

**Spring 2006  
Industry Study Paper**

**Final Report  
*The Aircraft Industry***



**The Industrial College of the Armed Forces**

National Defense University

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## The Aircraft Industry 2006

**ABSTRACT:** The aircraft industry is well positioned to meet the nation's strategic needs and is growing to meet increased demand fueled by strong U.S. and global economic growth. The overall outlook for the industry is positive. Orders for commercial aircraft are up from a boom in air travel that is likely to continue well into the next decade. Recent increases in defense spending provided a much-needed boost for the rotorcraft and unmanned aerial systems industries; the military fixed-wing sectors are expected to remain profitable as well. The industry is increasingly global and interdependent, and technological innovation and lean business practices are bringing greater efficiencies. Healthy competition exists across the industry. Challenges remain, to include domestic content and export control restrictions, declining aeronautics research, an air traffic management system near full capacity, and a shrinking, aging workforce. Government policy actions are required to address these challenges.



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### Domestic

Aerospace Industries Association, Washington, DC  
Bell Textron, V-22, Eagle Eye UAV, UH-1, Armed Recon Helicopter, Arlington, TX  
Boeing Commercial Airplanes Division, B-747/767/777 Production Facility, Seattle, WA  
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Lockheed Martin Aeronautics Company, F-16, F-22, JSF Production Facility, Fort Worth, TX  
Lockheed Martin Corporation Fighter Demonstration Center, Arlington, VA  
Northrop Grumman Integrated Systems, Global Hawk UAV and B-2, Palmdale, CA  
Pratt & Whitney Aircraft Engines, Middletown, CT  
Sikorsky Aircraft Corporation, Stratford, CT

### International

AgustaWestland, Yeovil, EH101 Production & Training Facility, Yeovil, United Kingdom  
Airbus S.A.S., A320/340/380 Production Lines, Blagnac, France  
BAE Systems plc Corporate Offices, London, United Kingdom  
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The image shows a large, faint watermark of the ICAF logo. The logo consists of a circular emblem with a central figure and the text 'ICAF' in large, bold, sans-serif letters below it. The emblem contains the text 'INTEGRITY AND DEFENSE' and 'UNION IS STRENGTH'.

## **INTRODUCTION**

The AY2006 Aircraft Industry Study (AIS) examined the current condition and outlook for eight aircraft industry sectors, identified major issues and challenges for the industry, and recommended changes in government policies to address those challenges. The overall health of the aircraft industry is good, and analysts are optimistic about most sectors over the next decade as the industry is buoyed by strong U.S. and global economic growth. After a decade of consolidation, it is an extremely competitive industry with a global network of suppliers and partnerships that transcend national boundaries and economies.

Increased demand for commercial air cargo and travel is fueling a boom in both the large commercial aircraft and regional jet sectors. The dominant large commercial aircraft makers had banner years in 2005 and expect orders to outpace deliveries in the foreseeable future, while the regional jet fleet is forecast to triple in size in the U.S. market alone over the next five years. European rotorcraft production dominates the civil market, but U.S. manufacturers, responding to a huge increase in U.S. military rotorcraft demand, are expected to be the major beneficiaries of nearly \$80 billion in sales over the next ten years. The competitive jet engine oligopoly is poised to benefit from overall industry growth, but engine makers are increasingly turning to aftermarket services and long-term support contracts for the bulk of their profits.

The future for the military fixed-wing aircraft sectors is less clear. U.S. tactical and strategic transport production lines are programmed to draw down at the same time European militaries expect to begin flying the A400M. Without a new U.S. strategic airlifter in the works, both sides of the Atlantic are vying to win DoD's Joint Cargo Aircraft and tanker replacement competitions. The market for next generation fighters is also uncertain as U.S., European, and Russian aircraft makers seek to replace current inventories as service lives expire.

Unmanned aerial systems (UAS) and aircraft systems integrators are immature sectors that bear watching. Military demand will drive the UAS market until barriers to civil operations are overcome, and over 30 nations offer more than 250 models of unmanned aircraft to meet the varied requirements. The systems integrator label is being applied to more companies as they seek efficiency through focusing on core competencies, outsourcing non-core tasks, and integrating airframes, sub-structures, and subsystems into finished aircraft. Mergers and acquisitions, technological innovation, and leaner manufacturing processes are squeezing excess capacity out of the industry, albeit at the expense of aircraft production surge capacity in the U.S.

While the industry is confident in a profitable future, major challenges remain. Domestic content and export control restrictions erect barriers to efficiency and frustrate international collaboration efforts. Additionally, challenges such as declining aeronautics research funding and fewer scientists and engineers joining the industry may combine to put the U.S. technological lead in jeopardy, and insufficient investment in air traffic management modernization will constrict air travel to the detriment of the overall aircraft industry.

The industry is healthy and able to meet the nation's strategic needs, but there are reasons to tamp the optimism. More in-depth analysis of the sectors, issues and challenges, and policy recommendations are included in the following pages.

## **CURRENT CONDITION AND OUTLOOK OF THE INDUSTRY**

The aircraft industry study focused on eight market sectors: large commercial aircraft, regional jets, rotorcraft, military transports and tankers, fighter aircraft, engine manufacturers, unmanned aerial systems, and aircraft systems integrators. The aircraft industry is largely dominated by revenues from sales and services of aircraft, parts, and related systems in the

commercial passenger aircraft market, though military sectors are also significant. Considerable barriers to entry exist including cost of capital, protected technology, and costly research and development (R&D), which make new entrants unlikely. Technological innovation should continue to influence market gains and losses by leaders in the several industry sectors, but business process innovation may prove more critical to supplier longevity and the long-term health of the aircraft industry. Historically, the health and growth of this strategically important industry is inextricably linked to the overall health and growth of the U.S. and global economies. Aircraft industry trends closely correspond to overall economic trends. Therefore, as analysts predict the U.S. and global economies to continue to grow and be healthy, they agree that the aircraft industry will do the same. As a consequence of those optimistic forecasts, major industry constituents are feeling and acting confidently.

The optimism should be guarded however, as the rising price of oil, the financial frailty of the U.S. airline industry, and the potential economic shock that could result from externalities such as terrorism, pandemics, natural disasters, or a downswing in overheated housing markets deserve a watchful eye during future industry planning. Growth may also be constrained by the ability of the supplier base to meet large manufacturers' demands to assume a larger share of development and production risks.

### **Economic Outlook**

Because aircraft industry business cycles tend to follow general trends in economic activity, the most-used predictor of industry growth is gross domestic product (GDP). U.S. and global economic forecasts are promising through 2017, with U.S. and world GDP increasing at a rate of 3.6 percent and 3.3 percent respectively. U.S. real GDP is expected to grow from \$11 trillion to \$16 trillion over this time period, while world GDP should grow from \$36.1 trillion to \$52.2 trillion. The Asia Pacific region, led by China and India, is expected to grow at a rate of 3.9 percent in 2006, and remain strong at 3.6 percent GDP growth per year from 2007 through 2017. Europe, Latin America, and Canada remain strong as well with projected GDP growth rates of 2.5 percent, 3.9 percent, and 2.5 percent. At the same time, the global rate of inflation is expected to remain at just 2.5 percent per year (FAA, 2006).

The health of the overall aircraft industry rests in large measure with the health of the large commercial and regional aircraft manufacturers. In turn, these producers depend upon the health of the airlines and air cargo companies. The FAA is forecasting a steady increase in air travel over the next 11 years. Commercial air carrier (mainline and regional) passenger loads in the U.S. are expected to increase at an annual rate of 3.1 percent, from 739 million in 2005 to 1.1 billion by 2017. Internationally, the FAA expects annual passenger traffic to increase by 5 percent through 2017, with passengers traveling into and out of the U.S. expected to return to pre-September 11th levels this year. Total revenue ton-miles (RTMs) of air cargo are forecast to increase as well, from 39 billion (2005) to 72 billion (2017), a worldwide annual average of 5.2 percent per year.

The aircraft industry is a sizeable engine within the U.S. economy, directly contributing nearly \$100 billion to the economy in 2005. Approximately 70 percent of the aircraft industry value was attributed to exports. In a year when the U.S. trade deficit reached a record high of nearly \$726 billion, the aerospace industry maintained a trade surplus of \$37 billion (Napier and Ruby, 2006). Excluding aftermarket services and smaller market sectors, industry analysts at the Teal Group are forecasting over a trillion dollars worth of worldwide aircraft production between 2005 and 2014 (Aboulaflia, 2005).

The outlook for the military sector is also strong, though analysts are somewhat less confident with respect to the stability of the DoD market. The Teal Group is forecasting that DoD will invest from \$94 billion to \$102 billion (including supplementals) between 2006 and 2011 for procurement and research, development, test and evaluation (RDT&E) (Aboulafia, 2005). DoD contracts are treated with caution by the aircraft industry, however, as the annual DoD budgeting process adds volatility to procurement and RDT&E budgets.

## **Market Sectors**

### *Large Commercial Aircraft*

The Boeing Company and Airbus, a subsidiary of European Aeronautic Defence and Space Company (EADS), dominate the commercial aircraft sector and are typically measured by deliveries, orders, and backlog. Since Airbus' first aircraft delivery in 1974, it began eroding Boeing's dominant lead until 2003 when it surpassed Boeing deliveries for the first time (US DoC, 2005). Airbus delivered \$23.3 billion worth of aircraft in 2005, up 12.5 percent from 2004, while Boeing delivered \$18.9, up just 2 percent for the same period. For both companies, 2005 was a banner year with \$84.1 billion in aircraft orders for Boeing, a 278 percent increase over 2004, and \$59.8 billion for Airbus, a 150 percent gain. Backorders, though an imperfect predictor of future performance, were also up significantly for both companies in 2005, \$146.6 billion for Airbus and \$140.3 billion for Boeing (Aboulafia, 2005).

Both companies are aggressively competing across the entire spectrum of large commercial aircraft. Each is investing where they suffer a disadvantage in terms of passenger and/or cargo load. Specifically, Boeing is investing heavily in the 250-seat B787 and intends to compete with the Airbus A380 with more capable B747 derivatives. Similarly, while Airbus is investing in the double-decker 550-seat A380, they intend to follow Boeing with a new introduction (A350) to compete with the B787. Both companies will continue to compete with heavy R&D investment in product improvements across the spectrum and seek to establish new supplier relationships in an effort to share product development cost and schedule risk. This competition will serve the public well, as it will reduce the cost of travel and cargo shipping in an increasingly global economy by improving aircraft performance and reducing operating costs.

Boeing and Airbus continue to address disputes regarding public funding or subsidies for research, development, and various parts of their manufacturing processes through the World Trade Organization (WTO). Airbus alleges that Boeing receives funding through state subsidies and R&D reimbursement from the U.S. government (through DoD), whereas Boeing contends that Airbus' R&D is largely funded through government-secured loans by several members of the European Union.

Because of the expected growth in commercial air travel and cargo, the FAA (2006) forecasts a 2.8 percent annual increase in the number of U.S. large commercial passenger planes to be manufactured and put into service through 2017, increasing the fleet from nearly 4,000 to almost 5,500 aircraft. The FAA also predicts a 2.3 percent increase in freighters, from 1,021 to 1,345, in this timeframe. According to Boeing's 2006 Current Market Outlook, the worldwide industry will need over 25,000 new commercial airliners over the next twenty years with a value of nearly \$2.1 trillion (2004 dollars).

### *Regional Jets*

The North American regional jet (RJ) market, dominated by Brazil's Embraer and Canada's Bombardier, has seen significant growth over the last decade, and currently comprises more than

16 percent of the commercial aircraft industry based on units produced (Aboulafia, 2005). While the mainline fleet size remained relatively constant from 2001 to 2004, the active RJ fleet rose by 27 percent in that period, and the FAA expects the number of RJs in U.S. regional/commuter service to more than triple by 2011 (Clement, 2001). Embraer and Bombardier recorded 299 deliveries in 2005, a slight drop from 2004, but saw 2005 orders rise by 23 percent over the year before (Speed News, 2005). The long-term forecast through 2014 shows steady growth in the RJ market with production of more than 2,300 total units valued in excess of \$47 billion dollars (Aboulafia, 2006).

Regional jets have taken over the market niche previously dominated by turboprops, changing the landscape of regional operations by providing increased speed and range and improved passenger comfort. These improvements offered airlines the ability to open longer routes and replace some larger aircraft that were less efficient for regional operations. After a peak in sales during 2001 and 2002, the RJ explosion of the late 1990s leveled off due to financial struggles of U.S. airlines and problems with airport overcrowding. As a result, airlines have cancelled or deferred RJ orders and in some cases returned to limited use of the more economical turboprops. However, as the economy improves and airlines recover from the post-September 11<sup>th</sup> shock, the demand for RJs is increasing.

In response to market changes, both Bombardier and Embraer are expanding their business strategies into 70-100 seat aircraft. Bombardier's CRJ-700/900 aircraft and Embraer's 170/190 E-Jet family will be introduced specifically designed to encroach on the large jet market. Jet Blue, United, US Airways and Canada Air have all placed orders for the new RJ design with the intent to take over routes flown by older and less efficient large aircraft. China, India, and Russia have also placed new Embraer RJ orders and seek to purchase idle aircraft from other RJ manufacturers.

Foreign public policy also plays an important role in the nature of the competition within the RJ market. Financial support by Brazilian and Canadian governments through direct capital investment (debt nationalization), export subsidies, public R&D programs, and other fiscal incentives have been used to bolster the success of RJ manufacturers (Goldstein, 2003). These policies serve as significant barriers to entry for other aircraft manufacturers into the RJ market.

### *Rotorcraft*

Unlike the other aircraft manufacturing market sectors in which the primary players have either a civil or a military focus, the top five rotorcraft manufacturers serve both. The four major vendors in the civil sector are Sikorsky, Bell Helicopter Textron, Eurocopter and Agusta Westland. Boeing joins the list as a military rotorcraft maker, and together these five companies account for 97 percent of the military market sales (Aboulafia, 2005). While Eurocopter leads the civil market by volume of sales (Dane, 2005), no manufacturer dominates the military rotorcraft market or commands a majority of either market segment. Since each manufacturer has a slightly different focus, the rotorcraft sector can be classified as a differentiated oligopoly.

After several years of uncertainty in the military market and stagnation in the civil market, the U.S. rotorcraft industry appears headed for sustained growth and stability. The primary reason for this growth is new orders in the U.S. military market, which dwarfs the civil market in value. Recent industry forecasts predict a total 10-year production of nearly 10,000 rotorcraft between 2005 and 2014. The value of the military market dominates the forecast with more than 5,100 units valued at \$78.8 billion, with the slower growing civil market producing almost 4,900 rotorcraft worth \$16.6 billion (Aboulafia, 2005).

The convergence of several factors, including much of the DoD fleet nearing the end of its service life and the heavy use of rotorcraft in current conflicts and disaster relief, is providing the market with a shot-in-the-arm. Recapitalization of military fleets (largely deferred over the last 10 years) is driving much of the projected growth over the next 10 years. Finding it to be more cost-effective, DoD has shifted to a new-build recapitalization strategy, marking a change from its long-standing practice of remanufacturing aging aircraft. Within the civil market, the resurgence of the economy and the rise in general aviation transportation, together with the growth in the business aviation market, is fueling the projected market growth.

Rotorcraft manufacturers in the U.S. are competing with a strategy of reduced cost through lean manufacturing, heavy R&D investment, and capitalizing on the benefits of civil/military technology transfer. Meanwhile, European manufacturers are attempting to sell on a more global scale at lower profit margins with a strategy of proliferating their products and capturing the aftermarket service revenues. While near-term rotorcraft forecasts are encouraging, the rotorcraft market reliance on government spending, particularly DoD, is reflected in the fact that there have been no breakthrough rotorcraft developments within the last 15 years. Tiltrotor technology has the potential over the long-term to transform the rotorcraft industry, although expected increases in range, payload, and reliability for helicopters like the S92 and the NH90 may close the market window of opportunity for tiltrotors to fill their civil rotorcraft sector niche.

#### *Military Transports and Tankers*

The military fixed-wing transport sector of the U.S. aircraft industry consists of strategic and tactical aircraft with Boeing (C-17) and Lockheed Martin (C-130J) as the two major manufacturers, capturing over 90 percent of the world's military transport market (Aboulafia, 2005). Airbus Military will join EADS CASA (CN-235 and C-295) and Italy's Alenia (C-27J) in the European market with the first A400M delivery in 2009.

The growth picture for military transport and tanker production is unclear. Without foreign military sales, current DoD programs have the C-17 production line beginning to draw down in 2008 and C-130J buys completed in 2009, while Lockheed Martin C-5s are undergoing a reliability enhancement and re-engining program to make them viable until 2040 (SPG Media, 2006). Even with the market sector in decline, it is expected to be worth around \$45 billion between 2005 and 2014 (Aboulafia, 2005). Airbus sees a potential market for the A400M, sized between the C-130J and the C-17, to be 435 aircraft and currently has orders for 192 (Airbus, 2006). The A400M's inability to carry outsized cargo may cause some potential buyers to reconsider their mobility fleet composition, as Australia did when they chose the C-17 to meet their defense force requirements (Ferguson, 2006 and Dane, 2005).

Without a viable strategic military transport market, Boeing and Airbus (teamed with Northrop Grumman) are focused on the Air Force tanker competition to replace the aging KC-135 fleet. A selection decision is expected next summer with an initial buy worth approximately \$20 billion. While there is no coherent plan for a follow-on strategic airlifter, DoD has articulated a requirement for a small intratheater transport aircraft, currently called the Joint Cargo Aircraft (JCA). Lockheed Martin, CASA, and a Boeing-Alenia team have all announced their intentions to compete for the JCA with deliveries to the U.S. Army beginning in 2008 and total program buy around 150 aircraft (Lopez, 2006). Other commercial aircraft derivative programs for the U.S. military include the Multi-Mission Aircraft, the U.S. Navy version of the B737 for anti-submarine warfare and intelligence, surveillance, and reconnaissance, with expected production of 108 aircraft beginning in 2010 (Ramsey, 2004).

### *Fighter Aircraft*

With continued global economic growth, countries are making up for defense procurement holidays, exemplified by the continuing demand for fighters around the world. Forecast International (FI) predicts that “4,000 fighter/attack/trainer jet aircraft will be produced between 2005 and 2014,” with a ten year value of \$157.6 billion (Jaworowski, 2004). Industry consolidations over the last decade resulted in the U.S. having only two fighter aircraft manufacturers, Lockheed Martin and Boeing. Depending on the foreign market and success of the Joint Strike Fighter (F-35), the U.S. may find itself with Lockheed Martin as the only “Fighter House” after 2011. EADS, Sukhoi, and Dassault round out the top five global fighter manufacturers. As opposed to U.S. fighter manufacturers, who compete primarily through innovation and the most advanced technology available, European manufacturers balance affordability with capability, and Sukhoi depends on rugged reliability.

With the exception of a restructured F-22 program production reduction in 2007, future projections for the worldwide fighter industry show a steady delivery rate of about 275 fighters per year through 2012, followed by a downward trend through 2015. Not all analysts agree entirely. Based on anticipated and firm aircraft orders, Aviation Week & Space Technology predicts a decline in the number of US fighters produced through 2009, with the trend reversing in 2011 as most of the world’s air forces recapitalize and JSF begins production (Dane, 2005). Total world market value (in 2006 dollars) through 2015 is estimated at \$113 billion with Lockheed Martin dominant share at \$51.5 billion, followed by EADS (\$30 billion), Boeing (\$21.5 billion), Sukhoi (\$11 billion), and Dassault (\$8.5 billion). U.S. production alone (F-16, F-15, F-18, F-22, and F-35) is valued at \$73 billion over the same period (Aboulafia, 2006).

Boeing and Lockheed Martin each have two open production lines. Boeing is producing the F-15C/E and F/A-18E/F/G while Lockheed Martin is producing the F-16 and F-22. Current DoD planning includes only F-35 purchases after 2010, so only foreign direct or foreign military sales will keep these four lines open beyond 2011. Part of Lockheed Martin’s strategy is to stretch their production lines long enough to facilitate the most cost effective production transition to the F-35.

Expected to be an extremely cost effective fighter, the F-35 will be produced in three variants: short takeoff and vertical landing for the U.S. Marines, a carrier variant for the Navy, and a conventional takeoff and landing (CTOL) version for the Air Force. The CTOL will logically be the variant of choice with foreign militaries, and future potential foreign sales are anticipated to be high. Since the introduction of the F-16 in 1975, over twenty foreign countries have purchased more than 2000 of these fighters (Lockheed Martin, 2005), and the F-35 CTOL variant is the primary contender as an F-16 replacement when their service life expires. A high volume of foreign direct and foreign military sales are essential to reducing the future cost of the F-35 for DoD, but foreign sales are in jeopardy pending resolution of technology transfer issues with partner nations.

Some analysts recommend canceling the CTOL variant, though that would greatly increase the unit cost for DoD. While the 2006 Quadrennial Defense Review opted to retain the CTOL variant, it leaves in question the potential for its cancellation in the future. Cutting the CTOL will likely encourage international customers to buy many of its 2000-plus F-16 replacements from a non-US manufacturer. The subsequent F-35 cost increase to DoD means this decision carries great weight, perhaps factoring as importantly as U.S. military requirements themselves.

### *Engine Manufacturers*

The global aircraft engine manufacturing market is an extremely competitive environment dominated by four major companies. General Electric Aircraft Engines (GEAE) is the largest producer, followed closely by the U.K.'s Rolls Royce Aerospace unit and United Technologies' Pratt & Whitney division; France's Snecma holds the smallest market share. These four companies create an oligopoly that accounts for nearly all of the aircraft jet engine industry.

With the large number of aircraft expected to be built over the next 10 to 15 years, the market remains strong with a good balance between the demand for military and civil engine requirements. In general, the civil market accounts for almost two-thirds of the revenue, but the military engine markets have been an important source of financial stability, allowing this industry sector to remain profitable through market disruptions on the civil side, such as occurred after September 11, 2001. In 2004, the global jet engine market was worth an estimated \$38.3 billion (S&P, 2006), with aircraft engine and engine parts valued at over \$16 billion per year (Napier and Ruby, 2006).

Intense competition has driven the four market leaders to move to a consortium approach, spreading both the risks and rewards associated with multi-billion dollar development costs for new aircraft engines. International Aerospace Engines is a Pratt & Whitney, Rolls-Royce, Japanese and German venture producing the primary engine for the Airbus A320 family, and CFM, a GEAE and Snecma venture produces the most popular engine in use today – the CFM-56. The strategy of international partnering is also useful for gaining access to markets (like DoD) dominated by other manufacturers (Bartron & Gamlin, 2004).

High development costs for new engine design have made revolutionary advances a risky proposition in the civilian engine market. Responding to narrow profit margins in the commercial airline industry, most manufacturers offer incremental technology improvements on already proven or derivative engine designs to deliver increased fuel efficiency and reliability. Additionally, environmental concerns over noise and emissions are beginning to drive some R&D efforts. Intense competition forces manufacturers to routinely price new engines at or below cost. As a result, engine producers are aggressively seeking additional profits by expanding their aftermarket service and long-term service support contract operations. (Licht, 2006) Pratt & Whitney's recent incursion into reverse engineering and manufacture of competitors' parts has the potential to destabilize aftermarket competition and ultimately force manufacturers to recoup development costs in their engine pricing strategy.

In contrast to the civilian market, military-funded programs continue to expand the envelope on jet engine design. The stringent requirements imposed by fifth generation fighter development pushed innovative designs that will deliver performance and reliability at even higher levels. Increased government emphasis on logistics support and maintainability has simplified maintenance procedures and reduced total ownership costs. Many of these improvements will work their way back into the civilian market and provide significant savings (Destefani, 2005).

### *Unmanned Aerial Systems*

The growth of the unmanned aircraft systems (UAS) market will make a small, but positive contribution to the aircraft industry. Over 30 nations are developing or manufacturing more than 250 models of unmanned aircraft, primarily for reconnaissance use, and over 9,000 unmanned aerial vehicles (UAV) are expected to be purchased over the next 10 years. The value of this

market, expected to be worth about \$13.6 billion (not quite a percent and a half of total industry revenues) through 2014, is generated largely from defense applications (Dickerson, 2005).

The increased demand for military UAS results from their ability to provide real-time intelligence, surveillance and reconnaissance to battlefield commanders, proven by tactical and theater UAS flying over 100,000 hours in the past year supporting the Global War on Terror. DoD invested \$2 billion in UAS in 2005 and has over 2,600 small UAVs and over 300 tactical and theater-level UAVs supporting military operations worldwide (Weatherington, 2006). The tactical and theater level UAV inventory is expected to grow to 1,400 by 2015, with a wider range of missions including signals intelligence, cargo, communications relay, and suppression of enemy air defenses (OSD, 2005).

There is potential for civil UAS market growth, mostly for homeland security, immigration control, and law enforcement, but growth in these non-defense unmanned systems is constrained by obstacles to integration into the national airspace. Obstacles to UAV integration into the national airspace are both practical and cultural. Practical obstacles include a paucity of command link frequency bandwidth available and a lack of mature see/sense-and-avoid technology, while cultural obstacles include concerns over mid-air collisions with unmanned vehicles that are too small to detect visually or with radar. Consequently, only a limited investment has been made by industry in the civil UAS market and, with the exception of some niche applications, analysts do not see an emerging commercial market over the next ten years.

#### *Aircraft System Integrators*

The consolidation within the aircraft industry, coupled with the rapidly accelerating complexity of aircraft and associated systems has resulted in far fewer prime aircraft manufacturers overall, and none that solely build complete aircraft. In order to reduce costs and spread developmental risks, many of today's aircraft manufacturers are focusing on their core capabilities and outsourcing large portions of aircraft design and manufacturing to a diffuse base of subcontractors that have more narrowly focused, and therefore greater expertise in the design and manufacture of aircraft sub-structure and subsystems. There remains the requirement by the prime contractors to be systems integrators, bringing it all together in the end, assembling and integrating all systems into a fully and effectively functioning operational aircraft.

Prime contractors like Lockheed Martin, Boeing, BAE, Northrop Grumman, and Raytheon are increasingly engaged at the subcontractor level as system integrators. For example, although Northrop Grumman did not compete at the prime level for the Joint Strike Fighter program, the company won the \$200 billion-plus contract to design and integrate the fuselage and weapons bay of the aircraft. Integrated systems accounted for 17 percent of Northrop Grumman's total sales base in 2005 (Hoovers, 2006). Lockheed Martin's Electronic Systems segment offers systems integration and program management for fixed- and rotary-wing aircraft and weapon systems, such as the systems-intensive MH-60R. Boeing Integrated Defense Systems accounted for 20 percent of Boeing's 2005 sales base and was formed when Boeing combined its Military Aircraft & Missile Systems and Space & Communications units. This division of Boeing is a subcontractor to Lockheed Martin for the F/A-22, responsible for wings, aft fuselage, and avionics integration. As prime contractors maneuver for greater market share, the systems integration sector is becoming extremely competitive and may change the way in which traditional aircraft manufacturers identify themselves.

## **Innovation**

Adaptive business practices and strategies may have the largest impact on the future health of the aircraft industry. Far ahead of most of their European peers, U.S. manufacturers and suppliers are aggressively employing the principles of Lean Manufacturing, Six Sigma, and Theory of Constraints to maximize efficiency, lower costs, and increase volume or reduce infrastructure to minimize excess capacity. Aircraft manufacturers are also focusing on core business functions, while globally outsourcing functions that can be accomplished more efficiently by other suppliers and engaging in intricate partnerships with traditional industry rivals. They also continue to consolidate and grow market share and revenue via mergers and acquisitions and, in cases such as BAE Systems and BAE plc, aggressively pursuing a strategy of mergers and acquisitions over one of product development. Finally, original equipment manufacturers are shifting their business strategies to expand their share of the aftermarket revenue available once they place their products in service. Selling spare parts, providing logistics and maintenance support, and conducting repair and overhaul in addition to traditional aircraft design, development and production, are becoming the business model norm. These business practices and strategies are improving overall industry efficiency.

Technological innovation also positively affects the outlook for the industry. Such innovation is evident at Boeing, for example, which is the first company in the commercial airline manufacturing market to develop primary aircraft structural components made from composite materials. Getting the B787 technology certified by the FAA will be a challenge and a risk for Boeing, but if they are successful, Boeing will be able to reduce basic aircraft weight and enhance performance and fuel efficiency – potentially as much as 20 percent per flight, according to Boeing representatives. Other major R&D examples include Pratt & Whitney with their Geared Turbine Fan engine and Sikorsky with their 250 knot X2 pusher-prop rotorcraft (Wang, March 17, 2006). Though generally viewed as key to growth, investment in R&D is not uniformly emphasized across the industry.

## **Surge Capacity**

Maximizing production efficiency comes at a cost, however. Aircraft industry structural characteristics, government policies, and resource constraints have combined to limit military aircraft production surge capacity. Most major military aircraft programs are being executed on a single production line with excess capacity estimated at 10-20 percent for fixed-wing and 20-25 percent for rotorcraft and engines. Another limiting factor is the consolidated supply base that has integrated into both civil and military markets as a single supply chain source provider. This shrinking number of suppliers provides over 70 percent of value added to aerospace products, and will have less excess capacity to respond to a surge in military aircraft demand as the commercial aircraft market expands (Beadle, 2006). Limited investment in long-lead items and domestic content restrictions, such as specialty metals, make some suppliers a critical link in the fragile supply chain.

The industry's relatively high fixed-cost structure and a rising number of developmental projects will continue to force companies to compete on the margins (S&P, 2005). Emphasis on leaning out excess production capacity in search of higher returns on invested capital is a common theme among major aircraft manufacturers, and will further limit the ability to surge. Besides plant capacity, the industry is limited in its ability to hire and train skilled workers, and attract science and engineering professionals. The large capital investment required to add back "leaned out" capacity would take several years to produce meaningful increases in aircraft

production. However, changes in DoD's force sizing construct and operational employment concepts with their emphasis on technological superiority make aircraft industry surge capacity requirements less important than in previous eras.

### **Guarded Optimism**

Woven through the confidence within the aircraft industry are threads of caution stemming from the price of oil, the financial health of airlines, and low, but ever-present potential for economic recession. While domestic mainline and regional air carrier passenger loads increased by 6.6 percent last year (628.5 million to 669.8 million), domestic airline financial yields decreased by 4.8 percent (Price, 2006). The per-barrel price of oil more than doubled since the beginning of 2004, resulting in an increase in jet fuel prices that is a serious drag on the airline industry even as the airlines begin to raise fares to compensate. While future prices are predicted to be lower than today's \$72 per barrel, further increases, combined with new emission standards, would have serious negative impacts on a cash-strapped airline industry struggling to replace legacy aircraft, and consequently on the commercial aircraft sector of the aircraft industry (Brown, 2006).

Another concern is the weak financial performance of U.S. airlines (Warlick, 2006). Five years of airline operating losses and negative cash flows have led to large levels of debt. Cash flows are highly sensitive to fuel prices and balance sheets depend upon the ability to make heavy principal payments. Therefore, the future inability of the airlines to make capital investments in their aircraft fleets is a risk for the aircraft industry.

Finally, while key analysts do not expect a near-term recession in the U.S. economy (Behraves, 2006), the economic effect of externalities to the industry should not be dismissed. Recent natural disasters around the world, pandemics such as Sudden Acute Respiratory Syndrome, and acts of terrorism have strained economic growth in some parts of the global economy. The U.S. economy weathered these events well, but potential economic shocks from future events combined with concerns about major economic drivers like the overheated housing market provide an undercurrent of caution for optimistic GDP growth predictions. Furthermore, with the global sourcing of materials and suppliers to all sectors within the aircraft industry, any major regional economic shock could have an impact on aircraft production throughout the industry. A downturn in U.S. and global economies would have a significant negative effect on the overall industry.

## **INDUSTRY CHALLENGES**

### *International Collaboration*

The major challenge to expanding international, especially transatlantic, cooperation lies in the debate over domestic content legislation, control of and foreign access to technology, the U.S. licensing process and organization of the export control system, and the economic effects on American industry of retaliation by foreign firms. When asked to comment on these issues, every defense contractor who briefed the aircraft industry study seminar expressed frustration at the complexity and costs of the current system.

Oversight of U.S. defense related exports is important and should be regulated to preclude transfer of sensitive or proprietary technologies to potential adversaries. However, the current system of oversight is complex, fragmented, and overlapping. Four executive departments, Commerce, State, Defense, and Energy, are involved in supervising/licensing exports. Industry

leaders commonly identify several problems with the existing system. First, overlapping jurisdiction for certain dual-use (civil/military) products often makes it unclear where exporters need to apply for licenses. Second, extended time periods required for license approval compromise the reliability of U.S. suppliers to meet component delivery schedules. Third, the current licensing system does not reflect trends towards globalized horizontal integration, foreign availability of dual-use items, and the economic impact of export controls on the industrial base. Finally, there is little opportunity for consistent judicial review of licensing decisions owing to the fragmented licensing decision process.

Domestic content legislation, like the Buy American Act and the Berry Amendment, make manufacturing and accounting processes more difficult and less efficient, hence more expensive for both manufacturers and DoD. Political rhetoric surrounding such protectionist measures invites foreign retaliation in purchasing decisions. This retaliatory mindset combines with frustrations over technology sharing to discourage international cooperation with close allies and has a negative economic effect on a major U.S. net exporting industry.

### *Declining Aeronautics Research*

There exists growing concern that the U.S. is investing too little in aeronautics science and technology (S&T) and too inefficiently in aeronautics research, development, test and evaluation (RDT&E). The DoD investment in S&T, which includes basic research (6.1), applied research (6.2), and applied technology (6.3), will decline by 18.6 percent from \$13.8 billion in 2006, to \$11.2 billion, in 2007. At the same time, DoD funding of RDT&E in 2007 has the potential to reach a record high of \$63 billion (Koizumi, 2006). While the trend in RDT&E investment might appear to positively offset a decrease in S&T investment, the Government Accountability Office (GAO) disagrees. The GAO has consistently reported that DoD inefficiently applies research funding in the RDT&E phase. Last year, the GAO estimated the top five defense development programs grew from an original estimate of \$281 million in 2001, to an actual cost of \$521 million. The GAO estimates that DoD development programs (RDT&E, 6.4 and higher funding) typically over run cost and schedule estimates by 20 to 50 percent (GAO, 2004).

U.S aircraft industry suppliers aren't emphasizing S&T investment relative to RDT&E investment either. Lockheed Martin reported substantial R&D investment last year and averaged approximately \$1 billion per year for the last three years. This investment however, was made primarily using DoD Independent Research and Development funds focused on defense related, near term RDT&E programs, vice (Lockheed Martin, 2005). The Boeing Company, which invested \$1.88 billion in R&D in 2004 and \$2.2 billion in 2005, was primarily investing in the research and development of the B787 (Boeing, 2005).

There are various potential long-term consequences to the U.S aircraft industry and the DoD disproportionately investing in nearer term aeronautics research and development at the expense of longer term yielding S&T. There is concern that fewer scientists and engineers will enter the aircraft industry and that fewer advanced innovations will be made relative to the rest of the global aircraft industry. Additionally, the maturity of high technology innovations, which would preferably occur in the S&T realm, will tend to be less mature when they are incorporated into RDT&E programs, causing unnecessary cost and schedule over runs. Overall, the long-term concern is that the U.S. aircraft industry might lose its technological lead in the industry, which could have damaging economic and security implications for the United States.

### *Air Traffic Management*

Providing safe, efficient, and effective air traffic control is essential for economic growth but will be challenging as it suffers from a sub-optimized program management structure and relatively low levels of investment capital. The Boeing Company expects the volume of commercial airliner traffic to double by the year 2025 (Boeing, 2006), while the GAO expects overall air traffic to triple during the same period (GAO, 2006). The Federal Aviation Administration (FAA) recognizes this future challenge, commenting in its FY 2007 Budget In Brief that, “We must be prepared to support a system that includes the A380 and the microjet (and everything in between)” (FAA, 2006).

“With the U.S. air traffic system at the point of gridlock, transformational improvements are needed to address capacity shortfalls and in other areas that facilitate long-term growth such as safety, security, efficiency, and environmental performance” (Romanowski, 2006). The current system is a highly compartmentalized, hierarchical, self-limiting architecture (Venneri, 2002). Initial modernization progress has been slow, prompting various GAO investigations that conclude that while recent initiatives appear promising, the complex modernization program management structure creates an extremely challenging environment (GAO, 2006).

Lean federal budgets are slowing air traffic control modernization. This will become more challenging as the President’s 2007 Budget Proposal reduces FAA funding by \$143 million overall (Douglas, 2006). The FAA requested \$2.5 billion for facilities and equipment in each of the last three years, of which \$1.7 billion was for infrastructure mobility improvements, \$3.7 million for navigational aids, \$479.7 million for safety improvements, and \$237.5 million for telecommunications improvements – all intended to help modernize air traffic control efficiency and effectiveness (FAA, 2006). While these appear to be large sums of funding, the GAO considers them insufficient. (GAO, 2006)

### *Effective Management of Human Capital*

Regardless of the industry or profession, the greatest asset of a highly industrious nation is its work force. Skills, experience, and intellectual capital are not easily replaced within the aircraft industry, where it takes years to educate and train highly specialized artisans and engineers. According to Aviation Week & Space Technology (January 2006), 27 percent of the aerospace manufacturing workforce will be eligible for retirement in 2008 (Napier, 2006). At the same time, labor union agreements at aircraft manufacturing facilities obstruct retention of younger employees. As a result, the manufacturing workforce within the aircraft industry averages in the mid-fifties across the nation, while the total employment within the aircraft industry is at a 59-year low (Napier, 2006). Facing stiff competition from newer industries like computing and biotechnology, the aerospace industry now employs just 2 percent of U.S. engineers and scientists, down from 20 percent in the mid-1950s (AW&ST, 2004). Within the education system as a whole, the National Science Board highlighted a growing national concern with pre-college education in science, technology, engineering, and mathematics (NSB, 2006).

Aircraft programs have become more complex and require in-depth education and experience to successfully integrate concepts across multiple high-tech systems and platforms to deliver reliable capability. At this juncture, with the industry on the cusp of significant growth over the next two decades, there is concern that there will be insufficient expertise to meet future demand. Boeing Commercial in Seattle, for example, is now hiring 500 new employees per month. The training and education challenge this presents as the factories are flooded with new, inexperienced laborers will impact production throughput, quality, cost, and potentially safety.

## **GOVERNMENT GOALS, ROLES, AND POLICY RECOMMENDATIONS**

### **Goals and Roles**

With respect to the U.S. industrial base and specifically the aircraft industry, the role of the U.S. Government should be guided by two overarching goals: a vital, growing economy and a safe and secure nation, people, and way of life. Objectives that support these goals include encouraging and nurturing economic competition and growth, industrial efficiency and effectiveness, and advancing innovation in science and technology for aircraft design and manufacturing. Additional objectives include overseeing the safety and efficiency of air travel and the safety and efficacy of both civil and military aircraft. Finally, the U.S. Government must keep in mind the basic philosophy of free market economics when interacting with the aircraft industry, which is to interfere as little as possible, and only when necessary to ensure it best serves the greater public good.

The U.S. Government plays the roles of regulator, customer, and advocate in support of its goals. As regulator, the government is responsible for setting and enforcing standards for the manufacture of safe aircraft and aircraft systems, ensuring their safe and efficient operation within the National Airspace System, and monitoring aircraft and aviation industrial safety. As regulator, the Government also oversees aerospace commerce to include mergers and acquisitions, export controls and licensing, and foreign military sales. As an aircraft industry customer, the U.S. Government is the lead buyer of aerospace products in the world, spending roughly \$46.7 billion in 2005 for DoD and NASA, with DoD aircraft and missile purchases accounting for nearly \$31 billion (Aerospace Research Center, 2006). Finally, the U.S. Government fills the role of industry advocate, attempting to nurture the aircraft industry, to enhance its efficiency and buttress its future health as part of the U.S. industrial base. The government supports the aircraft industry's position as the world's leading exporter of aircraft and aerospace products, and it serves as both an advocate and partner of the aircraft industry as it invests and incentivizes investment in research, development and science and technology innovation, to help maintain the industry's technological leadership position throughout the world.

### **Policy Recommendations**

While policy makers debate whether market forces are sufficient to shape the U.S. aircraft industry for future success and sustained economic growth, the AIS seminar believes the industry challenges described above require certain restrained governmental policy actions. These actions include reducing the barriers to effective international business collaboration, stimulating aeronautics research, re-engineering the ATC system, and encouraging investment in training and education for the future workforce.

The need to control the transfer of sensitive capabilities and technologies to potential adversaries is not in question, but the government needs to revamp the Export Administration Act to consolidate export oversight and licensing within a single executive agency, preferably the Commerce Department's Bureau of Industry and Security. This will clarify and streamline the export control process while simplifying Congressional oversight through the House and Senate Commerce Committees. Domestic content legislation should be changed to stimulate vice protect industries critical to national security and to integrate domestic suppliers into the aircraft industry's global supplier network. This must be accomplished without the burdensome and inefficient separation of manufacturing and accounting processes.

In an effort to maintain its global position of technological leadership the U.S. government should increase direct and indirect funding of science and technology investment. Direct funding increases, in the forms of grants and contracts, should be made to aeronautics-related 6.1, 6.2, 6.3 funding with funds being made available as a result of more disciplined, more efficient execution of development programs by DoD. Greater indirect funding of S&T investment by private industry should be incentivized by way of larger tax credits and allowances for these investments.

Current research and experimentation tax credit provisions incentivized claims from over 10,000 different claimants, for a total of \$6,356 million in 2001 (Moris, 2005). The government should increase the amount of tax credit allowed for research and experimentation, and to incentivize S&T over R&D, the tax law should discern between shorter-term research and development and longer term science and technology investments. Additionally, as these are not currently permanent tax credit provisions, the U.S. should make these credits part of the permanent tax law so companies can rely on them well into the future.

The current structure of the FAA's Joint Planning and Development Office (JPDO) is too complex to lead the transformation of the ATC system effectively. There should be a single joint/interagency manager for the modernization program, reporting to an independent acquisition authority and capitalizing on the analytical capabilities already funded by the U.S. government to study and validate the requirements and costs of infrastructure modernization. Further, the government must ensure adequate tax revenues are available (possibly through additional per-seat taxes) to fund capacity upgrades that will keep pace with expected growth in air travel.

Responding to the loss of industry expertise brought about by an aging, retiring workforce, policy makers must make a concerted effort to bolster pre-graduate level science, technology, engineering, and mathematics programs. Federal and state governments should collaborate with industry to expand industry-academia cooperative partnerships and non-degree apprentice training programs that provide a talent pool from which the aircraft industry can draw. Tax incentives should also be provided to stimulate industry investment in training and education programs.

## **SPECIAL INTEREST AREAS**

The Aircraft Industry Study Seminar also provided analysis for other government agencies on several special interest areas. These focused studies include "Follow-on Product Support", "Air Force RDT&E Investment and Procurement Expenditures", and "Challenges Facing the Expansion of the UAS Industry." Essays describing these issues follow.

### **Follow-on Product Support**

The AIS examined the growing trend of follow-on product support and aftermarket services provided by major aircraft and original engine equipment manufacturers. The increase of product support innovation and the expansion of corporate strategies in this area are of significant interest to DoD as it seeks to maximize the value of sustainment funds without expanding its support force structure. The objective was to identify and analyze the various aspects of key industry follow-on product support investment trends, implications of these trends for the U.S. military, and capture industry best practices that the U.S. government might consider as it develops policy and contractual agreements with aircraft and engine manufacturers.

The government spends billions of dollars annually in the procurement of defense equipment and even more to sustain it. As technology increases so does the capability and complexity of procured items, thus increasing the need for an extended product lifecycle. The need for more advanced and varied options in follow-on product support programs increases exponentially with the quality and technology of the items procured. As programs mature, options into the civil sector increase the potential for full contract product support. The commercial and government relationships garnished by future contractual agreements are a significant factor in the metrics of product support programs.

Among the leaders in product support, Caterpillar Inc. clearly serves as a non-aircraft “best of breed” product support model and benchmark for comparison and reference to aircraft and original equipment engine manufacturers. Additionally, within the aircraft and engine manufacturer industries, Rolls-Royce provides a wide range of product support options and reflects a dedication to customer support and long-term partnerships that dwarfs its competitors. The innovation and commitment to extended product life cycles that these two firms reflect is but the tip of the iceberg for a growing number of product support initiatives that may have potential implications with regard to future procurements within the government defense sector.

For decades, product support and customer service was routine and often a complimentary by-product of most original product sales; however, firms are expanding the scope and quality of their individual product support programs. Most industry firms and prime suppliers surveyed are now using advanced technology and greatly improved business practices to expand their corporate strategies in the product support sector. Industry surveys indicate uninterrupted product performance, long-term reliability, technical response, warranty fulfillment, and parts availability are the primary drivers of consumer satisfaction. Innovation and technology advancements have allowed firms to provide a wide range of product support capabilities, tailored and specially designed to meet the growing demand of individual customer requirements. The improvements in product support and respective service packages range from providing reliable, quality parts and technical advice to full spectrum service support agreements designed to ensure a guaranteed level of performance for a defined period of time over the lifecycle of a product.

As product support initiatives expand within the industry, the U.S. military must be keenly aware of these changes and their implications that may require a revision of current procurement policies, practices and strategies. Continuous review of specific business case analysis and confirmation of contractual product support metrics is critical with long-term and performance based contracts. Military commitment to long-term product support programs may also result in a reduction of current support capabilities (i.e. training, repair equipment, technical knowledge) that cannot be readily reproduced if product support metrics are not sustained or contract agreements are terminated. Of most concern is the implication of product support programs and their affect on aging legacy military aircraft. One final implication of key importance to the military is the cost of product support programs. Increased innovation and higher levels of performance come at a higher cost that future military funding levels may not be able to absorb.

Clearly, follow-on product support and aftermarket programs are emerging and changing rapidly as an innovative expansion of both the Aircraft Industry and original equipment and engine manufacturers. As technology advances the product capabilities and cost, the need for unique and tailored product support programs to extend their life cycle and reliability also increases. Despite potential implications, the emergence of innovative industry product support

trends provides a wide range of benefits for the military in future procurements and contractual agreements with aircraft and original engine manufacturers.

*Col Scott McGowan, USMC and COL Joe Dunaway, USA*

### **Air Force RDT&E Investment and Procurement Expenditures**

The AIS analyzed the United States Air Force (AF) investments in Research, Development, Test, & Evaluation (RDT&E) and procurement expenditures to determine if AF RDT&E investments are disproportionately high compared to procurement expenditures by reviewing past and projected AF RDT&E investment spending. This information was then compared with US Navy RDT&E investments and with overall DoD RDT&E investments.

According to the Congressional Budget Office (CBO), the AF has spent between \$10-20B (FY06\$) per year of its investment dollars on RDT&E since 1980. While procurement funding has varied significantly over the years, RDT&E funding has remained relatively stable. In the mid-90s, the AF went through a lull in procurement as a result of a natural recapitalization down cycle compounded with significant budget cuts and challenges. This period is commonly referred to as the “procurement holiday,” during which the ratio of procurement to RDT&E dropped to 1:1, an all time low. In 1984, that same ratio was 3:1, while current day projections average near 2:1 from 2007 to 2024 (CBO, 2006).

Like the AF, equipment used by the Navy is considered high-tech. By reviewing aircraft investment spending detailed in recent DoD P-1 and R-1 budget documents, one can see that the AF, in recent years, has invested at a higher procurement to RDT&E ratios for aircraft investments than the Navy. The average AF procurement to RDT&E ratio for the period 2004-2006 is 2.5:1, compared to the Navy’s 1.9:1 ratio for the same period. One program that clearly falls well outside this “norm” is the F-22 program (DoD, 2006). According to a GAO assessment of selected weapons systems, the F-22 total development cost is projected at \$32.8B, while its total procurement cost is projected to be \$32.1B, a 1:1 ratio. On the other hand, the same report projects the F-35 JSF total development cost to be \$45B, while its total procurement costs are projected at \$161B, nearly a 4:1 ratio (GAO, 2006). While some AF RDT&E programs have held high development costs, it is determined that the AF total RDT&E investment ratio is on par with the Navy procurement and RDT&E.

As a comparison to the overall DoD investment spending history, a study by Thor Hogan in a 2005 RAND National Defense Study, showed that from 1980 to 2003 the DoD maintained an overall procurement to RDT&E spending ratio approaching 2:1 (Hogan, 2005). More recent data from the Aerospace Industries Association (AIA) Aerospace Facts & Figures (2006) for the period 1997-2006 also shows an average procurement to RDT&E ratio approaching 2:1 for the overlapping periods. This ratio is the same as the current day projected AF average investment ratios of 2:1 from 2007 to 2024 (CBO, 2006).

Air Force investment in RDT&E for 2004-2006 showed that about half of these funds were for aircraft, space, and missile systems (Aerospace Research Center, 2006). The remaining was spent on activities such as applied research, advanced technology development, system development and demonstration, and advanced component development and prototypes. These other activities are not tied directly to an operational weapon system such as the F-22 or C-17 (Aerospace Research Center, 2006).

One might expect that the AF would experience a higher average RDT&E ratio than the DoD average due to the fact that its air and space weapon systems are very high tech items that are expensive to develop. Furthermore, as aircraft weapon systems become more high-tech,

fewer aircraft are usually required to accomplish a given mission. For example, in Operation Iraqi Freedom, two F-16CJs loaded with four Laser Guided or GPS aided bombs could destroy the same target set that required four to six F-16As using “dumb bombs” during Operation Desert Storm. As the AF recapitalizes its legacy aircraft fleet, its high tech aircraft that are required to operate effectively and efficiently in tomorrow’s war, are significantly more expensive than their predecessors. As AIA reported in the 2006 Aerospace Facts and Figures, an F-22 in 2004 cost the Air Force \$176M per copy. This is over double the cost of an F-15E, and over five times the cost of the most expensive AF version of the F-16 (Aerospace Research Center, 2006). Likewise, while airlift and tanker replacement aircraft are significantly more capable than their predecessors are, the technologies in these aircraft come at a premium RDT&E and per-unit cost.

A closer examination of more detailed AF aircraft and space investment spending reveals that the AF investment ratio is actually similar to the DoD investment ratio. All aircraft RDT&E and procurement funding for 2004-2006 includes the cost for new aircraft as well as legacy aircraft and engine modification (Aerospace Research Center, 2006). Development and modification funding for activities such as service life improvement programs are included for aircraft such as the F-15, B-1, and E-3. Another instructive data point shows a similar ratio (2:1) for space systems (Aerospace Research Center, 2006). Examples of key Air Force funded space systems include Space Based Infrared System (SBIRS), Global Positioning System (GPS), and Evolved Expendable Launch Vehicle (EELV). None of these programs benefits only the Air Force. Some, like GPS, not only serve the Joint/Allied forces, but also serve the world civilian users at no cost. The point here is that while the Air Force may not benefit financially by sharing the benefits of its space systems, the US and world economy, as well as the general welfare of the public, benefit by having access to technology developed under AF appropriations.

To summarize, AF investment spending ratios have varied significantly since the mid-80s. The concern that the AF is spending too much on RDT&E and not enough on procurement turns out to be not well founded. Based on available information, funding projections for aircraft RDT&E is near a 2:1 ratio and is comparable to the overall DoD and Navy ratios, and is not unreasonable based on historic trends.

*Col Scott Williams, USAF and Lt Col Gene Carter, USAF*

### **Challenges Facing the Expansion of the UAS Industry**

The UAS sector of the aircraft industry is a healthy and expanding market. To date, UAS have been used primarily for military operations. There is potential for a strong civil market. However, government and industry officials must first work to resolve several challenges associated with integrating UAS into the national airspace, including radio frequency spectrum management and public privacy concerns which are the subjects of this study.

The UAS sector of the aircraft industry has experienced consistent growth over the past 10 years and that trend is expected to continue over the next 10 years. To date, UAS market growth has been driven primarily by military demand for UAS capabilities. Estimates indicate the market should be worth an estimated \$13.6 to \$17 billion over the next 10 years with the production of approximately 9,000 new unmanned aircraft. The civil UAS market has the potential for significant growth. However, there are significant challenges to the commercial use of UAS. Specifically, current regulations to operate UAS in civil airspace are burdensome and restrictive. Federal agencies are working the UAS airspace integration challenge, although it will likely be several years before authorities determine a means to safely and quickly integrate

UAS into civil airspace. Further, industry officials are concerned about UAS safety and reliability and the associated insurance and indemnification liability. Consequently, only a limited investment has been made by industry in the civil UAS market. Therefore, a commercial (non-governmental) UAS market is not expected to emerge over the next 10 years except in some niche markets.

Among the challenges to UAS growth is the management of the radio frequency spectrum. The radio frequency spectrum is considered a vital and limited national resource. However, the existing legal and policy framework for spectrum management has not kept pace with the dramatic changes in technology and spectrum use. Consequently, in June 2003 President George W. Bush established the Spectrum Policy Initiative to develop and implement a United States spectrum policy for the 21st century. In response to the initiative, a Task Force was established which developed a plan to implement the spectrum policy initiative with seven focus areas. Although the initiative is a step in the right direction, it does not resolve the fundamental problem associated with the spectrum management process which is laborious, time consuming and considered arcane by several industry officials interviewed for this study. Although the spectrum management process is considered a burden, it was noted that it is not the primary challenge associated with integration of UAS into the civil airspace. Rather, the consensus of those interviewed for this study was that the primary impediment to operating UAS in civil airspace is obtaining approval to operate in civil airspace.

Another potential challenge to UAS growth is the public's concern about privacy. The primary privacy issue associated with the domestic use of UAS is that the aircraft are equipped with types of surveillance devices that could potentially be used to violate the Fourth Amendment of the United States Constitution. The specific portion of the Fourth Amendment that could be violated is that which protects citizens from unreasonable searches of persons, their houses, and/or their effects. The DoD is in the process of drafting guidance regarding the use of UAS in domestic operations. The draft Secretary of Defense guidance directs that no DoD entity shall use UAS to conduct surveillance on citizens of the United States unless approved within appropriate legal channels. The key element of the guidance is the requirement to obtain approval before conducting UAS operations as well as inter-agency coordination with civil law enforcement agencies when conducting any UAS operations. The Department of Homeland Security (DHS) is the responsible agency for civil UAS operations. However, the agency did not provide input for this study after numerous inquiries. Specifically, we requested DHS provide policy or regulations that address UAS operations in civil airspace. Since no response was provided we can only assume that none exists. Therefore, it is recommended that when policy is established it should include detailed directives about approval authorities for UAS operations, over-sight procedures by managers and leaders as well as penalties for violations of the procedures. The procedures should ensure that individual citizen's rights are not violated when conducting UAS operations.

*COL Don Woolverton, USA and Mr. Mike Padden, DA*

## **CONCLUSIONS**

The AIS seminar determined that optimistic forecasts for the aircraft industry are well founded. Barring unforeseen externalities that might reverse world economic growth trends, demand for commercial aircraft will keep pace with increases in air travel fueled by GDP growth. Defense spending is expected to continue at sufficient levels to recapitalize legacy fleets and support introductions of limited new platforms to meet known requirements, though

deliveries may not be at the most economical rate. There exists healthy and rigorous competition in each of the eight industry sectors examined. This competition is critical to providing reasonably priced value to customers and this serves the greater public good. Moreover, competition is expected to continue as no sector is in imminent danger of market failure.

The aircraft industry is truly global in nature. Both domestic and foreign companies increasingly outsource design, development, and manufacturing with less regard to national boundaries. Integrated supplier networks service both civil and military markets across all sectors. Larger companies have become integrators of airframes and subsystems made across the globe. They seek partnerships with foreign companies to overcome entry barriers into previously closed markets and to leverage specialization efficiencies.

Technological innovations such as greater use of composite materials and advanced computer aided design are becoming commonplace in the industry, and companies are expanding their portfolios with more emphasis on aftermarket services and long-term support contracts for both civil and military markets. More efficient business practices and effective use of infrastructure are leaning out the industry. While this will result in less surge capacity for U.S. military aircraft production, the DoD has accepted the risk of less capacity with a focus on effects-based capability versus quantity.

Still, there are challenges within the industry that require changes to government policies. Domestic content and export control restrictions are the most-often expressed concerns, followed by declining aeronautics research, an air traffic system at the point of gridlock, and effects of an aging aerospace workforce. Policy actions should include reducing the barriers to effective international business collaboration, stimulating aeronautics research, re-engineering the air traffic management system, and encouraging investment in training and education for the future workforce.

A strong U.S. and global aircraft industry is not only an important part of the U.S. economy, it is critical to meeting the DoD's requirements in support of the National Security Strategy. While the industry is well positioned to meet the nation's strategic needs, it is imperative that future defense and civilian leaders understand the globalized nature of the industry, the effects of uncertain increases in defense spending, and the inextricable link between aircraft manufacturers and the airline industry.

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