, in March 2011.

The most recent, complete data on the output of areospace sectors is for the year 2009. We estimate in the pie chart below U.S. output of civil aerospace products for eight categories.

Estimated U.S. Production of Civil Aerospace Products in 2009
(Billions of Dollars)



Readers are urged to view the above chart with several caveats. It is aimed at providing only a rough idea of the relative size of the constituent sectors of the U.S. civil aerospace manufacturing industry--and not a precise quantification. We excluded from our analysis entirely the manufacture of military aerospace products. The data for this chart was sourced from disparate organizations (such as the U.S. Census Bureau for aircraft engines and the Aerospace Industries Association for helicopters) that have no commonalities in how they collect and assess industry data.

In certain cases, Commerce Department aerospace industry specialists have had to make estimates associated with particular aerospace sectors. The data is a static snapshot that does not reflect aerospace industry economic trends over time or attempt to explain factors in 2009 that may have had an particularly weighty impact on one aerospace sector but not another. The data is based on a conservative definition of "aerospace manufacturing" that excludes certain activities, such as unspecified "services" that some analysts have included as "manufacturing."

Overview of individual aerospace industry sectors

Large civil aircraft (LCA) are produced by one U.S. manufacturer, Boeing. Boeing received net orders[4] for 530 LCA in 2010, more than tripling the number of its net orders in 2009 (for 142 aircraft). Boeing's single aisle model 737 dominated the company's 2010 order book, accounting for 486 orders--almost 92 percent of total net orders. Boeing delivered 462 LCA in 2010, a slight decrease from the 481 LCA it delivered in 2009.

Major developments in 2010 included clear signals of the emergence of new LCA competitors overseas. In November 2010, the Commercial Aircraft Corporation of China announced the first orders for its C919 model jetliner. Earlier in the year, Montreal-based Bombardier received its first order from a U.S. customer for its CSeries aircraft, the first LCA to be manufactured in Canada. In other developments, difficulties with flight testing of the 787 in late 2010 caused Boeing to further delay the first deliveries of that aircraft. In June 2010, a World Trade Organization dispute settlement panel ruled that much of the government subsidies provided to Airbus was inconsistent with WTO rules. (That decision is pending appeal.)

General aviation (GA) sales fell again in 2010 and are expected to be flat in 2011. Large business jet deliveries continue to be unaffected by the downturn while smaller jet sales are more volatile. GA manufacturers in the United States continued to shed jobs. Embraer is emerging as a strong competitor in the small jet area and is opening a facility to assemble these planes in Florida in 2011. Due to supply chain constraints and the significant number of layoffs at OEMs, it is unclear how the industry will respond to new orders as the economy continues to improve. Sales of bizjets tend to lag economic recovery by one year; piston aircraft tend to track in real time.

Rotorcraft Industry analysts expect recovery in the rotorcraft sector to lag behind the recovery of fixed wing general aviation (GA) aircraft manufacturing given that the downturn in GA manufacturing preceded that of helicopters. Helicopter shipments are expected to begin increasing in 2012, with China and India prominent foreign markets due to their lack of infrastructure. In 2010, U.S. helicopter manufacturers Bell and Sikorsky conducted research and development aimed at applying "fly-by-wire" technology to civil turbine helicopters. Sikorsky conducted test flights on its new X2 helicopter, with two counter-rotating blades on top and a high-speed pusher-prop in back.

[4] "Net orders" refers to the difference between the number of new orders for aircraft received in 2010 and the number of cancellations received in 2010 for existing orders. Orders that were cancelled in 2010 may have been placed in any of the previous years.

Unmanned Aircraft Systems (UAS) The UAS market is expected to grow rapidly in 2011, driven primarily by military procurement of UAS by the U.S and other countries. The U.S. accounts for the bulk of global UAS production and research and development (R&D) expenditures with the U.S. Department of Defense being the largest consumer of UAS technology in the world. A civil UAS market is beginning to emerge, but its growth is constrained due to lack of airspace access and regulatory and operational standards. The FAA's Unmanned Aircraft Program Office (UAPO) is expected to publish a Notice of Proposed Rulemaking (NPRM) for small UAS in late-2011 which will provide a process for small UAS to operate in the national airspace under low-risk conditions without undergoing the case-by-case approval process that is currently required. The FAA hopes to publish the final rule by the end of 2012.

Large civil aircraft jet engines The large civil aircraft jet engine market is dominated by U.S. manufacturers GE Aviation and Pratt & Whitney, and U.K. manufacturer Rolls-Royce. These three companies also participate in a number of joint ventures amongst themselves or along with a smaller company or group of companies. 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.

Aside from the continued and increasingly common use of joint ventures for cost and risk sharing purposes, major developments in 2010 relate to development of new engine technologies that reduce engine fuel consumption, noise and emissions. Representative of this trend are Pratt & Whitney's geared turbofan (GTF) engine and GE Aviation/SAFRAN joint venture CFM's LEAP-X engine. These engines utilize composite materials and other re-designed components to realize significant fuel savings, while operating more quietly and at lower emissions levels. Trends in the aircraft engine market are linked to aircraft sales, and these engines are the primary options on a number of new aircraft in development including Russia's United Aircraft Corporation/Irkut MS-21, Japan's Mitsubishi Regional Jet (MRJ), Canada's Bombardier C-Series aircraft and the Airbus A320 neo. As these aircraft become operational, engine manufacturers will face increasing pressure to develop more fuel efficient, quieter and clean burning engine options for other large civil aircraft already in service.

Aircraft parts In this report, we use include in "aircraft parts" all components of aircraft (excluding components of aircraft engines) and so-called aircraft "auxiliary equipment", such as crop dusting apparatus and external fuel tanks. Measured by value, U.S. production of civil and military aircraft parts reached a trough in 2002 and 2003 (with shipments each of those two years at $21.1 billion). Production increased each year afterward, peaking in 2008 at $33.1 billion. In 2009, the most recent year for which data is available, U.S. production of aircraft parts contracted by about 5 percent from the year before, to $31.4 billion.

We estimate that about 70 percent of total U.S. production of aircraft parts is comprised of civil parts. During times of economic downturn, as has been the case in recent years, the demand for replacement parts in used civil aircraft increases relative to the demand for parts produced for new aircraft because aircraft operators, such as airlines, are more inclined to extend the life of their existing fleet rather than to acquire new aircraft.

Airports Infrastructure and Aviation Security Equipment Worldwide airport capital expenditures (not counting new/greenfield airports or capital investment in the Middle East or China) was

approximately $34.6 billion (U.S) in 2009 and $38.5 billion in 2010. China is slated to become the second largest national aviation market in the near future and plans to add more than 80 civil airports to their aviation system by the year 2020. Brazil will host the 2014 FIFA World Cup and the 2016 Olympics, which will require upgrades to airports, air traffic management, aviation security, etc. India plans to increase the number of commercial air service airports from 80 today to more than 500 over the next decade. Such an increase will require India's air-traffic system to be transformed to handle two, three or even four times its current capacity. India plans to invest over $40 billion in airport infrastructure to help accommodate this projected growth.

The ten leading Middle-East airports will be investing over $33.7 billion in new capacity by 2012. NextGen upgrades in the United States alone could cost around $22 billion. Proposed acceleration by TSA of the requirement for 100 percent of U.S-bound international cargo on passenger flights from 2013 to the end of 2011 will require a massive upswing in cargo screening equipment research, development, engineering, and deployment, with the market value of such equipment easily reaching into the billions of dollars.

Commercial space sector In June 2010, President Obama signed a new National Space Policy, which put a much stronger emphasis on the use of commercial space capabilities and international cooperation to meet U.S. Government mission requirements. Additionally, the policy supports U.S. commercial space sector and business interests more than any previous policy by promoting U.S. exports, working to minimize the regulatory burden on the industry, and fostering fair and open international trade through suitable standards and regulations. The policy supports an environment that encourages growth and competitiveness for the U.S. commercial space industry—a big change from previous policies that focused primarily on national security space concerns.

2010 global commercial space launch activities nearly matched those held in 2009, with U.S. commercial launch providers securing 17 percent, or about $300 million, of the total global market. By definition, commercial satellite manufacturing reflected this flat trend. The satellite manufacturing and launch services industries are expected to remain stable over the next few years, but 10-13 percent growth is expected to continue in the satellite services sector. Such services as direct-to-home television, broadband, and a multitude of mapping applications will continue to increase demand for satellite communications and imaging services for the foreseeable future.

In December 2010, SpaceX achieved what only governments had previously accomplished when the company performed the first successful launch of its Falcon 9 rocket under NASA's "COTS" program, and then successfully recovered its spacecraft after re-entry from low-Earth orbit. The Commercial Orbital Transportation System (COTS) is designed to develop commercial supply services to the International Space Station. SpaceX is a private company, whose family of launch vehicles has been developed without federal support.

Aerospace trade

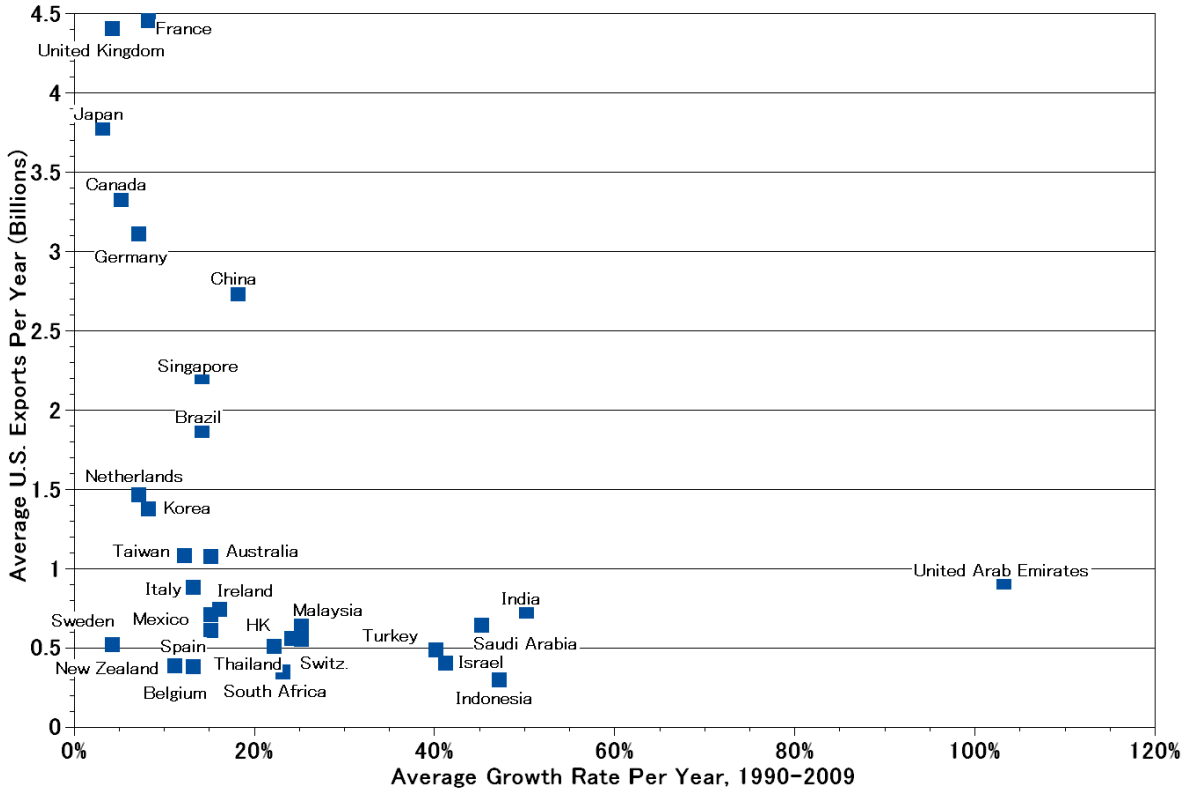
U.S. exports of total civil and military aerospace products in 2010 were valued at $77.8 billion and U.S. aerospace imports were valued at $34.2 billion, producing a U.S. aerospace trade surplus of $43.6 billion. The 2010 aerospace trade surplus was a contraction from the 2009 surplus of $48.3 billion, resulting from both a year-to-year decrease in U.S. aerospace exports and increase in U.S. aerospace imports.

The top five U.S. export markets accounted for 37percent of total U.S. aerospace exports: France, China, Japan, the United Kingdom, and Germany. The top five suppliers to the United States accounted for 75 percent of total U.S. aerospace imports: France, Canada, the United Kingdom, Japan and Germany.

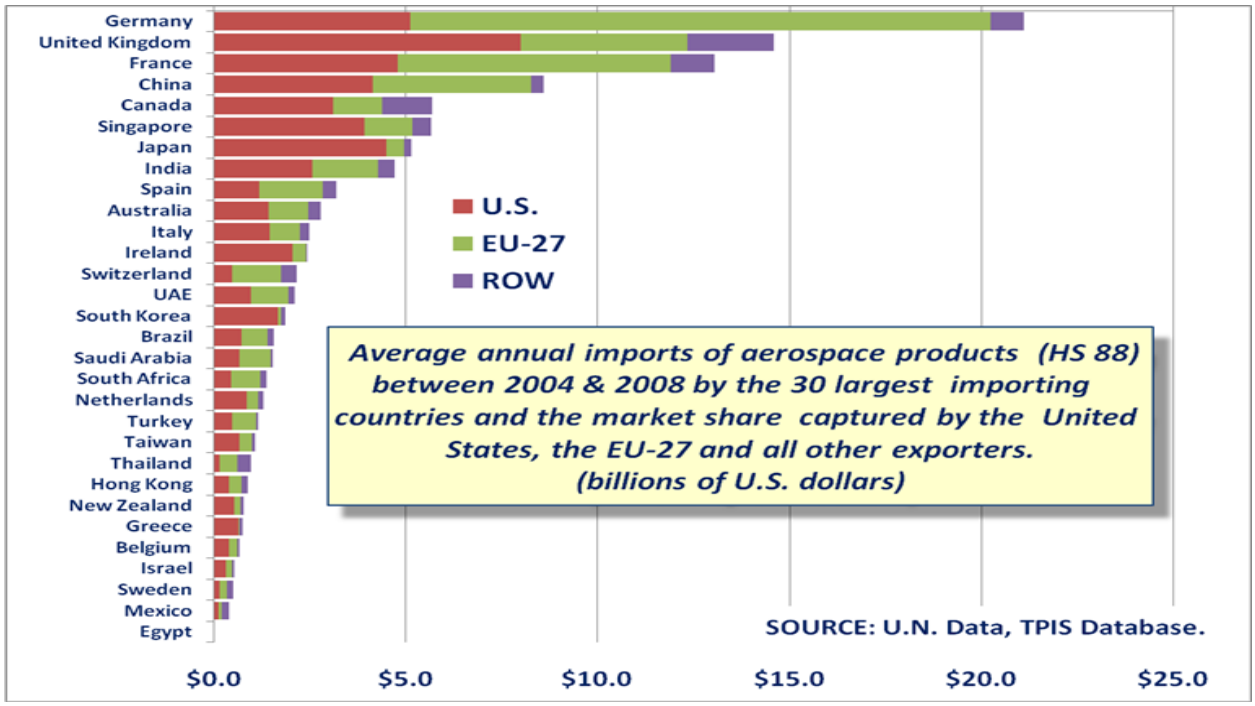
While the composition of total U.S. aerospace industry is roughly 50/50 civil and military, civil aerospace products dominate U.S. aerospace exports. Over the last five years, 86 percent of all U.S. aerospace exports consisted of civil products.

Over the last two decades, the average annual growth rates in U.S. civil aerospace exports to the largest, legacy U.S. aerospace export markets (such as France, the United Kingdom, Japan and Canada) have been on the order of 5-10 percent. Average annual growth rates of U.S. civil aerospace exports to smaller, emerging markets (such as India, Saudi Arabia, Israel and Indonesia) have been dramatically higher, on the order of 50 percent.

Top 30 U.S. Civil Aerospace Export Markets, 1990-2009



U.S. aerospace manufacturers' primary foreign competitors are European. In many of the major national aerospace markets, the United States and Europe have roughly even market shares. Exceptions include Germany (in which Europe has dominated) and Japan (in which the United States has dominated). The large EU share of Germany's imported aerospace products may be at least partially accounted for by the presence in Hamburg of an Airbus aircraft assembly facility which imports parts from other European countries.



Among the major trends in global trade and investment in aerospace products is an acceleration of the interconnectedness between manufacturers in different countries. An extreme example involves the production of CFM56 aircraft engine gearboxes in France by SNECMA. Some of the gearboxes are exported to the United States for assembly in the complete CFM56 engine. The engine may then to exported back to Europe to power an Airbus aircraft, some of which are exported to the United States for use by U.S. airlines.

Among the factors accelerating growth in the global supply chain are governmental policies aimed at fostering an indigenous aerospace manufacturing industry, the need to spread among numerous aircraft component suppliers the risk of bringing to market new aircraft models, and an interest by airframers in having a diversity of suppliers.

Another overarching trend is the move away of a duopoly of aerospace producers (in the United States and Europe) to global market with prominent competitors from many regions. Regional aircraft manufacturers in Brazil and Canada are beginning to produce aircraft that will compete with Boeing and Airbus. Other countries with emerging aerospace industries include China, Japan, India, Israel and Russia.

U.S. competitiveness

In the coming years, the international competitiveness of the U.S. aerospace industry will be shaped by challenges at home and abroad.

A major domestic initiative affecting U.S. aerospace manufacturers is reform of U.S. export controls, especially the International Traffic in Arms Regulations (ITAR). The export of a complete U.S. jetliner may be subject to adjudication under the ITAR if the aircraft contains a single component deemed to be a "munition" (such as certain components of the aircraft engines'

"hot section".) U.S. manufacturers complain that foreign companies are "designing out" U.S. parts with a view to being able to promote their end use items as ITAR-free.

Other domestic measures concern Federal Aviation Administration (FAA) regulations (such as a pending rule on Safety Management Systems), the extension of tax credits for industry-funded research and development (R&D), the provision of federally-funded aeronautical R&D (NASA and the FAA), and export credit financing by the U.S. Export-Import Bank.

Foreign governments may undertake measures to foster the development of their domestic aerospace manufacturers, sometimes in ways that affect the United States. A major concern has been government subsidies to Airbus. In June 2010, a World Trade Organization (WTO) dispute settlement panel ruled in a case initiated by the United States that many of subsidies provided to Airbus contravened WTO rules. This case likely will have important implications in regard to subsidies being provided by other governments to their aerospace manufacturers, such as Canada. (At the time this report was written, an appellate decision on the Airbus subsidies case was pending. In addition, the European Union initiated counter litigation against the United Sates, alleging that certain subsidies to Boeing were WTO-inconsistent.)

Other market impediments overseas include tariffs on U.S. exports of civil aircraft and aircraft parts, including by India, Russia, China and Brazil. The lack of sufficient airports or landing slots in some markets, such as India and Japan, is a challenge for U.S. exporters of general aviation aircraft. A requirement to provide "offsets", well established in connection with military aircraft sales, appears to be increasingly applied to the export of civil aircraft.[5]

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[5] Offsets are compensation practices required as a condition of purchase by government owned or controlled airlines. The aircraft seller may be required to transfer technology to the market of the aircraft purchaser, invest in local aerospace manufacturers, and/or purchase aircraft components from local suppliers.

General Aviation

Overview

Global general aviation (GA) manufacturers shipped 2,015 units in 2010, down almost 53 percent from 2007, which was the best year since the early 1980s.[6] The decline reflects the continuation of the economic downturn that began at the end of 2008. U.S. manufacturers' market share continued to fall, mostly due to significant production cutbacks at Cessna. Total U.S. shipments were down 15.8 percent over the previous year. The only bright spot for the industry was in large business jets, which saw a slight uptick in deliveries.

The diversification of general aviation operators continues. While North America remains the top market for aircraft sales, aircraft deliveries are becoming more evenly distributed amongst the regions. Asia-Pacific is now the second largest region for turbo-prop deliveries. This change, however, is due more to the fact that the North American market has shrunk than to significant growth elsewhere.

General Aviation Manufacturers

U.S. Manufacturers	Non-U.S. Manufacturers
American Champion	Airbus (EU)
Boeing Business Jets	Bombardier (Canada)
Cessna Aircraft Company	Dassault Falcon Jet (France)
Cirrus Design Corporation	Diamond Aircraft (Canada/Austria)
Emivest Aerospace Corp	Embraer (Brazil)
Gulfstream	GippsAero (Australia)
Hawker Beechcraft	Pacific Aerospace Corporation (New Zealand)
Liberty Aerospace	Piaggio (Italy)
Maule Air Incorporated	Pilatus (Switzerland)
Mooney Aircraft	Socata (France)
Piper Aircraft, Inc.	

Trends

For 2010, global shipments were down 11.4 percent from 2009 though billings (value of shipments) were up 1.2 percent. This reflects the fact that deliveries of larger, more expensive business jets were stable. Once again, however, shipments declined in all three industry segments from the previous year:

[6] All data taken from GAMA's 2010 General Aviation Statistical Databook and Industry Outlook unless otherwise indicated. Available on the web at: http://www.gama.aero/publications. GAMA estimates their data covers over 90 percent of the total market. Some Bombardier aircraft are manufactured in the United States and are included in the U.S. shipment figures; likewise, some Gulfstream aircraft are made in Israel and are not included.

- piston aircraft (down 7.7 percent)
- turboprops (down 17.7 percent)
- business jets (down 12.3 percent)

Despite the negative numbers, these figures actually present a more optimistic picture than the figures for 2009. Most notably, the drop-off in piston aircraft shipments was significantly less precipitous, improved from a 53 percent drop in 2009.

However, the U.S. manufacturers' share of worldwide shipments fell again, from 69 percent in 2009 to 66 percent in 2010. In the 2001-2010 timeframe, 2008 was the only year in which U.S. market share expanded, resulting in an average growth rate of -5 percent for that time period. By contrast, the average growth rate for the rest of the world during that time period was 8.6 percent.

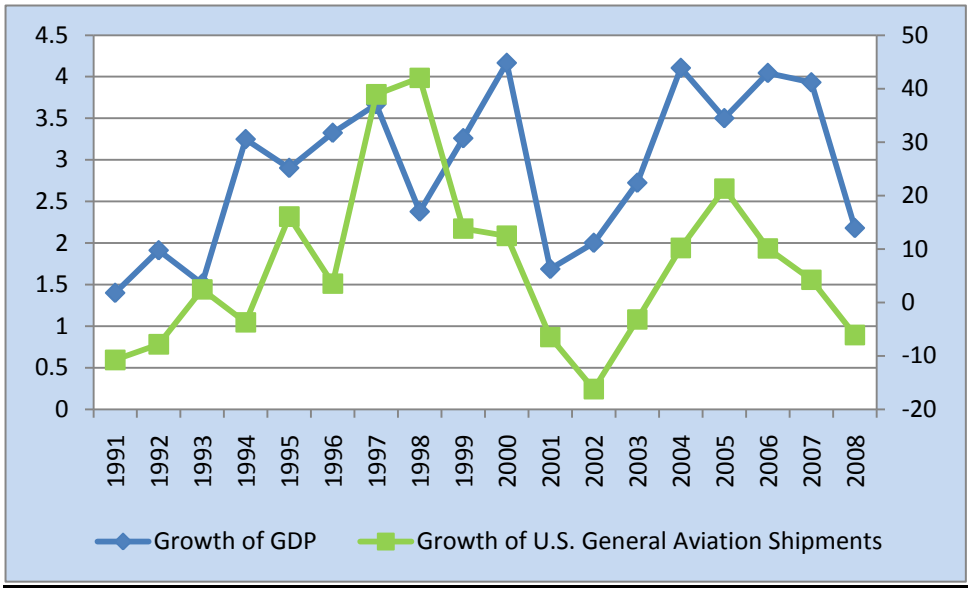
This most recent drop in market share was due entirely to the decline in market share for U.S.-made business jet shipments, which has declined 25 points in 2 years (the U.S. share of piston aircraft was steady in 2010 and the U.S. share of turboprops actually rose). In 2009, the decline in U.S. market share was due mostly to the loss of Eclipse Aviation, which stopped manufacturing in late 2008. While the remaining U.S. manufacturers all saw significant declines in production 2009, their individual market shares declined only slightly. Instead, Embraer's Phenom 100 filled the void created by Eclipse and caused Brazil's market share to rise from 3 percent to 14 percent.

In 2010, U.S. market share declined again, in this case due to cutbacks at Cessna, a division of Textron. Cessna typically dominates the market for business jets, with its share of global shipments averaging 36 percent from 2001-2009. In 2010, however, its market share was only 23 percent, in large part because Cessna produces only small and mid-sized jets, which have not fared well in the economic downturn. Hawker Beechcraft, another U.S. manufacturer, also lost market share but was balanced out by gains at Boeing and Gulfstream. Hawker also produces small and mid-sized jets, but it began to lose market share well in advance of the 2008 economic crisis.

At the same time, Embraer gained market share due to the introduction of its second very light jet, the Phenom 300. Introduction of new models often leads to an increase in demand as customers seek to try out new innovations—France's Dassault has also gained market share over the last several years after introducing the Falcon 7X in 2007. However, Cessna's own relatively new very light jet saw a 42 percent drop-off in shipments in 2010. It remains to be seen whether Embraer's performance is sustainable or whether they will see a similar drop-off as it fills its order backlog. It should be noted, however, that Embraer opened a second assembly facility for the Phenom 100 in February 2011, indicating that the company, at least, is optimistic.

Economic growth is the major factor in determining the health of the GA industry. Businesses tend to purchase a new plane or replace an old one when the economy is strong and profits are up. The following chart indicates that in recent years, changes in the GA market tend to lag economic growth by one year. GA shipments thus suffered during the recessions in the early 1990s and early 2000s and recovered when the economy grew during the second half of the decade.

Chart 1: Global GDP Growth and U.S. General Aviation Shipment Growth, 1991-2008[7]



A notable trend not captured in the data is the activity of the Chinese. Chinese firms have acquired or invested in several American general aviation aircraft firms, including Epic Air (mostly kit aircraft with one certified turbo-prop), Teledyne Continental (engines), and Cirrus (aircraft) and is reportedly interested in acquiring Emivest[8] (formerly Sino Swearingen), another cash-strapped airframer. In the past, it has looked at Grob (Germany) and Piper (U.S.).[9] In addition, Cessna and Diamond Aircraft (an Austro-Canadian manufacturer) are manufacturing piston aircraft in China. After reorganizing its aerospace industry in 2008, China announced its interest in entering the general aviation industry but has not launched a domestic program for business aircraft. Instead, the Aviation Industry Corporation (AVIC) has sought to acquire this capability by buying western firms. AVIC believes that this will help more easily gain certification in the west, where most general aviation aircraft are sold.

Outlook

Forecasting at this point remains uncertain. Industry experts are trying to interject optimism into their predictions, but there is no consensus on when overall shipments will begin to recover and to what degree. Though the inventory for used aircraft is declining, the percentage of aircraft for sale is still high. This suppresses both demand and price for aircraft.[10] Moreover, the significant drop in

[7] Data points represent percent changes over the previous year. GDP data from the National Accounts Main Aggregates Database, United Nations Statistical Division. (Search terms World, GDP (constant 1990 dollars), and years 1991-2008). Available at: http://unstats.un.org/unsd/snaama/selectionbasicFast.asp. Growth of general aviation shipments calculated as a percent change from the previous year.

[8] Molly McMillan. "Chinese buying spree creates some frustration." *The Wichita Eagle*. March 22, 2011. http://www.kansas.com/2011/03/22/1773873/ese-buying-spree-creates-some.html

[9] Leithen Francis. "Buying its way to the top?" *Flight International*. Oct 20-26, 2009.

[10] Honeywell Business Aviation Outlook Forecasts Next Period of Expansion to Begin by 2012. October 26, 2010. https://www.honeywellbusinessaviation.com/news/post/honeywell-aerospace-business-aviation-outlook-forecasts-next-period-of-industry-expansion-to-begin-by-2012

production at Cessna, which typically represents about one-third of all deliveries, has caused the supply chain to respond accordingly. To demonstrate the size of the problem, total production at Cessna dropped 43 percent in 2009 and an additional 28 percent in 2010 (from 1,300 aircraft in 2008 to 534 aircraft in 2010). By contrast, production dropped only 22 percent after 9/11 (from 1,202 to 944 aircraft). The speed with which the supply chain is able ramp up production will affect the airframers' ability to respond to any positive demand growth.

Figure 1: Fixed-wing Turbine Corporate Aircraft Fleet by Region, 2009[11]-2010[12]

Region	2009	2010	% change
North America	18,531	18,585	.2%
Europe	3,712	3,835	3.3%
Latin America	2,955	3,311	12.0%
Pacific Rim	825	917	11.2%
Africa	754	805	6.8%
Middle East	403	453	12.4%
South Asia	229	258	12.7%

Though North America is still the biggest market for GA aircraft, the market is not growing. The corporate overall fleet (which does not include piston aircraft but may include used aircraft) increased by only 54 aircraft (see above) in 2010. Growth in Europe is also slow. Other regions are experiencing healthier corporate fleet growth and Latin America actually reported the largest increase in terms of units. In addition, GAMA data shows that the market share for North American deliveries of new aircraft is shrinking relative to deliveries to other world regions.

However, while GAMA data indicates that non-U.S. deliveries are gaining in importance, this is not because deliveries to these markets have dramatically increased, but because deliveries to North American and European customers have dropped so precipitously. In the figure below, which translates GAMA market share percentages into numbers of aircraft, we see that between 2008 and 2010, deliveries to almost every region declined (except Middle East/Africa). In addition, the decline in North America was the biggest both in terms of the number of aircraft and the percent change (61 percent). Europe experienced the second biggest decline, at 49 percent at the end of two years. Meanwhile, deliveries to the third biggest market, Asia, are still about a quarter of North American deliveries. Thus while for U.S. companies, export markets are becoming relatively more important, to date, they are nowhere close to compensating for lost demand at home.

[11] Sarsfield, Kate. "Business Aviation Census: Global Fleets Buoyant but Traditional Markets Suffer." October 11, 2009. http://www.flightglobal.com/articles/2009/10/11/333296/business-aviation-census-global-fleets-buoyant-but-traditional-markets-suffer.html

[12] Sarsfield, Kate. "Rough but Ready: Business Aircraft Census 2010." October 11, 2010. http://www.flightglobal.com/articles/2010/10/11/348248/rough-but-ready-business-aircraft-census-2010.html

Figure 2: Regional deliveries of all GA aircraft, 2008-2010

Region	2008	2009	2010
North America	2,457	1,260	955
Europe	780	511	394
Latin America	315	182	240
Asia	252	200	271
Middle East/Africa	165	117	156

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Rotorcraft

Overview

The rotorcraft industry produces aircraft, powered by either turboshaft or reciprocating engines, capable of performing vertical take-off and landing (VTOL) operations. 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, such as the V-22 Osprey[13,] can take off vertically and then fly horizontally as a fixed-wing aircraft.

Rotorcraft are manufactured in most industrialized countries, based on indigenous design or in collaboration with, or under license from, other manufacturers. Manufacturers in the United States of civilian helicopters include American Eurocopter, Bell, Enstrom, Kaman, MD Helicopters, Robinson, Schweizer (now a subsidiary of Sikorsky), and Sikorsky. Bell moved its civilian helicopter production to Canada, with the last U.S. product completed in 1993.[14] American Eurocopter—a subsidiary of the European manufacturer and subsidiary of EADS NV—has manufacturing and assembly facilities in Grand Prairie, Texas and Columbus, Missouri.

European producers include AgustaWestland, Eurocopter, NHIndustries, and PZL Swidnik. Russian manufacturers including Mil Moscow, Kamov and Kazan helicopters, as well as a number of other rotorcraft related companies, have been consolidated under the Russian government majority-owned OAO OPK Oboronprom.[15] (See this report's Russia country analysis for a more detailed description of Oboronprom.)

Manufacturers in the United States

Company	**Products**
American Eurocopter[16]	military helicopters for U.S. Army
Bell Helicopter	civil and military helicopters, military and civil tiltrotors, UAVs
Boeing Rotorcraft Systems	military heavy and attack helicopters, military tiltrotors, UAVs
Enstrom Helicopter	piston and light turbine-powered helicopters
MD Helicopters	NOTAR®-equipped turbine-powered helicopters
Robinson Helicopter	light piston- and turbine-powered helicopters
Schweizer Aircraft	piston and light turbine-powered manned and unmanned helicopters, fixed-wing airplanes and airframe components
Sikorsky Helicopter	civil and military medium and heavy turbine-powered helicopters

[13] The V-22 Osprey was developed by Bell Helicopters and is manufactured by Bell in conjunction with Boeing Rotorcraft Systems. See http://www.boeing.com/rotorcraft/military/v22/ [13] Aerospace Industries Association, *Aerospace Facts & Figures 1995-96*, p.37

[14] Aerospace Industries Association, *Aerospace Facts & Figures 1995-96*, p.37

[15] http://www.oboronprom.com/en/show.cgi?/corporation/structure.htm

[16] A wholly owned subsidiary of Eurocopter, an EADS company.

Foreign Competitors

Company	Products	Countries
Eurocopter	civil turbine-powered helicopters	France-Germany
PZL Swidnik	single-engine, twin-engine light and light-medium turbine-powered helicopters	Poland
OAO OPK Oboronprom	Mil Moscow, Kazan, Kamov turbine-powered light, medium and heavy helicopters, rotorcraft related companies	Russia

Joint Ventures

Company	Products	Countries
AgustaWestland	civil and military turbine-powered helicopters	UK-Italy
Bell/Agusta Aerospace	civil tiltrotors	U.S.-Italy
NHIndustries	military large turbine-powered helicopters	Italy, UK, France, Germany, Netherlands

Market Trends

U.S. helicopter deliveries in 2010 declined 8.6 percent by value from 2009. Honeywell Aerospace forecasts that during the five-year period 2011-15, world deliveries of new turbine-powered civil helicopters will be 4,200 to 4,440. Orders for 2012 and 2013 are expected to increase 40 percent over 2011.[17] Rolls-Royce forecasts deliveries of about 10,900 new civil turbine helicopters, valued at $38.6 billion during the period 2011-2020. The civil market is expected to experience modest unit growth, especially for new entry-level turbine helicopters. Rolls-Royce projects about 10,300 civil helicopters to be delivered during the ten-year period with an estimated value of $38 billion. The civil market will be characterized by emerging near-term recovery followed by long-term growth.[18]

Future Markets

Emerging market demand and more favorable financing terms has caused the global rotorcraft industry to be more optimistic, than a year ago, about future orders in the long term. This optimism is based in part on the relative average age of the current fleet of operating helicopters, which is nearly thirty years old. Major customers like emergency medical service (EMS) providers and operators supporting offshore oil and gas exploration and production are seeking new, replacement aircraft, especially in the medium-sized twin-engine category, that meet the latest standards for design and safety features. Industry analysts anticipate that the large and fast-growing economies of

[17] "Honeywell Forecasts Modest Helicopter Market Recovery," *BCA Bulletin,* March 9, 2011.
[18] "Rolls-Royce 10-year Turbine Helicopter Market Forecast," *BCA Bulletin,* March 9, 2011.

India and China, for example, with their lack of airport infrastructure and their likelihood of huge construction projects, are ripe for rotorcraft.[19]

Developments

Robinson Helicopter delivered its first turbine-powered helicopter, the R66, in 2010. The R66 comes on the market just as Bell Helicopter is winding down the production of its light single turbine-powered helicopter, the 206B III JetRanger.

Several companies--including Sikorsky, Eurocopter, and Carter Aerospace Technologies--are developing compound helicopters to combine vertical/short take-off-and-landing capabilities with one or more propellers for increasing forward speed over conventional helicopter design. Sikorsky's X2 is a counter-rotating coaxial rotor helicopter with a pusher propeller behind the cabin. Eurocopter's X3 is a twin-engine turbine-powered helicopter with two propellers installed on short-span fixed wings.[20] Carter's Personal Air Vehicle (PAV) use's the company's slowed rotor/compound (SR/C) technology. The PAV has an unpowered rotor for low-speed flight and transitions to a pusher propeller and sailplane-like wing for high-speed flight.[21]

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[19] "Analyst: Civilian Helicopter Recovery to Lag Airplane Upturn," *BCA Bulletin*, February 23, 2011.

[20] "A Milestone for Eurocopter's X3 Hybrid Helicopter," Vertical Magazine on Line (http://www.verticalmag.com), December 9, 2010.

[21] "Compound Concept," *Aviation Week & Space Technology*, February 28, 2011.

Unmanned Aircraft Systems (UAS)

Unmanned Aircraft Systems (UAS), also commonly referred to as Unmanned Aerial Systems or Unmanned Aerial Vehicles (UAV), are air vehicles and associated equipment that do not carry a human operator, but instead fly autonomously or are remotely piloted. UAS must be considered in a systems context which includes the remote human operator(s), a command, control and communications (C3) system, a payload, as well as the air vehicle, or multiple vehicles.

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 UAS 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:

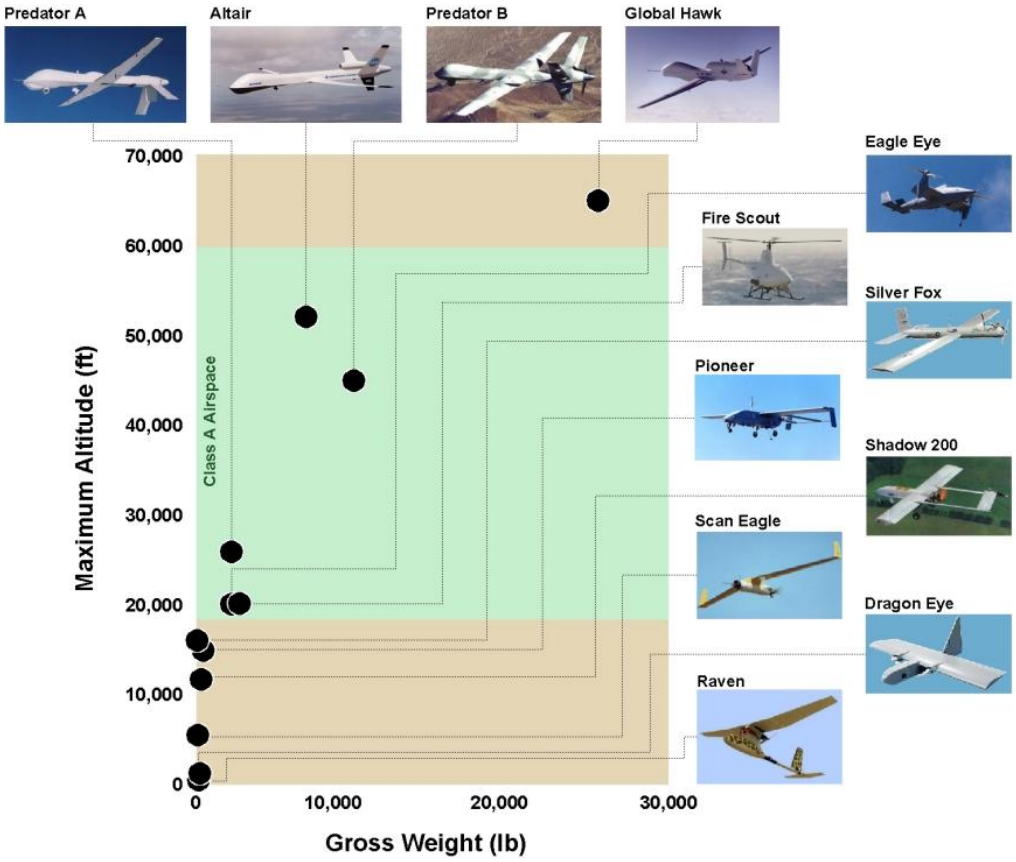
Table 1: UAS Categories and Uses

Name	Altitude	Endurance	Typical Uses
High Altitude	Over 60,000 ft (above class A airspace)[22]	Days/weeks	Surveillance, data gathering, signal relay
Medium Altitude	18,000 – 60,000 ft (class A airspace)	Days/weeks	Surveillance, cargo transportation
Low Altitude	Up to 18,000 ft (class E airspace)[23]	Up to 2 days	Surveillance, data gathering
Very Low Altitude	Below 1,000 ft	A few hours	Reconnaissance, inspection, surveillance

[22] In the U.S., Class A airspace is controlled airspace from 18,000 feet Mean Sea Level (MSL) up to and including Flight Level (FL) 600.

[23] In the U.S., Class E airspace is controlled airspace that is not designated as Class A, B, C, or D and is above Class G surface areas from 14,500 MSL to 18,000 MSL.

Figure 1: Current U.S. Operational UAS[24]



Market Trends

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[25] UAS into civilian air space are key factors limiting growth in the non-military UAS sector. In the short-term, existing military UAS manufacturers likely will dominate civil-use UAS markets if they are able to leverage their capabilities and technologies in the adaptation of existing platforms or development of new systems for civil purposes. In the long-term, however, military UAS manufacturers will likely face stiff competition from new entrants to the market.

Military Markets

The U.S. Department of Defense (DOD) continues to lead the development, ownership, and operation of UAS globally. The DOD currently has more than 7,000 unmanned aircraft in its inventory, compared to fewer than 50 in 2000.[26] The majority of these aircraft are currently being

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

[25] For purposes of this paper, "civil-use" UAS is defined as non-military (government agency or private operator)

[26] Unmanned Aircraft Systems: Comprehensive Planning and a Results-Oriented Training Strategy Are Needed to Support Growing Inventories GAO-10-331, March 26, 2010. Available at http://www.gao.gov/new.items/d10331.pdf;

used in support of ongoing operations overseas. In particular, the use of smaller, shorter range UAS has increased dramatically. Today's operational military UAS encompass a wide range of sizes, gross weights, speeds, and operating altitudes (Figure 1). The smallest operational UAS is the four-pound Raven that flies for about one 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 Department of Defense (DOD) plans to invest billions of dollars in the development and procurement of UAS. In fiscal year 2011 the DOD requested $6.1 billion and expects to need more than $24 billion from 2010 through 2015 for new UAS and expanded capabilities in existing ones.[27] Several Government Accountability Office (GAO) reports have identified issues with DOD's UAS programs, including cost increases, schedule delays, performance shortfalls and the need for personnel, facilities and communications' infrastructure to support growing UAS inventories.[28]

In recognition of the broad use of unmanned ground and maritime systems and the need to facilitate the integration among platforms as well as with manned systems, the DOD released the second edition of its integrated "Unmanned Systems Roadmap 2009-2034" (Roadmap) in March 2009.[29] The roadmap identifies a DOD-wide vision for all unmanned systems, identifying critical capabilities, obstacles and priorities for the next 25 years. The DOD is implementing the Roadmap despite a November 2008 GAO report that identified problems in the effectiveness of DOD's management and integration efforts.[30]

The 2010 DOD Quadrennial Defense Review (QDR) and the DOD's FY 2012 Budget Request[31] call for increased reliance on UAS for intelligence, surveillance, and reconnaissance (ISR) to succeed in DOD's counterinsurgency, stability, and counterterrorism operations. The FY 2012 budget includes $4.8 billion to develop and procure UAS in three UAS categories: the Global Hawk Class (RQ-4), Predator Class (MQ-1/9), and other smaller low altitude systems.[32] In FY 2012, the DOD aims to grow to a capacity of 65 Predator-Class Combat Air Patrols (CAPs)/orbits by the end of FY 2013.[33]

The Air Force plans to expand its Reaper/Predator UAS fleet and is developing a stealthy UAS to provide reconnaissance and surveillance support to forward deployed combat forces. The Army's

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March 23, 2011 statement by U.S. Representative John F. Tierney on the "Rise of Drones: Unmanned Systems and the Future of War". Statement available at https://hsdl.org/?view&doc=120460&coll=limited.

[27] Unmanned Aircraft Systems: Comprehensive Planning and a Results-Oriented Training Strategy Are Needed to Support Growing Inventories GAO-10-331, March 26, 2010. Defense Acquisitions: DOD Could Achieve Greater Commonality and Efficiencies among Its *Unmanned Aircraft Systems* GAO-10-508T, March 23, 2010. Available at http://www.gao.gov/new.items/d10508t.pdf.

[28] GAO-10-331; GAO-08-511; GAO-09-520.

[29] Department of Defense (DOD) Unmanned Systems Roadmap 2009-2034. Available at http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA522247.

[30] Unmanned Aircraft Systems: Additional Actions Needed to Improve Management and Integration of DOD Efforts to Support Warfighter Needs - GAO-09-175, November 14, 2008. Available at http://www.gao.gov/new.items/d09175.pdf.

[31] Department of Defense FY 2012 Budget Request: http://comptroller.defense.gov/budget.html.

[32] Ibid., p. 24.

[33] Ibid., p. 24.

FY 2012 Budget calls for expanding all classes of UAS, including accelerated procurement of the MQ-1 Grey Eagle Extended Range Multi-Purpose (ER/MP) UAS ($659 million, 36 aircraft), RQ-7 Shadow ($95 million) and development of a new vertical takeoff and landing UAS.[34] The U.S. Army is also working with several companies to develop a long-endurance multi-intelligence vehicle (LEMV) that will be capable of remaining aloft for 21 days at a time.[35] The Navy is introducing sea-based UAS and in March 2011 issued a broad agency announcement for the Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) program.[36] The Navy's MQ-4C Broad Area Maritime Surveillance (BAMS UAS) program is scheduled to reach Initial Operational Capability (IOC) in 2015.[37] The DOD is exploring ways to enhance the effectiveness of its fleet of ISR aircraft by developing innovative sensor technologies, support infrastructures, and operating concepts.[38]

Most governments around the world are seeking to integrate UAS capabilities into their defense forces, either through acquisition of foreign systems or through development of indigenous systems. Coalition forces are using UAS in Iraq and Afghanistan, as well as in security operations around the world. At least forty other countries are currently developing unmanned systems technology.[39]

Israeli manufacturers have influenced UAS development programs, entering into industrial partnerships, and marketing and co-production agreements around the world. Elbit Systems' Silver Arrow subsidiary is currently the Israeli Defense Force's principal supplier of UAS with the Hermes family of vehicles, and has worldwide business relationships. Israel Aircraft Industries' Malat division (IAI-Malat) has produced a broad range of UAS including the Searcher, Heron and Hunter lines.

Although many European companies are developing indigenous capabilities and technologies, some have entered into joint agreements with U.S. companies to develop and/or build new and derivative aircraft. For example, European Aerospace Defense and Space (EADS) and Northrop Grumman established a joint venture to develop the Euro Hawk, a derivative of the Global Hawk.

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[34] U.S. Army FY 2012 Budget Overview: http://usarmy.vo.llnwd.net/e1/rv5_downloads/misc/FY12-PBO-110210-FINAL.pdf.

[35] February 2, 2011 Flight International article, "LEMV Airship Design Gets U.S. Army Approval": http://www.flightglobal.com/articles/2011/02/02/352646/lemv-airship-design-gets-us-army-approval.html.

[36] Unmanned Carrier-Launched Airborne Surveillance and Strike Broad Agency Announcement (BAA): https://www.fbo.gov/download/2ee/2ee91b8c57fba6c7aaa9a9b0f6f6e79a/UCLASS_BAA.pdf.

[37] http://www.navair.navy.mil/index.cfm?fuseaction=home.displayPlatform&key=F685F52A-DAB8-43F4-B604-47425A4166F1

[38] 2010 DOD Quadrennial Defense Review, p. 22. Available at http://www.defense.gov/QDR/images/QDR_as_of_12Feb10_1000.pdf.

[39] March 23, 2011 statement by U.S. Representative John F. Tierney on the "Rise of Drones: Unmanned Systems and the Future of War". Statement available at https://hsdl.org/?view&doc=120460&coll=limited.

Civil Markets

There is large potential for civil applications of UAS, ranging from surveillance and reconnaissance to scientific data gathering or delivery of services (crop dusting, telecom relays, etc.). For purposes of this paper, "civil-use" is defined as non-military UAS operations (government agency or private/commercial operators). The vast majority of civil UAS operations in the U.S. are performed by government agencies. Private/commercial UAS operations in the U.S. are currently limited to testing and demonstration.

The absence of standards, regulations and procedures to govern the safe integration of civil-use UAS into civil airspace are key factors limiting growth in the non-military UAS sector. As a result, most civil operations of UAS in 2010 were related to test or demonstration flights. According to a 2011 study by the Teal Group, world civil UAS production is forecast to make up 8.7 percent ($296 million) of the $3.4 billion in 2011 global production value, falling to 5.64 percent ($498 million) of global production value ($8.8 billion) by 2020.[40]

The U.S. Federal Aviation Administration (FAA) has imposed strict limitations on UAS operations in the national air space (NAS) until sufficient standards and regulations can be developed. In February 2007, the FAA published policy guidance to clarify exactly which authorities exist for UAS operations in the NAS.[41] At the same time the FAA continues to develop domestic certification regulations that will address all relevant technology, policy, regulatory and infrastructure issues necessary to safely integrate UAS into the NAS.

In 2009, the FAA created the Unmanned Aircraft Program Office (UAPO) and the Air Traffic Organization (ATO) UAS office to integrate UAS safely and efficiently into the NAS and coordinate all FAA certification and operational policy activities related to UAS. In October 2010, the UAPO published a Civil/Public UAS roadmap to clarify the path toward normal certification and operation of UAS in the NAS. The roadmap predicts that routine civil UAS access to the NAS will occur sometime after 2020.[42]

For public operation (U.S. government organizations), UAS certification is granted under a Certificate of Authorization (COA) or Waiver.[43] For civil operation (private industry), organizations/individuals are permitted to operate UAS under the authority of a Special Airworthiness Certifications, Experimental Category (SAW-EC). Like the COA process, the SAW-EC is an exception process and requests are reviewed on a case-by-case basis. As of January 21, 2011, the FAA had 18 active certificates on 17 aircraft types.[44] In the United States, access to the NAS is predominately granted through COAs for public UAS operation. Under a COA, UAS operations are permitted only for specific times, locations and operations. The number of COAs

[40] Teal Group: 2011 World UAV Market Profile and Forecast. Executive Summary available at http://www.tealgroup.com/index.php?option=com_virtuemart&page=shop.product_details&flypage=flypage.tpl&product_id=98&Itemid=5.

[41] *Federal Register*: February 13, 2007 (Volume 72, Number 29), Rules and Regulations, Pages 6689-6690; available at http://www.gpoaccess.gov/fr/retrieve.html .

[42] Roadmap available at http://www.faa.gov/about/initiatives/uas/.

[43] http://www.faa.gov/aircraft/air_cert/design_approvals/uas/cert/

[44] February 4, 2011 presentation by FAA's UAS Group. Available at http://www.ofcm.gov/uas/workshop/07%20UAS%20Briefing%20for%20Meteorology%20Miniworkshop%20V1.1.pdf.

issued by the FAA has grown significantly in recent years, reflecting growing demand by non-military and civil users. 85 COAs were issued in CY 2007, 164 in CY 2008, 146 in CY 2009, and 298 in FY 2010.[45] In 2010 the agency issued COA's to 95 users on 72 different aircraft types.[46] As of January 21, 2011, the FAA had 266 active COAs and 151 total pending COAs.[47]

Most other countries also do not have civil certification regulations that permit the operation of non-military UAS in civil air space. However, extensive civil-use UAS operations exist in Japan, where unmanned rotorcraft are widely used in agriculture (primarily spraying). As of May 2009, there were an estimated 2,300 unmanned helicopters and over 12,000 certified UAS operators in Japan, compared to a total of 730 non-government-operated manned helicopters and 3,600 professional helicopter pilots.[48] Yamaha Motors Company currently supplies over 60 percent of the Japanese market for unmanned agricultural spraying applications. Yanmar Agricultural Equipment Co., Kawada Industries, Inc. and Fuji Heavy Industries share the rest of the market.[49] Australia also has robust civil UAS operations. The Australian Civil Aviation Safety Authority (CASA) permits public and commercial operation of UAS in its national airspace with proper approval.[50] Uses include advertising, aerial photography, surveying, and law enforcement. Canada[51] and the United Kingdom[52] also have regulations governing civil-use UAS.

Competitors

The U.S. UAS industry is undergoing a major transition. Almost all major U.S. aerospace prime contractors are involved in UAS programs and are expected to remain working on UAS 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. manufacturers are a mix of public and privately owned companies. Five of the twelve U.S. manufacturers of UAS that have operated in Operation Iraqi Freedom and/or with systems that have received experimental civil certification from the FAA are part of publicly traded corporations. For each of the publicly traded companies, UAS development, manufacture and operation make up a relatively small percentage of overall corporate revenues. Most privately held U.S. UAS manufacturers are not widely diversified out of this market segment, although they may produce a

[45] FAA UAS Factsheet, December 1, 2010. Available at http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=6287

[46] Ibid.

[47] February 4, 2011 presentation by FAA's UAS Group. Available at http://www.ofcm.gov/uas/workshop/07%20UAS%20Briefing%20for%20Meteorology%20Miniworkshop%20V1.1.pdf.

[48] UVS International 2009/2010 UAS Yearbook - UAS: The Global Perspective - 7th Edition - June 2009.

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

[50] CASA Civil Aviation Safety Regulation 101 (CASR101) covers UAS. Available at http://www.casa.gov.au/scripts/nc.dll?WCMS:STANDARD::pc=PC_100376.

[51] Section 101.01 of the *Canadian Aviation Regulations*: http://www.tc.gc.ca/eng/civilaviation/standards/general-recavi-brochures-uav-2270.htm.

[52] UK Civil Aviation Authority: http://www.caa.co.uk/application.aspx?catid=33&pagetype=65&appid=11&mode=detail&id=226.

variety of UAS. A number of U.S. manufacturers have established partnerships with non-U.S. companies to strengthen their market presence and to supply UAS to the U.S. military. In addition, some foreign companies have established subsidiaries in the U.S.

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. However, given the large number of uncertainties in the civil UAS market (absence of a measurable civil-use UAS market; prevalence of international partnerships to develop, manufacture and operate UAS; incomplete legal and regulatory structure to integrate UAS into the NAS), it is extremely difficult to perform an accurate and comprehensive assessment of competitors in the civil-use UAS market.

The following list of companies is intended only to provide a representative snapshot of the UAS industry through 2010. These U.S. companies manufacture UAS currently in use in Operation Iraqi Freedom (excluding very small "micro/mini" UAS) and/or have been granted experimental airworthiness certification by the FAA:

Table 2: U.S. UAS Manufacturers*

Company	**Products**
Aerovironment	Raven, Pointer, Dragon Eye
Aurora Flight Sciences	GE-50*
Cyber Aerospace (acquired by Vought March 2010)	CyberBug*, CyberScout
General Atomics	Predator*, Reaper, Altair, Sky Warrior*, GNAT, Mariner
Honeywell	gMAV*
Insitu (acquired by Boeing July 2008)	Scan Eagle, GeoRanger, Insight
Lockheed Martin	Desert Hawk
Northrop Grumman	Global Hawk, Fire Scout
Raytheon	Cobra*
Textron/AAI	Bell Eagle Eye*, AAI Shadow*
Telford Aviation	SkyBus 30K*

* Has received a civil experimental airworthiness certification

Outlook

In 2011, military use of UAS is expected to grow as new systems are fielded and new capabilities are tested. The U.S. military is seeking new UAS capabilities to support new war-fighting doctrines and operations. The DOD is seeking improved payload capabilities, adding the number and types of sensors available on different platforms. For example, it is pursuing new operational capabilities such as autonomous mission operations, multi-vehicle systems, aerial refueling, stealthy UAS for ISR, as well as increased modularity to enable "plug-and-play" systems and maintenance. The

DOD is evaluating options for weaponized unmanned combat air vehicles (UCAV) as force multipliers for fighter and bomber aircraft. Previous year estimates of growth across all sizes and classes may be impacted by current economic conditions and DOD budget constraints. The greatest increases in 2011 will be in small UAS as more systems are deployed in active combat at the unit level.

According to a report from Market Research Media, the U.S. military UAS market is projected to grow at a CAGR of 10 percent between 2010 and 2015 and will generate $62 billion in revenues during this period.[53] Industry analysts have found a widening gap between the growing UAS fleet and UAS infrastructure development, especially in sectors such as training; service, support and maintenance; and data management. This gap creates market opportunities for UAS vendors, both large defense contractors and small technology companies.[54]

U.S. federal agencies are expanding their use of non-military UAS as well. Recent examples include:

- In 2010, NASA's Global Hawk flew missions over tropical storms and hurricanes in partnership with NOAA to collect data on severe weather formation.
- The Department of Agriculture and NASA's Western States Fire Mission has a multi-year effort using the Ikhana Predator B for wildfire support.
- The Department of Homeland Security (DHS) continues to use its fleet of six UAS for border patrol activities.
- The U.S. Geological Survey (USGS) has supported the U.S. Forest Service and several Department of the Interior Agencies by flying Raven UAS to monitor wildfires and support wildlife inventories
- U.S. Air Force's Global Hawks provided imagery of the damage caused by the March 2011 earthquake and tsunami in Japan
- Various law enforcement agencies will continue additional demonstration tests.

A U.S. domestic policy initiative that will affect U.S. UAS operations is the FAA's Transportation Modernization and Safety Improvement Act (H.R. 658).[55] Some of the UAS-related aspects of the bill include: U.S. government-industry collaboration to develop a plan to accelerate the integration of civil UAS into the NAS (the plan shall provide for the safe integration of UAS not later than September 30, 2015); FAA establishment of pilot projects in Class G[56] airspace for small UAS experiments and data collection by government public safety agencies; and FAA establishment of a program to integrate UAS into the NAS at not fewer than four test ranges. As of April 4, 2011, the U.S. House of Representatives and the U.S. Senate still need to resolve the differences between the two versions of the bill before it is sent to the President for signature.

The FAA has initiated development of a Special Federal Aviation Regulation (SFAR) to govern operation of small, low-flying UAS within visual line-of-sight that are used for commercial

[53] Ibid.

[54] Ibid.

[55] April 22, 2011version of H.R. 658

[56] Class G (uncontrolled) airspace here refers to areas "outside of five statute miles from any airport, heliport, seaplane base or spaceport, or any location with aviation activities".

purposes. The SFAR will provide a process for small UAS to operate in the national airspace under low-risk conditions without undergoing the case-by-case approval process that is currently required. Such guidance could enable small UAS users to initiate or continue operations that do not present a safety threat to the public or to other aircraft prior to the finalization of complete certification regulations for all classes of UAS. To make recommendations on how to proceed with regulating small UAS (SUAS), the FAA chartered an Aviation Rulemaking Committee (ARC) composed of government and industry officials which submitted its recommendations in April 2009. The recommendations subdivide SUAS into five groups and provide guidance on operational capabilities and limitations, pilot-in-command (PIC) and observer training, airworthiness eligibility and certification, and other issues. The FAA's is expected to publish the proposed rule in late 2011, with a final rule expected in late 2012.

At the same time, the FAA will continue to develop standards and policies for all UAS systems, drawing on technical recommendations from the Radio Technical Commission for Aeronautics (RTCA) Special Committee-203[57], coordination with other civil aviation authorities directly and through the International Civil Aviation Organization (ICAO) UAS Study Group, and interagency collaboration as a member of the Department of Defense Joint Integrated Product Team (JIPT) for UAS. However, little appreciable increase in UAS operations will occur in the United States in 2011, based on the cumulative number of experimental airworthiness certifications estimated by the FAA to date.

Given the rapid growth of UAS operations for governmental purposes, there appears to be tremendous potential for U.S. industry in the evolving commercial UAS sector. However, it is extremely difficult to determine actual commercial market size in light of the many regulatory and technological obstacles to be overcome before UAS can be integrated into civilian air space. 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 actual market growth, which range from 10-15 percent per year to order of magnitude growth in civil market opportunities.

According to a 2011 study by the Teal Group, the current UAS market will more than double in the next decade: worldwide UAS Research, Development, Test & Evaluation (RDT&E) and procurement expenditures are expected to increase from $6.0 billion in 2011 to over $11.3 billion in 2020, totaling over $94 billion in the next ten years[58] The study suggests that the U.S. will account for 77 percent of RDT&E spending on UAS technology over the next decade and 38 percent of the procurement.[59] The study predicts that UAS demand will be highest in the U.S., with Asia-Pacific representing the second largest market, followed closely by Europe.[60]

The time needed to resolve UAS airspace issues will likely slow the growth of the global civil UAS market for the next several years. During this period, the civil UAS market will be concentrated

[57] RTCA Special Committee-203 UAS Homepage: http://www.rtca.org/comm/Committee.cfm?id=45

[58] Teal Group: 2011 World UAV Market Profile and Forecast. Executive Summary available at http://www.tealgroup.com/index.php?option=com_virtuemart&page=shop.product_details&flypage=flypage.tpl&product_id=98&Itemid=5.

[59] Ibid.

[60] Ibid.

around government organizations requiring military-type surveillance systems, such as coast guards, border patrol organizations and similar national security organizations. In addition, foreign and U.S. government agencies (the National Oceanographic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA) and the U.S. Geological Survey (USGS) are using UAS for scientific monitoring and data collection. Once the airspace issues are resolved, a commercial, non-governmental UAS market should slowly emerge.[61]

U.S. industry sources have cited two primary export barriers to U.S. UAS exports: (1) U.S. export control policy and (2) the multilateral Missile Technology Control Regime (MTCR), a multilateral regime designed to help slow the proliferation of unmanned weapons of mass destruction systems (WMD). Under current U.S. export control policy, some UAS are subject to the International Traffic in Arms Regulations (ITAR), which authorizes the U.S. State Department to control the export and import of defense articles and defense services.[62] In accordance with section 71(a) of the U.S. Arms Export Control Act (22 U.S.C. 2797), the list of items on the MTCR Annex is included on the U.S. Munitions List, thus subjecting UAS exports to licensing requirements.[63] In August 2009, President Obama announced the Export Control Reform Initiative (ECR Initiative), a broad-based interagency review of the U.S. export control system to enhance U.S. national security and strengthen the United States' ability to counter threats such as the proliferation of weapons of mass destruction.[64]

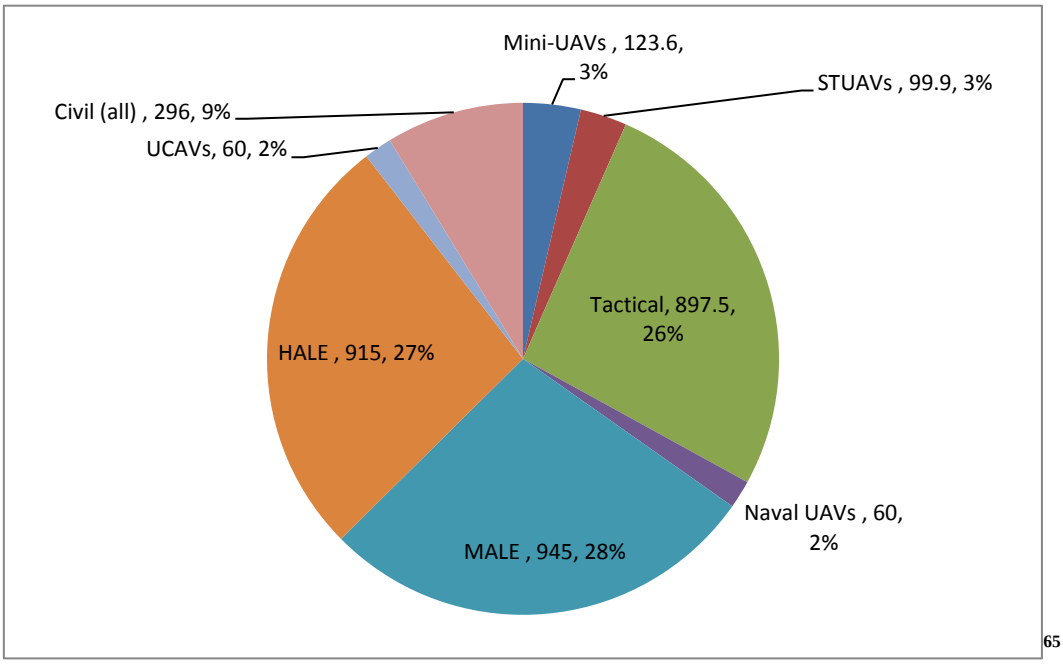
[61] Ibid.

[62] 22 U.S.C. 2778 of the Arms Export Control Act (AECA): http://www.pmddtc.state.gov/regulations_laws/aeca.html.

[63] ITAR Part 121 USML: http://www.pmddtc.state.gov/regulations_laws/documents/official_itar/ITAR_Part_121.pdf.

[64] Export Control Reform Initiative website: http://export.gov/ecr/index.asp.

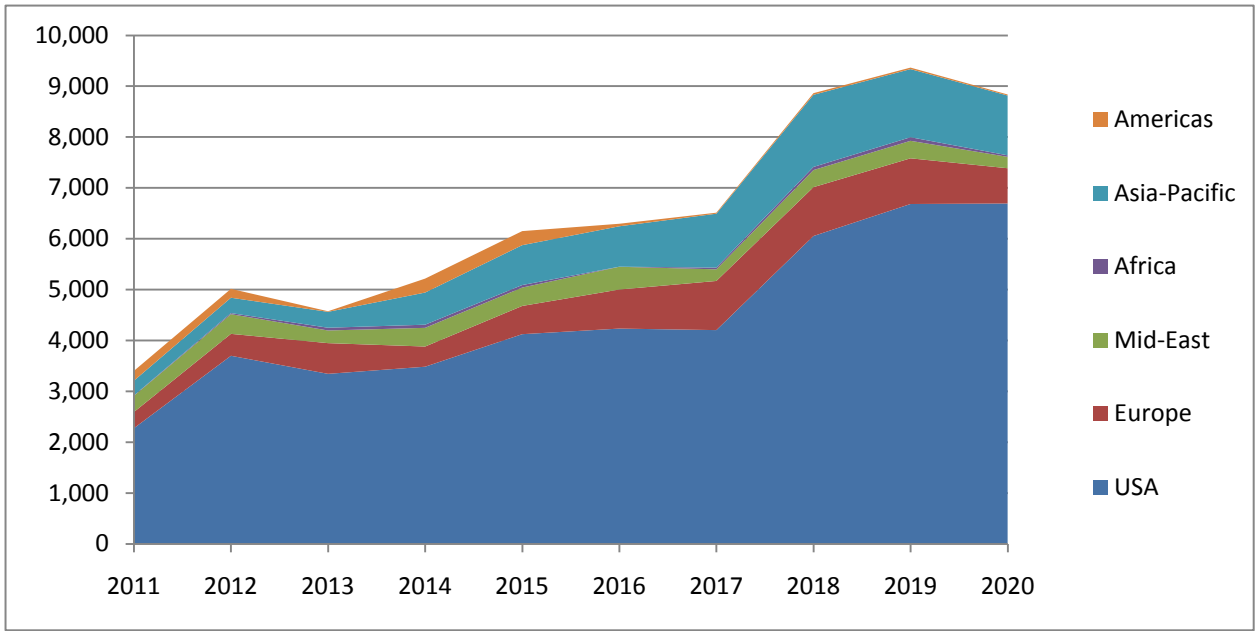
Figure 2: 2011 World UAS Production Forecast by Type (Value, $ Millions)--$3.4 Billion total



[65]

Source: Teal Group, "World UAV Systems 2011 Market Profile & Forecast"

Figure 3: World UAS Production Forecast by Region (Value, $ Millions) - contribution of each region to total value



Source: Teal Group, "World UAV Systems 2011 Market Profile & Forecast"

[65] Abbreviations: STUAV- Small Tactical UAVs; HALE – High Altitude Long Endurance; MALE – Medium Altitude Long Endurance; UCAV – Uninhabited Combat Air Vehicle.

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Airport Infrastructure and Aviation Security

Overview

The Airport Infrastructure and Aviation Security markets continue to grow due to a number of factors. Rebounding air traffic growth across all regions, post-9/11 security concerns, and an expected doubling or tripling of air traffic over the next 20 years are major contributors to this upward trend. Worldwide airport capital expenditures are expected to have grown from $34.6 billion in 2009 to $38.5 billion in 2010 (for upgrades and expansions, not entirely new airports).[66] Although constrained by regulations at multiple levels, airport authorities will need to expand capacity to keep up with current and future demand. Moreover, evolving security needs 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**	
L-3 Communications	Parsons	Battelle	SRA International/
Harris Corporation	Transportation Group	GE Security	Galaxy Security
Daktronics, Inc.	ESRI	TransCore	SecureScan
Elgin Sweeper Company	URS Corporation	SRS Technologies, Inc.	ARINC (Verified
	Alion Science		Identity Pass/Clear)
Penta Corporation	TYMCO	Nabco, Inc.	Matrix Systems, Inc.
Vidtronix	Unimark, Inc.	URS Corporation	Zortek Systems
FMC Technologies, Inc.	Trident Computer	Honeywell Aerospace	UTC
	Corp.		AS&E
ARINC	Unisys	MITRE/CAASD	TransSecure, Inc.
Zortek Systems	NBP Corporation	I.D. Systems, Inc.	DefenderTech
Oshkosh Truck	Bradford Airport	Pure Tech Systems	Privaris
Corporation	Logistics	Rapiscan Systems	L-3 Communications
Global Ground Support,	Airports Seating	Raytheon/McNeil	ICx Technologies/ FLIR
LLC	Alliance	Security	Systems
Rockwell Collins	All Weather Inc.	CSC	NCR

[66] Airports Council International. "New Release: ACI Airport Economics Survey 2010." Press Release. December 17, 2010.

Analysis and Trends

While the economic downturn led to reduced traffic flows and capital expenditure delays, both industry and government analysts 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)[67], a multiagency organization that manages a public/private partnership responsible for bringing the Next Generation Air Transportation System (NextGen) online, the USG is working to develop and implement policy and technology improvements that will support up to a tripling of air traffic by 2025. Privately owned airports and aviation infrastructure manufacturers are participating in this effort, both independently and in partnership with the JPDO through the NextGen Institute.[68] These efforts are being mirrored around the globe, most notably by the European Union through the Single European Sky ATM Research (SESAR) Joint Undertaking (SJU) as well as similar (though less well-developed) initiatives in China and Japan. NextGen and other such initiatives seek to improve air transportation by increasing system efficiency, reducing environmental impact, augmenting safety efforts, enhancing security, and helping communities make better use of their airports to attract new jobs and expand businesses.[69]

Airport Infrastructure

Large-scale expansion of existing airport capacity around the world, as well as a high number of new airports throughout the Middle East and Asia, are either planned or under construction to accommodate [current and future] global air traffic, with some analysts expecting China alone to build up to 80 new airports by the year 2020.[70] Leading airports in the Middle East, for example, are aggressively expanding capacity (with plans to invest in excess of $33 billion by 2012).[71] Similarly, India is seeking to increase its commercial airports from 80 to over 500 in ten years—with a concurrent $40 billion investment in airport infrastructure—to create a system capable of handling up to four times its current capacity.[72]

That said, the global economic recession caused a number of projects at airports around the world to be delayed, staggered, or put on hold.[73] The $34.6 billion invested in airport upgrades in 2009 was

[67] 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 NextGen. The JPDO coordinates the specialized efforts of the Departments of Transportation, Commerce, Homeland Security, Defense, FAA, NASA, and the White House Office of Science and Technology Policy.

[68] The NextGen Institute is the mechanism through which the JPDO accesses private sector expertise, tools, and facilities for application to NextGen activities and tasks (including planning, research, analysis, assessment, architecture, functional requirements setting, prototyping, simulation, and demonstrating future system attributes).

[69] FAA's NextGen Implementation Plan, March 2011. Available on the web at: http://www.faa.gov/nextgen/media/ng2011_implementation_plan.pdf

[70] Vinayak Khera and Harris Miller. "Going Global—A Primer to Entering Overseas Aviation Markets." *Airport Consulting*. Winter 2010/11.

[71] Ibid.

[72] Ibid.

[73] Airports Council International. "New Release: ACI Airport Economics Report 2009." Press Release. December 22, 2009.

20 percent lower than had been predicted previously.[74] Even so, a majority of projects already underway continued as planned, given that existing airports must renovate and expand in order to handle future increases in passenger and cargo traffic as well as larger aircraft such as the Airbus A380.[75] The JPDO and U.S. airports continue to develop plans for new construction, airport expansion, and modernization initiatives that will 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 (passenger terminal facilities, access control, information displays, and boarding bridges), the global business of building, maintaining, and operating airports already represents significant economic activity (approximately $185 billion in 2009).[76]

The need for new and/or expanded airport capacity as well as current and potential job growth have been tempered by the effects of the global economic downturn. The steep declines in both global air passenger traffic and global air freight shipments in 2008 into 2009 reversed in 2010. Global passenger traffic rose by 6.3 percent in 2010 compared to 2009, and freight rose by 15.2 percent in the same period.[77] Although employment levels at airports declined in relation to traffic, airports continue to be significant centers of job creation. Even with the downturn in passenger and freight traffic in 2008, according to ACI, 3.975 million persons were employed on airport sites worldwide.[78] Furthermore, the Air Transport Action Group estimates that around 8 million jobs worldwide are dependent on airport activity.[79]

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".[80] Airports worldwide derived approximately 46.5 percent of their revenue from non-aeronautical sources, such as shopping areas, restaurants, advertising, and parking facilities.[81] This aerotropolis concept was reinforced in the House version of the latest FAA reauthorization bill, which calls for development of multimodal transportation networks to support economic activities surrounding major airports.[82]

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[74] Airports Council International. "New Release: ACI Airport Economics Survey 2010." Press Release. December 17, 2010.
[75] Ibid.
[76] Airports Council International. "ACI Airport Economics Survey." December 2010.
[77] Airports Council International. "Preliminary World Airport Traffic 2010." Press Release. March 15, 2011.
[78] Airports Council International. "New Airport Economics 2008 Report." Press Release. December 23, 2008.
[79] Ibid.
[80] 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 the web at http://www.uli.org/AM/Template.cfm?Section=Home&CONTENTID=21387&TEMPLATE=/CM/ContentDisplay.cfm
[81] Airports Council International. "ACI Airport Economics Survey." December 2010.
[82] HR 658 RH SEC. 132. AEROTROPOLIS TRANSPORTATION SYSTEMS. *Section 47101(g) is amended by adding at the end the following: "(4) AEROTROPOLIS TRANSPORTATION SYSTEMS.—Encourage the development of aerotropolis transportation systems, which are planned and coordinated multimodal freight and passenger transportation networks that, as determined by the Secretary, provide efficient, cost-effective, sustainable, and intermodal connectivity to a defined region of economic significance centered around a major airport."*

Existing airports 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.[83]

Aviation Security

Security concerns have become an essential part of airport and aviation operations. The Transportation Security Administration produced a number of plans to address various aspects of transportation security, culminating in the drafting of the National Strategy for Aviation Security (NSAS).[84] Within the NSAS, a supporting plan regarding the Aviation Transportation Security System was created to help manage the development and implementation of new and improved security measures throughout U.S. airports and the National Air Space (NAS). The Airports and Aviation Security Working Groups of the JPDO partnered with industry and the governmental agencies involved in crafting the NSAS to ensure that costs, efficiencies, economic impact, and the changing nature of air transportation (e.g., the expected increases in air traffic) were considered and reflected in the Strategy. The NextGen aviation security model calls for a layered, adaptive security system that utilizes risk assessment and management to identify, prioritize, and assess homeland security needs. [85] This model adjusts resources to defeat evolving threats without unduly limiting mobility or making unwarranted intrusions on civil liberties while minimizing impacts to airline operations or aviation economics.[86]

Further, NextGen and Department of Homeland Security (DHS)/Transportation Security Administration (TSA) planning acknowledges that aviation security is a global issue that requires a high level of cooperation among trading partners. Along with collaborative policies and procedures, NextGen technologies must be interoperable to ensure that critical information reaches appropriate security and air traffic management authorities.[87]

The aviation security industry has moved forward with a number of possible solutions and technologies. The market for these technologies has significantly expanded; indeed, the global airport security equipment market is projected to reach $289 billion by 2015.[88] 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). The constantly evolving array of threats has forced airport operators and security technology manufacturers to test and deploy

[83] Airports Council International. "Airports Stimulate Employment and Economic Growth." Press Release. April 11, 2006.
[84] National Security Presidential Directive 47/Homeland Security Presidential Directive 16 (NSPD-47/HSPD-16). Available on the web at http://www.dhs.gov/xprevprot/laws/gc_1173113497603.shtm
[85] FAQ: What are NextGen's key capabilities? Available on the web at http://www.jpdo.gov/faq.asp
[86] Ibid.
[87] JPDO "Snap Shot" Series: Securing America's Air Transportation System". Available on the web at http://www.jpdo.gov/library/snapshot/JPDO%20Snap%20Shot_Securing.pdf
[88] "Aviation security market to reach $289 billion by 2015." *Homeland Security Newswire*. November 8, 2010.

various identification and screening technologies, such as biometrics, radio frequency identification (RFID), and prototype explosives/baggage screening devices. The attempted Christmas Day 2009 bombing, for instance, prompted DHS to request $433 million to purchase and install hundreds of advanced imaging technology (AIT) machines at airport checkpoints across the United States and an additional $60 million for several hundred portable explosives detectors for the Department's 2011 budget.[89]

Future 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 enhancing aviation security go forward. The 2011 FAA budget proposal includes $1.14 billion for NextGen—a 32 percent increase from fiscal year 2010.[90] ACI World reports that the 6 percent growth rate for global passenger traffic in 2010 takes the industry well beyond the steep declines experienced by the industry in 2009 in the aftermath of the global financial crisis.[91] Moreover, TSA has proposed accelerating the requirement for 100 percent screening of inbound international cargo on passenger aircraft from 2013 to the end of 2011. The expected growth in air traffic, the economic catalyst effect of large airports, and the demands of air travelers will pressure airports and vendors of infrastructure and security technologies to pursue greater efficiency.

U.S. providers of aviation security technology hold a leading position in the market. For example, the two leading manufacturers of AIT devices, L-3 Communications and Rapiscan Systems, are U.S-based. Almost all U.S. aviation security technologies are used internationally. DHS laboratories such as the Transportation Security Laboratory (TSL) continue to be primary centers of security research, testing, and certification for products and technologies. The TSL is internationally recognized for its role in the development of standards, protocols and test articles necessary for detection technology assessments.[92]

Manufacturers of aviation security equipment are working to create next generation technologies that will be smaller, faster, lighter, and able to detect a greater array of threats. These new systems will be more user-friendly and attempt to allay civil liberties concerns. These new systems and technologies also will be more adaptable to the airports in which they will be placed. Harmonized security requirements will allow cohesive systems of passenger management, baggage handling, and cargo shipments to be built around available and future technologies, such as backscatter and millimeter wave technologies that are capable of both full body passenger screening as well as mobile cargo scanning applications.

[89] Bruce Kennedy. "Flying High: U.S. Aviation Security Costs Keep Rising." *Daily Finance*. April 11, 2010. Available on the web at http://www.dailyfinance.com/story/when-the-cost-of-flying-safely-keeps-rising-who-pays/19433821/

[90] "2011 Budget Proposes $3.515 Billion for AIP." *Airport Magazine*. February/March 2010. Available on the web at http://airportmagazine.net/

[91] Airports Council International. "ACI World Report: February 2011." February 2011. Available on the web at: http://www.airports.org/aci/aci/file/World%20Report/2011/ACIWorldReportFebruary2011.pdf

[92] Available on the web at http://www.dhs.gov/files/labs/editorial_0903.shtm.

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Commercial Space

The commercial space sector is mainly composed of a few companies that provide launch services and manufacture commercial communications satellites. Commercial remote sensing satellites continue to emerge within this market, but have seen limited growth internationally. The companies comprising this market are also major suppliers to U.S. Government (USG) programs, where demand has remained stable.

Table 1: Major U.S. and Foreign Commercial Launch Providers

Launch Company	Vehicles/Products	2010 Commercial Launches	2010 Total Launches
Boeing	Delta II, Delta IV	2	4
Sea Launch (Multinational)	Sea Launch Zenit-3SL Land Launch Zenit-3SL	0	0
Lockheed Martin	Atlas V	0	4
Arianespace	Ariane 5	6	6
Russia and International Launch Services (ILS)	Proton, Rockot, Soyuz	13	31
Orbital Sciences Corporation	Pegasus, Taurus (light-weight), Minotaur	0	2
SpaceX	Falcon 1, Falcon 9	2	2

Source: "2010 Year in Review", Federal Aviation Administration, Office of Commercial Space Transportation, January, 2011.

Historically, four major companies have dominated the international commercial launch market: Boeing, Lockheed Martin, Arianespace (Europe) and International Launch Services (Russia). Boeing and Lockheed Martin also provide launch services to USG customers on their Delta and Atlas rockets through the United Launch Alliance (ULA), a 50-50 joint venture. ULA uses the same Atlas 5 and Delta 4 rockets that are marketed commercially. 2010 saw a decrease in commercial launches from 2009 (23 vs. 24).

International Launch Services (ILS) commercially offers Russian-built Proton launches, which are launched from the Russian government launch site in Kazakhstan. ILS performed 13 commercial

launches, which accounted for 57 percent of the market. Proton rockets are also widely used by the Russian government to launch government spacecraft.

In June 2009 Sea Launch filed for Chapter 11 bankruptcy resulting from a number of debts and damages to critical launch infrastructure during a launch failure.[93] On October 27, 2010 Sea Launch Company emerged from Chapter 11, after having successfully completed its reorganization process. Part of that plan included a majority ownership arrangement for Russia's Energia Overseas Limited. Sea Launch plans to return to launch operations in 2011, and has several satellites included on its manifest. Sea Launch's Land Launch also has several launches slated for 2011, including the launch of the Intelsat-18 communications satellite.

Orbital Sciences provides launch services for lighter-weight satellites, but also has carved out a strong 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. This market niche has seen steady growth and will continue to grow over the next few years. In April 2010, Orbital Sciences acquired the satellite manufacturing business of General Dynamics for $55 million, adding advanced medium-class defense and scientific spacecraft to the company's existing satellite product lines. The company experienced both highs and lows this year with the first successful launch of its Minotaur IV rocket for the U.S. Air Force in April 2010, successful test fires of the first stage engines of its Taurus II rocket, and the unsuccessful launch of the Taurus XL rocket for NASA in March 2011.

The most recent successful commercial market entrant is SpaceX, with its Falcon 1 and the larger Falcon 9 rockets. Privately funded, SpaceX's products are intended to lower launch costs and support NASA's Space Exploration Program. SpaceX currently has contracts or options for over 30 launches, which include a wide mix of commercial and civil customers.[94] The President's 2010 National Space Policy and subsequent budget proposals continue to encourage NASA's use of commercial services, especially for cargo delivery to the International Space Station. Both the Falcon 1 and Falcon 9 rockets performed successful launches in 2010, including a Falcon 9 launch that carried the Dragon re-entry capsule. The F-9 and Dragon capsule have been developed for the future transport of astronauts. On April 5, 2011, SpaceX revealed details on the Falcon Heavy rocket, whose design would make it the world's largest. It is planned to be able to launch 53 metric tons (117,000 lbs) to orbit. First launch is planned for late 2012.

[93] http://www.boeing.com/special/sea-launch/
[94] http://www.spacex.com/

Figure 1: 2010 Total Worldwide Launch Activity
Figure 2: 2010 Worldwide Commercial Market Share

Figure 1

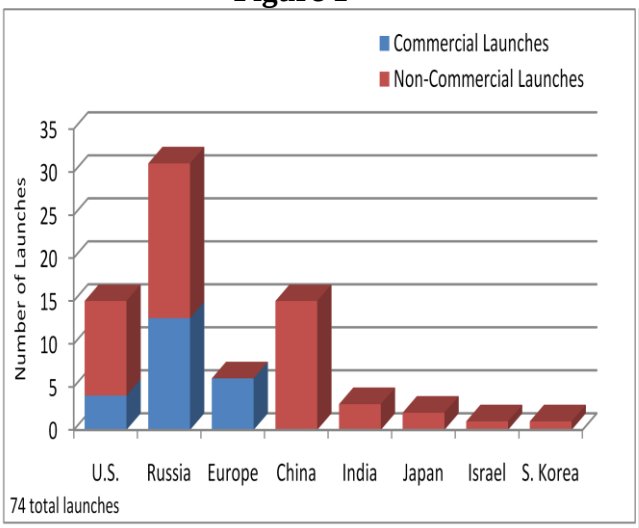
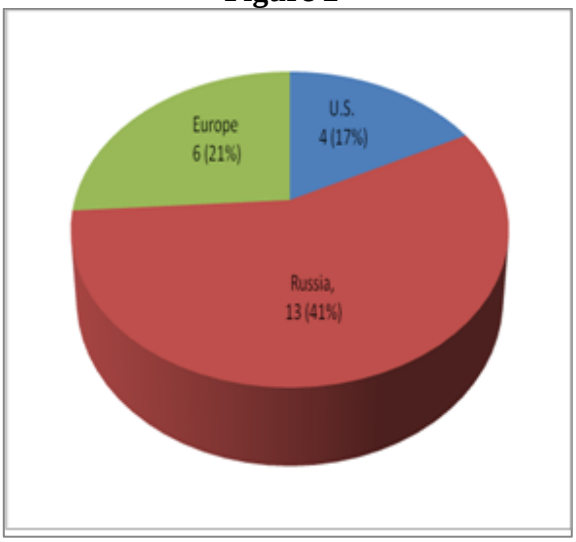


Figure 2



Source: FAA Commercial Space Transportation 2010 Year In Review
Note: A "commercial launch" here is defined as an FAA-licensed launch.

Market Trends

In 2010, 74 total orbital launches took place globally, of which 23 were commercial launches.[95] Four of the commercial launches were performed by U.S. ventures: Boeing's U.S.-built Delta II and Delta IV each had one launch, and Space X's Falcon 9 conducted two (including one demonstration flight). Arianespace launched 12 satellites on 6 commercial launches.[96] Russia launched 20 commercial satellites on 13 launch vehicles, of which eight were Proton M vehicles, three were Dnepr rockets, and one was a Rockot vehicle. Included in this figure is one Soyuz 2 launch that carried six Globalstar 2 commercial communications satellites. These figures demonstrate the stiff competition between European- and Russian-manufactured rockets in the commercial market and the recent focus on U.S. government launches for U.S.-built rockets. Recent data from a number of sources throughout the industry indicates that increases in Russian and European commercial launch prices are nearly high enough to make U.S. commercial launch prices competitive again internationally. Worldwide revenues from the 23 commercial launch events in 2010 are estimated at $2.45 billion, an increase of $43 million (2 percent) from 2009.[97]

The 74 total global launches carried 110 spacecraft into orbit in 2009. Of those 110 spacecraft, 33 provide commercial broadcast and communications services, while the remaining spacecraft were used for non-commercial civil government, military or non-profit services.[98] This is an increase in the share of commercial spacecraft launched.

[95] "2010 Year in Review", Federal Aviation Administration, Office of Commercial Space Transportation, January, 2011.
[96] Ibid.
[97] Ibid.
[98] Ibid.

In the commercial communications satellite manufacturing sector, U.S. companies have regularly maintained approximately 50 percent of the commercial market over the past five years.[99] Boeing, Lockheed Martin, Orbital Sciences, Alcatel Espace, Astrium, and Loral Space and Communications dominate the market, with European companies continuing to strive for additional market share. U.S. market share could continue to decline due to export control concerns and European technological advancements. In response to export control concerns, Europe's Thales manufactures satellites that contain no U.S. components, thereby avoiding U.S. export control regulations, and allowing launches from China at a prices lower than current Western market prices. While the United States maintains a small production cost advantage, aided in part by a weak dollar, this advantage has been shrinking as Europe produces a greater number of satellites and gains more technological expertise. Several factors will impact the demand for telecommunications services over the next 5-10 years including 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.[100]

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. Even though the 2004 national policy on remote sensing encourages trade in this sector, no U.S. company has sold one of these satellites to an international customer. Export control concerns and/or a 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 their data commercially. While the companies' success still hinges on purchases from their main customer, the USG, there is growing commercial demand for satellite imagery. The historical government-customer focus will not change in the near term, but it will slowly diminish as new applications are developed for commercial use, such as commercial mapping, mineral exploration, insurance appraisals, journalism/news media, and agriculture. Recent disasters, such as the Japanese earthquake and tsunami, highlight the value of such imagery for news organizations, disaster relief, insurance and infrastructure development.

The satellite radio sector saw steady growth over the past few years, but the global economic downturn and competition from other sources has slowed subscriptions. Satellite radio subscription revenues increased to an estimated $2.54 billion in 2010 compared to $2.45 billion in 2009.[101] Market growth is closely tied to U.S. economic growth, especially to declining auto sales in the U.S. Headquartered in Washington, D.C., Sirius XM is a global leader in satellite radio. Following bankruptcy rumors in early 2009, media conglomerate Liberty Media purchased a 40 percent stake in Sirius XM in March 2009. Industry analysts are closely monitoring Liberty Media's statements which often indicate a desire to take a controlling interest in the company. Through the current agreement, Sirius XM Liberty cannot purchase more than 49.9 percent until early 2011, but can make an offer for the entire company in 2012.

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[99] Satellite Industry Association.

[100] "2010 Year in Review", Federal Aviation Administration, Office of Commercial Space Transportation, January, 2011.

[101] The Space Foundation, The Space Report 2010: The Authoritative Guide to Global Space Activity. http://www.thespacereport.org.

China conducted fifteen orbital launches in 2010, but none were commercial.[102] Due to Tiananmen Square sanctions, U.S. satellites shipped to China for launch must receive a waiver from the President before shipment. When faced with such a difficult requirement, satellite customers have typically chosen other launch providers instead. New European satellites that are not subject to the export licenses under the International Trade in Arms Regulations (ITAR), called "ITAR-free" satellites, are allowing China to re-enter the commercial market, and several contracts have already been signed. With the appearance of these satellites, China likely will link low-cost launches with its satellite sales in Asia. Given the continued strong competition in the satellite market, China will only win these contracts with extremely low prices, thus negatively impacting U.S. manufacturers. China has also worked with Brazil and Europe to develop advanced satellite technology and is expected to begin offering low-cost, mid-size satellites on the international market within five years.

India continues its strong interest in entering the commercial launch services market. In 2010, India performed one successful launch of its Polar Satellite Launch Vehicle (PSLV), but suffered two failures of its larger GSLV launch vehicle.[103] The GSLV is intended to capture commercial market share for India, but these failures will delay its entry into the global market. Once 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. Because of Indian launch vehicles' limited capabilities and size, India likely will not gain a significant portion of the market in the short term. India also intends to enter the commercial communications satellite market.

Japan conducted two successful launches of its H-2A rocket in 2010 for the Japanese government. Reliability problems with the H-2A rocket and high costs of production have kept Japan from being competitive in this market to date, but Japan hopes to commercialize its H-2B rocket in the future. The need to lower costs may create opportunities for U.S. companies to supply some parts for these vehicles. Additionally, a recent compromise with Japan's fishing unions will allow launches soon to take place year round, which could create additional opportunities for Japan to enter the commercial market.

Several U.S. states continue to explore building commercial "spaceports" for commercial launches and space tourism flights. The FAA is currently reviewing safety factors impacting such facilities. States such as California, Florida and New Mexico have received licenses from the FAA. Several other states, such as Alabama, Washington, Hawaii, Wisconsin and Texas, have proposed the development of such sites, but are not yet licensed to conduct launches. These sites hope to become an alternative to U.S. federal launch sites in order to provide private or state-operated launch and re-entry, mostly likely in support of the space tourism business.

Trends

In 2009, President Obama signed a directive calling for a review of the existing Bush Administration federal space policies, which were signed in 2003-2006. The Bush Administration policies aimed to improve the health of the U.S. space industry and included four sector-focused

[102] Ibid.

[103] "2010 Year in Review," Federal Aviation Administration, Office of Commercial Space Transportation, January 2011.

policies covering the satellite remote sensing industry, global navigation satellite services, space exploration, and the space transportation industry. Those policies were followed by an "umbrella" National Space Policy (NSP) that addressed overarching issues impacting all commercial space sectors.

Signed in June 2010, the Obama Administration's new National Space Policy aims to improve the competitiveness of U.S. industry, increase U.S. jobs and address issues such as workforce training, standards and regulations and acquisition management. In accordance with the President's 2010 National Space Policy and the subsequent budget proposals, the Administration is encouraging increased reliance on commercial space products and services by the U.S. government. Another change in policy direction included the recommendation for increased international cooperation on government space programs. The new policy strongly encourages U.S. exports and coordination with international partners—something that previously policies shied away from in favor of the promotion of national security.

Satellite manufacturers are benefiting from a sudden turnaround in the market, which has included a return to historic satellite order levels. To meet customers' increasing demand for all types of satellite services, satellites are being built larger and heavier in order to provide greater capability 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. However, the greater size has initiated a resurgence of demand for heavy launch vehicles—which are now developing backlogs and increased prices. Prices for intermediate to heavy class launches on several recent competitions have increased from approximately $50 million to nearly $100 million in the last four years. On the other hand, Orbital Sciences has carved out a niche market providing small- to medium-sized satellites to customers requiring a smaller amount of capacity.

Even though the commercial market is recovering, USG satellite and launch purchases will remain very important for U.S. companies who rely upon government business to balance the highs and lows of the commercial sector. However, the unreliable schedule associated with government launches and the 2006 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 an 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 unless a lot buy is arranged.

There are several factors that may stimulate growth in the launch market. For instance, NASA's decision to rely mainly upon the use of commercial suppliers to deliver cargo and supplies to the International Space Station should supply a significant annual boost. The recently signed National Space Policy (June 2010) instructs NASA and all U.S. government departments and agencies to rely upon commercial providers to a much greater extent than in the past. This direction, if fully supported through Congressional appropriations, should lead to a more competitive commercial space industry, which is built upon new and more efficient technologies.

During the early to mid 1990s, the telecommunications boom encouraged a large number of entities around the globe to enter the market, but the late 1990s downturn created large oversupplies in the launch and satellite sectors which in turn eliminated normal profit margins through 2005 and

resulted in reduced launch prices. Over the past four years, those prices have nearly returned to the mid-1990s prices due to a resurgence of demand for satellite telecommunications services. Prices are expected to continue to rise slightly before stabilizing. Prices could continue to increase sharply if another launch failure were to occur and/or Russia limits access to its vehicles (Proton, Zenit for Sea Launch and Land Launch, and Soyuz).

Oversupply and extremely low launch prices also pushed some U.S. manufactured launch vehicles out of the commercial launch business. As launch prices returned to higher levels, U.S.-built rockets have again become more competitive internationally. This may provide Boeing an opportunity to offer its Delta 4 rocket in commercial competitions. Following the telecom market crash, only two telecommunications behemoths (composed of many entities) remained: SES Astra-GE Americom-New Skies and Intelsat-PanAmSat-Loral Satellite Services. 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.

Investors generally remain leery of space due in part to the sector's high risk and low returns on investment. However, investments in telecommunications satellite systems in 2009 pointed towards a return in investor confidence in this sector, and investment in some systems is increasing. As demand for these services increases, emerging launch providers such as India, China and small entrepreneurial ventures may find opportunities to enter the launch and satellite markets.

Another trend having an impact on the market is the increased interest from entrepreneurial manufacturers to develop low-cost alternatives to the established launch providers and/or opportunities for space tourism. This sector has been reenergized as a result of the successful flight of Virgin Galactic's Space Ship One and its 2008 release of Space Ship Two (which made its first captive-carry flight test on March 22, 2010), and the ongoing competitions sponsored by the FAA and private organizations to develop new technologies. However, huge investments are still required to turn these demonstration launches into successful suborbital and/or orbital space tourism operations. The sector will also require the development of new safety and operational guidelines and the ability to use new technologies regularly and at a reasonable cost. With Virgin Galactic's space tourism flights currently priced at $200,000 per person per flight, space tourism is quickly becoming accessible to more than just millionaires.[104] This market will remain small for several years, but advances in innovation will spur further research and development.

The more stringent enforcement of U.S. export control policies in the late 1990s and the international perception that U.S. export licensing laws would negatively impact a customer's ability to acquire a U.S. satellite appears to have hurt the ability of U.S. satellite manufacturers to compete internationally. This is mainly due to export control concerns and the development of satellites that contain no U.S. components. Even though larger companies have learned to manage export control requirements, they remain a heavy burden for smaller companies and entrepreneurial ventures that lack expertise in this area. As mentioned above, Europe's response to U.S. export control policies has been to develop communications satellites that do not contain any U.S. components. Several 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.

[104] http://www.virgingalactic.com/overview/space-tickets/

Another factor influencing the industry 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 will not be achieved for at least 10 years and will take substantial investments in inventories and production lines, which is unlikely in the near term given the current limited investment climate.

Outlook

Due to the limited size of the launch market, and the small nature of contracts, there are no individual ongoing competitions that would have a fundamental impact upon the international commercial market. However, within the civil space sector, NASA plans to use commercial providers to resupply the International Space Station with cargo and possibly people, following the planned 2011 retirement of the Space Shuttle. Depending upon how NASA decides to work with U.S. and foreign industry partners on this and other aspects of its Space Exploration program, U.S. companies could receive a large amount of work, which would have a substantial impact on the health of the sector, though not the "commercial" market.

Arianespace is expected to remain the leader in the commercial launch services sector, due to competitive pricing and a reliable service. In 2009, Arianespace began conducting launches of the medium-lift Russian Soyuz rocket. In 2011, Arianespace has six planned launches for its heavy-lift Ariane 5 vehicle, two with its medium-lift Soyuz rocket from French Guiana (and three more from Russia's Baikonur launch site) and the maiden flight of its light-weight Vega rocket.[105] The Soyuz project is co-funded by the European Space Agency, the European Union, Arianespace and Russia.

The space tourism continues to move closer to reality. The sector's front runner, Virgin Galactic, held test flights of its VSS Enterprise in March 2010. The VSS Enterprise is the world's first manned commercial spaceship. The company will offer commercial flights to private citizens from the New Mexico spaceport, Spaceport America, in coming years.

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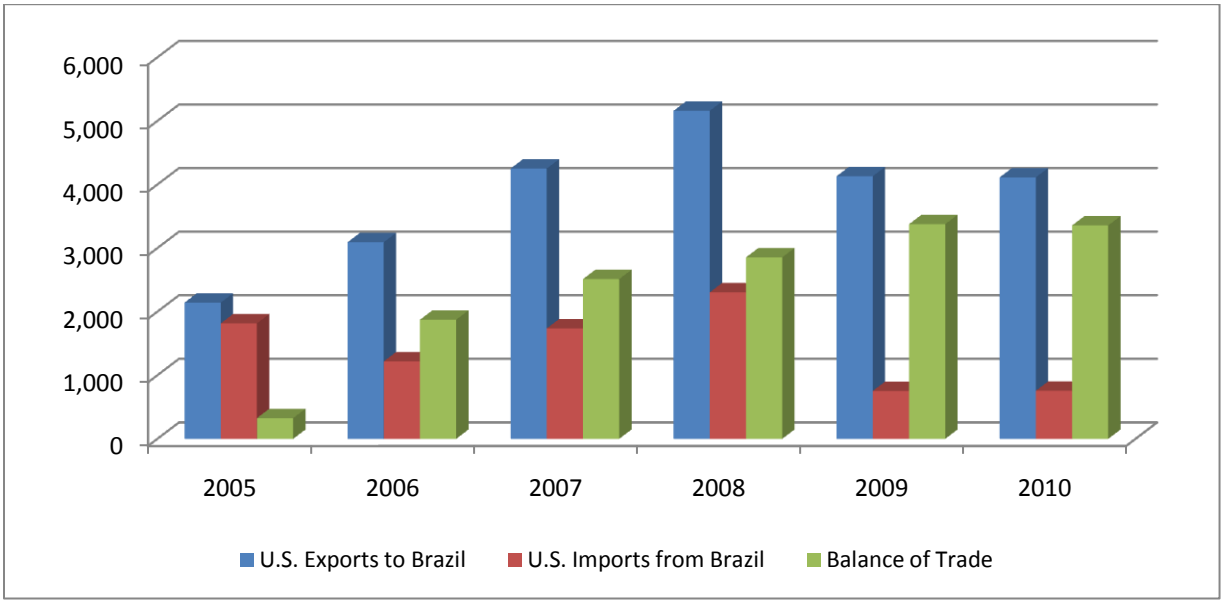
[105] http://www.nasaspaceflight.com/2010/04/live-ariane-5-eca-launch-with-astra-3b-comsatbw-2-satellites

Country Studies: Brazil



U.S. aerospace trade with Brazil in millions of dollars

Brazil is a strong competitor in aerospace manufacturing and produces a wide range of aerospace products. Perhaps best known for producing regional jets, Brazilian manufacturers also make turboprops, military aircraft, agricultural aircraft, business aircraft, helicopters, and other general aviation aircraft. The most well-known Brazilian manufacturer is Embraer, which has delivered more regional jets than its only competitor (Canada's Bombardier) each year since 2006. Brazilian firms are highly integrated into the global aerospace supply chain and have embarked on risk-sharing projects and joint ventures with foreign firms both in Brazil and abroad.

Brazil is a major supplier to the United States' market, though it competes more in sales of final aircraft than in sales of parts and components. In 2009, the Aerospace Industries Association of Brazil estimated that its members earned $7.11 billion in revenue[106]; according to company information, Embraer's portion of that total was around $5.5 billion[107]. Indeed, Brazilian manufacturers claim to import a significant amount of parts and components from non-Brazilian suppliers, including suppliers in the United States. However, it was only in the 2000s that Brazil consistently became one of the top ten U.S. export markets for aerospace equipment, likely due to the increasing success of Embraer's regional jet and business aircraft programs. In 2008, U.S. firms exported $5.76 billion worth of aerospace products to Brazil, $2.07 billion of which was complete aircraft and $3.69 billion of which were parts and components.[108]

[106] On the web at: http://www.aiab.org.br/english/index.php?option=com_content&task=view&id=17&Itemid=31
[107] Embraer in Numbers. On the web at: http://www.embraer.com/en-US/ConhecaEmbraer/EmbraerNumeros/Pages/Home.aspx
[108] ITA analysis of Census Bureau data.

Embraer was established in 1969 as a state-owned enterprise and though it was privatized in 1994, there is some government investment by BNDES, the Brazilian Development Bank (5.5% of shares).[109] It has been producing commercial aircraft since it was launched, starting with turboprops and moving to jets in the 1990s. Though its initial commercial aircraft were in the 20-30 seat range, today Embraer's largest aircraft can seat up to 122 passengers in a single-class configuration (additional discussion of regional jets can be found earlier in this report). Embraer has also become a serious competitor in the business jet market, particularly after the introduction of the Phenom 100 very light jet in 2008.

There are a significant number of foreign suppliers on Embraer's regional jet programs. Components and major segments of the airframe are subcontracted to non-Brazilian firms. For example, the wings for the ERJ-135/40/45 family were designed and manufactured by a Spanish firm (Gamesa, now called Aernnova) and the wings for the ERJ-170/75/90/95 families were initially made by Kawasaki Heavy Industries of Japan. Initially, many of the items supplied by foreign firms were manufactured abroad and imported; however, as Embraer became more successful, some companies set up facilities in Brazil in order to better serve their client. Embraer has also moved some production, such as the ERJ-170 wings, in house.

Although Embraer has a long history of making general aviation aircraft, it is just starting to become a major player in business jets. Its first business jet, the Legacy 600, is a modified ERJ-145; a second variant called the Legacy 650 entered the market in late 2010. Embraer has also introduced a business aircraft variant of the ERJ-190 and a very light jet, called the Phenom. The Phenom's entry into service was well-timed to take advantage of the void left when U.S.-based Eclipse ceased production of its VLJ in 2008. In addition to business jets, Embraer continues to be a player in the piston and turboprop market through its subsidiary, Neiva.

A vast majority of Embraer's 17,149 direct employees are located in Brazil[110], but Embraer does have facilities and joint ventures in other countries. There is an ERJ assembly plant in Harbin, China, which manufactures ERJ-145s from kits. Embraer announced in 2010 that it was considering adding an ERJ-190 assembly line to that facility as ERJ-145 sales have waned in China; this has since changed to a Legacy 650 assembly line. Embraer has also invested in OGMA, a maintenance, repair, and overhaul provider in Portugal that had previously been owned by the Portuguese government. Embraer opened an assembly facility for the Phenom in Melbourne, Florida, in February 2011.

[109]Embraer Capital Ownership. On the web at:
http://ri.embraer.com.br/Embraer/Show.aspx?id_canal=LxvuWZRvW6bFtiTxHCPt6w==
[110] Embraer Company Profile. On the web at: http://www.embraer.com.br/english/content/empresa/profile.asp.

Helibras, a subsidiary of EADS/Eurocopter, manufactures helicopters in Brazil for the Latin American market. Helibras has delivered about 500 units since 1978.[111] UASs are being developed by the military and by private companies such as Embraer and Santos Lab.

There is significant foreign investment in the Brazilian maintenance, repair, and overhaul industry, with GE, Rolls-Royce, Pratt & Whitney Canada, and Goodrich among the manufacturers operating MRO facilities in-country. In addition, in 2005, Portugal-based TAP Maintenance and Engineering bought a controlling share of VEM Maintenance & Engineering. VEM was renamed TAP Brazil in 2009. Over the past several years, TAP has expanded its Brazil services to include a wider range of aircraft types.

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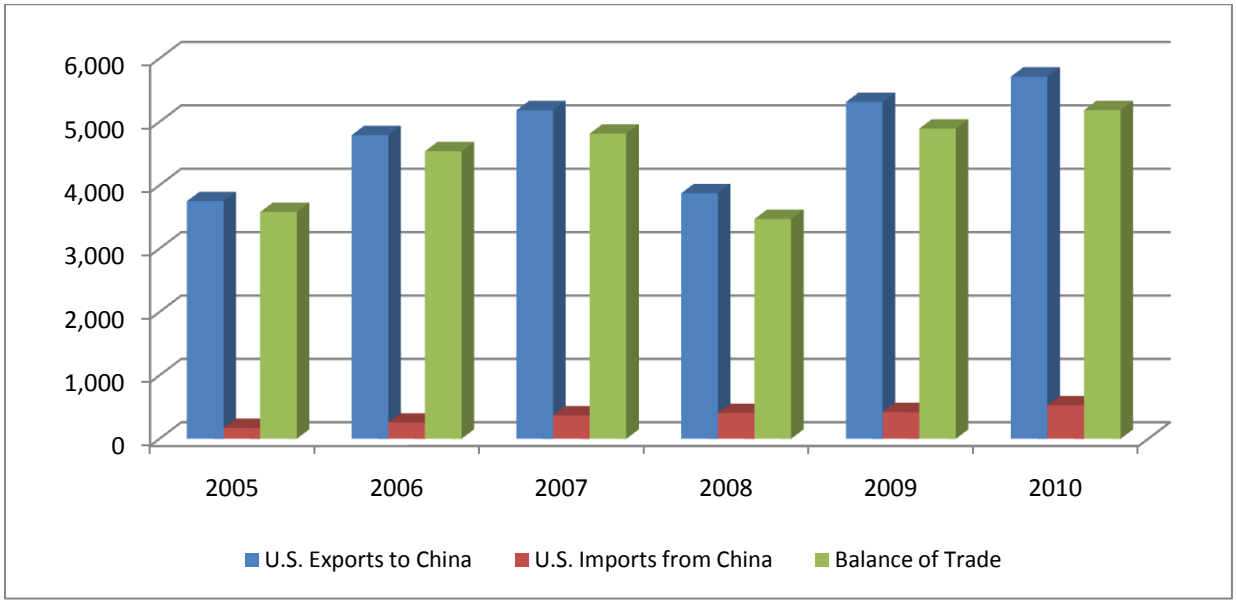
[111] Helibras. "A Empresa." On the web at: http://www.helibras.com.br/historico.asp.

Country Studies: China



U.S. aerospace trade with China in millions of dollars

The People's Republic of China is investing significant resources to become a competitor in the civil aircraft industry. With its regional jet program in the flight testing phase, the Chinese are embarking on a new program to develop a 150-seat narrow-body aircraft that would compete with aircraft currently sold by Boeing and Airbus. The effort to create a competitive civil aircraft production program in China is in part motivated by growth in domestic demand for air transportation, which should lead to orders for over 4,330 new aircraft by 2029.[112] Attempts to capitalize on this demand have led established manufacturers to engage Chinese suppliers in various joint ventures while simultaneously eyeing the Chinese as future competitors.

In 2008, China undertook a major reorganization of its aerospace manufacturing enterprises. In May 2008, China established the Commercial Aircraft Corporation of China (COMAC) to oversee the development and production of a large civil aircraft now called the C919. COMAC was given responsibility for most of China's commercial aircraft programs, including the ARJ21 regional jet. In October 2008, the central government merged China's two large aerospace entities, Aviation Industry Corporations (AVIC) I and II, creating one business unit with ten aerospace subsidiary companies.[113] The new company, which took the name AVIC, was formed from various pieces of the former AVIC family. AVIC is a partial shareholder of COMAC. Since late 2008, enterprises dedicated to aircraft engines, helicopters, composites, and general aviation have been announced or rumored. A strategic agreement on specialized steel for large civil aircraft was signed between

[112] Boeing Current Market Outlook 2010. Viewed April 14, 2011. Available on the web at: http://www.boeing.com/commercial/cmo/china.html

113 enAvBuyer.com. "China's new aviation giant targets 1 trln yuan revenues by 2017 – official." November 13, 2008. Available on the web at: http://www.avbuyer.com.cn/e/2008/30511.html.

Baosteel, China's largest steel producer and COMAC shareholder, and COMAC in January 2009. By early 2011, most of the major suppliers had been selected. As with the ARJ21 regional jet, most of the airframe will be produced by Chinese firms, while the subsystems will be made in conjunction with foreign suppliers. U.S. suppliers on the project include General Electric, Honeywell, Rockwell Collins, Eaton, Parker Aerospace, Crane, Kidde, DDC-I, Hamilton Sundstrand, and Nexcelle (GE nacelle joint venture with SAFRAN).[114] Many of these companies are also suppliers to the ARJ21.

The C919 was first mentioned in China's 11th 5-Year plan, released in March 2006. Initially, the goal was to produce the plane for military and civil purposes by 2015, with entry into commercial service in 2020.[115] China later moved up the date for commercial entry to 2016. The aircraft will be assembled in Shanghai and, as noted above, will have parts sourced globally. However, COMAC early on the selection process indicated that foreign suppliers would be required to participate in the project through joint ventures with Chinese manufacturers and to conduct a significant amount of the manufacturing in country. So far, that assertion has been reflected in most of the major systems procurements. One exception, at least for now, is the engine—the only C919 engine so far is the CFM LEAP-X1C engine, and it has not yet been determined if that engine will be assembled in China. COMAC has said that it intends to develop a domestic option.

While Chinese attention has turned to the C919, the ARJ21 regional jet has struggled. The original entry into service date for the ARJ21 was supposed to be 2007. Instead, the first ARJ21 rolled off of the assembly line in December 2007, and flight-testing was delayed until November 2008. The entry into service date has been pushed back several times, and the date currently stands at the end of 2011. Total orders for the ARJ21 stand at 240, mostly from Chinese airlines. No new orders were placed in 2010.[116]

Technological advancement of China's aviation industry has been directly related to cooperation and investment from international firms. On the one hand, western companies have sourced parts from China for several decades. Most major aerospace manufacturers outsource limited volumes of metalwork to Chinese machine tooling shops, due not only to lower labor rates but also to the wide availability of the latest tooling technology.

On the other hand, non-Chinese firms have played a significant historical role in the development of aircraft by Chinese firms, up to and including the C919. Many of China's early aircraft were based on Russian designs, though that cooperation stalled with the downturn of Russia's aviation industry. Later, U.S. and other western companies partnered with Chinese companies to incorporate western engines and components on Chinese aircraft. For example, starting in the late 1980s and into the early 1990s, Pratt & Whitney established joint ventures with Chinese firms to manufacture

[114] COMAC C919. http://www.airframer.com/aircraft_detail.html?model=C919

[115] Peder Andersen. U.S. International Trade Commission. "China's Growing Market for Large Civil Aircraft." p. 12. http://www.usitc.gov/ind_econ_ana/research_ana/research_work_papers/documents/ChinaLCA2-14-2008final.pdf.

[116] Speednews Commercial Aircraft Program Status: December 31, 2010.

turboprop engines for several of China's Y-series transport aircraft. More recently, at least 19 U.S. and European aerospace companies have supplied major components on the ARJ21, including the engines (GE), avionics (Rockwell Collins), flight control systems (Honeywell, Parker Aerospace), and the landing gear (Lieberherr Aerospace).[117] As noted above, a similar pattern is holding with the C919.

Western companies have also partnered with Chinese manufacturers to co-produce aircraft in China, though these programs 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 produced, five of which were sold in the U.S. market.[118] In 1994, McDonnell Douglas finalized an agreement to coproduce MD-90s in China, but only three of the planned 40 aircraft were assembled before the project was cancelled in 1998.[119] Plans by Chinese and Airbus officials to jointly build a 100-seat "Asian Express" aircraft that would be added to the Airbus product line never came to fruition.[120] Despite this history, in October 2006, Airbus signed a "Framework Agreement" with a Chinese consortium to assemble A320 aircraft in Tianjin, China, with production intended to serve the Chinese market. That facility delivered 11 aircraft in 2009, 26 in 2010[121], and is expected to deliver 36 in 2011.

Finally, AVIC 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 of aircraft in Harbin, China. The enterprise delivered its first plane in 2004; slow orders, however, placed some doubt on the long-term viability of the project.[122] In February 2010, Embraer announced it would consider adding an ERJ-190 assembly line in the Harbin facility but by April 2011, this had changed to a Legacy assembly line.[123] The Legacy is based on the ERJ 135.

China's growing relationship with Canada's Bombardier deserves special mention. In 2006, Bombardier announced that it would start outsourcing significant airframe elements to AVIC subsidiary Shenyang Aircraft Corporation; today, it outsources fuselage sections and the empennage for the Q400 turboprop to SAC. In addition, Bombardier and China announced that they would work together to develop aircraft in the 90 to 149-seat range. In practical terms, this meant that

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[117] Andersen. p.11.

[118] *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.

[119] Andersen. p. 8.

[120] Diane Brady and Charles Goldsmith. "Airbus is Set to Help China Build Jetliner." *The Wall Street Journal.* November 20, 1996.

[121] Zhuan Ti. Airbus Maintaining an Active China Presence and Plans on Expanding. *China Daily.* January 27, 2011. http://www.chinadaily.com.cn/cndy/2011-01/27/content_11923806.htm

[122] Nicholas Ionides. "ERJ-145 deal earns reprieve for Chinese assembly line." *Flight International.* Jan 24-30, 2006.

[123] Gregory Polek. More E190s destined for China; Embraer to build Legacies in Harbin. *AINOnline.* April 12, 2011. http://www.ainonline.com/news/single-news-page/article/more-e190s-destined-for-china-embraer-to-build-legacies-in-harbin-29287/

Bombardier would help the Chinese stretch the ARJ21 to 90+ seats and that Shenyang would invest in the development of the C-Series. The fuselage and doors for the C-Series will be made by SAC.

More recently, the collaboration was extended to also include the C919. In March 2011, a new agreement reached to explore ways of creating "commonality" between the C-Series and the C919. Commonality is attractive to airlines because it adds efficiency—commonality in the cockpit, for example, creates flexibility in pilot choice and commonality in components makes it cheaper to stock spare parts. Creating commonality would allow Bombardier and COMAC to market both aircraft as a family, which could presumably mean that they could help each other attract customers. The specific areas in which commonality will be sought have yet to be defined and may be limited by differences in partners. For example, while Goodrich and L-3 will provide the instruments and indicators for the C-Series, whereas GE and Honeywell are working on the comparable systems for COMAC.

China's transition to a competitive 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 has the world's fastest growing domestic aviation industry, with passenger traffic increasing at a rate of 7.6 percent per year.[124] Given that there are only about 1,570[125] commercial jets operating in China (compared to roughly 7,000 in the United States), industry analysts predict that Chinese airlines will need to add over 4,000[126] large- and medium-sized aircraft to their fleets over the next two decades to meet this demand. Not surprisingly, Boeing and Airbus have identified China as the single most important market for sales over the next 20 years, and both companies are working hard to win orders from Chinese airlines.

Business opportunities in China are not limited to sales of large aircraft. Fleet expansion has been accompanied by infrastructure improvements, with 33 new airports added and 33 airports upgraded between 2005 and 2010, valued at 250 billion yuan.[127] CAAC expects the number of airports serving scheduled flights to increase 230 by 2015 (this seems to surpass earlier estimates, which estimated that there would be 244 commercial airports 2020[128]). General aviation may eventually prove to be a significant market; for now, however, sales are limited by airspace, infrastructure, and tax restrictions. So far, rather than developing general aviation aircraft domestically, China has been acquiring general aviation capabilities through foreign direct investment. Over the past several years, Chinese companies have purchased several U.S. aerospace firms including Teledyne Continental, Epic Aircraft, and Cirrus (still pending) .

[124] Boeing Current Market Outlook 2010.
[125] Boeing Current Market Outlook 2010.
[126] Consolidated estimate from Boeing, COMAC, and industry analysts.
[127] "China to Build 56 New Airports in 5 Years." April 7, 2011. http://www.chinadaily.com.cn/china/2011-04/07/content_12288202.htm
[128] "97 Airports in 12 Years." *The China Daily via People's Daily Online.* March 25, 2008. On the web at: http://english.peopledaily.com.cn/90001/6380001.html.

In the end, future export prospects may be dampened if Chinese companies are able to satisfy some of China's growing demand with indigenously produced aircraft and other equipment. Western companies also may face new competition outside of China as Chinese manufacturers seek to expand their share of the global aircraft market. For now, aerospace companies are exercising cautious optimism while pursuing business opportunities in China.

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