

Spring 2007
Industry Study

Final Report

Aircraft Industry



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

ABSTRACT

The aircraft industry plays a critical role in today's global economy. Comprising a wide array of firms supplying various products and services to a diverse and dynamic customer base, this industry represents a compelling case study from three distinct perspectives: a business strategy analysis, a review of the underlying economics, and an overview of national security issues. To provide this perspective, the study provides a description of the major markets comprising the industry followed by an analysis of the issues outlined above. Finally, the report details policy recommendations outlining the proper role of government in maintaining a vibrant industry.

CAPT John Spicer, SC, USN, Seminar Leader
Col Fadel Mohammed Al Garni, Royal Saudi Air Force
Ms Deborah Bereda, DSCA
BG Janusz Bojarski, Polish Air Force
COL Bill Braley, USA
LtCol John Celigoy, USMC
Lt Col David Chandler, USAF
COL Bruce Crawford, USA
CDR Brian Goodwin, SC, USN
Ms. Linda Haines, DAF
COL Eric Johnson, USA
Lt Col Jim MacFarlane, USAF
CDR Jack Noel, USN
Lt Col Wesley Norris, USAF
CDR Bill Suggs, USN
Lt Col Pete Van Deusen, USAF
Mr. Donald Briggs, Faculty Leader
CAPT Paul Martinez, USN, Faculty
Dr Gerry Berg, Faculty

PLACES VISITED:

Domestic:

Aerospace Industries Association, Washington, DC

Bell Textron, Arlington, TX

- V-22
- XWORX Rotary Wing Special Projects Facility
- Armed Recon Helicopter

Boeing Commercial Airplanes Division, Everett/Renton, WA

- B-737/747/767/777/787 Production Facilities

Boeing Integrated Defense Systems, St. Louis, MO

General Atomics Aeronautical Systems, Inc, Butte, CA

- Predator UAV Flight Test Facility, Gray

Lockheed Martin Aeronautics Company, Fort Worth, TX

- F-16/JSF Production Facility

Lockheed Martin Corporation Fighter Demonstration Center, Arlington, VA

Northrop Grumman Integrated Systems, Palmdale, CA

- Global Hawk UAV
- B-2

Pratt & Whitney Aircraft Engines, Middletown, CT

Sikorsky Aircraft Corporation, Stratford, CT

International:

AgustaWestland, EH101 Production & Training Facility, Yeovil, United Kingdom

Airbus S.A.S., Blagnac, France

- A380 Production Lines

BAE Systems plc, London, United Kingdom

- Corporate Offices, London, United Kingdom
- Typhoon/F-35 Production Facility, Samlesbury, United Kingdom

Dassault Corporate Headquarters, St. Cloud, France

Eurocopter, Marignane, France

Rolls Royce Aircraft Engines, Civil Aerospace Division, Derby, United Kingdom

Snecma engine manufacturing facility, Evry, France

I. INTRODUCTION

America's aviation industry plays a key role in today's fast-paced, globally interconnected economy. A driving force in high technology, manufacturing, defense, and transportation, aviation contributes as much as 9% of gross domestic product (GDP) and generates over 11 million jobs for the U.S. economy. Investment in aviation infrastructure yields high returns, as much as \$5 for every dollar invested (Aerospace Industries Association (AIA), 2005). Aviation is truly a vital economic sector, and its sustained viability is critical to assuring the continued growth of the economy as a whole.

The aircraft industry comprises a wide array of firms supplying various products and services to a customer base that ranges from sovereign governments and multi-national enterprises to small companies and individuals. Transactions range from a multi-billion dollar acquisition of advanced military aircraft to a relatively small purchase of support services for a handful of privately owned business jets. In addition to acquisition programs, government action ranges from extensive regulatory measures to targeted tax incentives. While the scope of activities is both broad and varied, there are certain common elements and issues that cut across each market segment and the industry as a whole.

The aircraft industry has two microeconomic characteristics of a mature industry; oligopolies and high barriers to entry and exit. Barriers to entry include extremely high capitalization, large cash flow requirements, and complex technologies. These barriers to new entry have combined with a wave of consolidation among prime contractors in recent decades, shaping the aircraft industry into a collection of interconnected oligopolies, segregated by market. Within each sector, a small number of firms—in some cases, such as the large commercial aircraft market sector, only two—compete aggressively for market share.

The purpose of this study is two-fold. First, to provide a description of the major markets that make up the industry, and second, to provide an analysis of the issues confronting the aircraft industry, the forces driving these issues, and an examination of available policy alternatives. The aim of this structure is to provide the reader with a general overview of the industry in order to provide a factual reference for the subsequent analysis.

II. AIRCRAFT MARKET OVERVIEW

In 2007, three major players dominate the overall aircraft industry: Boeing, Lockheed Martin, and European Aerospace Defense Systems (EADS). Taken together these companies comprise over 60 percent of international aircraft sales, both military and commercial (Aboulafia, 2007). This represents a recent phenomenon for the industry as a whole. Twenty years ago, there existed a number of aircraft manufacturers in both the military and commercial market (Anderson et al., 2001). This included four companies that were viable competitors in the commercial aircraft business (Boeing, Lockheed, McDonnell Douglas, and Airbus) (Newhouse, 2007). With Lockheed (now Lockheed Martin) no longer competing in the commercial market and McDonnell Douglas acquired by Boeing, just two large commercial airplane manufacturers remain: Boeing and Airbus (Newhouse, 2007). The downsizing of the military aircraft market has followed a similar pattern. Industry consolidations following the end of the Cold War left just two domestic prime manufacturers of fixed wing military aircraft: Boeing and Lockheed Martin (Anderson, McGuinness, and Spicer, 2001). Rotary wing aircraft and aircraft engine manufacturers, while avoiding consolidation, face a similar competitive landscape. Currently there are five rotary wing manufacturers of significance (Sikorsky, Bell, Boeing,

AgustaWestland, and Eurocopter), as well as four major aircraft engine manufacturers (General Electric Aircraft Engines [GEAE], Pratt and Whitney [P&W], Rolls Royce [RR], and Snecma).

This consolidation comes at a time when both military and commercial aircraft orders are expected to increase over the next several years (AIA, 2007). However, in both the military and commercial sectors, this demand is increasingly in the form of very large orders from a narrowing customer base (Aboulafia, 2007). Whether this phenomenon is a result of consolidation or a contributing factor is open to debate. What matters for the industry is that the landscape has become hyper-competitive. Orders are increasingly a make-or-break proposition for all firms, both domestically and internationally. This environment creates a mutual interdependence across the industry. All firms are concerned with the activities of their rivals and each firm knows that the others will respond to its actions (Katz and Rosen, 1994).

Similarly, there is a mutual interdependence that exists between government and industry in the context of this strategic landscape. Deals are increasingly make-or-break for government and public policy as well. This explains to a large extent the measures government (both U.S. and foreign) are willing to take with regard to the aircraft industry. These actions, and the mutual interdependence that would seem to compel them, are underlying themes of this report.

III. MAJOR MARKETS

The aircraft market is comprised of many sub-markets, and making distinctions is as much art as science. In general, if consumers can not easily substitute products and producers can not easily transition from one product to another in manufacturing, the products constitute different markets. The markets analyzed in this study are based on this rationale.

Commercial Aircraft

The commercial aircraft market is comprised of the following market segments: Large Commercial Aircraft (LCA), regional aircraft (RJ), and very light jet aircraft (VLJ). The worldwide market has sales valued in excess of \$83.5 billion and projected to grow to \$110 billion by 2016 (Aboulafia, 2007). The defining characteristic is that the target customer is the civil rather than the military market. This is a critical distinction since there are civil aircraft that have military applications and some vendors market to both the military and civilian sectors.

Large Commercial Aircraft (LCA)

LCA are categorized as follows: very large aircraft (VLA) capable of carrying over 400 passengers, twin-aisle aircraft containing between 230 and 399 seats, single-aisle aircraft with a capacity of between 126 and 200 or more seats, and small single-aisle aircraft with approximately 100 seats. Any airplane with a capacity below this threshold is considered either a regional jet or a VLJ (Metcalf, 2007). Boeing and Airbus are the only manufacturers of LCA, twin-aisle, and single-aisle commercial aircraft, yet the market is competitive. While regional manufacturers Bombardier and Embraer are making inroads in the small, single-aisle market, this segment is still dominated by both Boeing and Airbus.

The primary challenges to operating in this potentially lucrative marketplace are the cost associated with developing and manufacturing commercial aircraft, the cyclical nature of the business, and the lead-times associated with designing and delivering a new product line (Aboulafia, 2007). For example, the cost to Airbus to develop the A380 was estimated to be \$13 billion. With an estimated price of \$216 million per airplane, it would require sales of over 60 aircraft just to clear the development cost. Boeing experienced similar challenges while

developing the 747 (Esty, 2000). Such daunting development costs are not unique to VLA such as the A380 and the 747. The cost for Boeing to develop the twin-aisle 787 Dreamliner is estimated between \$8 billion and \$10 billion (Kotha and Olesen, 2005). In addition to high developmental cost, commercial manufacturers must contend with the cyclical nature of the market. A period of strong orders is often followed by a period of decline (Aboulafia, 2007). The third major challenge is the lead-time to develop a new commercial airplane, in some cases as many as ten years prior (Esty, 2000). As a means to spread risk, companies are increasingly partnering with other firms, providing a portion of the production and associated revenue in exchange for sharing developmental costs. For example, Boeing has asked structural suppliers of the 787 to fund their own research and development (Kotha and Olesen, 2005).

The overall outlook for the LCA market is strong. Sales are expected to grow by over 30% over the next ten years (Aboulafia, 2007). In this environment of rising demand and the potential for increased revenues, the ability of each company to successfully predict the market will drive market share and profitability. Additionally, with both Bombardier and Embraer positioned to move up-market from small single-aisle to single-aisle aircraft capable of seating over 100 passengers, the business landscape is poised to become increasingly competitive.

Regional Jets (RJs)

RJs are single aisle aircraft designed to transport smaller numbers of travelers (30-100 seats) over shorter distances within a geographic region, often within 500-2,000 miles. For routes that require fewer seats per flight than the popular Boeing 737, airlines need a cost effective aircraft to allow flexible scheduling for regional commuters and business travelers while minimizing the operational cost of operating those routes. Regional jets allow airlines to satisfy short distance routes at economical operating costs. Embraer and Bombardier control 98% of the RJ market, however, with at least nine manufacturers of RJs world-wide and others expected to enter the market; the RJ market is highly competitive (Aboulafia, 2007).

RJ aircraft makers offer a range of aircraft from 25-30 seat models to the 70-to 110-seat models for various regional transport demands. Neither Boeing nor Airbus currently offers an RJ product. After a production run of 156 aircraft, Boeing discontinued its 717 in 2006 to focus on product improvements for the popular 737 model (Boeing, 2007). Boeing's 737 and Airbus' A318 could be used for regional airlines; however, with capacities in excess of 100 seats, the size and range of these aircraft make them less optimal for regional transportation. Instead, they are ideal platforms for long-range, low-cost carriers such as Southwest Airlines.

Embraer is now focusing on the 70- to 110-seat passenger jet engine aircraft, getting away from turbo-prop propulsion. Bombardier, Embraer's primary competitor, continues to focus on both turbo-prop and jet engine aircraft that carry fewer passengers (30 to 50), but are now developing models to compete in the 70-110-seat passenger market. Japanese Aircraft Corporation and Mitsubishi are now developing RJs to compete with Embraer and Bombardier for the Asian regional market. Entering the regional jet market with government funding and protections, the Aviation Industries of China Consortium (AVIC) intends to offer RJs that will support the Chinese domestic market. It is unlikely that AVIC can meet the Chinese domestic market requirements over the short term and will not be competitive on the international market in the near future. However, China has set a goal to produce 300 aircraft within 20 years (AP, 2005). Similarly, with a \$135 million loan and backing from the Russian government, as well as Boeing, Sukhoi Civil Aircraft Company has developed a new family of RJs for international competition that meets international development and environmental standards. With 134 aircraft

entering service with at least four airlines in 2008, Sukhoi may represent a competitive challenge to industry leaders Bombardier and Embraer (Aerospace-Technology, 2007).

The market is healthy with a growing industrial base. Deliveries between 1997 and 2005 averaged close to 350 aircraft per year; in 2006 approximately 390 aircraft valued at over \$6 billion were delivered (Aboulafia, 2007). Analysts expect market demand growth as China and India's developing middle class increase air travel, particularly regional travel. With a backlog of over 1,000 firm orders ("The Regional Jet Market," 2005) and a delivery forecast of 11,000 aircraft from 2007 to 2025 with a value of \$370 billion (Bombardier Forecast, 2006), the RJ market should continue to flourish for at least the next 18 years.

Very Light Jets (VLJs)

Rounding out commercial aircraft is the very light jet (VLJ) market. Airplanes categorized as VLJs typically seat fewer than 30 passengers and are designed primarily for executive transportation. This includes company jets, privately owned jets, and jets employed for air taxi services. Unlike large commercial aircraft and regional jets, VLJs provide point-to-point transportation to virtually any airport. Additionally, VLJs are not subject to the scheduling constraints imposed by commercial air carriers, or the delays inherent with ticketing and TSA security screening ("Snarl in the Sky," 2006). Catering to high-end customers, VLJs offer a convenient means of air transportation for those who can afford it (MacMillan, 2006). The VLJ market is experiencing a period of high demand. In the U.S. alone, more than 10,000 companies own private planes—nearly double the number a decade ago ("Snarl in the Sky," 2006). Given the increasingly global nature of business enterprises and the demands for business travel, this trend is likely to continue (MacMillan, 2006). Each of the firms visited agree that demand for VLJs will continue to rise and are adjusting their business strategies accordingly. Given the rapid growth of VLJs and the forecast for continued expansion, there are concerns that an already overtaxed air traffic infrastructure may not be able to accommodate all the extra aircraft ("Snarl in the Sky," 2006). In addition, major airlines contend that it costs just as much to land a VLJ as it does a large airplane, yet private aviation pays only a fraction of the cost to maintain the air traffic system despite the fact that private aviation (including VLJs) represents the bulk of airplane traffic in the U.S. It is likely that major airlines will lobby to have private aviation pay a large share of the planned modernization of the air traffic control system ("Snarl in the Sky," 2006). If these arguments are successful, VLJ operating costs will likely increase.

With the advent of a new generation of very small VLJs (known as micro-jets), the Federal Aviation Administration (FAA) estimates that 5,000 of these tiny planes will be flying by 2017. As the market becomes more lucrative, established manufacturers such as Cessna will vie for market share as well as new entrants such as Honda Motors (Snarl in the Sky, 2006). Assuming the air traffic issues can be resolved and the costs allocated to the air traffic upgrade do not significantly alter the structure of the market, the VLJ market outlook is positive.

Fixed Wing Combat Aircraft

The combat aircraft market is often collectively described as the fighter market. It is comprised of fighter, bomber, electronic attack, and maritime strike aircraft operated from land bases or aircraft carriers for missions including air superiority (offensive/defensive counter air), close air support of ground troops or surface units in direct contact with enemy forces, armed reconnaissance, battlefield air interdiction, and strategic attack. With few exceptions, aircraft in the fighter market are high performance jet aircraft of small to medium size, less than 100,000

lbs gross weight, and a crew of one or two. They have sophisticated avionics, sensors, and communications suites, are capable of conducting missions at night or in adverse weather, and increasingly incorporate low-observable or “stealth” technology. Although some degree of product differentiation exists – for example, carrier-based aircraft or dedicated electronic attack aircraft – fighter aircraft designs are broadly substitutable and most are adaptable to a variety of combat roles. Competition within the global combat aircraft market is driven by performance, technological sophistication, and price.

Domestically, Boeing Integrated Defense Systems and Lockheed Martin are the only producers of fighter aircraft with Boeing and Lockheed each having open production lines. Internationally, EADS (Eurofighter), Dassault, Saab, Mikoyan Gurevich (MiG), and Sukhoi represent the major 4th generation fighter aircraft manufacturers (Aerospaceweb, 2007). Major subcontractors include former primes such as BAE Systems and Northrop Grumman. Approximately 3,865 fighter/attack aircraft will be produced over the next ten years with the value of the market estimated at approximately \$156 billion (Forecast International website, 2007). Furthermore, industry analysts predict a yearly sales outlook of approximately \$31 billion over that timeframe representing 27% of the total aerospace market (Aboulafia, 2007). Boeing has two lines, producing the F-15E and F/A-18E/F/G while Lockheed Martin has three, producing the F-16 as well as the 5th generation stealth F-22 and F-35. Experts predict that these two stealth programs alone represent \$55 billion in sales over the next ten years with Lockheed estimating that 3,200 F-35s will be sold over the aircraft’s lifetime (Aboulafia, 2007). Active international fighter aircraft programs include the Eurofighter Typhoon, the Dassault Rafale, the Saab JAS-39 Gripen, the MiG-29 series, and Sukhoi’s Flanker family.

Primary challenges within the global fighter market today include budget constraints, technology transfer limitations that have the potential to impact export sales of the F-35, and the trend toward refurbishment of existing fighter aircraft in lieu of new fighter acquisitions. Declining U.S. defense acquisition budgets as a share of GDP coupled with operational and recapitalization expenses associated with operations in Afghanistan and Iraq have resulted in cutbacks in the F-22 program. The Air Force is forecasted to acquire just 180 F-22s out of an original planned procurement of approximately 700. Similarly, the Navy's long-range budget plan calls for a delay to acquisition of Navy and Marine Corps (USMC) F-35s by 12-14 months in order to save about \$1 billion during the 2008-13 timeframe. This strategy would slip deployment of the first USMC F-35 squadron from 2011 to 2012, while the Navy variants would be fielded in 2014, rather than in 2013. The U.S. Air Force is considering cutting 72 aircraft from its fiscal 2008-13 procurement buys, further exacerbating the problem. While total F-35 numbers remain unchanged, further production delays likely will result in increased unit costs, making the F-35 less attractive to export customers with limited budgets. Technology transfer constraints on sensitive stealth and propulsion systems may ultimately bar many potential international buyers from purchasing the F-35. What these developments represent is that countries will seek alternatives to the F-35 due to price and political constraints, thus expanding opportunities for 4th generation fighter manufacturers. The outlook for the next ten years appears robust for both 4th and 5th generation fighters with a number of fighter manufacturers chasing lucrative worldwide markets. Although budgetary constraints are a concern, industry is postured to meet demand with a variety of aircraft models to choose from. The total fighter market outlook remains good over the next ten years, although decreasing budgets and recapitalization of existing fleets may limit aircraft sales over that span.

Military Transports and Tankers

The military transport market consists of aircraft to rapidly transport cargo, vehicles, and personnel. The military tanker market is comprised primarily of large, commercial-derivative aircraft capable of providing strategic airlift and bulk aerial refueling capability to support redeployment of or extended-range operations by military combat aircraft. The military transport market is differentiated by three classes of aircraft described as small, medium, and large cargo aircraft. Small military cargo aircraft are distinguished by very short-field (less than 3,000 feet) take-off and landing capabilities, cargo capacity on the order of eight tons, and 1,000 nautical mile range. Medium military cargo aircraft are distinguished by short-field capability (3,000 feet), 20 ton cargo capacity, and medium range of 2,800 nautical miles. The large military cargo aircraft market includes aircraft with large and outsize cargo capacity, payloads in excess of 40 tons, and transoceanic range. Military transport/tanker manufacturers compete on the basis of capability, performance, and price.

Small military cargo aircraft producers include EADS-CASA and Alenia with aircraft such as the C-295 and C-27J. Medium military cargo aircraft are currently produced by Lockheed-Martin in the form of the C-130J aircraft. Airbus is developing a new military cargo aircraft, the A-400, which will enter the market as a super medium class aircraft with a short-field capability, a 37 ton cargo capacity and a 2,800 nautical mile range. Current production schedule is for 192 aircraft through 2020, with initial delivery scheduled for 2009 (Airbus, 2007). The large military cargo aircraft market is led by Boeing with the C-17A aircraft, which is distinguished by its outsize cargo capacity and short-field capability. The C-5 aircraft reliability enhancement and re-engine program is ongoing and is expected to significantly improve availability rates which may impact future aircraft orders.

The tanker aircraft market is focused on the outcome of the U.S. Air Force KC-X development source selection, with an announcement expected in late 2007. Boeing and Northrop Grumman submitted proposals in April 2007, with Boeing offering a variant of its 767-200 Extended Range aircraft and Northrop offering a variant of an Airbus 330 aircraft. Each of these tanker variants has been selected by other international customers and is in development. Beginning in FY10, the KC-X winner will deliver 179 tankers over 15 years, worth an estimated \$30 billion to \$40 billion. Even this requirement will not fulfill the service's need to replace its 531 KC-135 tankers, and the total tanker recapitalization effort could reach \$100 billion over the next 30 years (Sirak, 2007).

There are numerous challenges for the military transport market and the future of the market unclear. Mobility for the militaries of the world is becoming more critical. Existing military transports are aging at a rate which vastly outpaces the capability for replacement. Two major programs of record, Boeing's C-17A and Lockheed's C-130J, will complete their production runs in the near future if additional orders or customers are not secured. Airbus is attempting to enter the market with the A-400. If C-17A and C-130J production ends, customer choice for medium/large transport aircraft will be severely limited, potentially expanding the market for the A-400. Militaries and aircraft manufacturers have identified a long-term military cargo capability gap, but the current priority on tanker aircraft, particularly for the U.S. Air Force, means funding will be a major challenge. Further, the price of medium and large military transports is a barrier to consistent orders and efficient production. These realities will shape the future of the market and impede investment in developing new transport aircraft with increased capabilities, indicating an opening for commercial derivatives and possible extension of the C-17 or C-130J production lines.

Rotorcraft:

Valued at \$17 billion in 2006 annual sales, the rotorcraft market is a mature industry focused on profit margins, cash flow, and cost control (Chao, 2007). Bell Helicopters, Boeing and Sikorsky are the three major U.S. manufacturers comprising approximately half of the production value of the global rotorcraft market (Dane, 2007). The two largest European producers, Eurocopter and AgustaWestland, round out the global rotorcraft market. Products are delineated by sector (military and civil) and weight (light, intermediate, medium, and heavy). While other rotorcraft manufacturers exist world-wide, the number and types of aircraft produced are extremely limited. U.S. and international military markets each will account for 39% and 31% respectively of a projected \$183 billion rotorcraft and support market for the next ten years (Rolls Royce, 2007). Historically, international rotorcraft manufacturers experienced little success in breaking into the U.S. military rotorcraft market. However, within the past year, AgustaWestland and Eurocopter both entered the market by teaming or partnering with a U.S. manufacturer. The VH-71 Presidential Helicopter and the UH-72 Light Utility Helicopter are examples of such successful arrangements.

The civil rotorcraft sector accounts for nearly half of the helicopter market in actual aircraft. Unlike the larger aircraft industry, the military sector of the rotorcraft market dominates the annual revenues for rotorcraft sales. In 2006, civil-use rotorcraft production accounted for only \$2.6 billion of the \$17 billion rotorcraft market (Jaworowski and Dane, 2006). The civil-use market demand is driven mainly by demands in off-shore oil exploration, tour operators, law enforcement, and emergency medical services. Military market growth is driven by recapitalization of the DoD's aging in-service inventory and the demands of the global war on terror. The military sector will dominate the market for the next several years as the U.S. enters into full rate production on several major rotorcraft programs. Estimates indicate over 8,400 new or upgraded military rotorcraft valued in excess of \$120 billion through 2016 (Rolls-Royce, 2007).

While the civil sector remains a robust market, there are very few new rotary wing aircraft being developed for the military market. Current aircraft production is primarily replacement of aircraft to cover normal attrition and combat losses. Absent major new procurements, there is a potential for the military market to stagnate. This may result in the loss of skilled designers over time. However, military and commercial rotorcraft production is predicted to reach over 15,000 turbine powered units in the next 10 years with a combined airframe value exceeding \$144 billion. An additional \$82 billion is projected in engine and engine support for the rotorcraft market for the same time period (Rolls-Royce, 2007).

In the next five years, multiple rotorcraft platforms will enter full-rate production for delivery to the DoD. According to the Office of the Secretary of Defense for Acquisition, Technology and Logistics, numerous rotorcraft platforms for all the services will reach peak production rates and require significant procurements dollars to produce (Chu, 2007). This convergence of rotorcraft production coincides with several other large military aircraft programs, as well as several large scale commercial aircraft programs which will likely create an increased demand in critical industry areas. This leads to concerns about the availability of suppliers, specialty metals, trained work force, and funding.

Unmanned Aircraft Systems/Unmanned Aerial Vehicles (UAS/UAV)

Unmanned Aircraft (UA) have emerged to fill a unique market segment which provides a relatively low-cost alternative to manned systems. As technology has advanced, unmanned aircraft have evolved into Unmanned Aircraft Systems (UAS)—which include one or more UAs and the supporting equipment and data links. UAS are in the emerging market stage characterized by many suppliers and rapid technological change and growth. Primary UAS military applications are Intelligence, Surveillance, and Reconnaissance (ISR) and strike roles. Civilian applications are emerging and potentially could include homeland security, law enforcement, and disaster relief missions. The success of UAS in the Global War on Terror (GWOT) and potential civil applications is spurring a fast growing and profitable market segment.

The UAS market has over 50 manufacturers (AIA, 2006) from 32 countries offering or developing more than 250 models of UASs (U.S. Department of Commerce, 2006). In the US, the two major manufacturers are Northrop Grumman (Global Hawk) and General Atomics (Predator). Most of the UAS produced are tactical or mini-UASs, with no direct competitors to the Global Hawk and few to the Predator. Sixty percent of the UAS market is dominated by U.S. manufacturers, with the number expected to rise over the next decade. Estimates predict total global UAS expenditure (R&D, Production, and O&M) to reach approximately \$55 billion by 2015 with US industry producing almost 64% or over \$18 billion of the worldwide production (Aboulafia, 2007).

The roles and missions of UA continue to evolve as the multi-role capability, reliability, and survivability of UASs develops. DoD must define doctrine for military operation of UAS. Similarly, the FAA has not issued guidelines and regulations for civil UAS operations in national airspace. For safety reasons, the FAA is likely to require collision avoidance systems, communication, and weather avoidance systems before integration in civil airspace. Potential benefits to DHS mission to secure borders and populations will go unrealized until this is addressed (Bolkcom, 2005). A final concern with domestic UAS usage is the implications to civil liberties. Domestic UAS surveillance missions potentially could violate constitutional liberties and privacy laws.

The UAS market outlook is positive, with some consolidation likely to occur as the market matures. The 2006 Quadrennial Defense Review (QDR) calls for a doubling of DoD UAS capacity, with 45% of future long-range strike capability to be met by unmanned systems (U.S. Department of Commerce, 2006). However, potential downward budget pressures could retard military UAS growth. Civil UAS applications also have high potential if cost and operational constraints are resolved (Dickerson, 2007).

Engines

The highly competitive engine market is dominated by four major manufacturers who supply engines across the aircraft markets segments. In order of market share, they are GEAE, RR, P&W, a division of United Technologies Corporation, and Snecma, a French company under the SAFRAN Group. According to AIA, engines and engine parts generated more than \$16 billion sales in 2005, constituting nearly 25% of the aircraft and engines total of \$68 billion for the year (2007). The high price of engines relative to total aircraft cost makes buyers price sensitive and increases competition. Companies in this market frequently participate in joint ventures or alliances with their competitors and suppliers to offset or share R&D of new products and to gain access to international markets. For example, CFM international, a GEAE-Snecma

alliance, produces the world's most popular commercial engine, the CFM-56 (Newhouse, 2007). The large capital investment required and the dominance of known suppliers serves as entrance barriers to the engine market.

Most engine manufacturers offer maintenance agreements tailored to the customers needs. Given the degree of competition, analysts have called the market "unusually cutthroat" as suppliers engage in aggressive competitive strategies to gain market share. Often, engines are sold below catalog price, because the profit loss on the engine will be offset by the more lucrative aftermarket support agreements for parts and maintenance. These arrangements generate a revenue stream that easily surpasses the cost of the engine over its operational life (Lunsford & Kranhold, 2004). Companies are investing in independent research and development (IR&D), but the percentage rate of investment has slowed in recent years. Jet engine suppliers differentiate their engines through improved fuel consumption, weight, reliability, emissions, noise, and brand. Short of technological breakthroughs in airframes, regulatory requirements, or improved operational cost, buyers tend to prefer proven products across their fleets. This preference discourages manufacturers from substantial IR&D needed to develop break-through engine technology and innovative products.

With rising aircraft and engine orders, the industry's primary challenge is meeting demand with constrained resources. Lean manufacturing allows companies to maximize production facility throughput so that capacity is less an issue. However, human capital, raw materials, and supply chain limitations influence production rates. For example, titanium is increasingly used in critical engine and aircraft components, yet there are only three smelters worldwide capable of producing aircraft/engine quality grade alloy. With limited smelters, lead times are often measured in years and price has increased six-fold since 2002 (McAleese, 2006).

Industry book orders for near term delivery of commercial products are healthy. Boeing analysts expect air traffic to grow at an annual rate of 4.9% annually for the next 20 years which will drive the growth of the engine market at a comparable rate (Baseler, 2007). General Electric predicts that as many as 3,000 new engines will be required by 2020 to meet the expected growth in the worldwide airline industry (Maxwell, 2007). From a military perspective, the trend toward fewer procurements and longer lifecycles is expected to continue, placing increasing emphasis on sustainment and an industry focus on after market services in the form of Performance Based Logistics (PBL) contracts (Savage, 2007).

Aftermarket Support

The support market is characterized by products and services that include logistics support programs, contracted maintenance, and systems engineering. Patterned after commercial Maintenance Support Agreements, PBL support contracts are being explored for both new and legacy weapons systems. Changes to key policy documents now direct program managers to increase use of PBL solutions for life cycle support of weapons platforms. A robust and highly competitive market has evolved featuring large Original Equipment Manufacturers (OEMs) and some lower tier sub-contractors vying for long-term contracts for services and support.

OEMs generally have well established supply chains and systems engineering capacity that differentiates them from new entry competitors. Given these advantages, OEMs can shape market behavior and supporting technology choices. Additionally when compared to manufacturing, amassing capital to provide services is not a significant barrier to a firm's entry in this market. This allows second tier Third Party Logistics Providers (3PLs) to compete as leads or as partners, but leaves OEMs better positioned for larger logistics and maintenance

opportunities. OEMs appear to enjoy a competitive advantage; however, a few recent changes have challenged this premise. Boeing won a support contract for the Lockheed Martin manufactured C-130 aircraft. Likewise, substantial consolidation of Defense OEMs during the 1990s and a relatively flat decade for procurement meant that remaining OEMs had to acquire competitive capabilities for platforms they did not manufacture in order to capture market share. Smaller firms such as Caterpillar and Raytheon have found opportunities as 3PLs.

Aftermarket support works best under multi-year support agreements. This allows for long-term investment in logistics systems and upgrades that, while potentially unprofitable in the short-term, ultimately provide long-term profitability. Unfortunately, government financial regulations make multi-year funding vehicles difficult. Operations and Maintenance (O&M) funds may only be obligated a year at a time. To get around this, some Services are using Service Working Capital Funds to secure multi-year outlays. Unfortunately, this locks in mandatory funding (since the PBL locks in a funding stream over time) and has the potential to crowd out routine discretionary repair funding. Additionally, some uniformed Services are concerned that a PBL may constitute a service rather than a repair. When categorized as such, Service Contract Act rules would apply, adding a great deal of complexity to any PBL action.

The support and services market is rapidly expanding as OEMs emerge as large support integrators. OEMs are leveraging their 2nd through 4th tier providers in offering key support commodities, improving the strength of the supplier base for production as well. Thus there is benefit to suppliers in profitability, a stronger market and closeness to the OEM. Net benefit also accrues to customers because price advantages from consolidations of inventories and maintenance capabilities are increasingly attractive to military and commercial customer alike.

IV. INDUSTRY CHALLENGES

Workforce

A skilled and educated workforce represents the most valuable asset of the U.S. economy. According to the AIA, the aerospace industry employs more than 635,000 personnel, of which 380,000 are employed in the aircraft sector. Labor represents one of the highest costs in aircraft manufacturing. Aircraft industry labor skills are highly transferable and sought after by other industries. The U.S. must continue to support a highly skilled, stable, secure, and growing aerospace workforce (U.S. Dept. of Labor, 2005) capable of adapting to changes in market forces and production techniques in response to growing competition across the globe. Sustainment and growth of this workforce, both its engineering cadre and highly skilled manufacturing personnel, is critical to the industry's capacity, innovation, and success.

Workforce aging is a significant issue affecting the industry's ability to sustain a stable workforce. In 2005, approximately 55% of the aerospace workforce was over 45 and 27% of the aerospace manufacturing workforce will be eligible for retirement by 2008. Students in the U.S. rank near the bottom of the leading industrialized countries of the world in mathematics and science test performance—limiting the pool of qualified students to pursue degrees and careers in science and engineering. China and India now graduate 500-700,000 engineers a year compared with 80,000 U.S. graduates (AW&ST, 2007). Studies also find that aerospace now ranks last among almost all of the high-tech industries in providing desirable employment (AW&ST, 2007). Finally, the foreign students who receive more than half the S&E graduate degrees in the U.S., are less likely to stay in the U.S. than in the past due to high technology job opportunities in their home countries, as well as the expensive and time-consuming visa process and security clearance restrictions that limit access to defense jobs.

In November 2002, the Commission on the Future of the United States Aerospace Industry published its *Final Report* outlining critical challenges facing the aerospace workforce. The commission urged the Bush Administration to develop policies that would support the aerospace job force and recognize the importance of this industry to the nation's economy. In December 2006, President Bush signed Public Law 104-420 to ensure the stability of the high-skilled jobs and global competitiveness of the domestic aerospace industry.

Government Regulation

U.S. Government regulation of the aircraft industry is a challenge to the entire market, and can be broadly classified into two categories; export controls that seek to protect critical technologies and promote national security, and protectionist policies over items such as specialty metals that seek to ensure the health of the U.S. industrial base. Yet, with increasing international partnerships and global supply chains for components and parts, these policies have unintended consequences such as lost cost-saving opportunities, reduced competitiveness for American companies, and strained international relations.

Under the International Traffic in Arms Regulations (ITAR), export controls of defense-related items and services provide safeguards against critical technologies falling into the hands of potential adversaries. DOD acquisition directives do promote foreign collaboration in development and sales of U.S. defense equipment (DOD Instruction 5000.2), but this has little impact on the processing or outcome of export license applications, which is the major challenge with the system. While there is a valid need to control and protect vital U.S. technologies, the ITAR coordination and approval process for technology release is highly bureaucratic, involving multiple agencies, each with the authority to deny a request. The levels of review within each coordinating agency and the number of agencies involved combine to make the process inefficient, unpredictable, and lacking in transparency (Weinberger, 2006). An expert advocate is required simply to navigate through the DOD agencies and their complex decision-making hierarchies. While independent review of technological transfers may be prudent, the layers of oversight is representative of a system fraught with obstacles and barriers that detract from the DOD acquisition credo of simplifying the processes and streamlining operational delivery of essential systems (Adenot et al., 2007).

Export delays and prohibitions are perceived by international partners and allies as distrust, and failure to approve transfers is frequently viewed as protectionist, undermining U.S. credibility as a free trade partner and hampering allied interoperability. This fact was clearly demonstrated in the open disagreements between the U.S. and its international F-35 partners, particularly the U.K., which argued that U.S. refusal to share key technologies was hindering its ability to produce and support the aircraft ("F-35 JSF Program," 2006).

Specialty metals regulation is a critical issue for the aircraft industry. It began as a debate over the inclusion of specialty metals (primarily titanium) in the Berry Amendment, and recently migrated from the Berry Amendment to the FY2007 National Defense Authorization. This legislation states that funds may not be used for the procurement of strategic materials critical to national security which are not reprocessed, reused, or procured in the United States. Such items are specialty metals and items critical to national security as determined by the Strategic Materials Protection Board (Grasso, 2006). Effectively, this legislation requires that any system or component--from major structural components to 10-cent fasteners--acquired by DoD and containing specialty metal must be 100% derived from U.S. sources.

While manufacturers can, at some cost, ensure compliance on major DoD aircraft programs such as the Joint Strike Fighter, the issue is more complex on commercially derived products. The general consensus, derived from interviews with industry representatives, is that exceptions to the specialty metals legislation will be required for the use of commercially derived products on DoD applications, such as the KC-X tanker program. This issue is even more complex at the subcomponents and subsystems level. Second and third tier suppliers must also comply with the specialty metals legislation, meaning minor components such as fasteners must use 100 percent US derived titanium if any titanium is contained within the piece. It is likely that U.S. suppliers will lose competitive advantage to foreign suppliers who are exempt from the specialty metals restriction. The legislation provides an exception for countries with memorandums of understanding or other international agreement with the US, allowing components containing titanium from long-time allies to be used on DoD programs. (Grasso, 2006). This exemption in many situations will drive integrators to source specialty metal components from more cost-effective non-domestic suppliers.

Export controls and protectionist policies each can serve the national interest, but they also can have adverse second and third order effects that are increasingly adverse in a globalized industry. Government intervention is needed to improve export license processing and to reevaluate export control and protectionist policies to account for second and third order effects.

Defense Acquisition Instability

In 2005, overall military aircraft sales totaled \$28.2 billion compared to \$31.4 billion for all civil shipments (AIA, 2007). The U.S. government is a large, important, and highly influential customer for the aircraft industry. In addition to the negotiating advantage resulting from the size of procurements, government enjoys other negotiating advantages such as dictating the negotiation structure. To balance these advantages and provide for a more stable acquisition environment, the firms we interviewed expressed a common desire for measures designed to make the government a stable, predictable, and dependable customer.

A review of several recent aircraft acquisition programs shows the federal government to be a fickle and oftentimes capricious customer. Orders constantly changed. These changes included the number of projected aircraft deliveries, design specifications, production requirements, and test criteria (Aboulafia, 2007). Such changes invariably drive up the cost of the end item, in essence assessing a financial penalty to the federal government in the form of higher acquisition costs and to the affected firms in the form of reduced production runs and associated supply chain cost variability. Government negotiating power often compels producers to reduce their margins in order to capture business. This dynamic also makes the aircraft industry less attractive in the eyes of potential entrants and potential investors. Contrast this with the pharmaceutical industry where the U.S. government refrains from applying its power over the marketplace, thereby increasing profit margins and spurring private investment (Ghemawat, 2001). In the case of the aircraft industry, government application of negotiating power tends to reduce margins and corrode the competitive landscape to the detriment of the firms comprising the industry. It is far easier to attract investors if the competitive environment is stable and profitable (Anderson, 2001).

Declining Aerospace Research and Development

Since the mid 1980s, there has been a significant decline in funding for aviation research and development (R&D) by both the government and industry. Federal and non-federal funding

for aviation R&D peaked in 1987 at approximately \$35 billion and since then has seen over a 50% cut (Douglass, 2005). This decrease in funding has had a negative impact on the U.S. aviation infrastructure and in our ability to develop younger replacements to replenish an aging workforce. Over the past decade, the character of U.S. R&D funding and performance has undergone significant strategic changes. For example, federal funding of R&D has been refocused on special programs directed toward the GWOT and unanticipated damage associated with natural disasters (Military & Aerospace Electronics, 2007).

Funding for the National Aeronautics and Space Administration (NASA), which is the lead federal agency for U.S. aeronautics/aviation R&D activities also fell by approximately 50% in the last decade (Dodd, 2003). Additionally, over the past several years, de-emphasis of long-term aeronautical research in both NASA and DoD has impaired U.S. universities' ability to maintain vibrant aeronautical engineering programs. For the past 75 years American universities have provided creative, skilled engineers for national defense and aeronautical commerce. These universities are finding it increasingly difficult to contribute to near or long-term progress in aviation R&D without funding. As this situation continues, the U.S. is experiencing a diminishing pipeline of qualified aeronautical engineering students. The lack of an infusion of "new blood" in the workforce is directly related to the lack of funding for researching new technologies. Simply stated, young engineers in training do not see aerospace engineering as a stable enough career path to dedicate their education to that curriculum (AIAA, 2005).

Air Traffic Management Infrastructure

By 2025, America will require an Air Traffic Management (ATM) system that will support an economically viable U.S. aviation industry. This transformational air transportation system must be able to handle a doubling or even tripling of current air traffic volume, accommodate changing air traffic composition, from super jumbos to VLJs, UAVs, and spacecraft, and be responsive to developing national security and defense requirements. (Joint Program Development Office (JPDO), 2007, p. 1-2) In order to meet these requirements, the U.S. Government has initiated development of the Next Generation Air Transportation System (NGATS), or NextGen. This issue is addressed in more detail in the Special Studies Section

V. INDUSTRY OUTLOOK

Economic Performance

Airline profitability and air traffic growth are the key demand drivers for new aircraft orders; historically, both of these drivers have been influenced by global economic growth. The global end market for new aircraft consists of about 500 airlines with the major global airlines, led by the U.S. legacy airlines, buying the majority of new aircraft (S&P, 2006).

Many industry analysts believe the uninspiring fundamentals of the airline business—mature, highly cyclical markets, significant completion, high fixed operating costs and debt levels, and large capital expenditure requirements will be offset by continued global economic growth, resulting in an increase in aircraft sales for the next ten years (S&P, 2006). These same analysts presume the stronger the economy, the greater the likelihood that consumers and businesses will spend increasing discretionary income on air traffic.

The FAA predicts that U.S. and global GDP will grow at a 3.0-3.1% annual rate from 2007-2017, while global air passenger and cargo traffic will grow at 10-year compound annual growth rates (CAGR) of 6.0 and 7.0% respectively. The Asia-Pacific region is expected to grow at a 3.6% GDP growth per year from 2007 through 2017. China and India, the two most

populous Asian countries, are projected to grow at 7.0 and 5.8% per year through 2017. Europe, Latin America, and Canada also remain strong with projected GDP growth rates of 2.7%, 3.8%, and 2.6% respectively. At the same time, the global rate of inflation is expected to remain at just 2.5% per year (FAA, 2007).

While perceived as the most lucrative airline market, U.S. carriers have a history of inefficiency and low profitability. According to the FAA 2006-2017 Aerospace Forecast, in FY05 U.S. commercial airlines reported a \$1.5 billion operating loss and a net loss of \$11 billion, and for a five-year period had a cumulative operating and net loss of over \$21 billion and \$37 billion respectively. The 2005 net losses were driven by the legacy passenger carriers who had operating and net losses of \$3.5 and \$12.8 billion while the cargo carriers, driven by FedEx, reported operating and net profits of \$2.0 and \$1.1 billion. However, in 2006, the U.S. legacy carrier's fortunes turned with a posted profit of \$1.5 billion; cost cutting and consolidation combined with strong global economic growth were the catalysts in this turnaround. Additionally, international carriers reported operating and net profits of \$1.1 billion and \$582.3 million in 2005 (S&P, 2006).

Responses to Competitive Environment

Major U.S. aircraft manufacturing companies have rapidly become adept in responding to changing competitive environments and cyclical turns in defense spending. They have instituted a wide range of strategies that include lean manufacturing processes, global strategic partnering to spread development and production risk, supply chain management, and movement into lucrative aftermarket and Information Technology (IT) services.

Industry study visits show companies in various stages of employing the principles of lean manufacturing and six sigma to maximize efficiency, lower costs, increase volume, and minimize excess capacity. They have created global strategic partnerships in Europe, Asia, China, and India which is providing access to lower-cost labor while gaining access to potential markets. These partnerships have created a global supply base that makes it easier for companies to outsource the manufacture of aircraft system components, subassemblies and parts worldwide to the most cost-effective global supplier. Final assembly, integration and strategic manufacturing roles (e.g. Sikorsky composite propellers and Boeing composite wings) remain in-house.

Outsourcing manufacturing capability to the global supply base has reduced some U.S. aircraft industrial capability but overall makes the U.S. aircraft industry more responsive and efficient, creating a stronger competitive advantage.

Surge Capacity

According to AIA, the aircraft industry is operating at 79% production capacity ("Industrial Production," 2007). This figure suggests a healthy industry with capability to surge, but it is misleading for several interrelated reasons. First, lean processes and outsourcing have increased reliance on global supply chains, and second and third tier suppliers are now as critical to manufacturing as OEMs, which today are often only system integrators. Supply chain managers rely on accurate forecasts for production, inventory, and distribution decisions. While the commercial aircraft markets are better positioned to adjust to cyclical production, the intense volatility of military production makes it unlikely that lean, optimized supply chains can be responsive to surges. In addition, plant capacity figures do not fully address the industry's human capital issues. Lean and outsourcing initiatives have combined to shrink the U.S. aerospace

industry work force by over 50% since 1989 (AIA, 2007). Combined with demonstrated difficulties in attracting engineering and manufacturing employees the lack of a skilled work force becomes a major limiting factor to industrial surge capacity. As previously mentioned some raw materials are in short supply. Titanium, for example, is used increasingly in aircraft and engine components, and lead times are often measured in years. The problem is compounded by legislation mandating use of U.S. suppliers for OEMs executing government contracts.

The availability of equipment for ongoing operations in Iraq and Afghanistan is evidence of surge limitations, with senior military officials openly expressing dissatisfaction over industry's failure to get on its war footing (Jelinek, 2007). This view overlooks the government's responsibility as owner of onerous requirements, budget and acquisition processes, but the general frustration with the lack of surge capability is legitimate.

The government is concerned over the declining industrial base and seeks to keep it robust by retaining oversight on defense industry mergers and acquisitions. Still, these actions are more focused on industrial base health than surge capability, which are related but not the same. Declining surge capacity is a byproduct of today's lean, globally outsourced aircraft industry, and it would do more harm than good for the government to further protect the industry to permit greater surge capability. Ironically, a better alternative is to reduce protectionist measures to ensure access to global suppliers.

VI. GOVERNMENT GOALS, ROLES, AND POLICY RECOMMENDATIONS:

Because of the importance of the aircraft industry to national security, governments intervene in the industry for three primary reasons. First, many nations depend on the aircraft industry for a significant portion of their defense capabilities (and the industry depends on government as a consumer). Second, aircraft production and related industries represent a significant segment of the U.S. economy. Finally, other nations and national organizations are heavily involved in maintaining the vibrancy of their domestic aircraft industry, thus altering the competitive landscape. Government interventions cover five major areas: (1) Establishing and enforcing legal structures, (2), Regulation, (3) Tax policy and economic incentives, (4) Trade policy, and (5) Actions and influence of the government as a buyer.

A critical role for government is establishing and enforcing the legal framework within which firms, individuals, and government entities operate (Stiglitz, 1988). The ability of governmental entities to generate, enforce, and arbitrate rules and regulations is a critical aspect of the market (Friedman, 1962). Ideally, a stable and predictable structure would result. Unfortunately, because of the market structure and the participants' strategic behavior, disputes arise, requiring governmental intervention, often through arbitration.

In addition to the legal framework imposed by Congress and the courts, executive agencies also impose regulation and oversight of the industry to protect workers, consumers, and the environment, prevent discrimination, and thwart anticompetitive practices (Stiglitz, 1988). However, the government often acts in ways that are at odds with stated policy. During the 1993 "Last Supper" meeting, Secretary Perry made clear to defense industry leaders that defense budgets were shrinking and future defense buys would not sustain excess industrial capacity prompting a rash of mergers and acquisitions. In all, 32 defense firms eventually consolidated into seven major corporations (Anderson, et al, 2001). This deliberate government action forced a series of mergers narrowing the competitive landscape despite regulatory policies designed to foster competition. It is important to note that each consolidation or merger required government approval. To induce production expansion and retain jobs in particular locales, governments

often extend preferential tax policies and other economic incentives to industry. Providing preferential tax treatment, in effect, provides a disincentive to disciplined management and, with it, private investment. Firms not subject to government largess must operate efficiently to earn the same rates of return as firms subsidized either directly or through tax breaks.

Many times, government advocacy is needed to maintain a level international playing field. This advocacy ensures foreign companies do not benefit at the expense of domestic suppliers and domestic suppliers do not gain an unfair advantage over their foreign competitors. However, this involvement should not shield firms from the competition of the marketplace; rather it should ensure competitive forces apply equally to all. Since only national governments and international arbitration bodies have the span of authority to compel the degree of international action required in a global economy, governments and international organizations' (e.g. World Trade Organization) role should be to negate impediments to free trade (Stiglitz, 1988). This requires the uniform dismantling of tariffs, subsidy structures, quotas, and preferential tax policies to foster global competition (Gwartney, et al., 2006).

U.S. policies should strengthen the aircraft industry by promoting a level and highly competitive economic playing field. By doing this, government provides a degree of stability and predictability to the industry. Internationally, the rules of commerce should be stable, highly competitive, and equally enforced. This requires international cooperation and a clear message to industry that firms will fail or succeed on the skill of management teams and the quality of their products. Finally, the government can go a long way to providing predictability to manufacturers by acting as a fair and responsible customer.

Specific Policy Recommendations

Section IV discussed specific challenges to the aircraft industry. Following are Aircraft Industry Study policy recommendations to meet those challenges.

Workforce

- Increase standards for math and science teachers in the elementary and secondary schools. Furthermore, government must foster improved math and science curricula across the education system.
- Provide tax incentives to stimulate industry investment in worker education and develop and attract highly skilled employees where shortages exist.
- Initiate a joint government-industry strategic communication campaign to promote careers in the industry by improving the perception of aerospace employment opportunities and rewards to high school students.
- State and federal governments should collaborate with industry to expand industry-academia cooperative partnerships and non-degree apprentice training programs to develop the skilled individuals needed for industry positions.
- The aerospace industry must develop competitive employee compensation packages comparable to other high technology sectors to recruit and retain engineers, professionals and workers (AIA, 2006).

Government Regulation

- Government must find ways to streamline the export control process and add predictability and transparency.
- In addition to addressing the process, the government must reevaluate the rationale behind export controls and protectionist measures. Specifically, ITAR export control

lists should be continuously and rigorously evaluated to ensure only the critical, strategic articles and services are included.

- Approvals should be secured prior to entering international partnerships, and the unique nature of these relationships should provide latitude for industry self-certification on lower levels of technology transfers.
- Where protectionism and controls are deemed necessary, policies must be tailored to the target industries and markets and minimize second and third order effects on other industries.

Defense Acquisition Instability

- Government must formulate acquisition policies that will both foster a vibrant, healthy aircraft industry while also facilitating stable acquisition programs.
- Develop policies emphasizing the importance of stability and elevate its status in program management doctrine. Tradeoffs in acquisition programs should be modified to include program stability as well as cost, schedule, and performance.

Declining Aerospace R&D

- Government, particularly NASA, continue its historical role of supporting breakthrough, pre-competitive research that has a longer time horizon than industry can support—ten years or more—before it is mature enough to be considered for transition to product development (Douglass, 2001).
- Follow through on advanced R&D plans and priorities established in the 2007 National Aeronautics R&D Policy (Mertes, 2007).
- Act on recommendations in the 2003 President’s Commission on the Future of the U.S. Aerospace Industry, including:
 - A new business model, designed to promote a healthy and growing U.S. aerospace industry. This model is driven by increased and sustained government investment and the adoption of innovative government and industry policies that stimulate the flow of capital into new and established public and private companies.
 - Significantly increase federal government investment in basic aerospace research to enhance US national security, enable breakthrough capabilities, and foster an efficient, secure and safe aerospace transportation system.
 - The US civilian aerospace industry should also take a leading role in applying research to product development (Aerospace Commission Report, 2003).
- The Federal Government should continue to develop a national aerospace consensus that focuses the efforts of aerospace research and development. At present we do not have the level of consensus required to guide policies and programs. As previously stated, current efforts tend to focus on the here and now, driven primarily by the global war on terror and short term gains. (USAF S&T Board, 2004).
- Continue to incentivize U.S. industrial investment via increases in tax credits, with greater credit provided to long term efforts.
- Both industry and the federal government should look for opportunities to endorse international partnerships that promote research and development initiatives

Air Traffic Management Infrastructure: Policy recommendations for this challenge are addressed in the Special Studies Section.

VII. SPECIAL STUDIES

The Aircraft Industry Study Seminar provided analysis for the U.S. Air Force on the impacts of the Berry Amendment, the Defense Logistics Agency on improving business forecasting and inventory management, and the FAA on the Next Generation Air Transportation System. The Berry Amendment findings were captured in the earlier Challenges section. Abstracts from the DLA study and a student study on NGATS are included in this section.

Improving Business Forecasting and Inventory Management For Defense Logistics Aftermarket Services And Support

As part of an ongoing relationship between Defense Supply Center Richmond (DSCR), and the Industrial College of the Armed Forces (ICAF), two students from ICAF's Aircraft Industry Study (AIS) conducted research and interviews with industry, focusing on lessons from the commercial sector that could be used by DSCR to improve business planning and inventory management.

To capture relevant issues a review of the contemporary literature was conducted identifying current trends, concerns and strategies that are forefront in the minds of aircraft industry leadership. In addition to the literature review, the study team collected data via an extensive questionnaire sent to industry and designed to examine how commercial manufacturers address business planning and inventory management functions. The goal of the study was to assess the critical underpinning logic and assumptions supporting industry's forecasting and inventory strategies, and collect best practices that would be helpful to DSCR in managing DoD's aviation logistics support. During the course of research it became apparent that integration of key components of industry supply chains (e.g. human capital, physical infrastructure and supporting information technology investments) was critical to success in both new aircraft manufacturing and post-production support. The study team successfully engaged numerous industry representatives and gathered a rich data set during interviews. As a result, the study team was able to share several lessons and hard-earned advice from numerous industry experts with DSCR.

The Next-Generation Air Transportation System: Future Vehicle for America's Aviation Industry

By 2025, America will require an ATM system that will support an economically viable U.S. aviation industry. This transformational air transportation system must be able to handle a doubling or even tripling of current air traffic volume, accommodate changing air traffic composition, from super jumbos to VLJs, UAVs, and spacecraft, and be responsive to developing national security and defense requirements. (JPDO, 2007) In order to meet these requirements, the U.S. Government has initiated development of NGATS, or NextGen.

Public Law #108-176, passed by Congress in 2003, known as "Vision 100," mandated design and deployment of an air transportation system to meet the nation's needs in 2025. "Vision 100" simultaneously established the NGATS JPDO, a public-private partnership, to carry out the mission of developing the NextGen system. (JPDO, 2007) NextGen's scope extends beyond ATM to encompass all aspects of air transportation. (JPDO, 2007) To develop NextGen, the JPDO has created eight Integrated Product Teams (IPTs), drawing on government agencies, industry, and academia. The IPTs are focused on Agile Air Traffic Systems, Airport Infrastructure, Environment, Global Harmonization, Safety, Security, Shared Situational Awareness, and Weather. (NGATS Institute, 2007)

The JPDO's NextGen CONOPS is built on eight key capabilities identified in the *NGATS Vision* that will enable the system to achieve its goal: to significantly increase the safety, security, capacity, efficiency, and environmental compatibility of air transportation operations, and by doing so, to improve the overall economic well-being of the country. (JPDO, 2007) These capabilities, which loosely map to the eight IPTs, include network-enabled information access, performance-based operations/services, assimilating weather into decision-making, layered adaptive security, positioning, navigation, and timing services (PNT), four-dimensional aircraft trajectory-based operations (TBO), equivalent visual operations regardless of weather, and super-density operations. (JPDO, 2007)

For policy development purposes, key NextGen stakeholders are limited to the U.S. Government and organizations representing America's aviation industry. With both legislative and funding authority over NextGen, Congress is the most important government stakeholder. Within JPDO, DOT and NASA are the key federal agencies, although other government JPDO participants play important roles in defining NextGen capabilities and requirements. The most influential aviation industry stakeholder is the AIA, which provides collective lobbying power for the entire aerospace industry. Other significant industry stakeholders include the Airline Transport Association and Airline Pilots Association representing airline and air cargo interests, and the Aircraft Owners and Pilots Association, representing general aviation interests.

NextGen concerns common to key stakeholders fall into two broad categories—development issues and funding issues. Development issues include urgency of development, implementation of critical technologies required to support NextGen, user impacts and requirements to operate within the NextGen system, and harmonization issues as NextGen incrementally supplants legacy air transportation systems. Funding issues revolve around determining an accurate cost estimate for NextGen, and appropriate mechanisms for funding the system's development and operation.

The requirement for NextGen is real and immediate. Without a prompt, concerted, robustly funded effort to recapitalize our air transportation system using modern, networked information systems, gridlock is inevitable, and the associated costs in terms of reduced transportation capability and resulting lost productivity on the aviation industry and our nation's economy as a whole will be profound. To facilitate a timely and successful implementation of NextGen, the following strategic actions are recommended:

- JPDO must accelerate system definition and development to meet 2025 requirement.
- Congress must legislate funding for NGATS as scheduled in September 2007:
 - JPDO must present a viable cost estimate.
 - NGATS funding vehicles must consider both utilization rate and industry impact; user fees based on pure proportionality may not be the best answer.
- NGATS architecture must balance automation, capability, interoperability, backward compatibility, complexity, and user cost.
- JPDO must address legitimate general aviation cost/benefit concerns associated with the proposed NextGen architecture.

Properly funded and executed, the NextGen vision will deliver the first-rate air transportation infrastructure required to ensure the global preeminence of America's aviation industry throughout the 21st century.

VIII. CONCLUSIONS

The Aircraft industry provides aviation platforms, engines and services critical to today's fast-paced, globally interconnected economy. The 2007 study analyzed eight key industry market sectors and overall industry conditions, challenges and future outlook. We found the aircraft industry to be mature, with high barriers to entry and a small number of interconnected firms competing aggressively for market share. Boeing, Lockheed Martin, and EADS dominate the market with 60% of 2006 sales; approximately 15 firms share most of the rest, reflecting the post-Cold War consolidation of the aerospace and aircraft industries. The overall industry outlook is quite positive—record military and civil sales, three-to-five-year order backlogs, healthy profits and return on invested capital, with no sector in danger of market failure in the foreseeable future. Strong globalization factors and world-wide GDP growth should continue to fuel passenger and cargo travel at higher than GDP levels through 2017, driving strong demand for commercial aircraft and support services. Defense spending is expected to be sufficient to fund fleet recapitalizations begun in the early 2000s and production of new platforms to meet known requirements.

Globalization, consolidation, and risk sharing strategies are observed market responses to the cyclical nature of an aircraft market that demands an increasingly small-range of high risk programs. Aircraft companies are quite adept at responding to the changing competitive environment and cyclical turns in demand. Current strategies include lean manufacturing processes, global strategic partnering to spread development and production risk, supply chain management, and movement into lucrative aftermarket services. U.S. manufacturers and suppliers are aggressively applying lean processes to maximize efficiency, lower costs, increase volume, and minimize excess capacity. Economic imperatives will likely compel European manufacturers to adopt these business practices as well. Joint ventures with competitors and suppliers offset or share R&D of new products and help gain access to international markets, where aircraft jobs and high technology industrial bases are typically guarded by government policy and regulation.

The study found six major challenges that if unaddressed, could threaten the aircraft industry's long-term health and would benefit from government and industry policy action. These include: the aging and declining workforce, restrictive content regulations and complicated export control processes that limit globalization benefits, defense acquisition instability, declining aerospace R&D, and an overtaxed ATM system that must triple in size to accommodate projected aircraft growth. Policy actions include investment and training to grow and sustain the workforce, reducing the barriers to effective global collaboration, promoting stable acquisition program funding and management, implementing the national aeronautics R&D plan, and reenergizing the NGATS ATM infrastructure modernization program. Addressing these challenges will ensure the global aircraft industry has the workforce, business processes, and technologies necessary to maintain its critical role as a driver of the high technology global economy. A strong aircraft industry is also vital to U.S. National Security and this country's ability to meet its global security commitments. Today, the industry is well positioned to meet global strategic requirements. It will continue to do so with an international commitment to policies that recognize the global nature of the industry and encourage free and open competition for the highest public good

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