

AY 2004

## Industry Study Paper

# The Aircraft Industry

### Seminar 2 Aircraft Industry Study



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

# AIRCRAFT

## ABSTRACT

The aircraft industry now appears to have weathered the "perfect storm" of Severe Acute Respiratory Syndrome (SARS) and the Global War on Terrorism (GWOT), emerging somewhat battered but poised to begin a slow recovery in the coming years. Orders for new aircraft are up and thus revenues and profits should begin to climb in 2005, reversing declining trends since 2001. However, airlines remain under intense pressure to cut costs in order to remain profitable, forcing aircraft and engine manufacturers to adopt austere measures. Meanwhile, defense expenditures have received a boost from heightened security concerns and developing technologies such as unmanned air vehicles (UAVs) and unmanned combat air vehicles (UCAVs). The defense market will also continue to enjoy expansion as a result. The overall outlook for the aircraft industry now appears to indicate steady growth over the next decade and should provide sufficient demand for both Airbus' A380 and Boeing's 7E7, as well as the growing Regional Jet (RJ) market, albeit in an atmosphere of intense competition. However, security remains a top concern, as another terrorist attack on or involving passenger aircraft would have devastating long-term effects on the entire industry.

Col Sheron L. Bellizan, USAF  
LTC Thomas H. Bryant, USA  
Lt Col Brian D. Buell, USAF  
Brigadier General Settimo Caputo, Italian Air Force  
CAPT Devon G. Goldsmith, USN  
CDR Stephen A. Kozak, NOAA  
CDR Gregory L. Looney, USN  
Mr. David Mabee, Defense Contract Management Agency  
LTC Andrii V. Minaiev, Ukrainian Air Force  
Mr. Rick L. O'Neil, Dept. of Navy  
Mr. Jean-Michel Orozco, European Aeronautic Defence and Space (EADS)  
Company  
CDR Thomas J. Payne, USN  
Ms. Mary C. Puckett, Dept. of Air Force  
COL Jorge L. Silveira, USA  
Lt Col Robert L. Stine Jr., USAF  
Lt Col Ricky T. Valentine, USAF  
  
CAPT Stephen H. Morris, USN, Faculty Leader  
COL Dominic Archibald, USA, Faculty  
Dr. Gerry C. Berg, Ph.D., Faculty  
Col Edwin McDermott, USAF, Faculty  
Col Carl D. Rehberg, Ph.D., USAFR, Faculty

## **PLACES VISITED:**

### **Domestic:**

Aerospace Industries Association, Washington, DC  
Lockheed Martin Corporation Fighter Demonstration Center, Arlington, VA  
Sikorsky Aircraft Corporation, Stratford, CT  
Pratt & Whitney Aircraft Engines, Middletown, CT  
Pratt & Whitney Canada Corporation, Longueuil, Quebec, Canada  
Bombardier Aerospace, Regional Jets RJ 700/900 Facility, Dorval, Quebec, Canada  
Lockheed Martin Aeronautics Company Headquarters, Fort Worth, TX  
Shultz Steel Company, South Gate, CA  
Boeing Integrated Defense Systems Division, C-17 Production Facility, Long Beach, CA  
General Atomics Aeronautical Systems, Inc., Gray Butte Flt Ops Facility, Palmdale, CA  
Northrop Grumman Integrated Systems, Palmdale, CA  
Boeing Commercial Airplanes Division, Seattle, WA

### **International:**

Alenia Aeronautica Headquarters, Turin, Italy  
EADS Aeronautics Eurocopter Division, Marignane, France  
EADS Airbus Division, Toulouse, France  
Socete Nationale d'Etude et de Construction de Moteurs d'Aviation (SNECMA)  
Moteurs, Villaroche Plant, Salle Viercy, France  
EADS Corporate Research Center, Suresnes, France  
AgustaWestland, Yeovil, United Kingdom  
BAE/Thales Future Aircraft Carrier (CVF) Facility, Bristol, United Kingdom  
Rolls-Royce, Civil Aerospace & Defence Aerospace Divisions, Derby, United Kingdom  
BAE Systems Corporate Offices, London, United Kingdom

### **BRIEFINGS**

Aerosystems 101 – An Overview of the Aircraft Industry  
United States (US) Department of Commerce – US Aerospace Industry Overview from a Trade Perspective  
Teal Group – World Aviation Market Outlook  
View from the Fourth Estate: Aviation Week & Science Technology and Flight International  
V-22 System Program Director – Program Overview  
BAE Systems North America – Company Overview  
United Kingdom Ministry of Defence – Organisation, Requirements Generation, and Aircraft Programmes  
Office of the US Secretary of Defense (OSD) for Industrial Policy – Non-Fixed Wing Industrial Base

## **INTRODUCTION**

Despite the turbulence caused by 9/11, SARS, and the Department of Defense's (DoD's) transformation, the aircraft industry appears to have weathered the worst of the storm. Airline industry profits are expected to rebound this year driven by improving global economies and massive restructuring. Aircraft manufacturers are, in turn, seeing an increase in orders. The defense aircraft industry continues to see modest hikes in military spending and is expected to continue to grow.

However, the companies who stand to gain the most from the resurgence may be a surprise to industry watchers. Increased international competition shows the traditional leaders waning – for example, in 2003, Airbus delivered more commercial sales than Boeing. The RJ market has become more lucrative as airlines recognize the increased profits to be achieved by the more efficient RJs. And, the industry has also looked to technology – from materials, to improved manufacturing efficiencies – to increase productivity, quality, and profits.

Market segmentation continues to evolve in the industry at a remarkable pace as companies vie for their particular niche in the marketplace. From the commercial perspective, it comes down to RJs, the Airbus A380 Cruise Air Ship, or the Boeing 7E7 Dreamliner. And, in the defense arena, companies look at the transformation initiatives and what they can offer: F/A-22, UAVs, or Future Combat Systems.

Change is the one thing onlookers can be certain of in this industry. Will there be a long-term change in the industry and its players? Will the signs of upturn continue? Can the market ever reach its golden days prior to 9/11? In this report, we will start by defining the industry, look at its sectors, and in the process, answer these key questions.

## **THE INDUSTRY DEFINED**

This report focuses on four sectors of the aircraft industry: commercial fixed wing; military fixed wing; rotorcraft (helicopters and tiltrotor aircraft); and aircraft jet engines. Key players in the individual sectors will be highlighted in the respective section of the report. Special focus segments have also been included on RJs and UAVs.

## **COMMERCIAL FIXED WING AIRCRAFT**

For purposes of this discussion, commercial fixed-wing aircraft will include medium and large passenger and cargo aircraft with greater than 100 passenger capacity. This by no means diminishes the impact RJ aircraft have made and will continue to make in the jetliner market. To the contrary, this recognizes the fact the regional aircraft market is so significant that it requires dedicated discussion later in this report.

### **Current Condition**

The global commercial fixed-wing aircraft industry and airline industry have endured the most turbulent time of their 70-year history. Terrorism, war, sputtering global economies, weak financials, spiking oil prices, and SARS have created what analysts have termed a “perfect storm” of negative influences on both of these industries.<sup>1</sup> The resultant severe drop in air travel has caused a significant drop in commercial aircraft orders and projected profits. The domestic and international airline industry continues to evolve as low cost, discount carriers continue to expand their route networks and market share forcing major (legacy) high cost/full service airlines to reorganize both their line operations and

infrastructure. The top 10 major airlines suffered their third consecutive year of large losses in 2003, a combined \$3.7 billion.<sup>ii</sup> Estimated losses of the top ten airlines totaled \$11.3 billion in 2002 on revenues of \$80.8 billion, following a \$7.6 billion loss in 2001 on revenues of \$87.2 billion.<sup>iii</sup> However, the six largest low cost/discount airlines; Southwest, America West, Frontier, Jet Blue, Air Tran, and ATA continue to expand their route structures, take delivery of new aircraft, and remain profitable. The low cost/discount carriers now account for 25% of the domestic airline market. Straddled with high cost labor contracts and infrastructure costs, the major legacy airlines continue to restructure to achieve lower operating costs. United Airlines is operating in bankruptcy; US Air has emerged from bankruptcy, but struggles to regain profitability; and Delta Airlines indicates it may seek bankruptcy if it cannot get its unions to accept wage and benefit reductions. Industry analysts are cautiously optimistic that the worst days are behind the airline industry due to cost-cutting efforts, federal grants and slight improvements in consumer demand.<sup>iv</sup> However, not all analysts share this optimism. There is a nagging question, or more correctly an intimidating observation, that the historical correlation between growth in Gross Domestic Product (GDP) and increased commercial travel has been broken over the past two years.<sup>v</sup> This possible de-linkage in travel demand with the recently improving world economy may not bode well for commercial aircraft makers.

Airline difficulties and lack of profits primarily drive the lack of demand for commercial aircraft. The sales and earnings of the Boeing Company and Airbus S.A.S., the remaining manufacturers of large and medium aircraft, remain inextricably tied to the fortunes of the airline industry.<sup>vi</sup> The freefall in orders and delivery deferrals caused the companies combined revenues to decline 22% in the first half of 2003, their combined operating profits dropped some 62%.<sup>vii</sup> The precipitous decline in airline aircraft orders has hit Boeing harder than Airbus, given that 70% of Boeing's passenger jet revenues versus 50% for Airbus come from the harder hit US airline market.<sup>viii</sup>

The competition between Boeing and Airbus determines the development of the world commercial fixed-wing aircraft industry. Airbus has outpaced Boeing in commercial jet orders three of the last four years. In 2003, for the first time, Airbus delivered more jets than Boeing, an expected albeit historic changing of the guard in the industry. Airbus delivered 305 aircraft in 2003 up from 303 in 2002, exceeding Boeing's 2003 total of 281 deliveries down from 381 in 2002. This represents the second consecutive year of decline in large aircraft production, with deliveries falling 14% from the 2002 total of 684 wide-body aircraft.<sup>ix</sup> Airbus also surpassed Boeing in terms of new orders, achieving 284 firm orders last year versus 240 for the US manufacturer. The latest available data on total order backlog shows Airbus controlling 55% of the large passenger aircraft market; however, Boeing's revenues in this market remained 70% higher than Airbus in 2002.<sup>x</sup> Backlog numbers in today's environment are controversial, given the pressures and open opportunities to defer and cancel orders in these tenuous times. In 2004, Airbus will again deliver more commercial aircraft than Boeing. Boeing's expectations are for deliveries in the range of 275-290 aircraft for 2004.<sup>xi</sup> Although Boeing's commercial aircraft revenues were higher than Airbus' in 2003, this advantage is narrowing as current Airbus orders translate into deliveries.<sup>xii</sup>

The air cargo segment of the global airline industry generally fared better than the passenger market since 2001. Air cargo traffic declined only 7-10% in 2001 and is now

showing a significant rebound. On a global basis, 2003 produced a modest 3% increase in freight traffic over mediocre results in 2002.<sup>xiii</sup>

## **Challenges**

Lack of robust airline industry new aircraft orders is not the only challenge faced by Boeing and AIRBUS. The current weak US dollar is putting pressure on AIRBUS profits and both Boeing and AIRBUS are spending billions of dollars in capital outlays to develop new generation wide body large aircraft while RJ manufacturers are beginning to introduce and develop new aircraft that compete with the smaller, single aisle Boeing/AIRBUS jets (Boeing 717, 737-300; AIRBUS 318). Noel Forgeard, Airbus chief executive officer (CEO), has warned this will be a “very, very tough year” due to the downturn in orders and production, and the weakness of the dollar against the Euro.<sup>xiv</sup> The company expects around 250 new orders and 300 deliveries in 2004.<sup>xv</sup> The weakness of the dollar is no small matter for Airbus as their deliveries shrink, given that investment on their 555-seat A380 superjumbo airliner peaks this year.<sup>xvi</sup> The A380, currently scheduled to enter service in 2006, will provide the profit margins and volume the company is counting on to counter the weak dollar according to Airbus officials.<sup>xvii</sup> Boeing, by strategic design, does not intend to answer the A380 with a new aircraft start. Boeing market analysis has led the company to the mid-sized 7E7 Dreamliner (2008 introduction), a 200 to 250-seat replacement for the aging 757 and 767 fleets. This strategic decision will be discussed further later. Additionally, Boeing postulates upgrades leveraged from 7E7 technologies for the venerable 747 as a compromise counter to the A380.

The competition between Boeing and Airbus has led to questionable sales practices bordering on financial suicide at times. In the past 10 years, airlines have gained enormous pricing advantage, forcing discounts up to 40% off the list price. Boeing has stated a commitment to realistic pricing, i.e. above costs. This reality, combined with the current and the potential future influence of RJ manufacturers, creates another significant challenge for Boeing and Airbus. Not unlike the larger aircraft markets, the RJ sector’s near term outlook remains mixed with modest growth expected in 2003.<sup>xviii</sup> However, US airline subsidiaries are replacing some of their 100+ seat aircraft with smaller RJs.<sup>xix</sup> Industry analysts believe RJs are a necessary part of any airline recovery plan, and Airbus and Boeing’s 100-seat pricing and sales terms are not competitive.<sup>xx</sup> RJ makers see an opportunity in the 110 to 120-seat range that could further erode Boeing and Airbus market share.<sup>xxi</sup> Embraer came to this conclusion earlier and is already producing a 108-seat RJ.

There are more challenges. The slowdown seen in business travel, security costs, and the sizeable and appealing used aircraft market continue to burden Boeing and Airbus. Boeing also faces internal challenges -- labor costs and an aging workforce will continue to test its profitability in the out years.<sup>xxii</sup> The Society of Professional Engineering Employees in Aerospace recently claimed that Boeing is losing its technical advantage, failing to invest enough in research and development (R&D) and not developing the next generation of skilled engineers and technicians.<sup>xxiii</sup> The lack of R&D investment is perhaps Boeing’s most significant challenge.

## Outlook

By way of understatement, there are many differences between Boeing and Airbus. Perhaps none more pronounced than how they see the jetliner market evolving over the next two decades. Hub-to-hub dominates Airbus' thinking, while Boeing looks to the point-to-point model. Who is right? Perhaps both. Boeing displayed their commitment to their prediction with their December 2003 decision to commit to the 7E7 Dreamliner production. Their underlying analysis indicates strong middle-of-the-market (200-250 seat aircraft) due to customer demand for frequent, nonstop service to their ultimate destinations.<sup>xxiv</sup> In fact, at the time they released their Market Outlook, they had not finalized the final configuration of the aircraft. Boeing predicts that over the next twenty years world economies will grow at 3.2% and passenger traffic at 5.1%.<sup>xxv</sup> The more critical analysis, that which led them to the 7E7, is RJs will increase from 11% to 16% of the world fleet, intermediate-size jetliners increasing from 18% to 22% (read 7E7), and large aircraft (read 747 & A380) decreasing from 7% to 4%.<sup>xxvi</sup> With more specificity, Boeing predicts needed deliveries of intermediate-size jets to double to a range of 4,753.<sup>xxvii</sup> In contrast, they see the 747 or bigger aircraft growing by only one third, equating to 889 deliveries in the same twenty-year period.<sup>xxviii</sup> One final Boeing prediction: the market in the Asia/Pacific region should outpace the rest of the world.<sup>xxix</sup> Boeing believes itself well positioned in this market, particularly in Japan and China where they have strong, time-tested relationships.<sup>xxx</sup> Finally, Boeing sees increased profitability and orders beginning in the second half of 2005.<sup>xxxi</sup> Scheduled deliveries of 737 and 777 aircraft are critical not only to current profitability, but also as cash necessary for investment in their future – the 7E7.<sup>xxxii</sup> Given the strategic importance of the 7E7 for Boeing, a brief description of the program follows.

The basic/stretch versions accommodate 200-250 passengers with ranges to 8000 miles; there are also plans for a shorter-range version (3,500 nautical miles) with a 300-seat capacity. Through more efficient engines (8-10%); computer designed streamlining -- minimizing drag (3-4%); innovative wing design plus engines made of lighter materials (3-4%); and more efficient onboard systems (3-4%); Boeing plans to provide a state of the art jetliner that provides 15 to 20% better efficiency over legacy aircraft.<sup>xxxiii</sup>

The Airbus forecast is quite similar in terms of GDP and passenger growth predictions and total projected deliveries across the spectrum of commercial aircraft. However, Airbus' Global Market Forecast 2003-2022 displays the significant divergence from Boeing's projections and defines their strategic direction by predicting a need for 1,535 large aircraft versus 889 from Boeing's forecast, with a heavier emphasis on the freighter market. Interestingly, Airbus predictions for the small twin aisle (250 seat) plus the intermediate twin aisle (300-400 seat) market needs (4,744 aircraft) roughly equal Boeing's prediction of 4,753 in the intermediate size. Boeing obviously combined the small and intermediate twin-aisle numbers in their forecast.

It seems the jetliner market will continue in a state of parity in the near term, see further market segmentation between the two giants and the RJ makers, and experience modest long-term growth. Most aircraft industry watchers expect renewed demand in 2004 and increased deliveries in 2006. The view of the Airbus A380 versus Boeing 7E7 debate is it could broaden Boeing's eroding market share advantage.<sup>xxxiv</sup> However, there are serious market questions with Airbus' A380 business model and questions on Boeing's promises of efficiency improvements in the reported 7E7 technologies.<sup>xxxv</sup>

## **SPECIAL FOCUS: REGIONAL JETS**

Despite the continued slow growth and poorer than expected performance industry-wide, the RJ market is poised to have a more positive 2004 in terms of revenue, emplanements, and profits than the rest of the commercial industry. In addition, the RJ industry is experiencing positive growth, as represented by increasing orders and possible new entrants into the market. For the purposes of this report, we primarily define the RJ segment as twinjet powered, low-wing aircraft that carry 30 to 110 passengers.

### **Current Condition**

Like many sectors of the airline industry, the regional airlines have expanded greatly since the deregulatory legislation of 1978. However, it has only been since the RJ's introduction into the regional airline industry that regional airlines have exploded in their coverage and their size. For instance, in 1997, only 89 RJs were in service, as compared to over 1,000 today.<sup>xxxvi</sup> This dramatic increase in RJ usage has resulted in a 735% increase in RJ departures, a 300% increase in RJ trip lengths, and a 300% increase in seats available in their first three years of usage.<sup>xxxvii</sup> While these statistics are impressive, the following figures demonstrate the significant impact RJs have had on the industry. Between March 2000 and March 2004, the US Airline industries' seat capacity indicated RJs experienced a 236% growth in RJ seating capacity while the major airlines' "narrow body" fleets decreased by 10% in the same timeframe.<sup>xxxviii</sup> Today, the RJ fleets make up over 44% of the airlines' fleets, with several hundred aircraft delivered in 2003 and 2004 and over a thousand on backorder.<sup>xxxix</sup> Clearly, these statistics are impressive as indications of the RJ's importance to the present period of regional airline growth and the overall robust health of the RJ industry.

In addition to strong current sales, there have been many new developments with possible new manufacturers in the RJ industry in 2003. Some of the most interesting developments pertain to recognition by China and Russia that, despite significant risks involved, there is enough growth potential in the RJ industry to introduce new models.

With the advances in RJ technology making these aircraft more economically feasible over longer routes, the estimates for internal Chinese RJ usage number about 2,400.<sup>xl</sup> To fulfill this requirement, the Chinese government is seeking to develop an RJ and has stated that their project is their most important civil aircraft program.<sup>xli</sup> This RJ, called the ARJ21, is supposed to enter service in 2008 and is using imported, proven Western systems to ensure success and demonstrate their seriousness in this effort.<sup>xlii</sup> While the potential for this aircraft is high, it remains to be seen if world market economics can actually support another RJ entrant and if the Chinese aerospace industry can, in contrast to recent history, complete this project and bring it to market.

Similar to the ARJ-21 effort in China, the Russian and Ukrainian RJ programs are being designed for export, but it is really believed these entrants will be mostly for internal consumption. Two of the firms, one Russian and one Ukrainian, are pursuing an RJ developmental program that heavily leverages US or European technologies in order to produce an aircraft that is considered more exportable. The aircraft receiving the most press is the Sukhoi entry that has completed preliminary design and cost work, partnered with Boeing Commercial Aircraft, and is being compared to the Embraer 170.<sup>xliii</sup> The Ukrainian Antonov 148 (scheduled to deliver under an aggressive schedule in 2005) and

TU-334 are other entrants. While all three of these aircraft claim to be exportable and had important milestones in 2003, the current industry economics don't point to their successful entry into the market outside of limited Russian use.

**The Economics of Regional Jets.** The economics pertaining to the RJ industry are based on the missions they can perform more cheaply and with a higher frequency than either commercial narrow-body jets or turbo-propeller driven aircraft. These missions include turboprop replacement; mainline jet replacement (such as DC-9s and B-737s); hub building by adding spokes that turboprops can't reach and markets that are too small for mainline jets; hub creation through the reduction of the market population thresholds; and hub bypassing on point-to-point routes.<sup>xliv</sup> In all these missions, it is the RJ's ability to create marginal revenues exceeding marginal costs and create passenger appeal that makes them valuable. However, the lower RJ trip costs and comparable costs per available seat mile results in lower "break even" passenger totals over a 500-mile trip.<sup>xlv</sup> Also, the new, larger RJs are expanding to 2000 miles. This change is significant because it means an RJ can service a typical 500-mile to 2000-mile segment that turboprops can't reach and that mainline jets can't fly economically. Therefore, the RJs can haul fewer passengers at lower cost and be more profitable over these distances.

**The Two Survivors: Bombardier and Embraer.** With the rosy RJ economic data and the equally positive sales trends through 2020, one would think the market is wide open to entry by many competitors. However, almost all industry experts agree that 400 to 500 RJ sales per year, worth nearly \$6 billion, will only sustain two long-term RJ manufacturers over the next decade.<sup>xlvi</sup> These estimates are based on the low profit margin associated with the normal sale price of sophisticated RJs, rigorous competition, and the excess capacity in the sector. The airlines, concerned about a monopoly, will order from the two remaining companies.<sup>xlvii</sup> The two predicted RJ competition winners are Bombardier and Embraer, who hold 51% and 32% of the market today.<sup>xlviii</sup>

**Embraer.** Chasing on the heels of Bombardier is their largest and most innovative competitor, Embraer. As the challenger in the industry, Embraer has resorted to a riskier market strategy. They have focused on completely new, larger, and heterogeneous designs (when compared to Bombardier) to secure increased market share. The strategy seems to be working. For its new 170 to 190 series RJ aircraft, Embraer has not only secured typical orders from the regional, code sharing partners of major airlines such as US Airways and Air Canada, but has received orders for its 100+ seat version from JetBlue, a leading Low Cost carrier.<sup>xlix</sup> By buying 100 Embraer 190s, JetBlue may be shifting the Low Cost carrier paradigm into the 100 to 130-seat market with an aircraft that can reach over 2,000 nautical miles. It is clear Embraer will be able to compete with Bombardier and may even be better positioned for the hole or "sweet spot" in future regional airline economics – the 100 to 130-seat RJ aircraft.

**Bombardier.** The RJ industry leader, Bombardier has pursued the less risky strategy of offering larger aircraft by stretching the 50 seat RJ into a 70 seat and 90 seat models with one class or multi-class seating options. However, they recently announced a program to design and build a new 100-120 seat RJ that will compete with the Embraer 190 jet and be an option for airlines considering the smaller Boeing/AIRBUS jets.

## **Challenges**

By being lighter, smaller, cheaper to operate, and only slightly slower than the single aisle products of Boeing or Airbus, RJs are very popular; but the airlines' ever-expanding use of the RJ is creating some passenger backlash. The major challenge will be the flying customer's dislike of the features that make them so economically appealing and the industry's ability to grow within the constraints of the Airline Pilot's Union.

In order to be light, cheap to operate, and relatively fast, the RJ had to sacrifice some comfort and passengers are taking notice. The 30 to 50-seat RJs are experiencing nearly double-digit noise increases over mainline, single-aisle jets and reach 87 decibels in flight.<sup>i</sup> In addition, there are size restrictions on cabin crew (Continental has a maximum height of 5' 9'' for attendants on RJs), and while passengers are used to seat pitch limits cramping them from the front to the back, RJ window seats are now cramping passengers from side to side.<sup>ii</sup> Also, there are some less significant issues concerning a lack of food services, fewer bathrooms, and longer flight lengths.<sup>iii</sup> The increase in the number of complaints stem from the economic trends that support longer and longer flights in RJs, which make their comparably fewer comfort features more readily apparent. These issues are not being ignored, however, and the two major manufacturers are expanding the size and comfort of future aircraft as part of their strategies.

Perhaps the biggest challenge to the expansion of RJs is the "scope" clause portion of major airline pilot contracts. The ever-expanding range and size of RJs are seen as a threat to the jobs of pilots flying the larger jets with the major airlines, therefore almost all "majors" have restrictions to the number and/or the seat size of the RJs that each airline can have with its code sharing regional airline partners. Since the airlines are using RJs to directly lower pilot costs, this challenge to the RJ industry has no complete resolution forthcoming, though various experts disagree on the amount of scope clause maneuver room available in the future.

## **Outlook**

While the RJ industry has had its ups and downs over the last twelve months, the industry has had promising sales and revenues. RJ aircraft sales are expected to remain at 400 per year through 2008, and regional fleets will explode to include up to 8,345 aircraft in the next twenty years, with over one thousand being larger than 100 seats.<sup>liii</sup> The data suggests that the regional and Low Cost airlines will experience the majority of the airline market's growth, and there is a possible segmenting or specialization of aircraft types occurring among RJs, Boeing's mid-size aircraft, and Airbus' heavy models. This trend leaves the 100 to 120-seat aircraft market open, which will result in continued RJ aircraft size growth, increased regional airline market share through 2020, and challenges to the hub concept. In addition to having the larger RJs see increased service in typical regional airline markets, the continued growth trends in RJ size is expected to have 100+-seat RJs replace the older narrow-body jets, such as DC-9s and B-737s, on major airline routes. Exciting trends, such as RJ use by Low Cost carriers and increased foreign competition have occurred. With all these positive aspects of the RJ industry, the critical issues that must be resolved for continued industry growth are pilot scope clauses and National Airspace System (NAS) limitations.

## **MILITARY FIXED-WING AIRCRAFT**

The military fixed-wing sector of the aircraft industry includes strike, fighter, bomber, air mobility (transport), UAVs, and special mission aircraft specifically designed or modified for military mission requirements.

### **Current Condition**

In contrast to the commercial aircraft industry, the military fixed-wing sector actually gained a boost from the GWOT. Procurement dollars increased, reaching \$80 billion in fiscal 2004, and are projected to continue to climb to \$105.1 billion by fiscal 2008. Likewise, dollars for R&D are up and are expected to plateau at just over \$70 billion over the next several years.<sup>liv</sup> Deliveries of tactical aircraft (TACAIR) are up as well, and are expected to continue to climb. In 2002, military orders rose significantly, from \$64 billion to \$69 billion.<sup>lv</sup> In 2004, nearly 300 fighter aircraft (worldwide) worth almost \$13 billion will be delivered, up significantly from the "bathtub" years of 1998-2002, which averaged around \$8 billion per year.<sup>lvi</sup> Although the expenditures are up significantly, the US numbers have only grown slightly in recent years. The US fighter "bathtub" in numbers of aircraft is still very problematic until JSF is IOC, and there are sustained deliveries in the three digits (100+/yr) for a period of years.

In 2002, three programs dominated new aircraft procurement. The US Air Force's (USAF's) C-17 Globemaster III cargo aircraft program led with 15 planes worth \$3.7 billion; the Navy's F/A-18 Super Hornet strike fighter program came in next with 48 aircraft worth \$3.1 billion; and the USAF's F/A-22 Raptor fighter program was third, with 13 aircraft costing \$3.0 billion.

F/A-22 Raptor. The aviation program with the highest cumulative procurement value through fiscal 2006 is the USAF's F/A-22 Raptor, leading the pack at nearly \$23 billion.<sup>lvii</sup> As of February 2004, 25 aircraft have been built, including nine developmental aircraft, eight operational test and tactics development aircraft, and eight production aircraft. Producer Lockheed Martin is currently under contract for 52 aircraft, and the USAF has earmarked approximately \$42 billion to purchase 276 F/A-22s through 2011.<sup>lviii</sup>

C-17 Globemaster III. Coming in second with a cumulative procurement value of nearly \$20 billion through fiscal 2006 is the Air Force's C-17 Globemaster III transport aircraft.<sup>lix</sup> Today, the USAF has an inventory of 108 C-17s at an average unit cost of approximately \$200 million and is considering an order of 42 more Globemasters.<sup>lx</sup>

F/A-18 Super Hornet. The Navy's F/A-18 E/F Super Hornet program is the third largest in terms of cumulative procurement value, which will approach \$17 billion by 2006. In December 2003, the Navy awarded a five-year contract, worth nearly \$9 billion, for up to 210 new aircraft. A separate contract for \$979 million was awarded in order to create a new EA-18G "Growler" model as a replacement for the EA-6B.<sup>lxi</sup>

F-35 Joint Strike Fighter (JSF). Designed from inception as a "joint" and international aircraft, the JSF is intended to meet the requirements of all three US services – Air Force, Navy, and Marines – as well as the needs of the United Kingdom's (UK's) Royal Air Force and Navy.<sup>lxii</sup> There are currently eight partner nations in the program (Australia, Canada, Denmark, Italy, the Netherlands, Norway, Turkey and UK). In February 2003, Singapore joined Israel as a Security Cooperation Participant.<sup>lxiii</sup> Although struggling with cost overruns and delays,<sup>lxiv</sup> in particular weight issues on the

short take-off and vertical landing (STOVL) variant, Lockheed Martin is cautiously optimistic worldwide sales may eventually eclipse the 4000 F-16s sold.

The first flight of a test aircraft, a conventional takeoff and landing variant, is expected around mid-2006. The next version to fly will be the STOVL aircraft, followed by the carrier version (CV). Lockheed Martin expects the CV version will be operational in the US Navy beginning in 2012 or 2013.

F-16 Fighting Falcon. The Lockheed Martin F-16 line in Fort Worth is still in production with a backlog of orders through 2008, and company spokesmen anticipate as many as 200 to 300 additional orders for the new Block 60 aircraft.

## **Challenges**

In general, the defense sector of the aircraft industry thrives through innovation and exploitation of new technologies, and therefore tends to be more adaptable than the commercial sector. However, the military fixed-wing aircraft market remains susceptible to some unique challenges, described in the paragraphs below.

Recapitalization. Although procurement dollars are up, there remains concern that the US still is not replacing aging fighters, tankers, and transports quickly enough. For example, by 2020 (even with optimistic tanker deliveries ~100 new aircraft by 2020) almost 60% of all tankers (KC-135s) will be 55 years of age or older by 2020 (almost 2/3rds of all USAF tanker aircraft). So although the average age of the whole tanker fleet will be ~43.0 years, the median age would be 57.0 years (KC-135 only average age= 58.4 yrs; Median Age = 58.0 yrs).<sup>lxv</sup> Additionally, some 115 tankers would be over their max allowable age (60.0 years—set by the CSAF in 2000). Air Force bomber, fighter and transport fleets face similar dilemmas, but not quite as severe. While the Navy is somewhat better off due to ongoing procurement of Super Hornets, funds to fully recapitalize are not currently included in planned defense expenditures. The only way to meet the average age goals in most cases would be to significantly cut force structure (at least 25%).

Expense. Another challenge facing the domestic TACAIR industry, particularly the high-tech and expensive F/A-22 and F/A-18 programs, are the calls by some to make cuts in procurement programs that are not aligned with a credible threat. While JSF may be in a somewhat more protected position due to its international flavor and backing, the F/A-22 program alone accounts for a significant percentage of total defense procurement dollars. Expensive, high-tech programs such as these must answer to charges of being anachronistic and misaligned to the predominant threat. Many believe dollars spent on these programs should be redirected to answer more pressing needs.

Lack of Funding Stability. Another common complaint is the lack of funding stability in government acquisition programs. Contractors and military program managers alike cite the lack of alignment between the planning and budgeting cycles in relation to long-term R&D. In the words of a Sikorsky spokesman, the Program Objective Memorandum is a 6-year defense program managed by 3-year personnel on a 2-year budget funded by a 1-year appropriation – typically approved late. Multiyear contracts, such as those enjoyed by the F/A-18 Super Hornet program, provide a degree of stability and cost efficiencies,<sup>lxvi</sup> while other defense acquisition programs, such as the V-22 Osprey, face volatile instability.

Foreign Competition. Foreign fighters such as the French Dassault Aviation's Rafale, the Eurofighter, and the Swedish Saab Gripen are capable aircraft, although currently dealing with cost overruns and delays. Still, these aircraft will be looking for opportunities to increase world market share if the JSF program stumbles.

Boeing 767 Tanker. A challenge facing the large aircraft market is the attempt by the USAF to meet their strategic tanking requirement by leasing 100 Boeing 767 aircraft. Allegations of improprieties focused on illegal "revolving door" deals between Boeing and the Pentagon, as well as other irregularities, have brought the entire matter under Senate investigation.<sup>lxvii</sup> As a result, the Pentagon's plans for acquiring badly needed replacements for their aging tanker fleets have been significantly delayed. Recently, the Air Force announced plans to program money for the fiscal 2006 budget request for a KC-X tanker replacement program.<sup>lxviii</sup> With the mid-May release of a Defense Science Board (DSB) report concluding that "the Air Force's aging fleet of refueling tankers is not in need of immediate modernization," it is becoming increasingly doubtful that the current 767 tanker deal will be concluded anytime soon.<sup>lxix</sup> A more likely scenario is for the Air Force to initiate a new procurement after it conducts a formal Analysis of Alternatives (AoA; due Fall 2004) – a review that was originally planned/requested well before the 9/11 terrorist attacks. As things currently stand, however, the ultimate fate of the current tanker deal will be played out in Congressional budget negotiations. Although the House Armed Services Committee inserted new language into the 2005 Defense Authorization Bill that would add about \$100 million for the tanker program and waive the analysis of alternatives, opposition in the Senate Armed Services Committee is likely.<sup>lxx</sup> Additionally, OSD will wait for an analysis of the tanker portion of the Mobility Capabilities Study (MCS) due at the same time as the AoA.

## **Outlook**

Through a combination of F-16, F/A-18, F/A-22, and F-35 fighters, as well as updated tanker and transport aircraft, the US military fixed-wing aircraft industry appears to be poised to dominate the international market well into the next decade, and probably beyond.<sup>lxxi</sup> Forecasts predict US fighter aircraft will maintain about 60% share through 2013 while the European share stabilizes at approximately 25%.<sup>lxxii</sup> As long as the JSF program can successfully navigate challenges posed by politics, consensual cooperation and workshare issues, and the increasing pressure placed on the program by growing budget deficits, the future of the fighter market appears to belong to Lockheed Martin and the F-35.

## **SPECIAL FOCUS: UNMANNED AIR VEHICLES (UAVs)**

The UAV sector is broad and encompasses a wide range of air vehicles. The December 2002 OSD UAV Roadmap identifies fourteen UAV systems that are presently either operational or in development. These systems range from the low cost UAVs weighing as little as 4.5 pounds (Dragon Eye) to those approaching the size and weight of tactical jets. Rotary wing UAVs are also under development.

## **Current Conditions and Challenges**

There is a more diverse group of manufacturers of UAVs than manned TACAIR. The market for small UAVs is developing and a number of smaller companies are

competing for programs. Few barriers to entry and exit exist in the small UAV market. However, within the market niche of the larger, more expensive, air vehicles, the same major defense corporations of Boeing, Northrop Grumman, and Lockheed Martin dominate. An exception is perhaps General Atomics, maker of the intermediate sized and successful Predator UAV and the considerably larger Predator B. In general, the large UAV suppliers are the same as for TACAIR. Thus, the market can be characterized as an oligopoly of three primary suppliers and a buyer monopsony, the US Government.

**Competition: Supplier oligopoly/buyer monopsony in large UAV Market.** The suppliers face intense rivalry and competition that reduces average profitability.<sup>lxxiii</sup> The aerospace firms are homogenous and therefore easier coordination between firms is possible.<sup>lxxiv</sup> These firms are mature, largely vertically integrated, and have substantial specific assets. This suggests not only barriers to market entry, but also to exit.<sup>lxxv</sup>

**Substitute Products: UAVs versus manned tactical aircraft.** Should UAVs replace manned aircraft in further mission areas than reconnaissance, all three possible major suppliers will need to compete to maintain their respective market share.

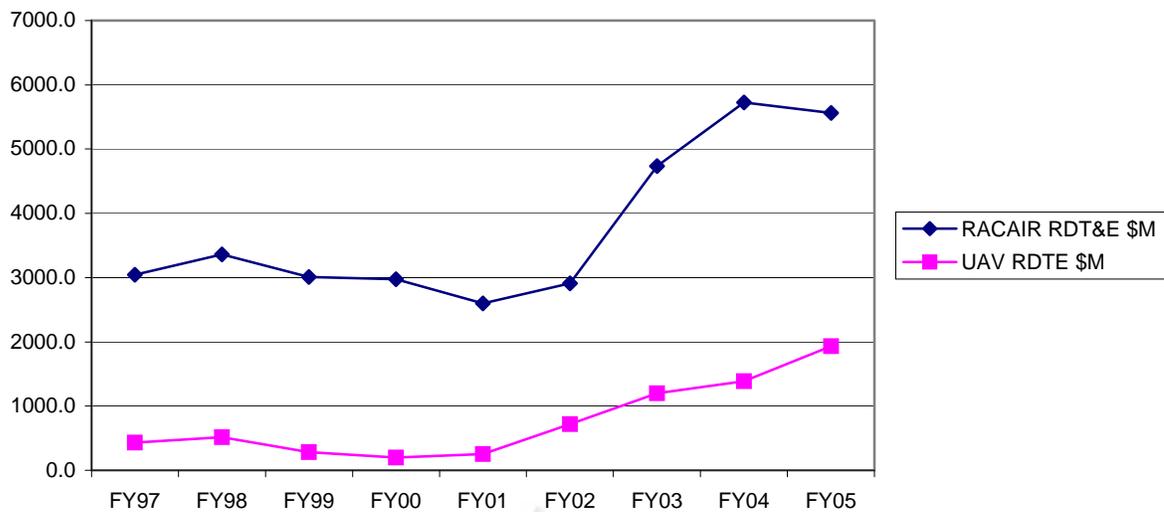
Downward pressure will be applied to defense budgets as the baby boomers begin to retire. In 2038, Social Security trust fund assets will be exhausted.<sup>lxxvi</sup> These factors suggest there will likely be strong cross elasticity in demand between manned aircraft and UAVs. Thus, if the promise UAVs offer in savings is realized, the numbers of manned TACAIR procured will be considerably diminished for the US military.

**Buyer Power and Supplier Power.** In the oligopoly/monopsony relationship between the US government and the three major producers of combat aircraft, there is mutual dependence.<sup>lxxvii</sup>

**Determinants of Buyer Preference.** Factors that will affect the DoD's preference of weapon system include: costs, risks, technology, mission suitability, and funding trends. Each of these factors is important, but cost will likely be the most important single criteria due to budgetary pressures. Optimism with procurement cost savings, according to the UAV Roadmap, is based upon "an informal aviation industry rule that production cost of an aircraft is directly proportional to its empty weight." For JSF, the cost is \$1500 per pound (Fiscal Year (FY) 94\$). Weights added for aircrew are nominally 3000 pounds for a single seat aircraft and 5000 pounds for a dual seat cockpit.<sup>lxxviii</sup>

## **Outlook**

In FY97, total UAV funding was approximately 8.5% of funding of TACAIR platforms across DoD.<sup>lxxix</sup> By FY05, that percentage will grow to 14%. More striking, and perhaps more predictive of the future force composition, is the change in R&D funding. In FY97, total UAV R&D was 14% of what was being spent on TACAIR. By FY05, that amount will have grown to almost 35%.



Interpreting these trends, we believe the UAV roadmap is being pursued as published, and larger percentages of R&D dollars will continue to be spent on unmanned platforms. As JSF begins Low Rate Initial Production in FY07,<sup>lxxx</sup> its 82% share of the TACAIR R&D in FY05 will be much smaller in future years. Increasing percentages of R&D budget may reflect future opportunities for UAVs to replace manned aircraft, but more likely are necessary to achieve the technical breakthroughs in platforms (propulsion & survivability), payloads (sensors & weapons), data links, and processors specified in the roadmap by 2027.

## ROTORCRAFT

Currently, there are three “major” prime manufacturers of rotorcraft in the US: Sikorsky Aircraft Corporation, a subsidiary of United Technologies Corporation;<sup>lxxxii</sup> Bell Helicopter Textron;<sup>lxxxiii</sup> and The Boeing Company (Helicopters).<sup>lxxxiii</sup> In addition, Europe hosts two major manufacturers: AgustaWestland<sup>lxxxiv</sup> and Eurocopter.<sup>lxxxv</sup> Together, these five companies account for 92% of the international market.

## Current Condition

In the words of M.E. Rhett Flater, Executive Director of American Helicopter Society International, the domestic rotorcraft industrial base is a “shadow of what it once was.”<sup>lxxxvi</sup> Flater attributed the erosion of what was once a “strong technical base for rotorcraft” with a precipitous decline in government investment. He highlighted the National Aeronautics and Space Administration’s (NASA) “unilateral determination in 2002 not to invest further in rotorcraft research” and their more recent decision to close down critical infrastructure as indicative of the deteriorating condition of the industry.<sup>lxxxvii</sup> While he asserts the industry continues to invest “independent R&D funds in new designs such as the S-92 and civil tiltrotor,” he maintains the lack of government investment has left the Army “isolated in its mission to broaden rotorcraft applications through improvements in performance and safety.”<sup>lxxxviii</sup>

Experts in industrial base analysis at DoD offer a slightly different perspective. They describe the domestic industry as an “inefficient interlocking 1970’s cartel” with no

incentive to innovate.<sup>lxxxix</sup> The military remains the industry's biggest customer. However, the lack of government investment, coupled with limited procurement dollars, has driven the military/industry partnership to rely on major modifications to legacy systems and lucrative (often sole-source) aftermarket sales. With the cancellation of Comanche, the V-22 is the only new growth area. Enormous cost growth on recent military programs has driven the top three to pursue lean-manufacturing initiatives; however, industrial capabilities remain broadly distributed. Current conditions encourage joint ventures and partnerships as a means to capture and hold market share.<sup>xc</sup> Representing 3.6%-16% of corporate revenues and high margins, DoD analysts conclude helicopter programs provide companies no incentive to manage them."<sup>xcii</sup>

Sales/Shipments. From 1993 to 2003, total rotorcraft revenues for the three prime manufacturers ranged from \$4.5 billion in 1997 to \$6.6 billion in 2002.<sup>xciii</sup> During the same 10-year period, the total number of employees ranged from a low of 24,182 in 2002 to a high of 28,293 in 1993.<sup>xciii</sup> From 1988 to 2002, civil helicopter shipments (domestic and export) ranged from a high of 493 (\$270 million) in 2000 to a low of 318 (\$157 million) in 2002.<sup>xciv</sup> Most notable, however, is domestic shipments in 2002 amounted to only 24 aircraft, the lowest number of aircraft since before 1969.<sup>xcv</sup> (Statistics for military rotorcraft were not available)

International Competition. In stark contrast to the US, the European Union (EU) has aggressively pursued the worldwide market. In fact, the EU recently doubled its aeronautics investment, propelling several European companies to a level of parity with the top three US companies.<sup>xcvi</sup> Only the heavy lift niche remains dominated by the US.<sup>xcvii</sup> According to The Teal Group, a defense research firm, Sikorsky's market share for medium transport choppers is expected to drop from 67% to 50% by 2009, while Eurocopter's will increase from 33% to 40%. The highly publicized competition between Sikorsky and AgustaWestland (teamed with Lockheed Martin) for the Marine One replacement currently spotlights the high stakes game and political nature of international competition.

Calls for Protection. European governments consistently and heavily subsidize rotorcraft R&D.<sup>xcviii</sup> More importantly, the EU's supplemental funding for aeronautics research, which jumped to more than \$1.5 billion (2002-2006), is in addition to even larger investments made by individual countries.<sup>xcix</sup> As a result, Sikorsky, Bell, and Boeing have all asked the US Government for support in competing with their European rivals. Just recently, John Murphey, CEO of Bell Helicopter, together with Roger Krone, a senior vice-president at Boeing, and Dean Borgman, president of Sikorsky, warned, "the rotorcraft industry faces a troubled future without greater government assistance."<sup>c</sup> Murphey specifically recommended that "Congress create a government-backed center of excellence" to advance rotorcraft technology."<sup>ci</sup>

Production Capacity. According to Paul Nisbet, defense analyst with JSA Research Incorporated, "Everybody involved wants the industry to consolidate," noting most contractors are at 50% capacity.<sup>cii</sup> Flater points out, however, "The problem with consolidation in this industry is that everybody wants to be the buyer."<sup>ciii</sup> DoD analysts agree, concluding the helicopter business is a profitable niche business with major program uncertainty and no impetus for consolidation.<sup>civ</sup> According to Heidi Wood, a Morgan Stanley analyst, helicopters have been the last weapon system to consolidate, "due to lack of clarity of future helicopters."<sup>cv</sup> Further consolidation has been discussed;

however, rising program costs and constantly changing projections of military orders make it difficult for companies to accurately predict future revenue.

Productivity. With the market down (25% from its 1990 peak), and industrial base capabilities spread across the prime manufacturers, the level of productivity is less than efficient.<sup>cv</sup> To compensate, the industry has come to rely on increasing demand for after-market services. Defense analysts surmise that in the end, “corporate liquidity provides companies the flexibility to “ride out” this period of level revenues.”<sup>cvii</sup>

Profitability. Sikorsky, Bell, and Boeing all maintain very healthy financial profiles. Earnings before interest, taxes, depreciation, and amortization ranged from 10-14% in 2002 and were projected to reach as high as 16.5% in 2005.<sup>cviii</sup> As Boeing’s CEO, Harry Stonecipher, recently put it, “Helicopters are a wonderful business.”<sup>cxix</sup>

## **Challenges**

Dwindling Investment. The steady decline in government investment has contributed to the stagnation of the industry. Sikorsky’s CEO, Stephen Finger, believes the loss of government investment “represents an imbalance between the importance of rotorcraft to the military and its financial commitment.”<sup>cx</sup> Patrick Shanahan, Boeing’s vice-president and general manager of rotorcraft systems noted, “When we get back to core technologies, real physics, we’ll see a revitalization of the industry.”<sup>cx</sup> Clearly, the industry is in need of capital investment, not only to upgrade design and manufacturing capability, but also spur innovation and advancements in technology. The challenge is in developing a strategic vision for rotorcraft applications and a resource plan supporting the vision. Unless government and industry develop an effective partnership to meet this challenge, the US will likely continue to lose market share to European rivals, placing the very future of the domestic industrial base in jeopardy.

Overcapacity. Industry experts agree, “While the military market rebounded in recent years, the civil market is stagnant, with too much capacity and too little demand.”<sup>cxii</sup> Unfortunately, the industry’s cartel-like structure (which will likely benefit from return of Comanche funds) will hold off any consolidation within the next 5 years.

Comanche Termination. Cancellation of Comanche is a signal that “the Pentagon’s attitude toward its helicopter industry is changing.”<sup>cxiii</sup> However, this attitude may be masked by the Army’s highly publicized plans to use Comanche funds to also “modernize about 1400 helicopters.”<sup>cxiv</sup> Obvious or not, the Pentagon is concerned with the lack of innovation in the rotorcraft industry. While the military may be content to refurbish and modernize its aging fleet of helicopters, the industry must be concerned with the long-term implications. While Boeing looks forward to revitalizing Apache, Phil Camus, CEO of EADS, expects the Eurocopter Tiger “to be even more successful” now that a future competitor has been eliminated.<sup>cxv</sup> For Sikorsky, losing Comanche places an increased premium on winning the Marine One competition. If nothing else, terminating Comanche will have a ripple effect through the industry that must be addressed.

Tiltrotor Success. Despite recent success, the V-22 program and its revolutionary tiltrotor technology is not out of the woods. Recently, an unexpected software anomaly led to “uncommanded motion” and forced program officials to delay operational evaluations from this fall to sometime in 2005.<sup>cxvi</sup> Initial operational capability is now not slated until late FY07.<sup>cxvii</sup> The V-22 program must build increased confidence in

tiltrotor technology in terms of quality (reliability, maintainability, manufacturing process), capability, and affordability (cost reduction initiatives). The “tiltrotor revolution” is hanging in the balance.

Vulnerability to Air Defenses. Helicopter losses in Iraq have highlighted the vulnerability of low, slow flying helicopters to ground fire, and led some to question the future role of helicopters in GWOT (nine helicopters were shot down in Iraq killing 32 people).<sup>cxviii</sup> While some would argue there is no safe alternative to the capability helicopters bring to the battlefield, a tri-service effort is now underway to “assess rotorcraft vulnerability” to air defenses, especially rocket-propelled grenades and shoulder-fired missiles.<sup>cxix</sup> In the meantime, the military has focused on installing advanced protective measures on combat helicopters. More significantly, the threat is driving changes in long standing tactics, techniques, and procedures that may influence future rotorcraft requirements. While long-term responses may focus on new platforms, such as the Unmanned Combat Armed Rotorcraft, supporters of rotorcraft technology contend that helicopters will be able to operate in combat “if the sound they produce can be cut by about 80% and if new rotor blade technology designs can offer a significant reduction in radar cross section and still be manufactured at a reasonable cost.”<sup>cxx</sup>

Additional Challenges. Roy Resavage, president of Helicopter Association International, identified a number of additional challenges including: 1) a pilot/mechanic shortage due to hit the industry by 2010; 2) new federal regulations that are very short on improving safety but long on imposing costly burdens on operators; 3) rising insurance costs; 4) the need to integrate helicopters and tiltrotors into the NAS infrastructure; and 5) coordinating use of civil helicopters to augment government aircraft in a crisis.<sup>cxxi</sup>

## **Outlook**

Military Forecast. Forecast International predicts, “Production of new-build rotorcraft will rise in 2004, compared to 2003, and will continue to rise through 2011.”<sup>cxxii</sup> “Increased production of such relatively complex aircraft such as the V-22 Osprey and NH-90 drive the change.”<sup>cxxiii</sup> They also predict value of this annual production (measured in constant FY04 dollars) will show an upward trend through 2012.<sup>cxxiv</sup> In addition, the forecast calls for over 1400 major modifications (all military) worth \$12.1 billion over the next 10 years.<sup>cxxv</sup> The US military will continue to dominate this market.

Civil Forecast. After falling in 2002, worldwide civil helicopter sales have rebounded in 2003 and are expected to total \$18.7 billion over the period from 2003 to 2012.<sup>cxxvi</sup> In that timeframe, Forecast International projects shipments of nearly 9,500 rotary wing aircraft valued at nearly \$19 billion.<sup>cxxvii</sup> Eurocopter is expected to dominate this sector of the market.<sup>cxxviii</sup> Law enforcement, offshore oil, and emergency medical service requirements will drive increased opportunities in commercial rotorcraft.

Implications. The projected outlook suggests “business as usual” for the domestic rotorcraft industry. Absent any significant change in the structure, conduct, or performance of the industry, the three companies will continue to live off derivatives of legacy aircraft, wide scale refurbishments and modernization programs, and expanding after-market services. They have a golden opportunity to capitalize on growth in the commercial market, particularly as it applies to homeland security requirements. Without significant investment, however, they will continue to lose market share to their European

rivals. The domestic rotorcraft industry will continue to meet the demands of national security, but will not likely be a key enabler in military/civilian aviation transformation.

## **JET AIRCRAFT GAS TURBINE ENGINES**

The global aircraft gas turbine engine industry operates as an oligopoly and is dominated by two domestic companies: General Electric's Aircraft Engines (GEAE) Division and Pratt & Whitney. International competition is from Rolls-Royce of the UK and SNECMA of France.<sup>cxxxix</sup> The industry is highly competitive, cyclical, and is in its mature stage of its product life cycle. Large gas turbine engines dominate the market and outpace small turbine, and turboprop sales. However, declining commercial air travel has increased the demand for smaller turbine engines in support of regional and business jet travel.

Aircraft engine manufacturing requires long-term development and production cycles along with significant expenditures in capital investment/R&D. These characteristics are significant barriers reducing new competitors while increasing joint ventures among companies to support the development of new turbine engines.<sup>cxxx</sup>

### **Current Condition**

A prosperous economy increases private industries' use of air travel and airfreight resulting in growth and profits for airlines. This, in turn, accelerates long-term aircraft fleet (to include rotorcraft) and engine replacement models. Additionally, increases in defense spending aid this industry as new engine procurements are made. The domestic jet engine market is flat to low growth from global commercial customers and low growth from defense customers. The 2003 global large jet engine manufacturing industry consisted of \$31.0 billion in revenues and was led by GEAE (\$10.7 billion in revenues), followed by Rolls-Royce (\$7.7 billion), Pratt & Whitney (\$7.5 billion), and SNECMA (\$5.1 billion). Operating profit margins for the industry reduced from 14.8% in 2000 to 12.3% in 2002 to 11.8% in 2003.<sup>cxxxii</sup> Major customers are the global air carriers (passenger and cargo) and military users. New aircraft engine and parts orders decreased from \$7.3 billion in 2001 to \$6.1 billion in 2002<sup>cxxxiii</sup> to \$5.9 billion in 2003.<sup>cxxxiii</sup> This trend should reverse as commercial and defense spending on new aircraft procurements are projected to increase in 2004 and beyond.

Small turbine engines have fared better than the large turbine sector due to increased demand. The less-than-150-seat passenger aircraft and military fighters are the prime customers. An increase in defense spending has positively affected the demand for military aircraft engines. Military engines to support sales of F-16's, F-18 Super Hornets, and the new F/A-22 and F-35 aircraft are leading demand.

The Commercial Maintenance, Repair, and Overhaul (MRO) sector is also a significant market that follows the expansion or contraction of the airline industry. Profits declined for the \$36.1 billion global MRO market from 14.6% in 2000 to 5.4% in 2002; however, a slight improvement to 5.9% was seen in 2003.<sup>cxxxiv</sup> Top MRO leaders include the large engine manufacturers as well as Singapore Airlines, Ltd., Lufthansa AG, Honeywell International, and Goodrich Corporation's aerospace unit.<sup>cxxxv</sup>

## Challenges

Anticipated major challenges to the jet engine sector include growth of the industry, intense competition, R&D costs, workforce employment availability, and import/export barriers. First, the commercial sector will continue to suffer as the major airlines strive to recover from their most challenging period in history. Lingering concerns over terrorism, sputtering global economies, and high oil prices drive this situation. In 2003, the top 10 US carriers lost \$3.7 billion as compared to \$9.8 billion in 2002. The 2003 losses would have been larger, but the airlines received federal funds from the Wartime Supplemental Appropriations Act that helped offset losses.<sup>cxxxvi</sup> However, the airlines could start seeing profits in late 2004 or 2005. The defense sector relies primarily on smaller turbine engines and looks more promising than the commercial market in the short-term. However, long-term prospects are not as bright as they once were because there is political pressure to balance budgets, fund homeland security initiatives, and pay larger social entitlements. These pressures will force Congress to limit defense spending.

Second, strong competition among the large engine manufacturers will continue as demand for new orders and sales remain low. This will also affect the MRO sector as companies attempt to bolster profits due to the lack of new sales by increasing revenue in sale of parts/services. Engine manufacturers will remain under intense pressure from customers to reduce prices while producing highly reliable, fuel efficient, environmentally compliant engines. These demands will affect engine manufacturers' profit margins and force them to find new and innovative ways to reduce operating costs and become more efficient.

Third, due to reduced sales and lower profit margins, engine manufacturers have less capital available for R&D. This has led to a rise in joint ventures between engine manufacturers in order to reduce risk, reduce costs, share expertise, share processes, gain access to new markets, and share facilities. As a result, many new engines entering both the commercial and defense markets are simply derivatives of existing engines.

Fourth, engine industry employment fell for its fifth straight year down from approximately 100,000 in 1998 to 82,500 in 2003.<sup>cxxxvii</sup> The current workforce is aging which will result in a shortage of personnel to support MRO providers, component, and overhaul repair shops. Blue-collar graduates from Airframe and Powerplant schools are finding employment in computer and automotive industries where compensation is often higher. Additionally, white-collar scientists and engineers have experienced a significant decline in the entire aerospace industry from 95,500 in 1996 to 19,100 in 2002.<sup>cxxxviii</sup> There has been marginal industry support for developing and implementing programs to draw people into the aerospace industry that may become a significant factor as the industry begins to recover economically.<sup>cxxxix</sup>

Fifth, existing import/export barriers are making it difficult to exchange technology across international barriers. Within the US, restrictions imposed by the Arms Control Act, International Traffic in Arms Regulations, and the Buy American Act restrict companies from taking full advantage of free trade and open markets.

## Outlook

The highly competitive jet aircraft turbine sector will continue to provide top quality engines to domestic and international customers. Engine manufacturing capacity

will be pared to meet present and projected demand. Profit margins will be dependent upon management's ability to reduce costs and mitigate risks. Engine customers will continue to seek (1) safe, reliable, and low maintenance engines, (2) improved fuel efficiency, (3) increased thrust and performance, and (4) quieter and lower emission engines to meet environmental requirements.

Growth in the commercial large turbine jet engine market is projected to correspond with an anticipated 3% growth in GDP and a 3.4% growth of the global commercial aircraft fleet through 2012. The fleet of 11,500 aircraft is projected to grow to 16,000 by 2012 with approximately 4,300 new orders to replace aircraft retiring from service and 4,500 new orders for aircraft to expand existing air carrier fleets.<sup>cxl</sup> Due to significant industry entrance barriers, the existing large engine manufacturers will continue to dominate the global market.

R&D costs will remain high and government funding for R&D will remain flat to low growth. Therefore, engine manufacturers will continue the use of joint ventures in order to share costs and expertise while reducing risks and users' choices of engines. For example, domestic rivals GEAE and Pratt & Whitney have combined efforts to develop the GP7200 engine for the Airbus A380 super jumbo in competition against the Rolls-Royce Trent 900 engine. Dual sourcing of commercial engines may be a new trend as seen by the Airbus A380 and additionally Boeing has announced the use of either the GEAE or Rolls-Royce engine for future 7E7 aircraft.

Growth in the global commercial MRO market is projected to correspond with the anticipated growth of the global commercial aircraft fleet through 2012. Moderate growth is forecasted for engine MRO companies leading to an increase in revenues from \$10.4 billion in 2002 to a forecasted \$16.4 billion in 2012.<sup>cxli</sup> Original Equipment Manufacturers (OEMs) will continue to pursue profitable product spares and MRO agreements with air carriers in competition against after-market service providers. It is anticipated that competition will increase in this market resulting in OEMs acquiring smaller after-market service providers as customer support packages.<sup>cxlii</sup>

The aging and declining workforce is expected to continue as current workers retire and the industry fails to attract and graduate enough students to meet demands.<sup>cxliii</sup>

Flat to low DoD spending is projected through 2008. Major weapon system procurements are anticipated to grow between 2% to 4% annually.<sup>cxliv</sup> The demand for engine workload will be driven by existing aircraft upgrades and new aircraft procurement to replace aging aircraft weapon systems. This includes the Navy awarding a \$2 billion contract to GEAE to provide 480 F414 engines to support its buy of 210 F/A-18E/F aircraft. Delivery is expected through 2009 allowing the F414 production line to stay open.<sup>cxlv</sup> Additionally, the Pratt and Whitney F119-PW-100 engine was selected to power the F/A-22. The projected \$71 billion program is expected to produce 277 aircraft.<sup>cxlvi</sup>

The largest tactical aircraft program is the JSF. This program is expected to exceed \$200 billion. Both GEAE (teamed with Rolls-Royce) and Pratt & Whitney are competing for the engine workload. Initial operating capability is scheduled for 2011 with the export version for 2014. The Pratt & Whitney F135 engine will be installed on initial JSF lots, but faces competition with the GEAE F136 engine on future lots.<sup>cxlvii</sup>

The DoD awarded a multiyear procurement contract for 60 C-17 aircraft valued at \$9.7 billion; this equates to a purchase of at least 240 Pratt & Whitney F117 engines.

Additionally, the C-5B fleet (50 aircraft) will be upgraded with new GEAE CF6-80C2 engines. This \$6 billion effort will result in a buy of at least 200 GEAE engines.<sup>cxlviii</sup>

European countries are developing and manufacturing the Eurofighter (Typhoon), Gripen, Mirage, and Rafale fighters. The EJ200 jet engine for the Eurofighter is being developed by a consortium of companies from four countries collectively known as EuroJet. The EuroJet consortium includes Rolls-Royce of the UK, Motoren-und Turbinen-Union of Germany, Fiat-Avio of Italy, and Industria de Turbo Propulsores of Spain. A Volvo RM12 currently powers the Gripen; however, in the future, a GE F414 and/or EuroJet EJ200 may also power it. Dassault's Mirage is powered by a SNECMA M53 jet engine. SNECMA also builds the M88 turbine engine for the Rafale fighter.

An emerging area for engine manufacturers is the increasing development of UAVs (Predator, Global Hawk, and UCAVs) in the domestic and European community. Growth will translate into increased sales for small turbine engine producers.

### **GOVERNMENT: GOALS AND ROLE**

The Government plays a key role in several elements of the industry. All sectors would benefit from increased funding for R&D and by offering further tax incentives to help offset capital equipment investments. The Government should also assist the predicted aging and declining skilled workforce shortfall in the industry with establishing a national aerospace policy to confront the problem. Funding should be provided for scholarships to college/technical schools to help recruit personnel. And, finally, the Federal government should conduct a review of the Buy American Act and International Traffic in Arms Regulations (ITAR) and rescind/revise unnecessary restrictions.

With respect to UAVs, the Federal Aviation Administration (FAA) approval to fly in unrestricted airspace is key to growing its potential roles and missions. In August 2003, approval was granted to Global Hawk.

A new Pentagon group, the Joint Vertical Aircraft Task Force, is researching such questions as "why the US needs a domestic helicopter base, what levels of government science and technology investment are needed to sustain it, and whether/how the rotorcraft industrial base can support efforts to transform the nation's military."<sup>cxlix</sup>

### **ESSAYS ON MAJOR ISSUES**

This year, the AIS Seminar conducted research in several special interest areas – supply chain management, subsidies, tankers, and fighter bathtub/ total force structure. Synopses of these efforts follow and highlight the diversity of challenges in the industry.

#### **Aircraft Industry Study (AIS) Analysis of Supply Chain Management (SCM) for the Defense Logistics Agency, Defense Supply Center Richmond**

COL Jorge L. Silveira, USA and Col (Sel) Ricky Valentine, USAF  
CAPT Stephen Morris, USN, Faculty Advisor

The AIS conducted research on domestic and foreign aircraft industry SCM best practices to identify possible enhancements to the Defense Logistics Agency's (DLA) SCM processes. The study evaluated current and future SCM industry best practices and attempted to validate DLA's ongoing initiatives. Additionally, it provided background

on SCM and its core advantages, reviewed electronic tools that may enhance DLA's transformation, and provided recommendations for possible application in the future.

### **Subsidies for Aircraft Manufacturers, US Department of Transportation, FAA**

BG Settimo Caputo, Italian AF, CDR Steve Kozak, NOAA

Col Edwin McDermott USAF, Faculty Advisor

The AIS conducted research to identify and analyze the functional and operational relationships that exist between national governments and commercial aircraft manufacturers. The research focused on methods or processes by which subsidies are provided to manufacturers, and the effects that subsidies have on the commercial aircraft industry. The research also made recommendations for the US government and US commercial aircraft industry for effective subsidy initiatives to benefit US interests.

### **USAF Tanker Lease "Lessons Learned"**

David L. Mabee, Defense Contract Management Agency

Dr. Gerald Abbott, Ph.D., ICAF Review Team Chair

Dr. Francis A'Hearn, PhD, Faculty Advisor, ICAF Team Co-Chair

A team of National Defense University acquisition professionals reviewed the USAF Tanker Lease acquisition to identify "lessons learned" at the request of Deputy Secretary of Defense Paul Wolfowitz. The ICAF AIS provided a participant to determine whether the program office complied with statutory and regulatory cost and pricing guidelines during contract negotiations. As things currently stand, the Pentagon is unlikely to make a final decision on the tanker lease contract until November 2004.<sup>cl</sup>

### **Resolving the USAF Fighter Bathtub?**

**Col Carl Rehberg, Ph.D., USAFR, Director, ICAF Study Team**

The USAF is facing a significant mismatch between the cost of its plans and the level of funding likely to be available to pay for even its Long Range Plans. This is most problematic in the Combat Air Force (CAF) fighter force structure. This mismatch is one of the central national security issues that USAF leaders will have to confront, manage and resolve in coming years. Many of the assumptions that have gone into future fighter force structure plans may be overly optimistic and not viable (e.g., F-22 numbers; JSF timing, cost and numbers). This paper provided additional options for the USAF that would be more affordable, and meet NMS/NDS requirements for national security.

### **Solving Future Tanker Problems**

Col Carl Rehberg, Ph.D., USAFR, Director, ICAF Tanker Study Team

It is essential that the United States become more innovative and transformational in how we acquire and operate our air refueling (AR) forces. The importance of the AR mission has grown in the post-Cold War period. Both OEF and OIF were very tanker-intensive wars; it is abundantly clear how essential AR forces are to the new National Security Strategy (NSS) and National Military Strategy (NMS). No other weapon system in the

USAF inventory could be so completely disparaged or discounted with even half the facts surrounding the real (true) need to recapitalize KC-135s. Many call the KC-135--the “orphan” of the USAF. Our analysis shows that current plans will NOT get the tanker fleet well by 2020 under “normal” methods. Additionally, it is absolutely vital to have real competition vice monopolies in the tanker world. We propose a mix of aircraft (one type does not solve the problems) with new operational constructs (e.g., TRAF) as the only probable way to meet those needs. Some of our most critical primary recommendations (partial list) include: 1) Develop a Next Generation Modular Universal Boom as a transformation enabler—critical to other recommendations; 2) Ensure KC-135Es retired by NLT 2010.

## **CONCLUSION**

The US aircraft industry has long been a hallmark of American ingenuity and a key element of its national power, but it faces significant challenges. From our review, it appears Airbus will likely outperform Boeing based on current offerings as well as early delivery of the A380 in 2006 versus 7E7 in 2008. In the wake of downsizing and consolidation coupled with declining defense budgets, the industry strategy will involve transnational partnerships.

In general, when the commercial sector of the aerospace industry is weak, defense is strong, and vice versa. In recent years, defense expenditures were up while airlines were losing money; conversely, defense spending is forecast to taper off at about the time when the commercial sector starts its recovery in 2006-07.

As the overall market demand approaches its next cyclic upswing, the industry continues to react and transition to a new business environment created by declining defense budgets and a more balanced market share among competitors. Both industry and government must continue to evolve creating strategies, policies, and processes that balance national security goals with corporate realities.

## **RECOMMENDATIONS**

- Support and encourage sustained R&D. The Government can a) subsidize private R&D by means of the tax code, b) join private companies in collaborative research efforts, and c) invest directly in R&D through the DoD and NASA.<sup>cli</sup>
- Develop a Capabilities Roadmap. Highlight key industry partners, and planned/potential joint concepts of operation. It should focus on broad capabilities needed to accomplish specific missions, thus facilitating creative solutions.
- Embed a “high performance culture”. Team with industry in an analysis of current conditions and encourage private companies to proactively seek a solution to the overcapacity problem. Companies must create an atmosphere conducive to investment through a higher sales to capacity ratio.<sup>cliii</sup> This strategy may be accomplished by market expansion, market growth (UAVs), and/or overcapacity reduction through consolidation.
- Review restrictive regulations. The Government needs to conduct a complete review of the Buy American Act and International Traffic in Arms Regulations and work with Congress and private industry to identify and eliminate overly restrictive import/export requirements and other regulatory and statutory barriers to free trade.

- Prepare the future aerospace workforce. Establish programs to help develop and attract future aerospace workers, especially engineers, mathematicians, and scientists.
- Increase UAV R&D funds. Further investment is necessary to attain the promise and savings of UAVs. Caution in hurrying to force structure savings is also prudent.

## ENDNOTES

- <sup>i</sup> Standard and Poor's Industry Surveys, Aerospace and Defense 15 Apr 2004: 1.
- <sup>ii</sup> Ibid.
- <sup>iii</sup> Standard & Poor's Industry Survey, Aerospace and Defense 25 Sep 2003: 1.
- <sup>iv</sup> Ibid.
- <sup>v</sup> Not for Attribution Briefing to AIS Seminar, Spring 2004.
- <sup>vi</sup> Standard and Poor's Industry Surveys, Aerospace and Defense 23 Oct 2003: 1.
- <sup>vii</sup> Ibid.
- <sup>viii</sup> Ibid.
- <sup>ix</sup> Alexander Campbell, "Turning a Corner," Flight International 23 Dec 2003.
- <sup>x</sup> Standard and Poor's Industry Surveys, Aerospace and Defense 23 Oct 2003: 1.
- <sup>xi</sup> Michael Mecham, "Defense Holds," Aviation Week and Space Technology 3 Nov 2003: 51.
- <sup>xii</sup> "Commercial Aircraft Market: Darkest before the Dawn" Aerospace & Defense Industry Survey Oct 2003.
- <sup>xiii</sup> Ibid.
- <sup>xiv</sup> Michael Harrison, "Airbus Warns On Orders and Weak Dollars," The Independent 16 Jan 2004: 1.
- <sup>xv</sup> Ibid.
- <sup>xvi</sup> Ibid.
- <sup>xvii</sup> Ibid.
- <sup>xviii</sup> Standard and Poor's Industry Surveys, Aerospace and Defense 23 Oct 2003: 2.
- <sup>xix</sup> Ibid.
- <sup>xx</sup> Not for Attribution Briefing to AIS Seminar, Spring 2004.
- <sup>xxi</sup> Not for Attribution Briefing to AIS Seminar, Spring 2004.
- <sup>xxii</sup> John Gillie, "Boeing's Executive Defends Firm's Steep Lay Offs," The News Tribune [Tacoma] 3 Mar 2004.
- <sup>xxiii</sup> Ibid.
- <sup>xxiv</sup> Boeing Company, Commercial Airplanes, Current Market Outlook, Online, [www.boeing.com](http://www.boeing.com), 21 Mar 2004: 4.
- <sup>xxv</sup> Ibid: 4.
- <sup>xxvi</sup> Ibid: 5.
- <sup>xxvii</sup> Ibid: 14.
- <sup>xxviii</sup> Ibid.
- <sup>xxix</sup> This prediction for the Asia/Pacific region is the one significant forecast that Boeing and Airbus agree. Global Market Forecast 2003, Airbus, Online, [www.airbus.com](http://www.airbus.com), Dec 2003: 6.
- <sup>xxx</sup> Ken Hiebert, Boeing Company, Commercial Airplanes, telephone interview, 24 Mar 2004.
- <sup>xxxi</sup> Ibid.
- <sup>xxxii</sup> Ibid.
- <sup>xxxiii</sup> "Boeing Board of Directors Grants 7E7 Program Authority to offer," Efficient Section' Online [www.newairplane.com](http://www.newairplane.com).
- <sup>xxxiv</sup> Not for Attribution Briefing to AIS Seminar, Spring 2004.
- <sup>xxxv</sup> Not for Attribution Briefing to AIS Seminar, Spring 2004.
- <sup>xxxvi</sup> US General Accounting Office, Aviation Competition: Regional Jet Service Yet to Reach Many Small Communities Washington, DC, Feb 2001: 8.
- <sup>xxxvii</sup> Ibid: 9 and Fred Klein, "An Overview of the Regional Airline Market," Equipment Financing Journal: 1.
- <sup>xxxviii</sup> Steven A. Ridolfi, "Regional Transports, The Regional Revolution Continues," presented at the International Air & Space Symposium – The Next 100 Years, Bombardier Website, originally given on 1 Jul 2003, slide 15 and Bombardier Industry Study Brief, 19 Mar 2004.

- 
- xxxix Regional Airline Association Fact Sheet 12 Aug 2003: 1 (from RAA website).
- xl Ibid: 77.
- xli William Dennis, "ARJ21 Looks West," Aviation Week & Space Technology 29 Sep 2003: 39.
- xliv Ibid: 39-40.
- xlvi Mike Taverna with Douglas Barrie and Alexey Komarov, "Regional Progress," Aviation Week & Space Technology 15 Dec 2003: 88.
- xlvi Klein: 4.
- xlvi Ridolfi: slide 17.
- xlvi Interview with Richard E. Robeson, Aerospace Industries Association and Industry Study Session Number 4 with Teal Group, 11 Feb 2004, and Phone Interview with Rich Golaszewski from Gelman Research Associates, 27 Feb 2004.
- xlvi Industry Study Session Number 4 with Teal Group, 11 Feb 2004, and Phone Interview with Rich Golaszewski from Gelman Research Associates, 27 Feb 2004.
- xlvi Deborah McElroy, "Regional Airlines: Leading the Industry to Recovery" Brief: slide 9.
- xlvi Embraer Website, "JetBlue Buys Embraer 190 and Becomes Launching Customer for the Type": 1.
- l Paula Szuchman, "Sky-High Headache," The New York Times 12 Dec 2003: W-1.
- li Ibid: W-1.
- lii Ibid: W-1.
- lii The Aviation and Aerospace Almanac, McGraw-Hill, Washington, DC: 213, Forecasts on Bombardier Website, and Industry Study Site Visit, 19 Mar 2004.
- lii Teal Group Figures – Not for Attribution Briefing to AIS Seminar, Spring 2004
- lii Aerospace Facts and Figures 2003/2004, Aerospace Industries Association of America, Inc. (AIA), Arlington, Virginia, 2003.
- lii Richard Aboulafia, "Fighter/Attack Aircraft," World Military and Civil Aircraft Briefing Teal Group Corporation, Feb 2004.
- lii Ibid.
- lii Lockheed Martin, F/A-22 Overview Lockheed Martin Corporation Briefing to AIS Seminar, Feb 2004.
- lii Richard Aboulafia, "Fighter/Attack Aircraft," World Military and Civil Aircraft Briefing Teal Group Corporation, Feb 2004.
- lii Bill Sweetman, "Airlifter Turnaround: How the C-17 Came Good Both in Production and in Action" International Defense Review 1 Nov 2003.
- lii Bloomberg News, "Boeing Wins Contract to Build Navy Jets" The New York Times 30 Dec 2003.
- lii Lockheed Martin, F/A-22 Overview Lockheed Martin Corporation Briefing to AIS Seminar, Feb 2004.
- lii Michael Sirak, "Singapore Joins JSF Programme" Jane's Defence Weekly 24 Mar 2004.
- lii Renae Merle, "Price Tag Jumps for Aircraft; Joint Strike Fighter to be Delayed" The Washington Post 19 Feb 2004.
- lii Analysis by Col Carl Rehberg, Ph.D., USAF
- lii Bloomberg News, "Boeing Wins Contract to Build Navy Jets" The New York Times 30 Dec 2003.
- lii Niels Sorrells, "Commerce Watchdog Growls at Industry's 'Revolving Door'" CQ Weekly 24 Jan 2004.
- lii Amy Klamper, "Senate Budget Chief Defends Air Force Tanker Leasing Plan" Government Executive 24 Mar 2004.
- lii Renae Merle, "Price Tag Jumps for Aircraft; Joint Strike Fighter to be Delayed" The Washington Post 19 Feb 2004.
- lii Matthew Daly, "Boeing Tanker Lease Gets a Push in House" Seattle Post-Intelligencer 14 May 2004.
- lii John Birkler et al, Competition and Innovation in the US Fixed-Wing Military Aircraft Industry RAND (Santa Monica CA): 80.
- lii Richard Aboulafia, "Fighter/Attack Aircraft," World Military and Civil Aircraft Briefing Teal Group Corporation, Feb 2004.
- lii Sharon M. Oster, Modern Competitive Analysis (New York: Oxford, 1999): 31.
- lii Ibid: 35.
- lii Ibid: 37.
- lii "Social Security: Why Action Should be Taken Soon," Social Security Advisory Board, Jul 2001: 10.
- lii Oster: 43.
- lii "Unmanned Aerial Vehicles Roadmap 2002-2027": 59.

---

<sup>lxxxix</sup> Department of Defense, “Defense Budget Materials FY98 through FY04,” [Internet – WWW – URL], <http://www.dod.mil/comptroller/defbudget/fy2004/index.html>.

<sup>lxxx</sup> Rdml. Steve Enewold, “JSF Program Update” Washington, DC 10 Feb 2004.

<sup>lxxxii</sup> Sikorsky is recognized worldwide as a leader in the design and manufacture of both military and commercial rotorcraft. Military production is based on H-60, a utility tactical transport helicopter, and the H-53E heavy-lift helicopter. Sikorsky’s joint venture with Boeing to develop its first stealth helicopter, the RAH-66 Comanche, was recently cancelled. Commercial platforms include the S-76, designed specifically for commercial markets (e.g. corporate, off shore oil, hospital, airline operations), and S-92, a “large cabin derivative” of the H-60.

<sup>lxxxiii</sup> Bell is widely regarded as the world’s leader in *commercial* helicopter production and the pioneer of tiltrotor aircraft development. They currently have seven commercial helicopter models, each seating between five and fifteen passengers. Mission applications include basic transport, emergency medical services, and search and rescue. Military helicopter models include the “all new” UH-1Y Huey and AH-1Z Super Cobra reconnaissance/attack helicopter. Military platforms also include the V-22 Osprey (co-prime with Boeing) and the Eagle Eye UAV – both incorporating tiltrotor technology. Bell has also teamed with Italy’s Augusta Aerospace Company on the AB139 – medium twin-engine helicopter, and the BA609 commercial tiltrotor aircraft.

<sup>lxxxiiii</sup> Boeing’s helicopter business is entirely military related. Platforms include the AH-64D Apache Longbow – a multi-role combat attack helicopter, the H-47 Chinook – a heavy lift transport helicopter, and the CH-46 Sea Knight used for shipboard delivery of cargo and personnel. Boeing has partnered with Bell to produce the V-22 Osprey and is specifically responsible for the fuselage and all subsystems, digital avionics, and fly-by-wire flight control system.

<sup>lxxxv</sup> AgustaWestland is jointly owned by Italy’s Finmeccanica and the United Kingdom’s GKN. Primary systems range from the 2.5-ton light single engine A119 Koala to the 15-ton three-engine multi-role EH101. (A military version of the EH101 (US101) is in direct competition with Sikorsky’s H-92 for replacement of US presidential helicopters. A decision has been delayed until after Nov 2004 elections.) Other key products include the A109 Power (light utility), A129 (combat), the Super Lynx 300, and NH90 (military multi-role) helicopters, and the AH Mk1 Apache produced under Boeing license. AgustaWestland has also teamed with Bell in joint ventures for new technology AB139, medium twin-engine multi-role aircraft, and the BA609 civil tiltrotor aircraft.

<sup>lxxxvi</sup> Eurocopter is the result of a merger between the helicopter division of Aerospatiale-matra (France) and DaimlerChrysler Aerospace (Germany) and is now a wholly owned subsidiary of EADS. Military products include the EC120B (training/light utility), AS550C3 (reconnaissance, fire support, protection), EC635 (troop transport, training, reconnaissance, search and rescue), AS565UB Panther (military version of the Dauphin; troop transport; logistics support), AS532SC (anti-sub, anti-surface warfare), and the Tigre (air-to-air combat and fire support). Civil products include the Colibri EC120, AS350 Ecureuil, EC135, BK117C, AS365, and Super Puma – covering a full range of missions including passenger/executive transport, police/rescuer operations, and aerial work.

<sup>lxxxvii</sup> M.E. Rhett Flater, “Why the US Needs a Domestic Rotorcraft Industrial Base,” Vertiflite Winter 2003: 6.

<sup>lxxxviii</sup> *Ibid*: 6.

<sup>lxxxix</sup> Flater, “Aviation Industrial Base and the Department of Defense Rotorcraft Investment Programs”: 3.

<sup>xc</sup> Steve Thompson (Briefer), “Helicopter Industry Study” to OSD (AT&L), 1 Apr 2002, Slide 9.

<sup>xc</sup> *Ibid*, Slide 7. Source DCMA Data.

<sup>xc</sup> *Ibid*, Slide 12. Source: First Equity Analysis.

<sup>xcii</sup> Flater, “Aviation Industrial Base and the Department of Defense Rotorcraft Investment Programs”

Appendix 1, page 13.

<sup>xciii</sup> *Ibid*, Appendix 1, page 13.

<sup>xciv</sup> Aerospace Research Center, Aerospace Facts and Figures, Arlington, VA: Aerospace Industries Association of America, Inc., 2003: 31.

<sup>xcv</sup> *Ibid*: 28.

<sup>xcvi</sup> Flater, “Aviation Industrial Base and the Department of Defense Rotorcraft Investment Programs” 3.

<sup>xcvii</sup> *Ibid*: 3.

<sup>xcviii</sup> *Ibid*: 3.

<sup>xcix</sup> *Ibid*: 4.

- 
- <sup>c</sup> Dave Montgomery, "US Helicopter Makers Ask for Federal Support Against Foreign Rivals," Fort Worth Star Telegram 13 Mar 2003 Online. LexisNexis. 9 Mar 2004.
- <sup>ci</sup> Ibid.
- <sup>cii</sup> Renae Merle, "Comanche Cancellation May Reshape Industry," Washington Post 25 Feb 2004. Online. LexisNexis. 9 Mar 2004.
- <sup>ciii</sup> Lynn J. Lunsford, "Helicopter Sector May Consolidate; Comanche Halt May Bring Long-Debated Shrinkage Among Three US Player" Wall Street Journal 25 Feb 2004. Online. ProQuest. 8 Mar 2004.
- <sup>civ</sup> Thompson, Slide 12. Source First Equity Analysis.
- <sup>cv</sup> Renae Merle, "Comanche Cancellation May Reshape Industry" Washington Post 25 Feb 2004. Online. LexisNexis. 9 Mar 2004.
- <sup>cvi</sup> Thompson, Slide 6. Source: Derived from Teal Group Data.
- <sup>cvii</sup> Thompson, Slide 12. Source: First Equity Analysis.
- <sup>cviii</sup> Thompson, Slide 11. Source: First Equity Analysis.
- <sup>cix</sup> Anthony L. Velocci Jr. and Michael Mecham, "Stonecipher: On Point" Aviation Week & Space Technology, 16 Feb 2004: 40.
- <sup>cx</sup> Robert Wall, "Mixed Message" Aviation Week & Space Technology 19 Jan 2004: 414. Online. EBSCOhost. 10 Mar 2004.
- <sup>cxii</sup> Renae Merle, "Comanche Cancellation May Reshape Industry" Washington Post 25 Feb 2004. Online. LexisNexis. 9 Mar 2004.
- <sup>cxiii</sup> Robert Wall and David A. Fullghum, "What Next? Helicopter Industry Assesses Impact of Comanche's Demise to the Trade" Aviation Week & Space Technology 1 Mar 2004: 22. Online. ProQuest. 8 Mar 2004.
- <sup>cxiv</sup> Ann Roosevelt, Calvin Biesecker and Amy Butler, "Army Terminates Comanche Helicopter Program" Helicopter News 24 Feb 2004. Online. LexisNexis. 9 Mar 2004.
- <sup>cxv</sup> Robert Wall and David A. Fullghum, "What Next? Helicopter Industry Assesses Impact of Comanche's Demise to the Trade" Aviation Week & Space Technology 1 Mar 2004: 22. Online. ProQuest. 8 Mar 2004.
- <sup>cxvi</sup> Christopher J. Castelli, "Behind the Scenes, V-22 Wrestles with Flight Control Software Bug" Inside the Navy 23 Feb 2004. Online. Internet. <<http://ebird.afis.osd.mil>>. 27 Feb 2004.
- <sup>cxvii</sup> Col Craig Olsen, "V-22 Program Brief" Presented to AIS Seminar, 12 Mar 2004, Chart 14.
- <sup>cxviii</sup> Fulghum, David A. and Robert Wall. "Army Air Shocked and Awed." Aviation Week & Space Technology 1 Mar 2004: 20. Online. LexisNexis. 9 Mar 2004.
- <sup>cxix</sup> Robert Wall, "Report Card" Aviation Week & Space Technology 2 Feb 2004: 55. Online. EBSCOhost. 10 Mar 2004.
- <sup>cxx</sup> David A. Fulghum, "Surviving the Future: Unmanned Helos assigned to Low Level Combat Will Need Speed, Silence, and Cooperation" Aviation Week & Space Technology 20 Oct 2003: 69-70. Online. ProQuest. 8 Mar 2004.
- <sup>cxxi</sup> Edward H. Philips, "Looking for Lift" Aviation Week & Space Technology 15 Mar 2004: 46-48.
- <sup>cxxii</sup> Kathy Gambrell, "Aerospace Industrial Base "Healthy," Officials Say" Aerospace Daily 5 Mar 2004. Online. Internet. <<https://ebird.afis.osd.mil>>. 9 Mar 2004.
- <sup>cxxiii</sup> Ibid.
- <sup>cxxiv</sup> Flater, "Aviation Industrial Base and the Department of Defense Rotorcraft Investment Programs": 2.
- <sup>cxxv</sup> Ibid: 2.
- <sup>cxxvi</sup> Jefferson Morris, "World Civil Helicopter Sales on the Rebound, Forecast Says" Aerospace Daily 13 Jan 2004: 1. Online. LexisNexis. 9 Mar 2004.
- <sup>cxxvii</sup> Bill Dane (Contact), "Civil Helicopter Market on Rebound, 10 Year Sales of \$19 Billion Expected" Forecast International Inc. Press Release, 17 Dec 2003. Online. Internet <<http://www.forecastI.com/press/press105.htm>>. 23 Mar 2004.
- <sup>cxxviii</sup> Ibid
- <sup>cxxix</sup> Standard and Poor's Industry Surveys, Aerospace and Defense 15 Apr 2004: 6.
- <sup>cxxxi</sup> Ibid: 17.
- <sup>cxli</sup> Ibid: 1, 6.
- <sup>cxlii</sup> US Census Civil Aircraft and Aircraft Engines 2002, table 1.
- <sup>cxliiii</sup> US Census Bureau, "Civil Aircraft and Aircraft Engines," Jan 2004, table 1.

- 
- <sup>cxxxiv</sup> Standard and Poor's Industry Surveys, Aerospace and Defense 15 Apr 2004: 1, 6.
- <sup>cxxxv</sup> Ibid: 6.
- <sup>cxxxvi</sup> Ibid: 1.
- <sup>cxxxvii</sup> David H. Napier, "2003 Year-End Review and 2004 Forecast" Aerospace Industries Association, Arlington VA, 2004: 3.
- <sup>cxxxviii</sup> Aerospace Facts and Figures (2003/2004), Arlington VA, Aerospace Industries Association of America, 2004: 136-137.
- <sup>cxxxix</sup> Edward H. Phillips, "Innovation Key to MRO Survival Plans" Aviation Week and Space Technology 24 Feb 2003: 2.
- <sup>cxli</sup> Standard and Poor's Industry Surveys, Aerospace and Defense 15 Apr 2004: 8.
- <sup>cxlii</sup> The Aviation and Aerospace Almanac (2003). Aviation Week Business Intelligence Service, Washington DC, 2003: 901.
- <sup>cxliii</sup> Edward H. Phillips, "Innovation Key to MRO Survival Plans" Aviation Week and Space Technology 24 Feb 2003: 1-2.
- <sup>cxliiii</sup> Ibid: 2.
- <sup>cxliv</sup> Standard and Poor's Industry Surveys, Aerospace and Defense 15 Apr 2004: 11.
- <sup>cxlv</sup> Robert Wall, "Boeing Snags Over \$9 Billion in F/A-18 Work" Aviation Week & Space Technology 5 Jan 2004: 1.
- <sup>cxlvi</sup> William H. McMichael, "Raptor's Pilots Give Strike Fighter Vote of Confidence" Air Force Times 12 Jan 2004: 16.
- <sup>cxlvii</sup> Jane's Aero-Engines, "Joint Strike Fighter" 18 Dec 2003: 1-2.
- <sup>cxlviii</sup> Richard Aboulafia, "US Offerings Dominate Military Transport Markets" Aviation Week & Space Technology 24 Feb 2003: 1-2.
- <sup>cxlix</sup> M.E. Rhett Flater, "Why the US Needs a Domestic Rotorcraft Industrial Base" Vertiflite. Winter 2003: 6.
- <sup>cl</sup> Tony Capaccio, "Boeing Tanker Proposal Mishandled, New Pentagon Report Says," Bloomberg Reports, 18 May 2004. Online. LexisNexis. 18 May 2004.
- <sup>cli</sup> William J. Baumal and Alan S. Blinder, Economics: Principles and Policy, 9<sup>th</sup> ed, Ohio: Thomson Southwestern, 2003: 498.
- <sup>clii</sup> Baumal and Blinder: 495.

---

## **BIBLIOGRAPHY**

Aboulafia, Richard. "Fighter/Attack Aircraft," World Military and Civil Aircraft Briefing, Teal Corporation, 11 February 2004.

Aboulafia, Richard. "Rotorcraft: Politics to the Fore," Aviation Week & Space Technology, 19 January 2004, page 75. Online. EBSCOhost. 10 March 2004.

Aboulafia, Richard. "U.S. Offerings Dominate Military Transport Markets," Aviation Week & Space Technology, 24 February 2003, Online, [aviationnow.com/avnow/news/channel\\_awst\\_story.jsp?id=news/sb03\\_3.xml/](http://aviationnow.com/avnow/news/channel_awst_story.jsp?id=news/sb03_3.xml/).

Aerospace Industries Association of America (AIA) Aerospace Facts and Figures 2003/2004. Washington, DC, AIA, 2003.

Aerospace Research Center. Aerospace Facts and Figures. Arlington, VA. Aerospace Industries Association of America, Inc., 2003.

AgustaWestland Home Page. Online. Internet. <http://www.agustawestland.com>. 17 May 2004.

"Air Bosnia brings UK era to a close," Flight International, 19-25 August 2003, page 12.

Airbus S.A.S. Global Market Forecast 2003. Online, [www.airbus.com](http://www.airbus.com), December 2003.

Alegre, Pierre. Bombardier briefing to ICAF AIS, 19 March 2004.

Annual Industrial Capabilities Report to Congress, February 2003.

Barnes, Frederick. "The Pentagon Report: War at Treetop Level: Domain of the Army Budget," Defense & Foreign Affairs Daily, 24 November 2003. Online. LexisNexis. 9 March 2004.

---

Baumal, William J. and Alan S. Blinder. Economics: Principles and Policy, 9<sup>th</sup> ed. Ohio: Thomson Southwestern, 2003.

Bell Helicopter Textron. Home Page. Online. Internet. <<http://www.bellhelicopter.textron.com>> 11 March 2004.

Benoff, Dave. "2003 Purchase Planning Handbook: Helicopters," Business and Commercial Aviation, May 2003, page 19. Online. LexisNexis. 9 March 2004.

Birkler, John et al., Competition and Innovation in the U.S. Fixed-Wing Military Aircraft Industry, RAND, Santa Monica, CA, 2003.

Bloomberg News. "Boeing Wins Contract to Build Navy Jets," The New York Times, 30 December 2003.

The Boeing Company. Home Page. Online. Internet. <<http://www.boeing.com>>. 11 March 2004.

"Boeing Board of Directors Grants 7E7 Program Authority to Offer," Efficient Section, Online, [www.newairplane.com](http://www.newairplane.com).

Boeing Company. Commercial Airplanes, Online, [www.boeing.com](http://www.boeing.com), 21 March 2004.

Boeing Company. Commercial Airplanes, Current Market Outlook. Online, [www.boeing.com](http://www.boeing.com), 21 March 2004.

"The Boeing Company: Company Profile." February 2004. Datamonitor. Online. Internet. <<http://www.datamonitor.com>>. 12 March 2004.

Bombardier Industry Visit Brief, 19 March 2004.

Bombardier Website – Latest News section, article dated December 2003.

Bond, David. "AIA's Issues for 2004," Aviation Week & Space Technology, 15 December 2003.

Brownlee, Les (Presenter). "Briefing on the Restructure and Revitalization of Army Aviation." 23 February 2004. Online. Internet. <http://www.globalsecurity.org/military/library/news/2004/02/mil-040223-dod02.html>>. 2 March 2004.

Brubaker, Harold. "Helicopter Industry Signs Off on Plan to Create Pennsylvania Research Center," Philadelphia Inquirer, 5 March 2004. Online. LexisNexis. 9 March 2004.

---

Campbell, Alexander. "Turning A Corner," Flight International, 23 December 2003.

Capaccio, Tony. "Boeing Tanker Proposal Mishandled, New Pentagon Report Says," Bloomberg Reports, 18 May 2004. Online. LexisNexis. 18 May 2004.

Castelli, Christopher J. "Behind the Scenes, V-22 Wrestles with Flight Control Software Bug," Inside the Navy, 23 February 2004. Online. Internet. <<http://ebird.afis.osd.mil>>. 27 February 2004.

"Commercial Aircraft Market: Darkest before the Dawn," Aerospace & Defense Industry Survey, October 2003.

Commission on the Future of the United States Aerospace Industry. "Final Report of the Commission on the Future of the United States Aerospace Industry." November 2002.

Cox, Bobby. "Bell Helicopter Competes for U.S. Government Business," Fort Worth Star Telegram, 5 November 2003. Online. LexisNexis. 9 March 2004.

Cox, Bobby. "Politics Plays Big Role in Whether Presidential Helicopter is U.S.-Built," Fort Worth Star-Telegram, 26 January 2004. Online. LexisNexis. 9 March 2004.

Daly, Matthew. "Boeing Tanker Lease Gets A Push In House," Seattle Post-Intelligencer, 14 May 2004.

Dane, Bill (Contact). "Civil Helicopter Market on Rebound, 10 Year Sales of \$19 Billion Expected," Forecast International Inc. Press Release. 17 December 2003. Online. Internet <<http://www.forecast1.com/press/press105.htm>>. 23 March 2004.

Datamonitor. Bombardier Company Profile on [www.datamonitor.com](http://www.datamonitor.com), 26 January 2004, page 13.

Datamonitor. Embraer Company Profile on [www.datamonitor.com](http://www.datamonitor.com), 5 January 2004, page 5.

Datamonitor. The Boeing Company, Company Profile. Online, [www.datamonitor.com](http://www.datamonitor.com), February 2004.

Dennis, William. "ARJ21 Looks West," Aviation Week & Space Technology, 29 September 2003, page 39.

Douglass, John. Aerospace Industries Association briefing to Aircraft AIS, 6 February 2004.

Embraer Website. "Jet Blue buys Embraer 190 and becomes launching customer for the type," page 1.

---

Enewold, Rdml Steven. Joint Strike Fighter Program Update. Washington, DC, 10 February 2004.

Eurocopter Home Page. Online. Internet. <http://www.eurocopter.com>. 17 May 2004.

Final Report of the Commission on the Future of the United States Aerospace Industry, November 2002.

Fiorino, Frances. "Independence Move," Aviation Week & Space Technology, 24 November 2003, page 32.

Fiorino, Frances. "China Deal and Future Outlook," Aviation Week & Space Technology, 17 November 2003, page 77.

Flater, M.E. Rhett. "American Helicopter Society International Letter from the Washington Post regarding NASA Aeronautics Funding," 27 March 2001. Online. Internet. <<http://www.spaceref.com>>. 17 March 2004.

Flater, M.E. Rhett. "Aviation Industrial Base and the Department of Defense Rotorcraft Investment Programs." Testimony Before the House Armed Services Committee, Subcommittee on Tactical Air and Land Forces, 108<sup>th</sup> Congress. 4 Mar 2004. Online. Internet. <[https://www.globalsecurity.org/military/library/congress/2004\\_hr/040304-flater.htm](https://www.globalsecurity.org/military/library/congress/2004_hr/040304-flater.htm)>. 26 March 2004.

Flater, M.E. Rhett. "The U.S. Rotorcraft Industrial Base." Testimony Before the House Armed Services Committee, Subcommittee on Tactical Air and Land Forces, 108<sup>th</sup> Congress. 12 March 2003. Online. 9 March 2004.

Flater, M.E. Rhett. "Why the U.S. Needs a Domestic Rotorcraft Industrial Base," Vertiflite, Winter 2003, page 6.

Flottau, Jens. "Regional Uptrend," Aviation Week & Space Technology, 20 October 2003, page 64.

Flottau, Jens. "Regionals Reposition," Aviation Week & Space Technology, 30 June 2003, page 58.

Flottau, Jens. "Back from the Dead," Aviation Week & Space Technology, 30 June 2003, page 47.

Foster, Sharon. "European Chopper Targets U.S. Market," National Defense, July 2003, page 12. Online. ProQuest. 8 March 2004.

---

Friedman, Robert E. "Standard & Poor's Aerospace & Defense Industry Survey (2004)," 15 April 2004.

Fulghum, David A. "Surviving the Future: Unmanned Helos assigned to Low Level Combat Will Need Speed, Silence, and Cooperation," Aviation Week & Space Technology. 20 Oct 2003, pages 69-70. Online. ProQuest. 8 March 2004.

Fulghum, David A. and Robert Wall. "Army Air Shocked and Awed," Aviation Week & Space Technology, 1 March 2004, page 20. Online. LexisNexis. 9 March 2004.

Gambrell, Kathy. "Aerospace Industrial Base "Healthy," Officials Say," Aerospace Daily, 5 March 2004. Online. Internet. <<https://ebird.afis.osd.mil>>. 9 March 2004.

Gibbs, Roger. "Helicopter Industry and Market." Briefing to the Industrial College of the Armed Forces, Aircraft Industry Seminar. Hartford, CT.: Sikorsky Aircraft Corporation. 4 March 2004.

Gillie, John. "Boeing's Defends Executive Firm's Steep Lay Offs," The News Tribune, 3 March 2004.

Global Market Forecast 2003. Airbus, Online at [www.airbus.com](http://www.airbus.com) December 2003.

Graham, Bradley. "Military Spending Sparks Warnings," The Washington Post, 8 March 2004.

Harrison, Michael. "Airbus Warns On Orders and Weak Dollars," The Independent, 16 January 2004.

Healey, Andrew. "Civil Tiltrotor Designs Fly in Face of Several Challenges," Aviation International News, March 2004. Online. Internet. <<https://www.ainonline.com>>. 17 March 2004.

Healey, Andrew. "HeliExpo to Test Mettle of Helicopter Industry," Aviation International News, February 2004. Online. Internet. <[http://www.ainonline.com/issues/02\\_04/02\\_04\\_heliexpotestp60.html](http://www.ainonline.com/issues/02_04/02_04_heliexpotestp60.html)>. 17 March 2004.

Henderson, Rich. "Military Helicopter Sales Will Spur Increase in Turboshift Engine Orders," Forecast International Inc. Press Release. 19 February 2004. Online. Internet. <<http://www.forecast1.com/press/press110.htm>>. 23 March 2004.

Hiebert, Ken. Boeing Company Commercial Airplanes Unit, telephone interview, 24 March 2004.

Hoovers Online, The Business Information Authority. Home Page, 11 March 2004. Online. Internet. <<http://www.hoovers.com>>.

---

“Industry Briefs,” Vertiflite. Winter 2003, page 8.

Jane’s Aero-Engines. “Joint Strike Fighter,” 18 December 2003, Online, [jae.janes.com/subscribe/jae/doc\\_view\\_print.jsp?K2DocKey=/content1/janesdata/binder/jae/jae\\_05](http://jae.janes.com/subscribe/jae/doc_view_print.jsp?K2DocKey=/content1/janesdata/binder/jae/jae_05).

Jaworowski, Ray. “Military Rotorcraft Market on the Rise,” Forecast International Inc. Press Release. 5 December 2003. Online. Internet. <<http://www.forecast1.com/press/press104.htm>>. 23 March 2004.

Jaworowski, Ray and William Dane. “The World Rotorcraft Market 2003-2012,” Vertiflite, Spring 2003. Online. Internet. <<https://www.forecast1.com>>.

Jung, Helen, "Aerospace in 'Perfect Storm'," The Olympian, 4 April 2003.

Kaman Aerospace. Home Page. Online. Internet. <<https://www.kamanaero.com>>. 11 March 2004.

Klamper, Amy. "Senate budget chief defends Air Force tanker leasing plan," Government Executive Magazine, 24 March 2004.

Klein, Fred. “An Overview of the Regional Airline Market,” Equipment Financing Journal, page 1.

Lockheed Martin. “F/A-22 Overview,” Corporation Briefing to AIS Seminar, February 2004.

Lomax, David. "Air Farce One," Sunday Telegraph (London), 4 January 2004.

Lunsford, J. Lynn. “Helicopter Sector May Consolidate; Comanche Halt May Bring Long-Debated Shrinkage Among Three U.S. Players,” Wall Street Journal, 25 February 2004. Online. ProQuest. 8 March 2004.

Lunsford, J. Lynn. “Helicopter Seeks Made-In-U.S. Label,” Wall Street Journal, 2 March 2004, Eastern Edition, page A.3. Online. ProQuest. 8 March 2004.

McElroy, Deborah. “Regional Airlines: Leading the Industry to Recovery,” 12<sup>th</sup> ACI-NA Conference and Exhibit, 1 September 2003.

McMichael, William H. “Raptor’s Pilots Give Strike Fighter Vote of Confidence,” Air Force Times, 12 January 2004, page 16.

Merle, Renae. “Comanche Cancellation May Reshape Industry,” Washington Post, 25 February 2004. Online. LexisNexis. 9 March 2004.

---

Merle, Renae. "In Defense Bidding, Yankee Doodle Does It: Foreign Firms See U.S. Component as Decisive," The Washington Post, 18 March 2004, Section E, page 1.

Merle, Renae. "New Tankers Not Needed, Report Says – Conclusions May Affect Boeing-Air Force Deal," The Washington Post, 13 May 2004.

Merle, Renae. "Price Tag Jumps for Aircraft; Joint Strike Fighter To Be Delayed," The Washington Post, 19 February 2004.

Mecham, Michael. "Boeing Bets On the Long Haul," Aviation Week & Space Technology, 22 December 2003.

Mecham, Michael. "Defense Holds," Aviation Week & Space Technology, 3 November 2003.

Michaels, Daniel. "Sukhoi Has the World in Its Sights," The New York Times, 7 August 2003, page A9.

"Misspending Military Dollars," NYTimes.com, 5 February 2004.

Montgomery, Dave. "U.S. Helicopter Makers Ask for Federal Support Against Foreign Rivals," Fort Worth Star Telegram, 13 March 2003. Online. LexisNexis. 9 March 2004.

Morris, Jefferson. "Industry Reporting to DoD Panel on Future Heavy Lift Helo," Aerospace Daily, page 5, 24 February 2004. Online. LexisNexis. 9 March 2004.

Morris, Jefferson. "World Civil Helicopter Sales on the Rebound, Forecast Says," Aerospace Daily, 13 January 2004, page 1. Online. LexisNexis. 9 March 2004.

Morris, CAPT Steve. Industrial College of the Armed Forces, Aircraft Industry Seminar, Spring 2004.

Mulholland, David. "Global Hawk authorization lifts UAV industry," Jane's Defence Weekly, 10 September 2003.

Napier, David H. "2003 Year-End Review and 2004 Forecast – An Analysis," Aerospace Industries Association of America, Inc. (AIA), Arlington, VA, 10 December 2003 Online [aia-aerospace.org/stats/yr\\_ender/tables/2003/table4.cfm](http://aia-aerospace.org/stats/yr_ender/tables/2003/table4.cfm).

News Staff, Helicopter Association International. HAI President Submits Testimony to Congress on Reopening DCA to General Aviation," Helicopter Association International, 15 March 2004. Online. Internet. <<https://www.rotor.com>>. 24 March 2004.

---

No Author or Title, Aviation Week & Space Technology, 1 December 2003, page 21.

No Author. "Stretching It," Aviation Week & Space Technology, 6 October 2003, page 57.

Olsen, Col Craig. "V-22 Program Brief." Presented to the Industrial College of the Armed Forces, 12 March 2004.

Onley, Dawn S. and Matt McLaughlin. "Online extra: Defense budget focuses on Transformation," Government Computer News (GCN.com), 9 February 2004.

"OSD Explains Joint Multi-Role Helicopter," AHS International, March 2004. Online. Internet. <<https://www.vtol.org>>. 17 March 2004.

Oster, Sharon M. Modern Competitive Analysis. New York: Oxford, 1999.

Ott, James. "Titanic Struggle Looms," Aviation Week & Space Technology, 22 December 2003, page 50.

"Pentagon Gets it Right," Milwaukee Journal Sentinel, 25 Feb 2004. Online. Internet. <<http://ebird.afis.osd.mil>>. 2 March 2004.

Phillips, Edward H. "Air Canada Jet Order," Aviation Week & Space Technology, 5 January 2004, page 35.

Philips, Edward H. "Demand Rising," Aviation Week & Space Technology, 5 January 2004, page 26. Online. LexisNexis. 9 March 2004.

Phillips, Edward H. "Innovation Key to MRO Survival Plans," Aviation Week & Space Technology, 24 February 2003, Online, [aviationnow.com/avnow/news/channel\\_awst\\_story.jsp?id=news/sb03\\_7.xml](http://aviationnow.com/avnow/news/channel_awst_story.jsp?id=news/sb03_7.xml).

Philips, Edward H. "Looking for Lift," Aviation Week & Space Technology, 15 March 2004, pages 46-48.

Philips, Edward H. "Weak Market, High Costs Hammer Helo Industry," Aviation Week & Space Technology, 10 February 2003, pages 50-53. Online. ProQuest. 8 March 2004.

Phone Interview with Rich Golaszewski from Gelman Research Associates, 27 February 2004.

Phone Interview with Robeson, Richard E., Aerospace Industries Association.

---

Phone Interview with John Menin, Airline Transport Association (ATA).

"Recapitalization: A QDR Issue," Headquarters US Air Force brief, 20 March 2004.

Regional Airline Association Fact Sheet, 12 August 2003, page 1 (from RAA website).

Resavage, Roy. "Commercial Rotorcraft Industry Issues." Helicopter Association International Testimony Submitted for the Record, Tactical Air and Land Forces Subcommittee, House of Representatives Armed Services Committee, 108<sup>th</sup> Congress. 3 March 2004. Online. Internet. 26 March 2004.

Ridolfi, Steven A. "Regional Transports, The Regional Revolution Continues," presented at the International Air & Space Symposium – The Next 100 Years, Bombardier Website, Originally given on 1 July 2003.

Robinson Helicopter Company. Home Page. Online. Internet. <<https://www.robinsonheli.com>>. 11 March 2004.

Roosevelt, Ann; Calvin Biesecker and Amy Butler. "Army Terminates Comanche Helicopter Program," Helicopter News, 24 February 2004. Online. LexisNexis. 9 March 2004.

Schweizer Aircraft Corporation. Home Page. Online. Internet. <<https://www.sacusa.com>> 11 March 2004.

"The Science of Vertical Flight," AgustaWestland Product Brochure, page 4.

Sikorsky, A United Technologies Company. Home Page, 2 March 2004. Online. Internet. <<http://www.sikorsky.com>>.

Sirak, Michael. "Singapore joins JSF programme," Jane's Defence Weekly, 24 March 2004.

Sobie, Brendan. "Japan targets regionals for manufacturing return," Flight International, 19-25 August 2003, page 12.

Sorrells, Niels C. "Commerce Watchdog Growls at Industry's 'Revolving Door,'" CQ Weekly, 24 January 2004.

Sparaco, Pierre, "European Reality Check," Aviation Week & Space Technology, 24 November 2003, page 29.

Standard & Poor's Aerospace and Defense Industry Survey, 23 October 2003.

Standard & Poor's Airlines Industry Survey, 25 September 2003.

---

Sweetman, Bill. "Airlifter turnaround: How the C-17 came good both in production and In action," International Defense Review, 1 November 2003.

Szuchman, Paula. "Sky-High Headache," The New York Times, 12 December 2003, Page W-1.

Taverna, Michael A. "Export Boost," Aviation Week & Space Technology, 23 February 2004.

Taverna, Mike with Douglas Barrie and Alexey Komarov. "Regional Progress," Aviation Week & Space Technology, 15 December 2003, Page 88.

Tellier, Paul. "For a Canadian Aerospace Policy," Bombardier President's Speech given on 17 February 2004 {Bombardier Website}.

"Textron, Incorporated: Company Profile." 19 January 2004. Datamonitor. Online. Internet. <<http://www.datamonitor.com>>. 12 March 2004.

Textron. Home Page, Online. Internet. <<https://www.textron.com>>. 11 March 2004.

The Aviation and Aerospace Almanac (2003). Aviation Week Business Intelligence Service, Washington, DC, 2003

Thompson, Steve (Briefer). "Helicopter Industry Study." Briefing to OSD (AT&L). OSD/IP/BC&R. 1 April 2002.

United States Census Bureau. "Civil Aircraft and Aircraft Engines January 2004," Online [www.census.gov/industry/1/m336g0401.pdf](http://www.census.gov/industry/1/m336g0401.pdf).

United States Census Bureau. "Civil Aircraft and Aircraft Engines 2002," Online [www.census.gov/industry/1/m336g0213.pdf](http://www.census.gov/industry/1/m336g0213.pdf).

United States Department of Defense. Defense Budget Materials FY98 through FY04. <<http://www.dod.mil/comptroller/defbudget/fy2004/index.html>>.

United States Department of Defense. Unmanned Aerial Vehicles Roadmap 2002-2027. 2002.

United States General Accounting Office. Aviation Competition: Regional Jet Service Yet to Reach many Small Communities, Washington, DC, General Accounting Office, February 2001, page 8.

United States Navy Fact File. Online. Internet. <<http://www.chinfo.navy.mil>> 20 March 2004.

---

United States Social Security Advisory Board. Social Security: Why Action Should be Taken Soon. July 2001.

“United Technologies Corporation: Company Profile.” February 2004. Datamonitor. <<http://www.datamonitor.com>>. 12 March 2004.

United Technologies Corporation. Home Page, Online. Internet. <<http://www.datamonitor.com>>. 11 March 2004.

Velocci Jr., Anthony L. and Michael Mecham. “Stonecipher: On Point,” Aviation Week & Space Technology, 16 February 2004, page 40.

Wall, Robert. “Boeing Snags Over \$9 billion in F/A-18 Work,” Aviation Week & Space Technology, 5 January 2004, Online, [aviationnow.com/awin/awin\\_awst\\_story.jsp?issueDate=2004-01-05](http://aviationnow.com/awin/awin_awst_story.jsp?issueDate=2004-01-05)

Wall, Robert. “Mixed Message,” Aviation Week & Space Technology, 19 January 2004, page 414. Online. EBSCOhost. 10 March 2004.

Wall, Robert. “Report Card,” Aviation Week & Space Technology, 2 February 2004, page 55. Online. EBSCOhost. 10 March 2004.

Wall, Robert and David A. Fullghum. “What Next? Helicopter Industry Assesses Impact of Comanche’s Demise to the Trade,” Aviation Week & Space Technology, 1 March 2004, page 22. Online. ProQuest. 8 March 2004.

Wayne, Leslie. “Pentagon Says it Plans to Kill Copter Program,” New York Times, 24 February 2004, page A1. Online. Proquest. 8 March 2004.