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The Aircraft Industry

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The Industrial College of the Armed Forces
National Defense University
Fort McNair, Washington, D.C. 20319-5062

AIRCRAFT

ABSTRACT

The aircraft industry is continuing its recovery from the devastating effects of 9/11 and the associated economic slow down. As the airline companies prepare to buy new Boeing and Airbus passenger jets, they remain under intense pressure to cut costs in order to remain profitable, forcing aircraft and engine manufacturers to adopt austere measures. While airlines have seen improved financial statements, the recent increases in fuel costs have continued to limit profitability for most airlines. In contrast, defense expenditures have seen continued strength from heightened security concerns and developing technologies such as unmanned air vehicles and systems (UAVs/UASs). While UAVs are currently a small fraction of the overall aircraft market, they hold great promise for innovation in both military and civilian applications. The U.S. is still the dominant player in the fighter/attack sector with the development of the Joint Strike Fighter (JSF) and the F/A-22 Raptor. In the rotorcraft sector, European firms have penetrated the U.S. commercial market with technologically superior helicopters; they are similarly poised to do the same in the military market. The only innovative U.S. design is the tilt-rotor aircraft, which has been in development for 20 years. However, despite these challenges the U.S. aircraft industry is sufficiently robust and healthy to meet current and future strategic needs.

LtCol Tim Fitzgerald, USMC, Seminar Leader
Lt Col Noureddine Baiche, Algerian AF
Lt Col Mike Brewer, USAF
CAPT Al Collins, USN
LTC Kathy Knapp, USA
Lt Col Marilyn Kott, USAF
LTC Duncan McGill, USA
Mr Dunstan Mensah, DON
Mr Mark Neighbors, DON
Mrs Dee Reardon, DAF
Lt Col Jose Rivera, USAF
Col Na-Res Sungwanna, Thailand AF
CDR Mike Taylor, USN
Mr Eric Waggoner, CIA
CDR Key Watkins, USN
Col Jerry Whitley, USAF

CAPT Stephen Morris, USN, Faculty Leader
Dr. Gerry Berg, Ph.D., Faculty
Mr Donald Briggs, FAA, Faculty
CAPT Paul Martinez, USN, Faculty
Col Tedd Ogren, USAF, Faculty

PLACES VISITED

Domestic:
Lockheed Martin Corporation Fighter Demonstration Center, Arlington, VA
Aerospace Industries Association, Washington, DC
Sikorsky Aircraft Corporation, Stratford, CT
Pratt & Whitney Aircraft Engines, Middleton, CT
Warner Robins Air Logistics Center, Robbins AFB, GA
Lockheed Martin Corporation, Marietta, GA
Lockheed Martin Aeronautics Company Headquarters, Fort Worth, TX
Shultz Steel Company, Los Angeles, CA
Boeing Integrated Defense Systems Division, C-17 Production Facility, Long Beach, CA
General Atomics Aeronautical Systems, Inc, Flight Operations Facility, Gray Butte, CA
Northrop Grumman Integrated Systems, Palmdale, CA
Boeing Commercial Airplanes Division, Seattle, WA

International:
EADS, Manching, Germany
Eurocopter, Marignane, France
Airbus, Toulouse, France
Soceite Nationale d'Etude et de Construction de Moteurs d'Aviation (SNECMA)
Moteurs, Villaroche Plant, Salle Viercy, France
Organization of Economic Cooperation and Development, Paris, France
AgustaWestland, Yeovil, United Kingdom
Rolls Royce, Civil Aerospace & Defence Aerospace Divisions, Derby, United Kingdom
BAE Systems Corporate Offices, London, United Kingdom

BRIEFINGS RECEIVED

Aerosystems 101—Overview of the Aircraft Industry
United States Department of Commerce—U.S. Aerospace Industry Overview
Teal Group—World Aviation Market Outlook
V-22 System Program Director—Program Overview
Aviation Week & Space Technology/Flight International—View from the Fourth Estate
Embraer Aircraft Corporation—Regional and Military Aircraft
GE Aircraft Engines—Corporate Briefing
BAE Systems, North America—Company Overview
United Kingdom Ministry of Defence—The UK Perspective
EADS, North America—Company Overview

INTRODUCTION

The purpose of this study was to examine the aircraft industry's current condition, the challenges it faces, and the outlook for its future. The seminar analyzed the aircraft industrial base as well as its development, resourcing, and manufacturing processes, taking special note of how its products support or affect the National Security Strategy of the United States. Focusing on both domestic and international aspects of the industry, the seminar studied nine key sectors to include commercial fixed wing aircraft, military fixed wing aircraft, commercial rotorcraft, military rotorcraft, unmanned aerial systems (UAS), jet engines, workforce, supply/maintenance, and airspace management.

In the commercial sector, Airbus and Boeing are in a "neck and neck" competition with each owning approximately 50 percent of the market share. Both competitors have new products entering the market with the Airbus A380 due around 2006, and the Boeing 787 scheduled for service in 2008. The U.S. is still the dominant player in the fighter/attack sector with the development of the Joint Strike Fighter (JSF) and the F/A-22 Raptor. There are no documented follow on fighter/attack aircraft development programs after the JSF. Moreover, there are no new U.S. military transports being developed, although the U.S. aircraft industry is modifying and upgrading extant systems. In the rotorcraft sector, European firms have penetrated the U.S. commercial market with technologically superior helicopters; they are similarly poised to do the same in the military market. The three U.S. helicopter companies have no new platforms in development and are relying on refitting and upgrading legacy systems. The only innovative U.S. design is the tilt-rotor aircraft, which has been in developmental, testing and evaluation phase for 20 years.

The industry's two success stories are UAS and jet engines. UAS, although a relatively small segment of the industry, is the fastest growing sector driven principally by highly successful military applications in Operations Enduring Freedom and Iraqi Freedom. Based on these military successes, numerous potential civil applications have emerged, to include law enforcement support, maritime/border patrol and forestry surveillance, to name a few. Reflecting a worldwide aircraft industry trend, the two primary domestic jet engine companies are profitable and stable, but their cost for producing new engines takes many years to recoup. Both U.S. companies remain viable and continue to sell new engines at marginal profits with the intent of gaining revenue in the lucrative aftermarket. Although a factor in nearly all major U.S. industries, a significant challenge for the aircraft industry is its aging workforce and the increasing difficulty of attracting new, qualified talent, particularly with science and engineering skills. The seminar's study of the last two sectors revealed mixed results. The supply and maintenance sector is transitioning toward lean manufacturing, consolidation, and performance based contracts in order to increase efficiency and reduce costs. Finally, the airspace management sector of the industry is currently antiquated and severely congested. A major government investment is required to modernize this system.

Overall, the aircraft industry, although facing significant challenges, is mature, healthy, and capable of meeting the nation's future strategic needs.

THE INDUSTRY DEFINED

As indicated above, the seminar focused on nine separate sectors of the aircraft industry: commercial and military fixed wing, commercial and military rotorcraft, UAS,

jet engines, aviation workforce, supply/industrial base issues, and air space management. The following sections of this report provide the seminar's principal observations, findings and assessment relative to each sector.

COMMERCIAL FIXED WING

The aircraft and airline industries have for the past decade experienced continued crises, which, in the aggregate, placed great pressure on each firm's financial bottom line. If there has been a silver lining for the airlines over the past few years, it is the low cost carriers (LCCs) with their no frills model, both challenging and continuously eroding the dominant position held by the legacy airlines. Likewise, in aircraft manufacturing Boeing and Airbus are locked in a struggle for the title of the world's leading producer of medium (50 to 120 seats) to large (250 seats or greater) commercial passenger aircraft.

Current Conditions/Challenges

The commercial fixed wing sector of the industry performed poorly over the last few years, primarily because of the world-wide decline in demand for air travel following the terrorist attacks of September 11th. Air travel demand is now on the rise again, and airline companies and aircraft manufacturers are struggling to regain their post September 11 legs. The major airlines continue to lose money as they try to match the low fares offered by the LCCs.

With respect to the commercial airline sector, the major carriers continued operating in the red, posting losses of $21B since 9/11 despite the U.S. Government's (USG) infusion of $6B to bolster the industry. Losses in 2003 alone amounted to $6.6B or 2.1 percent of revenue.[1] The industry ferried 18 million more passengers to various destinations and flew 17 billion passenger miles, an increase of less than 1 percent from the previous year.[2]

One industry source interviewed by the seminar pointed out that competition from the LCCs and other factors such as rising fuel costs, have contributed to keeping prices significantly lower than the consumer price index. The same source believes that LCC operating costs will eventually rival those of the major carriers as their equipment ages; this, in turn, will affect LCC profitability. However, this prediction will hold true only if the LCCs fail to recapitalize their equipment, and, as demonstrated by Southwest Airlines, that does not appear to be the case. Although Southwest is more than 30 years old as an airline company, the average age of its aircraft is 9.6 years compared to the average U.S. commercial fleet airliner with an age of 12.8 years.[3] Of Southwest's newest 153 aircraft, the average age is 3.4 years. Further, Southwest keeps it maintenance and operation costs low by flying newer and more efficient aircraft of just one make and model – the 737. The success of the LCC business model has and will cause further restructuring of the airline industry. Inefficient carriers will enter into partnership agreements, mergers or fold, and others will adopt the Southwest model or that of a successful hybrid in order to stay viable. United Airlines, for example, has entered the LCC market launching its TED subsidiary.

Turning to commercial fixed wing aircraft manufacturers, 66 fewer aircraft were made in 2003 than in the previous year, resulting in a total production of 2130

aircraft.[4] Airbus captured 52 percent of the market, delivering 305 aircraft; this was the first time Airbus deliveries exceeded Boeing's. Also in 2003, Airbus generated 253 orders valued at $31.8B with 52 percent of the equipment orders and 65 percent of the sector's value.[5] In 2003, Boeing had about 14,000 commercial aircraft in service worldwide, although its domestic aircraft sales declined by 43 percent in 2003 and its exports fell by 31 percent to 214 aircraft.[6] Nevertheless, Boeing is predicting higher future sales—particularly of its 787 Dreamliner—banking on an air travel model quite different from Airbus's vision for the A380. Boeing espouses passenger preference for point-to-point travel between city pairs on medium-sized aircraft; Airbus believes the 'hub and spoke' alternative currently employed by the major airlines will continue to sustain its sales.

The spectacular unveiling of the Airbus A380 on 18 January, 2005 was the latest volley in the battle between the two giants of the civil aircraft manufacturing industry. Not to be outdone, Boeing turned up its media campaign by taking out full page advertisements in major publications to announce the renaming of its 7E7 jetliner to the 787. The fanfare and media activity did not mask the high stakes game with thousands of jobs on the line in both Europe and America. The action on both sides of the Atlantic will affect the balance of trade and has key implications for the health of U.S. national economy. For the A380 to be successful, major airports will have to find innovative ways to process simultaneous arrivals and departures of 500+ passengers and their luggage. The U.S. General Accounting Office (GAO) reports that 14 major U.S. airports will by necessity spend $2.1B in upgrades to accommodate the A380. Los Angeles International alone will spend $1.2B.[7] The physical and operational characteristics of Boeing's 787 suggests that the company visualizes a point-to-point, city pair future where passengers fly directly to their destinations via smaller, more decentralized airports. *Aviation Week & Space Technology* characterizes Boeing's belief that "fragmentation will be the dominant trend in the market".[8]

Boeing has conceded the ultra high capacity market to Airbus's A380, but Airbus will not let the 787 go unchallenged, planning to launch the 787-comparable A350 to compete with Boeing.[9] Beginning as early as 2000 and continuing through this report's publication, the punch and counter-punch of these two companies and their political advocates has spawned numerous charges and claims filed at the World Trade Organization.[10] Boeing charges that Airbus receives unfair subsidies from the European governments underwriting the Airbus consortium. Airbus counter-charges that Boeing receives financial support and incentives through its significant USG defense contracts.[11] Substantiating Boeing's claims, *BusinessWeek* reports that Airbus has received $15B from European governments since its start up in 1970.[12] Conversely, the German sources say Boeing has been the beneficiary of $23B in U.S. subsidies since 1992.[13] Reflecting the increasingly contentious nature of the competition, these reports underscore the high stakes sparring between the two corporate giants, as well as the deep involvement of their government advocates.

Outlook

Estimates indicate that Boeing and Airbus will ship 306 and 350 aircraft, respectively, in 2005.[14] Projected five year (2005 -2009) production levels will yield

5,032 aircraft. In terms of value, this translates to $145B for Boeing or 45.3 percent, and $138B for Airbus or 43.1 percent of market share.[15]

According to the Federal Aviation Administration (FAA) officials, airline passenger traffic this year is expected to return to pre-September 11 levels, raising concerns about more airport congestion and potential flight delays. The FAA has projected that U.S. commercial airline passenger traffic will rise 5 percent per annum for the next several years representing a 45 percent increase by 2015. If correct, this projection supports a trend in commercial aviation that points to the transport of more than one billion passengers annually within a decade.[16] FAA projections further indicate that:

- Major airlines such as United and American will grow at a slow pace, with the number of passengers increasing from 502.2 million in 2004 to 700 million by 2016, equal to 2.8 percent increase annually.
- The trend is for passengers flying regional carriers to increase by 15.4 percent next year and an upgrading of equipment with 70 or fewer seats by the regional carriers.
- International passenger travel increased from 54.1 million in 2003 to 61.3 million in 2004, an increase of 13.4 percent.
- Contribution to U.S. GDP is projected to increase from $10.7B in 2004 to $15.6B in 2016.

These developments will create clear pressures on the aircraft industry. Increasing fuel prices will greatly stress input costs in the short and medium term. Globalization will require restructuring of the industry. For example, the major carriers will move toward no-frills model of Southwest Airlines and Jet Blue in order to garner a greater share of domestic markets. Convenience, comfort and luxury apply to a very limited percentage of the flying public. For the majority of airline passengers, price is by far the primary reason for choosing a carrier. Given this pronounced trend, transition by the major carriers to an LCC or equivalent model is expected to continue. Boeing and Airbus have generated different product solutions for long-range inter-continental routes, the former emphasizing point-to-point, city pair travel, the latter betting on the traditional hub and spoke format. Since both have produced or are producing aircraft that will compete in either format, it clear that both are hedging their bets.

REGIONAL JETS

Regional Jets (RJ) are a special segment within the commercial fixed wing market. Typically, size and range define these aircraft.[17] Because of their smaller size, they are able to operate profitably in city pairs that might not support a standard single aisle commercial jet. As airlines aggressively compete against one another, regional airlines continue to replace their older, smaller aircraft (both turbo-props and jets) with newer and larger RJs in order to maximize profits.

Eager to fill this demand, Bombardier and Embraer have become the RJ segment's leading manufacturers and currently control the market. Each is in the process of certifying larger sized RJs, which will increase the passenger load and range, nearing the capacity and performance of low-end products offered by Boeing and Airbus.

The industry shows growth potential, with both China and Russia developing new designs to compete in a market which has been largely ceded by American and French firms. How the larger RJs will compete in the hotly contested bottom end of the single aisle market remains to be seen. Given their overall operating cost advantages, they may do well by enticing airlines to trade up from their older and smaller DC-9, MD-80, and 737 models.

Given the potential for aviation growth in China and India, new foreign designs will likely be competitive and could lead to an increased market share in terms of sales revenue in the RJ segment. Because of the market's small size and number of competitors, Boeing and Airbus will probably remain outside it. However, they will likely aggressively defend the bottom end of the single aisle commercial market in an attempt to prevent the success of the new larger RJ designs.

MILITARY FIXED-WING AIRCRAFT

Against the DoD backdrop of financial scrutiny, the fixed-wing portion of this industry fared well in 2004. Sales for this year headed for an all-time record in current dollars, all courtesy of vigorous defense spending. Military aircraft sales underwent an impressive 15 percent growth, topping off at a projected $46.2B in 2004, with an expected $48.3B in 2005.[18]

Current Condition/Challenges

Transport Aircraft

Airlift is considered a critical part of the U.S. mobilization capability, especially as it relates to the movement of highly specialized forces between CONUS and overseas bases. The total value of the transport aircraft market is approximately $3B to $4B per year. Lift requirements for the air transport fleet have catapulted from 49.4 million ton-miles in 2000 to 54.5 million ton-miles today. This fact provides the rationale for a robust and healthy outlook for this segment of the industry. Projections estimate this trend will continue until 2013. At that point, a strong sense of uncertainty will pervade this sector of the military fixed wing market. The U.S. Air Force is currently in the requirements definition phase for a family of stealthy transports and special mission aircraft. It is envisioned that this new family will include a basic transport (C-X), stealthy transport (M-X), a stealthy penetrating tanker (K-X), and a gunship variant (AC-X). Utilizing internal resources, Lockheed Martin has generated several aircraft configurations with its MACK (M, AC, K-X) proposal.[19]

The most vibrant transport aircraft acquisition program is the C-17, Globemaster III. The current production schedule shows that the Air Force will purchase a total of 180 aircraft by 2008.[20] The Air Force has expressed a need for an additional 42 aircraft, potentially raising the total order to 222. In addition to the USAF order, the United Kingdom's Royal Air Force signed a lease for four aircraft.

The aging C-5 fleet is undergoing a comprehensive upgrade effort. The C-5 Avionics Modernization Program began in 1998 and includes upgrading avionics to Global Air Traffic Management compliance, improving navigation and safety equipment, and installing a new autopilot system.[21] The first modernized C-5 was delivered in October 2004 and installation in all C-5 aircraft is scheduled to be completed by 2007.

Lockheed Martin's Reliability Enhancement and Re-engining Program (RERP) will replace the General Electric (GE) TF 39 engines with modern and more reliable GE CF6-80C2 turbofans. These comprehensive upgrade programs ensure the capability of the C-5 fleet up to at least 2040.[22]

The Lockheed Martin C-130 is the U.S Air Force's principal tactical cargo and personnel transport aircraft. The latest variant of this venerable air lifter, the C-130J, entered production in 1997. It has enhanced performance in terms of range, cruise ceiling time to climb, speed and airfield requirements. Four Allison AE2100D3 engines serve as the propulsion system for this aircraft and generate 29 percent more thrust while increasing fuel efficiency by 15 percent. The C-130J entered active service with the USAF at Little Rock Air Force Base in April 2004 and was first deployed in December 2004. A stretch version, the C-130J-30, has been developed. The first C-130J-30 for the UK RAF was delivered in November 1999. Over 180 C-130J and C-130J-30 aircraft have been ordered and more than 118 have been delivered. All 25 ordered by the UK have been delivered. Deliveries are underway for the USAF, U.S. Air National Guard, U.S. Marine Corps, U.S. Coast Guard, Italian Air Force, Royal Australian Air Force, Kuwaiti Air Force, and the Danish Air Force.[23]

Fighter/Attack Aircraft

According to one of the most respected aerospace industry research entities, The Teal Group, "2004 was the best year for the fighter market since 1998 with some 292 aircraft worth approximately $13.7B delivered."[24] These impressive figures contrast sharply with the relatively anemic market experienced in the late 1990's when annual sales deliveries totaled less than $8.0B.

The U.S Navy F/A-18E/F Super Hornet maritime strike attack aircraft is about 25 percent larger than its predecessor, the F/A-18C/D, but contains 42 percent fewer structural parts. Initial production aircraft were delivered in December 1998, with the total requirement for at least 548 aircraft. To date, over 200 aircraft have been delivered. A late addition to the Super Hornet family is the F/A-18 G or E/A-18G, Growler. This new variant will serve as an electronic warfare jammer and a replacement for the E/A-6B Prowler. The Navy is planning to acquire 90 E/A-18 Growlers out of the 548 aircraft total.[25]

The F/A-22 Raptor program is the next-generation air superiority fighter for the USAF. Its stealthy characteristics greatly increase survivability and lethality by denying the enemy critical situational awareness required for successful attack. The F/A-22's integrated avionics suite provides its pilots with an unprecedented capability to fuse on and off board information. Likewise, the supercruise feature not only enhances weapons effectiveness, but provides rapid transit through contested airspace and reduces the enemy's opportunity for a timely counter attack.[26]

The F-35 JSF is a multi-role fighter optimized for the air-to-ground role, designed to meet the needs of the Air Force, Navy, Marine Corps and allies. The main characteristics of the program are improved survivability, precision engagement capability and the mobility necessary for future joint operations. Additionally, the design incorporates sharply reduced life cycle costs. "JSF will benefit from many of the same technologies developed for the F/A-22 and will capitalize on commonality and modularity to maximize affordability."[27] This aircraft family is comprised of three

variants: a conventional take-off and landing aircraft (CTOL) for the USAF; a carrier-based variant (CV) for the U.S. Navy; and a short take-off and vertical landing (STOVL) aircraft for the U.S. Marine Corps and the U.K.'s Royal Navy. All variants have 70 – 90 percent commonality on all systems and technologies. First production models are expected to be delivered in 2008. Initial operating capability (IOC) for the U.S Marine Corps variant is scheduled for 2012. Similarly, the USAF and USN aircraft are expected to reach IOC in 2013. Initial 2000 DoD program development costs were estimated at $45B (today's dollars), with an estimated total acquisition cost of $199B.[28]

Outlook

In December 2004, Presidential Budget Directive (PBD) 753 shocked the aircraft production community. PBD 753 calls for the termination of the multiyear procurement of the C-130J aircraft and terminates the original FY03-08 USAF/USMC joint service contract in FY06. As a consequence, the USAF will alter its planned buy from 42 down to 15 aircraft, truncating the USAF's and USMC's C-130 modernization roadmap. Opponents argue that, if enacted as written, PDB 753 would spend two thirds of the remaining multiyear program dollars to terminate the program and buy less than one third of the remaining aircraft in the original contract.[29]

The F/A-22 is another program impacted by PBD 753. The overall objective of the PBD is to reduce military spending by about $6B in FY06 and $30B across the Future Years Defense Plan (FYDP). A third of this amount comes from the F/A-22 program in the form of 100 fewer aircraft than originally programmed between the FY08-11. Initial program figures in 1986 estimated the total buy of the F-22s to be 750 planes with a production schedule of 75 per year. After almost 20 years, the revised estimate calls for a total of 277 aircraft (some analysts estimate this number as low as 218).[30] Currently, it is estimated that this program will cost between $60-72B. Current estimates put the unit cost at $125-132M.

Sustained government support for the C-130J, F/A-22 and F-35 is essential for continued success of these programs. Aggressive marketing to our allies on both the C-130J and F-35 programs is also needed if we aspire to keep the U.S. military fixed-wing portion of the aircraft industry healthy and vigorous.

COMMERCIAL ROTORCRAFT

Commercial rotorcraft is a very diverse marketplace with a wide variety of users. The commercial marketplace ranges from companies producing single person utility helicopters to global enterprises, such as Petroleum Helicopters, Inc, with dealings in 43 countries. The global competition in the rotorcraft industry consists of three major U.S. competitors and two major European competitors who focus on light to medium rotorcraft. Other countries produce a small volume of helicopters but are not significant global competitors. U.S. competitors are Robinson, Sikorsky and Bell. European competitors are AgustaWestland and Eurocopter.

Helicopters are either piston or turbine powered, and are further categorized by weight class.[31] For the past several years, higher output of the smaller, piston-powered helicopters, led to increases in civil rotorcraft production, with U.S. owned Robinson lightweight products showing the greatest worldwide marketability. In the civil market,

piston helicopters currently hold approximately 45 percent of the annual unit production.[32] Sikorsky, Bell, AgustaWestland and Eurocopter all produce turbine-powered rotorcraft.

Current Condition/Challenges

As the aircraft market struggles, the civil rotorcraft market is clearly rebounding and is providing much needed support to the aircraft industry. The civil rotorcraft market is worth between one-fourth and one-seventh of the military market, depending on the year and the total rotorcraft market is less than 10 percent of the entire aircraft industry.[33] The U.S. light commercial rotorcraft industry should remain highly competitive on the world market with Robinson leading production and sales in the entry-level markets. European companies AgustaWestland and Eurocopter appear to hold strong market positions, while U.S. owned Bell and Sikorsky market positions are more tenuous. This is due to the European market infusion of new technologies and offerings of broad product lines. In comparison, most of the U.S. rotorcraft technology development funding focused on very specific military mission helicopters and on tilt rotorcraft. U.S. civil rotorcraft technologies are stagnating and becoming obsolete.

Tiltrotor Technology

In March of 2003, Bell/Agusta made aviation history with the inaugural test flight of the world's first civilian tiltrotor, the BA609. The European tiltrotor program has been slow to get started. Eurocopter is proposing its Eurotilt, a 12-19 seat machine designed for offshore, search and rescue, and executive applications.[34] Civil acceptance of tiltrotor technology will ultimately depend on the safety and success of Boeing/Bell's military tiltrotor development.

Research and Development

Historically, U.S. rotorcraft markets prospered due to development of new technologies for the military. This trend may be changing. In 2004, DoD dedicated approximately $2.17B towards military rotorcraft research, development, testing and evaluation. In 2005, DoD cut this to $1.5B, of which roughly $1.1B went towards the Presidential helicopter and the V-22 tiltrotor aircraft development.[35] This is not adequate for the development of new technology to insertion into the civil rotorcraft sector. In comparison, Eurocopter's wide range of up-to-date civilian rotorcraft has given the company a commanding position in the civil market. Many of the technologies in these new models are the result of government funded research and development efforts and are very attractive to the military. In short, the potential impact of tiltrotors on the competitive standing of U.S. rotorcraft companies cannot be overstated. If tiltrotor technology proves to be a dead end, Europe will have a broad range of new machines, while the U.S. will have a collection of legacy programs and derivatives.[36]

Outlook

Although production quantities will probably slow over the next 10 years, forecasts show that annual production value should increase through 2008 before beginning to decline. Worldwide helicopter market forecasts for new aircraft and major modifications from 2003 – 2012 are estimated to be $84B, with $17B (23 percent) focused toward civil markets. Of the $17B, $7B will go towards light, $6B towards

intermediate and $4B towards medium helicopters.[37] Forecasters agree that the piston helicopters will continue to outsell the more expensive turbine helicopters.

Industry experts estimate that about 35 percent of the private sector helicopter demand comes from civil support (police, parapublic, firefighting, maritime/border patrol), 4 percent of the market comes from corporate demand, and the remaining 60 percent comes from "no growth" segments (resource extraction, news and media, utility).[38] Rotorcraft manufacturers can probably be optimistic towards an increase in use of helicopters for business travel. As dissatisfaction with airline travel continues to grow and security requirements persist, this trend could lead to an upswing in this market segment. Manufacturers are putting considerable effort into creating new models and upgrading current products for the high-end corporate needs. Security and law enforcement requirements for helicopters are on the rise. Mission sets are emerging for Homeland Security, police helicopters are nearing the end of their service life, and maritime/border patrol requirements are on the rise. New helicopters will likely fill this niche.

The leading civil rotorcraft producers are strong competitors and are not likely to leave the market in the foreseeable future. Most likely, they will rely more and more on interdependent relationships to optimize scarce research and development resources. If the U.S. ventures are slow to gain market attention, the U.S. will be at serious risk of being technologically left behind in the rotorcraft market. The U.S government and private industry will need to increase research and development funding for sustainment of the U.S. medium rotorcraft industry.

MILITARY ROTORCRAFT

This industry is small, mature and very competitive. Although there are three primary U.S. manufacturers in this industry, Boeing, Sikorsky, and Bell Helicopter Textron, the industry generates small revenue by comparison to the other major markets in the aerospace industry. The military rotorcraft industry is in a transitional period. The primary companies are reducing excess capacity, streamlining processes, making the transition to production integrators and revamping supplier/manufacturer relationships. The U.S. military rotorcraft industry will remain small, very competitive internally, face increasingly stiff competition from European companies, and continue to operate within an uncertain future niche market.

Current Condition/Challenges

Each of these companies has acquired several smaller companies who specialize in rotorcraft or aerospace products. Boeing's acquisition of McDonnell Douglas brought light, attack and heavy lift helicopters into the Boeing aerospace family. Sikorsky has acquired Schweizer and focuses on medium and heavy lift helicopters. Bell has been the leading provider of light utility and light attack helicopters. All three companies have a commercial base, but Sikorsky and Bell rely heavily on their military rotorcraft industries. The fourth ranked DoD procurement program dealt with the eleven V-22 Ospreys costing $1.2B. Other than the upgrades to the UH/AH-ls and UH/MH-60s, these were the only new rotorcraft in the procurement cycle.[39] In 2004, revenues in the U.S.

military helicopter market were $1.2B for new aircraft and major modifications in 2002 dollars.

In January 2005, Lockheed Martin with AgustaWestland in association with Bell Textron was awarded the Marine One Presidential helicopter contract. This contract is small by aerospace industry standards with Lockheed Martin building only 23 helicopters over a six-year period. Boeing who currently has the largest market share relies on their light, attack and heavy helicopter production. Current models are the OH-58 (light), AH-64 (attack), CH-46 (medium), and CH-47 (heavy) lift helicopters. The modifications to these aircraft, new productions and modifications to the CH-47 and MD-500 are promising prospects for the Boeing helicopter division. Sikorsky produces medium and heavy rotorcraft and has the U.S. industry lead in heavy lift helicopters. Currently the UH-60 is Sikorsky's mainstay with over 2115 sold worldwide with 29 airframes on order for 2005 and an additional 232 during the 2006-2013 timeframe.[40] After the cancellation of the Comanche program and loss of the Marine One program, Sikorsky re-directed its efforts towards operating as an integrator. Sikorsky's lifeblood may be the DoD's new requirement for a new heavy lift helicopter. The CH-53X future heavy lift requirement is budgeted for $100Million in 2005. Ultimately, Sikorsky will rely on upgrading legacy helicopters and count the CH-53X as its only future production model. The key military program for Bell is the V-22 Osprey. Bell is in a joint venture with Boeing on this military tilt-rotor aircraft. The projected procurement is 458 aircraft at $78.1M per airframe.[41] The complexity, cost and safety record are potential challenges to the success of this program. The tilt-rotor program is the only true innovative U.S. helicopter technology on the table. Bell, like the two other U.S. companies, will rely on upgrading legacy airframes with the V-22 as its future project. Overall, the current military helicopter industry is stable and viable at least for the next five years. After 2010, they will compete directly with the European companies for the next generation of rotorcraft.

There are five key challenges to the U.S. domestic and international military helicopter market.

- First is the penetration of the U.S. market by foreign competitors. Several European companies target the U.S. defense industry looking for a way to enter the market. In 2004, EADS scored with a sale of 55 EC-120 light helicopters, to the HLS Department.[42] EADS plans to pursue future challenges in the light, intermediate, and medium helicopter weight categories. These include the U.S. Army's proposed light utility, and armed reconnaissance helicopter programs, along with the Air Force's medium weight Personnel Recovery Vehicle (PRV) program. The Eurocopter NH-90 is a key competitor along with the AgustaWestland EH-101 against the Sikorsky H-92. The strategy of the European companies is to make money in the U.S. defense market by partnering with U.S. companies.
- The second challenge is the U.S. military helicopter reliance on DoD funding. Both Bell and Sikorsky sell 85 percent of their helicopters to military organizations. Their dependence on defense funding makes them vulnerable to defense spending cuts. The U.S. military helicopter market share has continued to decline. The Teal Group projects that Sikorsky will lose more market share in the medium weight class dropping down to 50 percent from 67 percent by 2009.
- The third challenge is with RDT&E. In 2003, RDT&E was only $1.8B with $865.6Million assigned to the RAH-66 program. In 2004, the projected rotorcraft

RDT&E was $2.17B with the majority assigned to the Comanche program.[43] The Army cancelled this program and RDT&E funds were reassigned. The only other helicopter to receive RDT&E funds last year was the V-22. Continuing declines in USG RDT&E funds could put the U.S. military helicopter industry at risk of losing competitive advantage in both market share and technology to the European industry.

- The fourth challenge is to foster continued success for the V-22 and tilt-rotor technology. This is the only area the U.S. helicopter market maintains a substantial lead. The program has returned to the operational evaluation phase after a lengthy delay following two tragic mishaps in 2000. The industry and military are confident the problems identified in the mishaps have been solved. Currently the aircraft has successfully flown all operational evaluations to date.
- The final challenge is for JROC approval of the heavy lift helicopter requirement. The aging U.S. heavy lift helicopters currently in service, the CH-53E and the CH-47 are 25-30 years old and GWOT use demonstrates the critical need for this future capability. The CH-53X is one U.S. produced replacement option for the heavy helicopter category.

Outlook

Overall, Forecast International projects a positive growth rate in the worldwide military helicopter market. From 2003-2013, 3,960 new-build military helicopters will be produced at an estimated value of $73.7B. The U.S. companies must win some of these new contracts to remain viable in the future. In 2004, 318 new helicopters were built, valued at $4.4B, and Forecast International projects that in 2011, 447 new helicopters will be built valued at $9.9B. Modifications will become a major U.S. industry niche. In 2003, 100 airframes were scheduled for modifications. This will rise to 174 airframes annually by 2013. The outlook for the next ten years is positive with all three U.S. companies gaining business domestically and internationally in the retrofitting/modification business. They will need to pick a niche helicopter category and aggressively pursue the necessary RDT&E programs if they are close the gap with the European companies in new rotorcraft production.

Due to the political nature of appropriations, the industry will operate in an uncertain environment. For the next five years, domestic production, export opportunities, and niche capabilities look positive and profitable. The worldwide military helicopter market is healthy, and currently stable. From 2005-2014 the market will open up providing a 15 percent opportunity window. Bell and Sikorsky must pursue these opportunities to remain viable outside of the modification business. After market sales and retrofitting programs are also key for U.S. companies. Joint ventures and risk sharing is the future for these companies, but mergers between them are not likely with the exception of AgustaWestland and Bell Helicopter. The industry will continue to go "lean" increasing efficiency and production.

UAS/UAV

Demand for unmanned aerial systems (UAS) and unmanned aerial vehicles (UAV),[44] both in the U.S. and internationally, is climbing rapidly with the market poised for major expansion in the next ten to fifteen years. Dominated largely by defense-

related procurement, the global market will see several billion dollars in investment over the next decade.[45] Other estimates are slightly less optimistic, but the overall trend is toward heavy market growth.[46] Moreover, the civil market for UAS, leveraging from military successes, is projected to increase dramatically once airspace management issues are resolved and UAVs are integrated into controlled airspace with manned aircraft.[47]

Current Condition/Challenges

Underscoring America's dominance in the worldwide market, a recent industry analysis assessed that "U.S. [expenditures] on UAVs amounted to about 73 percent of total global research and production spending in 2003."[48] The industrial base supports a diversity of applications at home and overseas, from reconnaissance and weapons delivery for military operations, to weather surveillance and environmental monitoring for the scientific community. DoD is largely responsible for the size of the market, but as UAS reliability, safety and technology improve, the potential for civil applications will grow, with that segment of the market is expected to expand significantly by 2020.[49] By a factor of three, spending exceeds the UAS investment made by DoD in the 1990s and is on track to reach the $3B per year level by 2011.

The industrial base is composed of a range of companies from the world's largest defense contractors to small businesses. A total of 49 U.S. manufacturers were active in the market in 2002, producing air vehicles as large as Northrop Grumman's Global Hawk and as small as AeroVironment's Wasp Micro UAV. The U.S. UAS industry is in the midst of a transition wherein larger companies are gradually acquiring smaller producers, and the trend is expected to continue over the next several years.[50] Yet, in spite of this transition and the dominance of major defense and aerospace corporations, smaller companies, particularly suppliers, remain critical and are often sought out by larger firms for specialized expertise, especially in tactical systems.

In 2002, the Deputy Under Secretary of Defense for Industrial Policy assessed the nation's UAS industrial capability to meet current and future defense needs.[51] The assessment found that the U.S. industrial base was fully capable of meeting planned UAS requirements for DoD. Given the similarities of most civil UAS applications, such as border patrol and coastal surveillance, to the military's tactical missions, it's possible that a burgeoning civil demand could compensate for any mid-term (3-5 years) drop in DoD investment.

Outside the U.S., the UAS industry is similarly monopolized by defense contractors, primarily in Europe[52] and Israel, with a number of international alliances emerging to capture market share. According to Teal Group, Inc., the preponderance of European UAS production, however, is aimed at shorter-range, tactical systems, and less at the strategic, longer-range vehicles.[53] The principal manufacturing nations in Europe are France, The Netherlands, and Germany, all of which are angling to become the industry leader on the continent. The United Kingdom, Italy and Russia retain significant UAV manufacturing capabilities although they, like other European developers, compete against U.S. products. Other European countries – notably Poland, Bulgaria, Romania, the Czech Republic, Slovakia, Hungary and Albania – have also produced UASs but little is known about their products or production capabilities and capacities.[54] Egypt, Iran and the United Arab Emirates (UAE) are known to have developed UAS, but the extent of their production capabilities and capacities is likewise relatively unknown. South Africa

leads several indigenous UAS manufacturers on the African continent. Lastly, Japan and Korea have all produced UAS for their internal military markets.[55]

The domestic market for civil and commercial UASs is still embryonic, although the scientific community has used them for a wide range of purposes. Non-military demand for UAS is limited by a number of factors, including national airspace management restrictions, vehicle reliability and safety concerns. Ironically, despite the U.S.'s worldwide leadership in military and intelligence related UAS operations, the UAV National Task Force recently found that America is not the global leader in civil UAV applications. In fact, civil UAS usage in this country is rather minimal compared to some nations (most notably Japan and South Korea), with most U.S. private sector flights conducted in strictly controlled airspace and generally under contract to the federal government.[56] As a consequence, the market for civil or commercial UAS is extremely small when compared to the military's.

The dominant driver of civil UAS applications in the U.S is homeland protection. Following the events of 11 September 2001, the Department of Homeland Security (DHS) initiated an intensive effort to discern UAS utility in securing the nation's borders, ports of entry and critical infrastructure. With growing Congressional support,[57] DHS has launched a number of pilot programs, which proved the utility and relevance of UAS in civil applications and paved the way for more extensive UAV use in the non-defense sector.[58] Other federal agencies, such as the U.S. Forest Service and Secret Service, as well as state and local governments have expressed interest in UAS.

The greatest challenge faced by the UAS sector—both producers and consumers—is the task of safely, reliably, and economically integrating Remotely Operated Aircraft (ROA) into the NAS along with manned aircraft; indeed, it is the principal inhibitor to growth in the civil UAS market. To address these challenges, the Federal Aviation Administration, NASA, DoD, and major industry players have teamed under a program titled Access 5, to develop procedures, regulations, and the technology necessary to enable ROA to operate in the NAS.

UASs are dependent on large amounts of bandwidth within the radio frequency spectrum, which is increasingly in short supply for a military transforming toward a more network-centric force. Moreover, bandwidth limitations will become more acute as UAVs extend their range (requiring over-the-horizon linking through satellite systems), employ bandwidth saturating payloads with electro-optical and radar imagery capabilities, and operate in tandem (multiple air vehicles).[59] With the possibility of a UAS growth in the civil and commercial sectors, bandwidth overload will remain a future hurdle for the industry.

U.S. export policies and political agreements restrict the sale of some American UAS to foreign customers. Although the restrictions have been relaxed to some degree through DoD and State Department actions, the expanding ranges, accuracies, and payloads of U.S. UAVs make them subject to export control.[60] Until export licensing and disclosure/releasability policies are permanently amended, U.S. UAS industry members will find it difficult to compete with foreign firms that aren't similarly encumbered.

A key factor in the integration of civil and commercial UAVs in the NAS will be the public's acceptance of them.[61] There are at least two core aspects to public acceptance: familiarity and privacy. UAVs will be subject to public skepticism,

especially with regard to their safety and reliability. With respect to public privacy, citizens groups are increasingly wary of yet another means by which individuals can be surreptitiously monitored and fear the potential for civil rights violations. UAS expansion into the non-defense sector will pivot on the inevitable public debate over the need for and motives behind UAS proliferation.

Outlook

If industry analyst predictions, the 2005-2035 DoD Roadmap investment estimates, and the UAV National Task Force Final Report are correct, the outlook for the UAS industry is quite rosy. As the UAV National Task Force report indicated, the only certainty about the UAV industry is its continued technological progress.[62]
For defense-related UAS manufacturers, the future is extremely bright, despite the concerns of some that tactical UAS investment will drop as Operations Enduring Freedom and Iraqi Freedom eventually come to a close. The industry is highly optimistic about defense-related growth in the industry, projecting market growth through 2014. Although not as predictable as defense-related growth, civil UAS expansion as anticipated by the UAV National Task Force portends even greater opportunities for the industry, particularly when national airspace management issues are sorted out.

Based on the study's examination of the UAS industry's health and viability, projected growth, level of investment, implications for its base, and challenges to its expansion, the following recommendations are forwarded for federal government consideration:

- Initiate formal review of the U.S. export licensing process to validate or eliminate restrictions unfavorable to the sale of U.S. UAS in the international market.
- Initiate a formal review of the existing Missile Technology Control Regime in order to either validate or eliminate its restrictions on UAS.
- Initiate a formal review by appropriate federal agencies, such as FCC, DoD and FAA, of existing bandwidth in order to facilitate the operation of UAS and UAV.
- Fully fund and accelerate Access 5 project efforts to integrate UAS into the U.S. NAS.

ENGINES

The worldwide jet aircraft gas turbine engine industry continues to operate as an oligopoly. It has two domestic leaders, General Electric's Aircraft Engines (GEAE) and Pratt & Whitney (P&W), as well as two international leaders, Rolls-Royce in the United Kingdom and SNECMA in France. All bring significant competition to the market for both large and small gas turbine engines and turboprop engines. This industry requires significant investment in research and development and long lead development and production, both of which serve as barriers to market entry by others.

Current Condition/Challenges

The jet engine market is dominated by big commercial aircraft manufacturers (mainly Boeing and Airbus) and global airlines.[63] The global jet engine manufacturing industry enjoys sales of $31B. Profits for the main players in 2003 were as follows: GEAE $10.7B, Rolls Royce $7.7B, Pratt & Whitney $7.5B and SNECMA $5.1B.[64] U.S.

aerospace industry sales increased 8 percent in 2004, from $149B to $161B, and profits increased to approximately $10B, the highest level in five years.[65] "Sales of military aircraft, engines, parts, and services increased 15 percent, or $5.9B, in 2004 to $46B."[66] Civil aircraft sector sales, including engines and parts, increased only slightly in 2004. Overall, the aerospace industry improved in 2004 but did not surpass profit margins for the overall manufacturing sector.

The U.S. aerospace industry trade balance is positive. Exports of both engine and aircraft parts increased almost $2B above 2003's $16.8B while exports of complete civil aircraft engines totaled $5.2B, or $800Million greater than in 2003.[67] Imports of whole engines were about the same as in 2003, while aircraft and engine parts imports increased. This resulted in a 2004 trade surplus of $32B in 2004 ($3.8B dollar increase in exports and a $700Million decrease in imports resulting in a $4.6B increase in the trade surplus), the highest trade balance of all industry categories.[68]

Cooperative endeavors are on the rise. "Consolidation and cooperation among military engine makers" has increased due to the following: a decrease in the number of small military platforms with gas turbines, very high development costs, "smaller post Cold-War budgets," and less aircraft required to accomplish the mission due to increased sophistication of those on hand.[69] To make large development costs more manageable, big engine manufacturers are partnering.

With regard to jet aircraft gas turbine engines, significant challenges exist in the areas of spending, competition, investment, fuel efficiency and the environment. The biggest challenge to the aerospace and jet engine industry may well be any cuts to military spending. Another significant challenge is the tendency to limit competition in times of economic stress. The very high cost and technological sophistication of military fighter aircraft today limits the competition of military turbine engine manufacturers. Additionally, a trend toward decreasing customer research and development funds pushed engine manufacturers to invest their own capital for R&D.

A continuing trend is the increase in fuel prices. "Fuel cost as a percentage of cash operating expenses rose from 12 percent to 13 percent, according to data from the Air Transport Association of America."[70] At the same time, fuel efficiency is improving. "Better engines, aerodynamics, and other factors have improved airliner fuel efficiency 60 percent in the past 35 years."[71] Finally, manufacturers must be prepared to address the more stringent environmental regulations in the near future. "By 2050, the carbon-dioxide emissions from airliners are expected to grow two to ten times the 1992 level, thanks to increasing air traffic, according to the Intergovernmental panel on Climate Change report."[72] "Reducing the environmental impact of jet propulsion operation will result in quieter, cleaner aircraft that will be able to operate without curfews and emission penalties around the globe."[73]

Outlook

Two main factors contribute to the positive outlook for engine and engine parts sales: the renewed interest in a strong military following the events of September 11, and the demand associated with an aging fleet in need of modernization and/or replacement.[74] Additionally, new procurements of aircraft will cause new engine buys. A significant contributor to engine sales is re-engining. The military expansion of the roll of UAVs will increase the need for small engines offering this market an additional opportunity.

Production of aviation engines should increase by about 21 percent, from 7,500 to 9,500 powerplants in the next few years but by 2011 the engine market will be in another downward trend.[75] The military market will demand approximately 56,000 turbofan engines worth $175B between 2005 and 2014.[76] Additionally, there's a trend toward outsourcing the maintenance and repair of aerospace operations, especially engines due to their cost and complexity. These contracts protect suppliers by ensuring stability as well as long-term revenue and earnings streams.[77]

The environment for gas turbine engine development and production is changing. The leaders must make a concerted effort to employ leading edge technology while heeding restrictions and price challenges. "The technology focus must be on economical performance, environmental efficiency, reliability, easy-to-service designs, and long service-life, resulting in rapid return on invested capital."[78]

WORKFORCE

Moving into the new century, the U.S. aircraft industry is experiencing the first tremors of a potential crisis concerning its ability to attract and maintain a quality science and engineering (S&E) workforce. Trends associated with changing demographics, the end of the Cold War, new technologies, aerospace industry consolidation, and competition from other high-paying career fields have culminated into a dynamic pointing to a near-term shortage in the S&E availability at the very time when hiring requirements in the aviation industry are accelerating. Despite rising industry wages and other competitive market factors, many people support Government intervention into this burgeoning aviation workforce crisis.

Current Condition/Challenges

Since its peak of 1.3 million workers in 1989, the industry has lost more than 56 percent (751,300) of its workers.[79] The greatest cause of the industry's contraction was the end of the Cold War; the Clinton administration began shifting money out of aviation procurement, research, and development. Aerospace procurement by the military fell nearly 53 percent from 1987 to 2000[80], and DoD reduced its overall investment in RDT&E by nearly 20 percent from 1987-1999.[81] Concurrently, the aerospace industry reduced its investment in industry led R&D by 37 percent from 1986-1999.[82]

As defense dollars evaporated, the industry shifted its emphasis to the commercial aircraft market. Despite the expanding commercial market in the 1990s, the increased foreign competition with Airbus Industries and the growth of Bombardier and Embraer increasingly squeezed an already contracting U.S. industry. According to the European Association of Aerospace Industries, U.S. share of world aerospace markets as measured by annual revenue fell from over 70 percent in the mid-1980s to below 50 percent in 2000.[83]

The industry's consolidation caused the change in the S&E position of the aerospace workforce. In 1979, aerospace employed 20 percent of our nation's research and development scientists and engineers. By 2003, that percentage had dropped to nearly 3 percent.[84] Industry consolidation caused much of the S&E personnel reductions, but software engineering is another important dynamic. Computer Aided Design and Computer Aided Manufacturing (CADCAM) software began entering the marketplace in

the early 1980's, enhancing the productivity of individual engineers. Design changes could take place nearly simultaneously. The affect was a shift in the S&E workforce from an aircraft design engineering led force to a software engineering led force.

Industry consolidation and contraction resulted in an associated aging of the workforce. Consolidating the industry coupled with the parallel contracting of the workforce initially resulted in companies retiring personnel early while concurrently furloughing large numbers of its younger less experienced workers. As the contraction trend continued, further personnel cuts resulted in a near freeze on new hires and continued attrition of older employees. Many of the best and the brightest recognized the trend and migrated to other promising career fields.

The resultant trend was an aging workforce. The portion of workers younger than 35 declined from 32 percent in 1992 to an industry low of 16 percent in 2003.[85] The increased age of the workforce resulted in today's state of the aviation industry workforce where 26-27 percent of the workers will be retirement eligible by 2008.[86] Compounding the near-term need to replace these workers is the hiring stress associated with the recent growth in the aircraft industry workforce following its post 9-11 low point.

Magnifying the crisis created by the aviation industry requirement to replace the retirement eligible workers while allowing for industry expansion is the competing nature of other S&E industries. Since 1980, the U.S. S&E workforce has grown four times faster than the overall U.S. labor force.[87] The National Defense Industrial Association believes the S&E demand will increase over the next ten years with increases of up to 20 percent for aerospace engineers, 35 percent for both computer hardware and software engineers, and 20 percent for electronic and electrical engineers.[88] Additionally, in only 30 U.S. companies, nearly 3,500 Bachelors, Masters, and PhD level S&E personnel requisitions are unfilled.[89]

The growing economies in China and India as well, as the visa difficulties following 9-11, pressure many foreign students to seek employment outside the U.S. Additionally, many foreign-born students do not qualify for the clearances required for national security sensitive aviation industry jobs.

Outlook

Without significant governmental assistance coupled with aviation industry partnership, there is the potential for further erosion in the aviation industry's S&E workforce.

The Commission on the Future of the United States Aerospace Industry proposed three recommendations to Congress and the Administration for approval. These include creation of an interagency workforce to develop an aerospace workforce national strategy, educational reform establishing lifelong learning and infusion of long-term investments in math and science education. Gradual increases in research and development spending will help the industry attract a quality S&E workforce while continuing the U.S.'s competitive advantage in aerospace. The R&D infusion should be gradual to ensure that the problems, associated with both the graying and expansion of the S&E workforce, are not exacerbated. Government needs to consider how it can move education into the 21st century with increased emphasis on the practical side versus theoretical side of education. Finally, industry and Government need to partner on an information campaign to sell the long-term benefits associated with a career in aviation.

Changing the economic outlook will assist the industry through rapid growth in available aviation qualified S&E personnel.

Despite the aviation industry's challenges and Government's need to be an active supporter of long-term R&D and education, it is irresponsible to forget the benefits associated with fair and open markets. The Aircraft Industry needs to be prepared to provide viable and interesting career opportunities for new employees in the aircraft S&E fields. Specialized education programs coupled with quality jobs exploring leading edge technology will improve the industries efforts to lure workers from potentially more lucrative competing fields such as medicine, business, and law.

AIRSPACE MANAGEMENT

The FAA is facing two significant and expensive challenges in the next five years; its essential computers are wearing out and must be replaced, and over half of its air traffic controllers will reach mandatory retirement age. These two issues will be the predominate factors determining whether or not the U.S. air space management system will be able to handle the demands of the future.

Current Condition/Challenges

The current air space management system is a large complex system that includes: air traffic control systems and equipment; more that 18,000 airports and 750 control facilities; the people who operate the system such as controllers and maintenance technicians; the people who use the system such as pilots, airlines and the flying public; about 45,000 pieces of equipment and many detailed procedures and levels of certification. As the economy has improved, the demand for aviation services has expanded and capacity constraints have again become a significant problem. U.S. scheduled airlines are expected to carry 50 million more passengers this year than last year and traffic is expected to reach or exceed the pre 9/11 levels within the next two years. Within ten years, U.S. commercial carriers are expected to transport nearly 1.1 billion passengers - compared to 650 million in 2003. These are some of the many reasons we need to rebuild an air space management system for the 21st century with efficiency and capacity needed to meet the growing demands.[90]

The plan to modernize the computers used by the air traffic offices to handle planes at low altitudes has run into major problems. The original plan was for a Standard Terminal Automation Replacement System, or Stars, that would cost $940Million and use equipment that was already commercially available. System modifications, cost overruns and scheduling delays are causing the FAA to question its suitability and functionality.

Another major problem is a result of the air traffic controllers' (ATC) strike of 1980. President Reagan responded by firing thousands of controllers, and the FAA replaced them with young employees. These ATCs form a bulge in the demographic profile of FAA employees, and most of them will be eligible to retire in the next few years, partly because many of them were hurriedly hired from the military and can count their time in the service toward the years required before retirement. By late in this decade about half will be required to retire at age 56, under current rules. Marion C. Blakey, the FAA administrator, said in a briefing last November that she was hopeful that

the budget for the next fiscal year, which will be announced in the late winter, would have some money for training. This year, Ms. Blakey said her agency hired only a handful of controllers.[91]

Yet another challenge facing the industry is that the skilled software and information technology people needed for aerospace and ATC modernization are also in high demand by the entertainment and video game sector, as well as for homeland security. The implication is that if they leave aerospace, they probably won't come back.

Outlook

In the U.S., an automated controller aid is showing clear benefits for improving traffic flow into airports. Five U.S. sites have added time-based metering to their Traffic Management Advisor aid, which controllers use to sequence the flow of aircraft arriving from high-altitude airways into terminal areas. With time-based metering, an aircraft is scheduled to pass certain fixes at precise times, as well as on specified headings, altitudes and airspeed. Time-based metering produces more consistent traffic flow and reduces the times aircraft need to be placed in holding patterns. Safety is also enhanced, but the big winner is airspace capacity, which at LAX increased by about 5 percent, under instrument conditions. Not all projects proceed smoothly, but success is finally on the horizon for the Advanced Technology and Oceanic Procedures (ATOP) program, set to become operational at Oakland, Calif., Anchorage and New York Centers this year. The Flight Information Regions controlled by those centers affect nearly 80 percent of the world's oceanic controlled airspace. The FAA has been under considerable pressure for years from governments and air carriers in the Pacific who purchased ATOP equipment in the mid-1990s. Since the U.S. did not live up to promised schedules for implementing Automatic Dependent Surveillance and Controller-to-Pilot Data Link Communications, these Pacific governments could not reap the obvious benefits.

To address the current issues and future challenges, the FAA has developed an Operational Evolution Plan (OEP). The objective of the OEP is to add capacity enhancements that will accommodate an approximate 30 percent increase in demand over a ten-year period while enhancing safety and security. OEP specifically addresses air transportation services delivered to FAA customers. It reflects collaboration with the aviation, airports, manufacturers, DoD, the National Weather Service, and the National Aeronautics and Space Administration. The full plan includes solution sets that describe program management approaches and timelines for solving specific capacity issues, along with the names of FAA executives accountable for each issue. This plan is a good step towards providing the U.S. with the best possible management of our nation's air traffic management system.

GOVERNMENT: ROLE AND GOALS

Role

The government plays a key role in several elements of the industry, three of which we will discuss here.

First, the federal government is a major <u>consumer</u> of aerospace products -- military and parapublic use. In 2004, the value of U.S. aerospace products and services sold was $160B.[92] The USG was the consumer of more than two-thirds of this, spending

$46B on the procurement of military aircraft products and services alone, and another $52.5B on Space and Missile development. As the sole U.S customer of military aerospace products, the USG has a vested interest in ensuring the health of the industry. USG is active in various aspects of the industry, as a consumer, and as the authoritative regulator of activity such as technology transfer. It also regulates other aspects of the industry with varying levels of interest. It has greatly affected product manufacture location through the "Buy America" Act. The USG gets involved in aspects of market competitiveness through approval or denial of mergers and acquisitions. It guides future aircraft development by administering research and development funding. It is not the sole director of aerospace research and development, however. USG RDT&E funding has declined, particularly in relation to commercial research and development funding, over the last few decades. In 2002, the USG spent $4.3B on RDT&E, while private industry spent $5.35B.[93]

Second, the government plays a major role as an arbitrator and regulator of the commercial market. Aerospace accounts for 1.5 percent of the U.S. GDP, and is an export industry, contributing a net of $30B per year to the U.S. export balance sheet. Industry is highly subject to regulation, restriction and subsidy, both in the U.S. and abroad. The USG gets involved in merger and acquisition requests, as well as in company disputes which cross national borders.

Finally, the USG plays a major role as the regulator of aircraft operations, directing safety and security measures and practices, and as the controller of the U.S. airspace and air traffic control system. USG safety and security regulation causes aircraft manufacturers and airlines to offer and consume products and services they might not consume if market forces alone were at work. Examples include reinforced cockpit doors, ground proximity and air traffic proximity warning systems, and passenger screening.

Goals

We believe the USG should play a more active role in the aircraft development and manufacture industry, encouraging its long term health and vibrancy by:

- Increasing the size and quality of the U.S science and engineering (S&E) workforce through scholarships, RDT&E funding, and RDT&E project starts
- Transforming the air traffic control system to accommodate increased volume, and to work through UAS/UAV procedures
- Increase global competitiveness of U.S companies by conducting a major inter-governmental agency review of export policies, ITAR, and the Missile Technology Control regime.

ESSAYS ON MAJOR ISSUES

The AIS Seminar conducted additional research in several special interest areas including the following: Reducing DoD Aircraft Repair Parts and Consumable Inventories, U.S. Government Aerospace Acquisition Funding, Russian and Chinese Helicopter Manufacturing Outlook and the Civil Reserve Air Fleet (CRAF). Synopses of these efforts follow and highlight the diversity of challenges in the industry.

Analysis of Reducing Repair Parts and Consumable Inventories for the Defense Logistics Agency, Defense Supply Center Richmond
(COL Jerry D. Whitley, USAF and CDR Michael L. Taylor, SC, USN. CAPT Stephen Morris, SC, USN, Faculty Advisor)

The AIS conducted research to high-light current practices and future proposals to reduce aircraft initial and follow-on investment in repair parts and consumables in the manufacturing and repair of aircraft and aircraft engines. The research focused on efforts, initiatives, and programs of a sampling of DoD prime contractors, Original Equipment Manufacturers (OEMs), second and third tier suppliers, Maintenance/Repair Organizations (MROs) and similar domestic and foreign commercial entities. These industry findings were summarized so that they may enhance DLA's future transformational efforts.

Analysis of Acquisition Funding Since 1980 for Headquarters USAF Strategic Planning Directorate, Pentagon, Washington D.C.
(Lt Col Mike Brewer, USAF and Lt Col Marilyn Kott, USAF. Col Tedd Ogren, USAF, Faculty Advisor.)

The AIS analyzed government aerospace acquisition funding (procurement and R&D) to identify correlations between government spending and industry structure and performance. Funding profiles were evaluated to determine the effects on aerospace industry health, profits, employment, costs, and industrial base. The reduction in government acquisition funding has resulted in aerospace industrial consolidation, reduced aircraft production, and higher unit costs. Another affect has been a shift from aircraft production to services, systems integration and non-aerospace businesses.

Analysis of Russian and Chinese Helicopter Manufacturing
(LTC Noureddine Baiche, Algerian Air Force)

Although, the Russian military rotor wing aircraft industry has faced many economic and political challenges, signs point to its future success. Thousands of Russian helicopters remain in service, and Russian firms continue to build products for their export markets. Questions will remain regarding their long-term survival in a market dominated by Europe and the U.S. Although maintenance and operations remain viable in the near term, a complete overhaul of the existing Russian helicopter fleet is required to guarantee long-term success.

China has more than 30 years experience working with western companies. China has made slow but steady progress in the civilian and military rotor craft market. China's economic transformation guarantees they are a future helicopters market. One might argue that China's increasing demand will lead the world growth in rotorcraft requirements.

Analysis of the Civil Reserve Air Fleet (CRAF)
(Col Na-Res Sungwanna, Thailand Air Force)

CRAF augmentation of military airlift will remain an essential resource for U.S. national security, but there is concern that the program may not be sustainable in the face of likely developments in the aviation industry and in the global security environment. Several challenges, including restructuring of the aircraft industry, new logistical

approaches, the number of participants, and safety, need to be overcome in the near future to ensure the survivability and success of the CRAF.

CONCLUSION

Throughout this study, we have identified a number of issues regarding the strengths and weaknesses of the U.S. aircraft industrial base. Despite the problems identified, the industrial capability of the U.S. remains strong, and the industry remains capable of meeting the strategic needs of the U.S.

The workforce crisis and the rotorcraft technology gap are the two areas most in need of improvement, and both would stand to gain from a steady influx of R&D expenditures. Government funded research and development is encouraged and should be leveled for predictability. Steady, long-term R&D funding will help the industry face the hiring crises we are likely to see for the S&E workforce as it begins to retire in the next ten years.

The UAS/UAV market is likely to accelerate in the next ten years. The U.S. remains at the forefront of this market segment. Continued government investment in this burgeoning segment will ensure our continued overall technology lead in the industry.

In the highly competitive commercial market, the manufacturers are pulling out of the 9/11 slump and the future looks competitive, but bright, for the U.S. We believe Boeing has the right solution for the future. Reducing the reliance on hub and spoke is essential for managing the projected increasing demand in air travel over the next ten years.

Finally, the U.S. must make a concerted effort to bring airspace management into the 21st century. We have the capability today to incorporate aircraft into the knowledge management loop and to reduce the reliance on manned air traffic controllers. Continued investment in this area is necessary to bring new UAS/UAV technologies into the airspace system.

ENDNOTES

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[44] For purposes of this study, the authors employed DoD's preferred term "unmanned aerial system" or "UAS" by and large, instead of the more familiar UAV. Although a multitude of terms and acronyms have been and remain in use, "UAS" more accurately describes the collection of subsystems and components required to launch, operate, and recover an air vehicle. DoD also points out that, while "Unmanned Aerial Vehicle (UAV)" is a universally recognized term that encompasses a spectrum of aircraft that are autonomous, semi-autonomous, or remotely operated, the Federal Aviation Administration has historically used the term "Remotely Operated Aircraft (ROA)" for matters dealing with airspace. The term 'UAV' is used on occasion, but only in the context of air vehicles alone without reference to control and support systems, and in sections that deal with airspace the term 'ROA' is used. Additionally, unless specified otherwise, the study focuses only on UAVs and UASs used in reconnaissance and air combat roles. It does not address target or decoy drones, ballistic or semi-ballistic vehicles, cruise missiles, and artillery projectiles, which are occasionally categorized as UAVs by some industry analysts.

[45] "Analysis 1 – The Market for UAV Reconnaissance Systems through 2013," Dickerson, Larry, Unmanned Vehicles Forecast, pp. 2-4, Forecast International, Newton, CT. October 2004.

[46] "Unmanned Aerial Vehicles Market Overview," Zaloga, Steven J., World Missiles Briefing, Teal Group Corporation, p.1-3, January 2005. As noted in Teal Group Inc.'s forecast, air vehicle costs represent as little as 15 percent of the total costs of some UAS. The addition of ground control systems, payloads, R&D and other related costs will significantly increase the total cost of the UAS.

[47] Ibid., p. 9.

[48] "Unmanned Aerial Vehicles Market Overview," p. 5.

[49] "Prospective Unmanned Aerial Vehicle Operations in the Future National Airspace System," DeGarmo, Matthew and Nelson, Gregory M., American Institute of Aeronautics and Astronautics, Mitre Corporation, McLean, VA, 2004, p. 1.
[50] "The Impact of Unmanned Aerial Vehicles on the Next Generation Air Transport System," Final Report prepared by the Unmanned Aerial Vehicle (UAV) National Task Force (UNTF), 22 October 2004.
[51] Office of Deputy Under Secretary of Defense for Industrial Policy Briefing, Unmanned Aerial Vehicle Industrial Capability Assessment, 30 May 2002.
[52] According to Teal Group, Inc., Europe is expected to increase its share of the global UAV market by a factor of two within ten years. "Unmanned Aerial Vehicles Market Overview," p. 6
[53] Ibid., p 6-7.
[54] "Analysis 1 – The Market for UAV Reconnaissance Systems through 2013," p. 12-13.
[55] Ibid., p. 13-14.
[56] "The Impact of Unmanned Aerial Vehicles on the Next Generation Air Transport System," p. 7
[57] See "Homeland Security: Unmanned Aerial Vehicles and Border Surveillance," Bolkcom, Christopher CRS Report for Congress, Congressional Research Service, Library of Congress, Washington, DC, 7 Feb 2005 for a summary of UAS-related appropriations.
[58] Draft Department of Homeland Security Unmanned Aviation Systems (UAS) Roadmap, p. 1, courtesy of Mr. Paul Polski, Director, Aviation Joint Programs, Department of Homeland Security. 25 Apr 2005.
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