Washington State Aerospace Defense Export Market Research

Discussion Draft

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Washington MilitaryAlliance

Prepared by:

cai community attributes inc

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Community Attributes Inc. tells data-rich stories about communities that are important to decision makers.

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EXECUTIVE SUMMARY

Background and Purpose

Washington's aerospace defense sector is an important element of the state's economy. In fiscal year 2015, there were 117 unique aerospace defense contractors located in Washington. Boeing, the largest of these, was awarded defense contracts in in excess of $3.3 billion in 2015.

Beyond Boeing, Washington aerospace firms had $45.9 million in prime contracts with the Department of Defense (DOD) and the Coast Guard. These contracts range across the following subsectors of activities:

- **Unmanned aerial vehicles**, notably Insitu (a Boeing subsidiary) and Silicon Forest Electronics.
- **Maintenance, repair & overhaul** and **aircraft-on-ground** (AOG) services.
- **Weapons and missile systems**, such as Systima Technologies.
- **Systems design and parts manufacturing**, including Crane Aerospace and Pacific Aerospace & Electronics.
- **Aviation modeling, simulation systems, technology design, and testing**, including Plexsys Interface Products and Olympus Scientific Technologies.
- **Aerospace research & development**, like Bothell-based Tethers Unlimited.

Despite the robust nature of the aerospace defense sector, future possible changes in federal spending may challenge the continued vitality and health of these businesses. One method for hedging against these possible headwinds is the expansion into overseas markets, both for defense and civilian work.

The Washington State Department of Commerce (Commerce) has requested this report to assess overseas exporting opportunities for Washington-based aerospace defense contractors. This report includes a review of defense activities in Washington, global trends in the aerospace sector (defense and civilian), potential market opportunities, and a set of recommended strategies for Commerce to implement to help these firms diversify abroad.

Exporting entails numerous challenges, including regulatory/export controls, economies of scale needed to expand overseas, and important information gaps on where opportunities might exist. This report will help address many of these challenges and provide a strategic framework for Commerce to help defense contractors expand their business into overseas markets. Recommendations address key trends and considerations specific to aerospace businesses in Washington engaged in defense contracting.

Key Findings

The following paragraphs summarizes key findings shaping the set of recommended actions Commerce should take to support the diversification of aerospace defense contractors into overseas markets. Findings are organized by important trends and considerations, followed by potential opportunities.

Industry Trends and Baseline Conditions

- **Barriers to entry**. Whether aircraft manufacturing or maintenance, repair and overhaul support, Washington's aerospace defense contractors will face prohibitive barriers to entry into existing programs they are not already engaged in. On either side—defense and civilian—tier I suppliers and original equipment manufacturers (OEMs) prefer to work with their existing suppliers rather than replace them. Supply chains are organized early on in the development of a new program. In order to diversify, firms must focus on new programs and continually cultivate relationships.
- **Systems integration model**. As evidenced in the 787 and A350 programs, an increasing amount of intellectual property and development will take place among tier I systems integrators. Relationships with these suppliers may prove of equal or greater value to those with OEMs in the future.
- **Many overseas OEMs actively seek new relationships with U.S. contractors**. These include Airbus Americas and qualified supplier systems.
- **Certifications**, such as AS9100, are critical to communicating quality and a standardized process, and are universally accepted in the industry. However, certifications can be very expensive.
- **Clarifying regulatory barriers**. ITAR is perceived to be a formidable barrier for many firms, but recent export control reforms have attempted to ease certain restrictions and move many products from munitions lists to commercial control lists.

Opportunities

Future programs include both foreign and domestic OEMs. Even for U.S. federal government programs, tier I integrators will likely include overseas contractors, for example BAE Systems (U.K.), Dassault (France), Leonardo, Saab, and Korean Aerospace Industries, among many others. Many of these overseas contractors, OEMs and tier I integrators have established locations within the U.S., such as BAE Systems in New Hampshire and Airbus in Virginia.

New overseas programs in the civilian space may present opportunities for local contractors, such as Comac C919 and AVIC regional turboprop program in China and Franco-Italian ATR's 90-seater turboprop initiative.

Strategies for Support Aerospace Defense Contractors

Opportunity/Theme	Key Findings/Considerations	Strategy	Type of Assistance
Industry-wide—building relationships for future opportunities	It is very difficult/rare to replace existing suppliers in the supply chain. It is critical to get involved early to foster these connections.	**Lead domestic delegations** to U.S.-based offices of European, Asian, and South American OEMs and tier I suppliers. Airbus America actively seeks to build relationships with U.S. suppliers.	Education and training/market research
	Companies need to stay ahead on new programs, e.g., reemergence of turbo-prop class. Number of Washington firms already registered as overseas suppliers to original equipment manufacturers (OEMs).	**Convene events in Washington.** Organize a special session at a future aerospace industry conference in Washington to convene defense contractors and overseas OEM representatives.	Education and training/market research
	Future programs include U.S. Air Force and Navy craft with foreign tier I suppliers.	**Lead outbound delegations.** Lead an annual outbound delegation of defense contractors to meet with OEMs and tier I suppliers in Europe and Asia, including BAE Systems in the United Kingdom and Korea Aerospace Industries Ltd.	Education and training
	Airshows provide an important venue for strengthening relationships with tier I and OEM clients.	**Recruit contractors to attend airshows.** Continue to actively recruit local defense contractors to participate in the Paris and Farnborough Airshows, and consider leading a delegation to the Dubai Airshow.	Education and training
	Zodiac, Thales, BEA Systems, others have offices in WA.	**Leverage the presence of overseas firms already located in Washington.** Convene meetings between defense contractors in Washington and these overseas offices to discuss opportunities for future supply chain work.	Market research

Opportunity/Theme	Key Findings/Considerations	Strategy	Type of Assistance
Industry-wide—staying informed of current and future trends	Smaller contractors may not have the resources needed to stay on top of important industry trends.	**Expand the Washington Military & Defense Economic Impact Tool** to include current information on aerospace defense trends.	Market research
Industry-wide—support innovation among local suppliers	Staying competitive requires investment in innovation	**Help firms access DARPA, SBIR,** and other grant-supported research.	Technical assistance

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INTRODUCTION

Background and Purpose

Washington State economic development practitioners have become increasingly concerned with how best to support defense contractors to weather future uncertainty in the federal defense budget. Defense contractors are an essential link the U.S.'s defense supply chain, and the Department of Defense wants to ensure they will be available for future defense needs. Export markets are an important opportunity for mitigating this uncertainty for defense firms, reducing individual contractor reliance on defense contracts while ensuring they will be available for future national defense projects.

Washington is already one of the most trade-reliant states in the U.S. The state has one of the most heavily trafficked port systems in the U.S., and has a long history of linkages with other parts of the world, including Asia and Northern Europe. In 2012, the Washington Council on International Trade and Trade Development Alliance of Greater Seattle (TDA) found that 40% of all jobs across the state were tied to trade, the majority through export activities. TDA confirmed and updated this estimate in 2015 in partnership with the Brookings Institute and the JPMorgan Chase Global Cities initiative.

However, trade comes with risks. In addition to finance risk and uncertainty in overseas markets, local defense firms must also comply with U.S. federal government export controls, including the International Traffic in Arms Regulations (ITAR). Failure to comply with ITAR can result in significant penalties that may deter businesses from pursuing export opportunities. Export Administration Regulations (EAR) apply to commercial products with potential military applications, and rules vary based on the country destination of sales. The U.S. government also administers financial sanctions through the Office of Foreign Assets Control. These sanctions cover specific individuals, organizations, and nations pursuant to the U.S.'s national security goals.

With these considerations in mind and pursuant to the goal of ensuring defense contractor stability, the Washington State Department of Commerce (Commerce) retained Community Attributes Inc. to develop an analysis of overseas market opportunities for aerospace defense contractors in Washington state. The analysis leverages public data sources, interviews, reports, news articles, and other sources to present an extensive survey of the opportunities and challenges aerospace companies can face in overseas markets.

Based on these findings, a set of actionable strategies was developed to help defense contractors diversify into overseas markets.

Organization of Report

- **Aerospace Defense Spending in Washington**. An overview of leading aerospace subsectors and contractors in Washington.
- **Industry Trends and Considerations**. Factors and trends shaping opportunities and challenges for aerospace defense contractors, including domestic and overseas barriers.
- **Exporting and Competitiveness Factors**. Strengths and weaknesses of Washington aerospace defense contractors in overseas markets.
- **Market Opportunities**. Country and region-specific opportunities for defense contractors, based on the matching of current, resident capabilities and overseas demand and market conditions.
- **Recommended Strategies**. Actionable strategies the Washington State Department of Commerce can undertake to support aerospace defense contractor exports.

DEFENSE CONTRACTORS AND SPENDING IN WASHINGTON

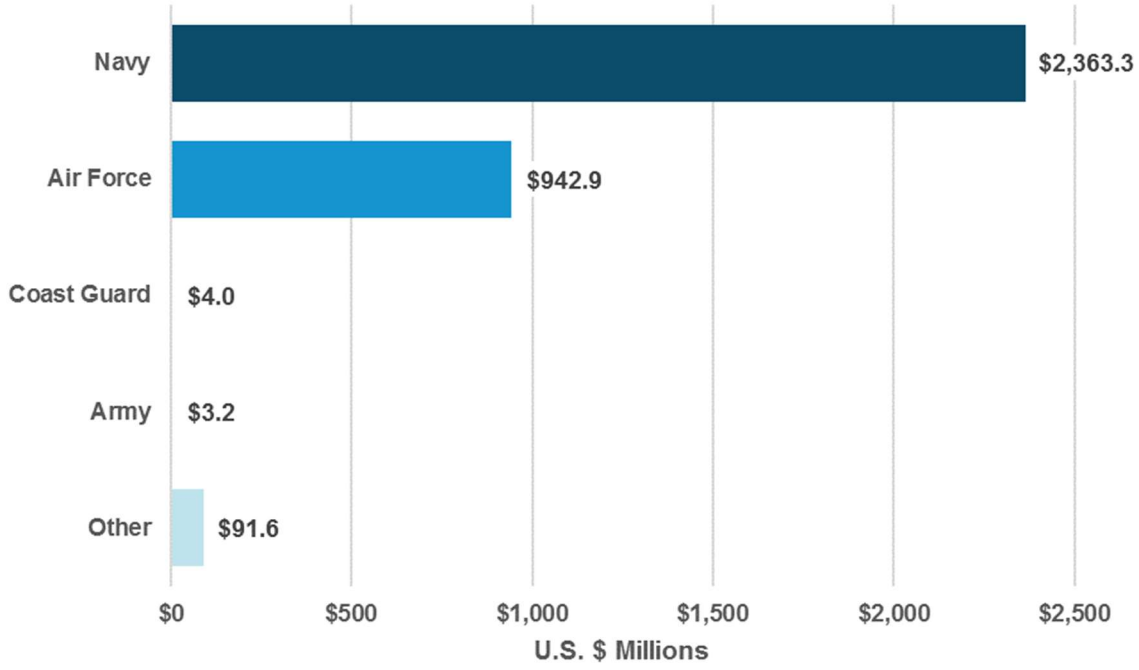
Washington's defense aerospace sector includes a diverse range of activities and products and services. The Boeing Company constitutes the single largest and dominant component of the sector, but across the state exist Boeing suppliers as well as firms supporting other defense aerospace programs, including subcontractors to Northrup Grumman, components manufacturers for the F-35, and drone manufacturing. The sections below provide an overview of aerospace defense contracting in Washington, followed by a detailed discussion of major subsectors with illustrative contractors in each.

Overview of Aerospace Defense Spending in Washington

In fiscal year 2015, there were 117 unique aerospace defense contractors located in Washington. Boeing, the largest of these, was awarded work in in excess of $3.3 billion in defense contracts in 2015. Beyond Boeing, Washington aerospace firms had $45.9 million in contracts with the Department of Defense (DOD) and the Coast Guard (Office of Management and Budget, 2015).

Contractors in Washington serve all three of the military services, as well as the Coast Guard. In fiscal year 2015 the Navy awarded Washington state firms $2.4 billion in aerospace contracts; the Air Force, $0.9 billion; the Coast Guard, $3.8 million; and the Army, $0.7 million (Office of Management and Budget, 2015). (**Exhibit 1**)

Exhibit 1. Aerospace Defense Contracts Awarded to Washington Firms by Branch of Service, Fiscal Year 2015



Source: U.S. Office of Management and Budget, 2016; Community Attributes Inc., 2016.

Washington Aerospace firms supply parts and services to many of the global aerospace OEMs, including Boeing, Airbus, Lockheed Martin, Rolls-Royce and more. Additionally, Washington's MRO and aftermarket parts manufacturers have a depth of expertise in legacy platforms both in the commercial and defense markets.

Among Washington's defense contractors, a large majority perform work in both the defense and civilian aerospace sectors. In addition to aerospace, a large subset of these firms sell transferable technologies to other industries. For example, Pacific Aerospace & Electronics sells hermetically-sealed electronics casings to customers in the medical device field and advanced manufacturing. For defense contractors more generally, opportunities may similarly exist to sell their goods and services to non-aerospace sectors and diversify away from defense work.

Moreover, a large number of firms that perform DOD work domestically similarly sell their products to overseas supply chains—civilian and defense—with such examples of Crane Aerospace, Pacific Propeller, and

Esterline, to name only a few. Prominent markets include Canada, Australia Europe, China, Southeast Asia, and South America.

The deep expertise available among Washington's defense contractors is also in demand among other state and federal agencies. Firms with contracts with the Department of Defense also have contracts with Customs and Border Control, the Federal Aviation Administration, NASA, the Department of Veterans Affairs, and others.

Boeing, the largest aircraft and component manufacturer in Washington dominates the aerospace market as a whole, and is also the state's largest aerospace defense contractor. In fiscal year 2015, Boeing was under contract for more than $3.3 billion in work with the Department of Defense. These contracts were primarily in service of the Navy Poseidon (P-8) and the Air Force Refueling Tanker programs, also known as the KC-46 (Office of Management and Budget, 2015).

Although Boeing dominates the defense aircraft and component manufacturing sector, there is an extensive network of Washington aerospace suppliers performing work for the DOD and Coast Guard, including additional suppliers to Boeing in support of its major defense projects.

Subcontracts. Eighteen Washington companies had subcontracts with DOD or Coast Guard prime contractors in fiscal year 2015. These companies were all within the aircraft sector themselves, manufacturing aircraft parts, auxiliary equipment, missile components, and other aircraft and aerospace parts. Everett-based Korry Electronics manufactures cockpit controls, optic filters, switches, and displays for aircraft. The company had $4.2 million in sub-awards in fiscal year 2015, in addition $450,000 in prime award contracts from the DOD (Office of Management and Budget, 2015; Korry Electronics, 2016).

Aerospace Defense Subsectors and Contractors

Aerospace defense contractors in Washington fall generally within six major categories of activities, delineated below:

- **Aircraft manufacturing**, dominated by The Boeing Company and its two major defense aircraft programs in Washington, the P-8 and the KC-46.
- **Unmanned aerial vehicles (UAVs)**. The largest contractor in this space, Boeing subsidiary Insitu, manufactures reconnaissance drones, including the ScanEagle, out of its facility in Bingen, Washington. Other contractors, such as Silicon Forest Electronics, provide critical UAV components.

- **Maintenance, repair & overhaul (MRO) operations and aircraft-on-ground (AOG) services**. Ongoing support for in-service aircraft, including after-market component replacements, distribution, and parts cleaning and related supporting services.
- **Weapons and missile development**. Both manufacturing and grant-funded research and development.
- **Systems design and parts manufacturers**. Avionics, other on-board electronics, fluid systems, related components, and replacement parts distribution.
- **Aviation modeling, simulation systems, and technology design**. Software that assists in design and development of new defense systems.
- **Aerospace research and development**. Both private sector and DARPA grant-funded research in support of aerospace defense systems.

The sections below detail some of the major types of aerospace defense contracting in Washington.

Aircraft Manufacturing

This subsector is dominated by The Boeing Company. Since 2008, the company has been awarded approximately $80 billion in DOD contracts for aircraft defense systems and platforms to be performed in Washington, most notably the Poseidon anti-submarine reconnaissance aircraft (also known as the P-8) manufacturing in Renton, Washington and the KC-46 in Everett, Washington.

Because both of the above programs are based on civilian aircraft platforms manufactured in Washington—the P-8 based on a 737 platform, the KC-46 on a 767 platform—many of the same suppliers supporting these commercial programs also support various components of these two major defense programs. While Boeing is already a major exporter, many of these small suppliers—ranging from avionics and more completed, integrated parts systems down to machine shops and materials suppliers—may readily benefit from export assistance and diversification into other, global supply chains.

Unmanned Aerial Vehicles (UAVs)

- **Insitu**, based in Bingen, WA, is an aerospace manufacturer of unmanned aerial vehicles (UAV). Lines include civil, defense and commercial products, including information-gathering drones. In 2015, one of Insitu's ScanEagle drones was used by the Royal Navy to track six vessels headed to Tanzania that were carrying heroin. The subsequent interdiction resulted in the seizure of

heroin valued at $150 million—nearly a ton of narcotics (Office of Management and Budget, 2015; Insitu, 2015).

- **Silicon Forest Electronics** is another Washington-based manufacturer working in the UAV industry. This firm manufactures printed circuit boards and electro-mechanical assemblies out of its facilities in Vancouver, Washington. In addition to producing electronics for UAVs, Silicon Forest Electronics also manufactures products for the aerospace industry, the medical industry, the defense industry, and the oil and gas industry. (Silicon Forest Electronics, 2016)

MRO Services and AOG Services

Maintenance, repair & overhaul (MRO) services and aircraft-on-ground (AOG) services are a major commercial activity as airlines, among others, require extensive maintenance services for their fleets. Washington's defense industry has deep expertise in providing aircraft and rotorcraft maintenance and repair services for defense aircraft.

Firms profiled below include:

- Pacific Propeller International
- Howco Distributing
- New Era Contract Sales
- Ves Company
- LKD Aerospace
- LRT Inc.
- Helicopter Parts International
- Eclipse Aeronautical Corporation
- Clarus Technologies

Pacific Propeller International (PPI) received more than $8 million in DOD contracts in 2015 and almost $67 million since 2008. PPI provides MRO services for a broad spectrum of propeller craft. Services include a large parts inventory and complete repair and overhaul services at their Kent facility; additionally, the company is increasingly providing new blade manufacturing services. Platforms they provide MRO services for include: the DASH 8, DASH 7, ATR 42, ATR 72, C-130 Hercules, P-3 Orion propeller assemblies, Lockheed L-188 Electra, Convair 580, Embraer EMB 120 Brasilia, SAAB 340, Casa cn 235 among many others. Additionally, Pacific Propeller International provides services globally, and have an FAA authorized repair station. Customers include the Navy, Coast Guard, Customs and Border Protection, Air Force, Lockheed Martin, NATO Maintenance and Supply Agency, Rolls-Royce and EASA (Pacific Propeller International, 2016).

In fiscal year 2015 PPI sold $4.5 million in propellers, gas turbines, jet engines and other components to the DOD (Office of Management and Budget, 2015).

PPI Technical Services specializes in providing technical and business support for aerospace operators, both military and commercial globally. This includes services to help with government contracting; training programs for most aircraft systems and components, including MRO facilities; back shop logistics from construction of the facility to the acquisition of specialized equipment; management services; facilitating equipment sales and more. PPI Technical services works with clients across the globe, including South America, Asia, Africa and Europe. (PPI Technical Services, 2016)

Aircraft parts distribution is an integral part of the supply chain between parts manufacturers and OEMs as well as parts manufacturers and MROs. Additionally, these services are utilized across the air transport system, and the defense air transport system.

Howco Distributing supplies spare and replacement aviation parts across the globe and domestically to a wide variety of federal agencies including the Department of Defense. Their parts supply not only the aerospace industry, but also the transportation, heavy equipment, and construction industries. (Howco Distributing, 2016)

Other Washington parts distributors include **New Era Contract Sales**, **Ves Company** specializing in hose and piping products, **LKD Aerospace** which provides manufacturing and MRO services, **LRT Inc.** suppling tools for aircraft maintenance and repair as well as AOG services, **Helicopter Parts International** specializing in helicopter parts, and **Eclipse Aeronautical Corporation** stocking parts and components for both military and commercial aircraft.

Another essential maintenance technology is parts cleaning. **Clarus Technologies** of Bellingham, Washington specializes in green cleaning technologies. Products include parts washers, weapons cleaners, and oil/fuel reclaiming products. In 2012 the Clarus PCS-10 was installed at Joint Base McGuire-Dix-Lakehurst to clean aircraft parts that can't be exposed to water. Clarus Technologies crosses between the defense, aerospace, and clean technologies industries with its specialized cleaning products. (Clarus Technologies, 2016)

Weapons and Missile Development

Kirkland-based **Systima Technologies** announced in June 2015 that it had won a $12.5 million indefinite-delivery/indefinite-quantity contract with the Air Force. Systima will support munition system carriages, in

addition to release and precision strike packages (Systima Technologies, 2016). In 2015 alone, the company worked on almost $4.5 million in Department of Defense contracts (Office of Management and Budget, 2015). Since 2008, the company has received nearly $46 million in contracts from the DOD.

In January 2016, Systima Technologies announced it had further won a $4.9 million grant with the Air Force Research Laboratory to support the next generation general purpose bombs program, also known as GBU-X. Systima's contribution to the program will include research for the Weapon Interface and Carriage System Control. The overall goal of this project is to enhance or develop a new family of weapons made out of flexible, interchangeable, and open architecture components. (Systima Technologies, 2016)

Systima Technologies also works in the field of space flight. They provided the Forward Bay Cover Thrusters for the NASA Orion EFT-1 flight test. This work was through a contract with Lockheed Martin. Along with Lockheed Martin, Systima Technologies also works with The Boeing Company, Pioneer Aerospace, and Raytheon Missile Systems. (Systima Technologies, 2016)

Systima Technologies has four major areas of products and services. One key area is the engineering, design, and production of energetic ordinance based products. They can produce either full products or custom parts. This includes missile systems and other ordinance and space systems, such as parachute mortars. At their environmental testing lab, they test both their own products and products developed by third parties. Systima has experience in mechanical engineering, electronics engineering, simulation processes, and testing, all within an environment of rapid development. The testing lab facilitates aerospace testing, medical testing and more, and can test to military, medical, and commercial standards (Systima Technologies, 2016).

Systems Design and Parts Manufacturers

This is a broad category that includes: the manufacture of electronic parts; development of weapons and missile systems; aircraft interiors; hydraulic components; advanced technologies for aviation and space; human-machine interface solutions; transponders; composites and molded elastomers; and machining and sheet metal fabrication.

Notable aerospace defense firms in this space and profiled below include:

- Crane Aerospace & Electronics
- Triumph Aerospace Systems and Triumph Actuation Systems – Yakima
- Pacific Aerospace & Electronics
- Lifeport, Inc.

ELDEC is a brand of electronic and electromechanical products for the aerospace industry, designed and manufactured by **Crane Aerospace & Electronics**. These products provide fluid management solutions, power management solutions, and sensing components and systems solutions. Products include: proximity sensing technology that are used on aircraft landing gear, doors flight control surfaces and more; true mass fuel flowmeters used on military, commercial, business and other aircraft; battery storage systems, transformer rectifier units and flight-control uninterruptible DC power systems for commercial aircraft; silicon-on-sapphire pressure sensors for aircraft turbine engines, air data systems and flight control systems; low and high voltage power supplies; fuel gauging systems used on jets, helicopters and UAVs. ELDEC has locations in Lynnwood, Washington and Lyon, France. (Crane Aerospace & Electronics, 2016)

Triumph Aerospace Systems is part of the larger Triumph Group that has a variety of companies and many locations worldwide. Triumph Aerospace Systems specializes in motion, control and power systems for all types of aircraft from commercial to military, airplanes and helicopters.

Triumph Actuation Systems - Yakima performed work on nearly $1.7 million in contracts with the Department of Defense in fiscal year 2015, the majority of which ($1.3 million) was for aircraft launching equipment (Office of Management and Budget, 2015). Triumph is ISO 9001 certified and their quality systems are approved by all of their customers. These customers include Boeing, Airbus, Bombardier, Northrop Grumman, Sikorsky, and Cirrus among others (Triumph Group, 2016).

Triumph Group's specific capabilities include aircraft system design, hydraulic component design, electrical component design, system/component analysis, systems integration/spatial integration, and electrical/hydraulic and mechanical testing. Their aircraft systems design capability focuses on hydraulic systems, cargo and cowl door actuation systems, primary and auxiliary landing gear systems, smart controls on general aviation. They also design hydraulic valves, hydraulic actuators, and hydraulic piston type accumulators. (Triumph Group, 2016)

Pacific Aerospace & Electronics, based in Wenatchee, is a producer of hermetic seals and precision welding for aerospace defense applications. Since 2008, the company has received nearly $8.3 million in DOD contracts, including nearly $4.0 million in 2011.

Lifeport, Inc.—a producer of custom aircraft armor and aircraft medical systems—had contracts to provide aerospace products to the DOD and Coast Guard in excess of $2.9 million in fiscal year 2015.

Aviation Modeling, Simulation Systems, Technology Design, and Testing

Modeling and simulation technologies are an important part of both aircraft and space research and training. **Plexsys Interface Products** produces advanced air combat trainers for the Air Force, focusing on advanced simulation software. In fiscal year 2015, Plexsys sold $9.1 million in professional support and training equipment to the Air Force. (Office of Management and Budget, 2015; Plexsys, 2016)

Environmental testing of aircraft and aircraft components is essential in quality control and assurance. **Olympus Scientific Technologies** develops and sells industrial quality control equipment. Its Washington activities are centered in Kennewick. In fiscal year 2015 the company sold $425,000 in aircraft maintenance equipment to the Navy.

Olympus's ultrasonic and phased array flaw detectors help welders and machinists detect and inspect hidden cracks, voids and porosity in metals, composites, plastics, and ceramics. Their other products, like thickness gages and inspection probes are also geared toward quality control. (Office of Management and Budget, 2015; Olympus Technologies, 2016)

Aerospace Research & Development

Contractors in Washington also provide aerospace research services. In fiscal year 2015, **Tethers Unlimited** in Bothell received contracts worth $375,000 for research and development activities for the Air Force. The company has also completed work for the Army. Tethers Unlimited specializes in the development of advanced propulsion, power, communications, and robotics systems for air, space, and sea applications. Their past research has included 3D-printed radiation flight shielding and a cable anchor for rapid bridging of rivers and ravines that can be launched from a standard mortar. The company is also currently funded to develop sensor towing systems for UAVs. (Office of Management and Budget, 2015; Tethers Unlimited, 2016)

INDUSTRY TRENDS AND CONSIDERATIONS

A wide variety of industry and economic factors will shape and intermediate current and future opportunities for Washington's defense contractors to export abroad. These factors range from industry-wide trends—such as important shifts in supply chain management—to domestic considerations and foreign government interventions and policies in the aerospace sector.

This section reviews the following categories of factors:

- **Industry-wide trends and considerations**. Common challenges faced by aerospace suppliers, irrespective of their engagement in civilian or defense work.
- **Domestic factors**. The influence of domestic conditions on an aerospace contractor's long-term export plan, including the draw of opportunities much closer to home.
- **Foreign challenges**. Overseas subsidies and other forms of foreign trade barriers that complicate long-term overseas planning.
- **The aerospace supply chain**. Unlike other types of supply chains, the aerospace sector is highly organized around an OEM and tier I systems integrators. Given the development costs, intellectual property, program longevity, and critical role and low substitutability of various aircraft components, newcomers may find it extremely difficult to access existing supply chains.
- **Sources of global demand**. The future of aircraft demand and new models on the horizon.
- **Regulatory and institutional factors** influencing the export of aerospace technologies, including government export controls (e.g., ITAR, EAR) and ubiquitous standardization certifications as a prerequisite for selling into a supply chain, such as AS9100.

Industry-wide Challenges and Considerations

Demand is completely customer driven. Aerospace suppliers sell where the production is. For example, there is an increasing trend among major tier I suppliers, such as Rolls-Royce and Pratt & Whitney, to build engine parts in India. This has led to export growth in India among some suppliers to these manufacturers.

Diversifying work across OEMs is accepted and sometimes encouraged. Boeing and the other large aircraft manufacturers generally do not restrict tooling and machine firms from selling to other OEMs. There are intellectual property protections in their contracts so the technology cannot be disseminated.

Domestic Considerations and Challenges

Draw of Existing Domestic Programs

Many foreign OEMs and primes already in the U.S. A significant portion of the largest aerospace companies across the world are headquartered within the United States; these include Boeing, Northrop Grumman, Lockheed Martin, GKN, Pratt & Whitney, GE, and many others. The access to domestic OEMs and tier I suppliers may dampen the degree to which Washington aerospace firms may want to explore the option of overseas exports given the greater barriers to entry. Additionally, the large number of aerospace firms from the United States increases opportunities for Washington companies to sell to U.S. companies either within the U.S. or to overseas branches. Additionally, many overseas OEMs also have a significant presence in the U.S., exemplified by Airbus in Virginia and Alabama, as well as BAE Systems in New Hampshire.

One of the largest domestic challenges in supporting aerospace exports is the **draw and opportunities tied to domestic OEMs**. With the amount and value of defense work available in the U.S., many firms may not see a need to seek diversification through export markets. Most recently, the Air Force's Long Range Strike Bomber (LRS-B) program was awarded to a team led by Northrop Grumman in October 2015. While The Boeing Company unsuccessfully bid on this program, already one Washington-based aerospace supplier—Janicki Industries, a carbon fiber composite and tooling manufacturer based out of Sedro-Woolly—has been named one of six prime contractors (in addition to Northrop Grumman) on the project (Seligman, Pratt & Whitney, BAE Among Major B-21 Contractors, 2016). As planning and supply chain selection progresses, further opportunities may exist for Washington-based aerospace defense contractors.

Similarly, the U.S. Air Force recently released a draft RFP for the **T-X next-generation training aircraft**. The RFP includes incentives for submittals that exceed the threshold limits for specific performance features, including high-g maneuvering, high angle-of-attack maneuvering and aerial refueling (Seligman, 2016). Teams that are expected to compete, and are already developing their prototypes include: Boeing/Saab; a Northrop Grumman led coalition including BAE Systems and L-3; a team of Korean Aerospace Industries and Lockheed Martin; Raytheon teamed with Leonardo and CAE. Each of these teams already has a plan for the prototype they will submit to the Air Force, some are based on existing platforms and others are "clean sheet" designs (Seligman, 2016).

Although the T-X bidding teams are already in place for these programs, aerospace manufacturers should keep track of how this RFP process goes.

The RFP is expected to be released in December of 2016, for 350 training aircraft. The release of the RFP will be the start of a year-long competitive process (Drew, 2016). It is possible that, depending on the selection of the program, there may be openings and needs in the supply chain for this updated training aircraft.

Certifications and evidence of quality. Stringent standards and quality controls, in particular the Federal Aviation Administration (FAA) has a long history of ensuring the quality of U.S. made aircraft parts, combined with the global acceptance of these quality controls. Certification procedures of aftermarket parts, the FAA has the "Parts Manufacturer Approval," manufacturers that receive this approval can offer significant discounts but still have certification for airworthiness design and production certification. These certification procedures are almost unique to the United States.

Foreign Challenges in the Aerospace Industry

Aerospace is often a highly-protected industry, owing to the vast supply chain requirements and industrialization assets needed and coveted by many governments around the world. In recent years, Boeing and Airbus have been engaged in bitter disputes over various accusations of subsidies for their respective programs, notably the over government tax incentives, subsidies for R&D, and other forms of support for the A350 and 787 programs.

There are some challenges that domestic aircraft parts manufacturers face globally. These include:

- Subsidies
- "Localization" requirements
- Difficult airworthiness approval procedures
- In many markets aviation is an emerging market that requires more support than a parts manufacturer can provide (International Trade Administration, 2015)
- Although a major market for defense products, India's government has focused on policies to support import substitution and indigenous innovation, making it difficult for many firms to sell into the market. (The Dwight D. Eisenhower School for National Security and Resource Strategy, 2015)

Foreign subsidies in support of indigenous aerospace manufacturers and suppliers are fairly common, even in countries that would otherwise be attractive export markets. Examples of countries with significant domestic subsidies include:

- The Belgian government provides subsidies to Belgian manufacturers that supply Airbus
- OSEO, a state-backed company in France, provides reimbursable advances to French manufacturers, which totaled $95 million in 2010
- Zodiac Aerospace received €230 million between August 2008 and August 2009
- Laécoère received €50.4 million in 2009
- Figeac Aero received €10 million in 2011
- Slicom received €1 million in 2011 (International Trade Administration, 2015)

Some governments have formal policies that are intended to promote strong domestic aerospace manufacturing industries. Policies include:

- Purchasing major aerospace products domestically
- Encouraging foreign airframe and aircraft engine manufacturers to establish in-country manufacturing sites, as well as purchasing components from in-country suppliers
- Encouraging technology transfer to in-country organizations (International Trade Administration, 2015)

These practices have been visible within military aircraft procurement practices of global governments. Additionally, offsets are another method of encouraging strong domestic markets, by requiring the purchasing of components from in-country suppliers. (International Trade Administration, 2015)

The validation of airworthiness certificates can be a lengthy and difficult process. For example, the European Aviation Safety Agency charges high fees for validation. (International Trade Administration, 2015)

Aerospace Supply Chain Considerations

The aerospace industry is organized around extensive, dense supply chains, from tier I suppliers that include engine manufacturers to machine shops and materials suppliers often considered to be tier III or tier IV in the supply chain. This section reviews important trends and structural considerations in the aerospace supply chain system. These considerations will inform a subsequent understanding of global opportunities for existing Washington aerospace defense contractors, both for defense and civilian opportunities.

Aircraft Supply Chain Structure

Producers of complete aircraft tend to be large corporations, which rely on a strong supply chain. This supply chain is composed principally of parts manufacturers, which tend to be small and medium-sized businesses. Aircraft parts are supplied to complete aircraft manufacturers, airliners and other private sector aircraft operators, military and civil government agencies and aircraft MRO operations (International Trade Administration, 2015).

Although there are a larger number of small and medium parts suppliers, there is also a large concentration of value among major parts suppliers. These major tier I suppliers, such as Rolls-Royce and SAFRAN own a significant portion of aerospace intellectual property.

As a tiered industry, some parts may pass through many hands, and go through a variety of markets before arriving at a complete aircraft manufacturer. Additionally, airlines and MROs may get their parts through distributors, from OEMs, or directly from parts manufacturers. In the case of foreign military sales, parts are purchased through the U.S. government. (International Trade Administration, 2015)

Role of Integrators

In recent years Aerospace OEMs have shifted toward greater risk-sharing in aircraft development costs and production between the OEM and tier I suppliers. In the past, major OEMs—most notable Boeing and Airbus—worked directly with a larger number of suppliers and controlled a greater share of the program development costs and management. Beginning with the Boeing 787 and Airbus 350 programs, each OEM has transitioned to a smaller number of direct suppliers and greater sharing of capital expenditures and risk among these firms (Mocenco, 2015). These prime contractors assume a greater responsibility for sub-tier suppliers, serving as "integrators" of different tier II components and subsystems.

The consequences of this shift are to reduce in-house production of parts, reduce the number of direct suppliers and increasingly rely on their tier I suppliers to assist with product design, and in contracting tier II and III suppliers (International Trade Administration, 2015). For Washington-based aerospace defense contractors, this important industry trend suggests that exporting opportunities with overseas suppliers will increasingly exist with tier I suppliers, and less directly with the OEM.

With this shift has also comes a greater role for tier I suppliers in intellectual property and innovation. A useful comparison is between the Boeing 737 and 787 programs. In the former program, an estimated 35-50% of the supply chain (by value) was outsourced among suppliers; this

compares with upwards of 70% in the 787 program. Sub-tier systems produced by Boeing's suppliers are then further integrated into a final aircraft in Everett (Tang & Zimmerman, 2009).

The integrator model is an important factor shaping exporting opportunities for defense contractors. As primes control more of the supply chain and sub-systems, aerospace defense contractors with relationships with OEMs must also cultivate similar ties with prime contractors in order to be considered for future programs. In some cases, even if the OEM is a U.S. company (e.g., Boeing, Lockheed, Sikorsky), the prime contractor may be an overseas firm, requiring an international contract to participate in a U.S.-based final assembly program.

Difficulty accessing a supply chain mid-stream. Interview feedback has pointed to the difficulties of accessing existing aircraft program and MRO supply chains. Despite the alignment of technology and competencies between Washington defense suppliers and overseas civilian and defense aircraft manufacturers and MRO operations, it is unusual for an existing program to change suppliers mid-stream. Many OEMs would prefer to work with their existing supply chain and resolve issues with their subcontractors, rather than replace them with another firm.

After-Market Sale and MRO Activities

After aircraft are purchased and have started to be used for either civil or military activities they need continual maintenance, repair and overhaul. MRO activities can be served by OEMs and other aftermarket parts suppliers. The maintenance industry is broken out into several subsectors:

- Airframe maintenance and overhaul
- Engine maintenance and overhaul
- Line maintenance (done by airlines)
- Component maintenance
- Cabin upgrades and design
- Aircraft painting (International Trade Administration, 2015)

Some OEMs actually make a larger proportion of revenue by selling parts to the MRO market. This can limit the potential for this market for aftermarket parts suppliers.

Based on interview feedback, the MRO market can be conceived as organized into four general quadrants of activities, summarized in **Exhibit 2**. below. The four quadrants of MRO activities consist of parts for defense programs, parts for civilian programs, services for defense programs, and services for civilian programs. Importantly, each category

of activity brings unique challenges and barriers to entry that may complicate opportunities for Washington aerospace defense contractors.

In general, it is very difficult to provide support for existing models in the defense industry. According to interview findings, the DOD does not like to replace parts suppliers throughout the lifecycle of an aircraft. The lack of interchangeability of even simpler components at the tier III and tier IV supplier levels can be just as demanding and controlled as those among the tier I and II integrator and major components level. On the civilian side, barriers are similarly challenging for aftermarket parts; civilian aircraft programs would typically prefer working with existing lower tier suppliers to resolve a technology or supply chain issue rather than replace a supplier.

Because defense services for aircraft are commonly performed by a pre-determined set of contractors, in addition to DOD staff, at the aircraft depot, new services providers are often precluded from entry in the MRO defense space. Some opportunities may exist on the civilian defense side, but the civilian MRO services industry is a highly competitive space subject to low margins. Much of the work today is performed in Ecuador and other low-labor cost markets.

Exhibit 2. Composition of the Aerospace MRO Industry

	Defense	Civilian
Parts	**Very Difficult** • Very high barriers to entry	**Very Difficult** • Very high barriers to entry • New suppliers would need to supplant an existing supplier • Would require significant upfront investments
Services	**Very Difficult** • Largely controlled internally by the military • Work is done at depots and by existing contractors • Much less product interchangeability, even at the tier III and tier IV levels • Include many black box elements	**Difficult with Potential** • Possible avenues for entry • The industry operations on very low margins, making the space highly competitive • High degree of competition from low-labor cost markets

Source: Community Attributes Inc., 2016.

Supply Chain Purchasing Patterns

The aerospace industry purchases a small portion of total spending from a wide variety of industries. Compensation for employees and investors typically compose the largest share of spending required to produce output for aircraft industries.

Exhibit 3 details the industries from which aircraft manufacturers purchase goods and services. Those industries for which purchases represent more than 1% of total inter-industry purchases, wages, and investor returns are highlighted in particular.

Purchases of intermediate inputs (goods and services) by aircraft manufacturers across the U.S. is equal to 56% of total aircraft manufacturing output. Labor costs for aircraft manufacturers total 23% of total purchases. Aerospace industry purchases from other aerospace businesses is equal to a quarter (24%) of total industry output.

Exhibit 3. Purchases by Aircraft Manufacturers, U.S., 2012

Category	Share
Inter-Industry Purchases	
Aircraft engine and engine parts manufacturing	11%
Other aircraft parts and auxiliary equipment manufacturing	11%
Semiconductor and related device manufacturing	3%
Iron and steel mills and ferroalloy manufacturing	3%
Aircraft manufacturing	2%
Other motor vehicle parts manufacturing	1%
Valve and fittings other than plumbing	1%
Watch, clock, and other measuring and controlling device manufacturing	1%
Search, detection, and navigation instruments manufacturing	1%
Wholesale trade	3%
Management of companies and enterprises	5%
Other	15%
Total Inter-Industry Purchases	56%
Value Added	
Compensation of employees	23%
Gross operating surplus**	21%
Total Value Added	44%

**Analysis is based on the 2012 U.S. Benchmark Input-Output Table. Gross operating surplus refers to returns to investment, less depreciation.
Sources: Bureau of Economic Analysis, 2016; Community Attributes, Inc., 2016.

Inter-industry purchases and total output are outlined in detail within the U.S. Benchmark Input-Output table, which helps identify supply chain linkages, including major parts and inputs for aircraft production. At the

same time the model helps identify other industries that purchase similar intermediate goods and services, which in turn can be used to help identify potential overseas markets.

Within the U.S. Benchmark Input Output table, the aerospace industry is composed of three subsectors: aircraft manufacturing; aircraft engine and engine parts manufacturing; and other aircraft parts and auxiliary equipment manufacturing.

On the reverse side, aircraft manufacturers sell finished products to several other industries. Air transportation and the federal government are two key examples. Across the U.S., an average of 29% of all industry sales are with the federal government, including both inputs into federal government defense output and final sales to the federal government for defense purposes. More than 45% of aircraft manufacturing commodity output is exported.

Across the three primary sectors of the aerospace industry, more than half of total commodity output is exported. More than 18% of total commodity output across the industry is sold to the federal government for defense. Additionally, 14.5% of total commodity output is sold as inputs to the aircraft manufacturing sector.

Global OEMs and Supply Chain Clusters

Aerospace has major markets across the globe. The United States has the largest market for aerospace and is home to some of the largest aerospace OEMs across the globe. Boeing is headquartered in Washington, and employs more than 77,000 people in the state, as of March 2016. Boeing also has locations across the U.S. in California, Missouri, and South Carolina among others. Other major OEMs based in the U.S. include Lockheed Martin, Northrop Grumman, GE, and Raytheon.

In addition to being the headquarters for many OEMs, global OEMs are establishing manufacturing locations in the United States. In recent years Airbus established an assembly plant in Mobile, Alabama, and the company's first U.S-manufactured A321 was delivered in April 2016 (Airbus, 2016). According to Airbus, the Mobile facility should be able to produce 40 to 50 aircraft per year by 2018. This is just three to four aircraft per month, which is much less than Boeing's monthly production of 42 737s in Renton. However, the Airbus Mobile facility has room to expand production over time.

In 2012 Airbus announced its intention to slowly expand its supplier base in Washington, potentially doubling by 2022, which goes hand-in-hand with their expansion of production into the United States (Boeing, 2016;

Price Waterhouse Cooper, 2015; Wilhelm, Airbus could double Washington state business in 10 years, 2012).

The U.S. and Washington both have strong export relationships with many of the world's largest aerospace clusters (**Exhibit 4**). The largest recipient of U.S. and Washington aerospace exports is China, with more than $15.4 billion in U.S. aerospace exports and more than $11.4 billion in Washington aerospace exports in 2015. Following China are the United Kingdom, France, Canada, Japan and Germany, each of which are home to major aerospace OEMs and tier Is. Washington's largest aerospace export destinations are China, the United Arab Emirates ($2.8 billion), South Korea ($2.4 billion), and Japan ($2.3 billion).

Exhibit 4. U.S. and Washington Aerospace Exports, by Largest Markets, 2015, Millions of Dollars

Rank	County	US Exports	WA Exports
1	China	$15,440.9	$11,440.0
2	United Kingdom	$9,683.8	$1,701.4
3	France	$9,622.1	$1,005.6
4	Canada	$8,292.6	$1,552.9
5	Japan	$7,119.2	$2,326.2
6	Germany	$6,710.8	$1,174.9
7	United Arab Emirates	$5,825.6	$2,812.3
8	Singapore	$5,776.3	$1,658.7
9	Brazil	$4,722.7	$256.1
10	Korea, South	$4,438.2	$2,405.9
	All other markets	$53,995.7	$25,230.9
	Total	**$131,627.9**	**$51,564.7**

Sources: U.S. Census Bureau, 2016; Community Attributes Inc., 2016.

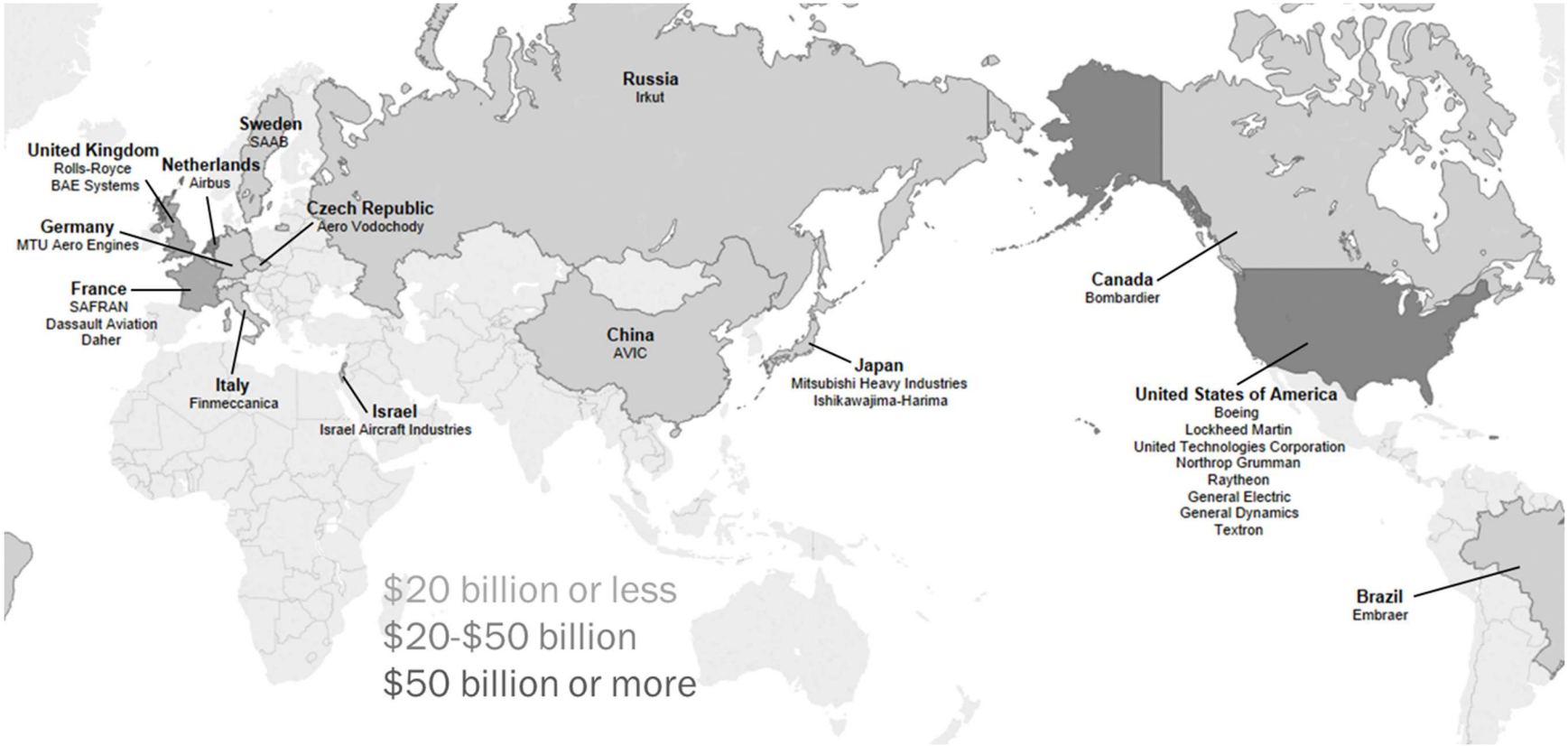
The primary manufacturers of large civil aircraft (LCA), which are defined as airplanes with 100 seats or more or capacity for equivalent cargo, include:

- **Boeing**. Based in the U.S., with a significant presence in Washington, including production lines for the 747, 767, 777 (and future 777X), and 787 at the company's Everett facility, and the 737 in Renton. In addition to a significant presence in LCA manufacturing, Boeing also has a strong defense presence, including final assembly lines for the P-8 and KC-46 programs. Additionally, Boeing manufactures composite components and fabricated parts at their Auburn and Frederickson facilities.

- **Airbus**. Based in France, but with locations in the U.S. According to an interview with Airbus Americas, the company is actively seeking U.S. suppliers for civilian and defense projects. Airbus currently approximately 42% of procurement for jetliners in the U.S. According to Airbus, in 2013 Washington was the company's second largest supplier state by number of companies (25 tier I suppliers, plus many more tier II and tier III suppliers), and sixth largest source by dollar volume. Airbus suppliers including Electroimpact, Fatigue, and Exotic Metals. Airbus's parent company, Airbus Group (previously known as EADS), has stated publicly its desire to source more components in the U.S. to take advantage of the dollar-denominated sales of its aircraft, diversify risk, and address U.S. political calculus factors. As of 2013, Airbus was already spending $13 billion annually in the U.S., and expects this amount to rise to $20 billion by 2020 (Leeham News and Comment, 2013; Wilhelm, 2013).
- **Bombardier**. Based on Montreal, Canada. Bombardier has estimated roughly 52% of components for their C Series jetliner will be sourced from the U.S. The company requires suppliers to be approved either by doing business directly with the company or by being referred by a risk-sharing partner.
- **Embraer**. Brazilian-based manufacturer is slated to introduce E-Jet E2 family of aircraft by 2018. The new aircraft's maiden flight took place in May 2016 (International Trade Administration, 2015; Dubois, 2016)

Europe and the United Kingdom—home to major OEMS such as Airbus, SAFRAN, Rolls-Royce and others—follows the United States as a major aerospace hub. Canada, Russia and Brazil are also home to some of the world's top OEMs. (**Exhibit 5**)

Exhibit 5. Top 25 Aerospace OEMs by Country, Total Country Aerospace Revenue, 2013



Note: Original Equipment Manufacturers (OEM) includes both aircraft final assembly integrators and engine manufacturers, e.g., Rolls-Royce.
Sources: Price Waterhouse Cooper, 2015; Community Attributes Inc., 2016.

Sources of Demand and Future Global Growth

Manufacturers of Large Civil Aircraft (LCAs) are major drivers of global demand for civil aircraft parts. As such the LCA industry is a significant opportunity for OEM sales (International Trade Administration, 2015).

Another major area of growth for aircraft parts manufacturers is within the global aircraft fleet. Aftermarket parts suppliers will need to meet demand for parts for the maintenance and repair of aircraft worldwide. According to Boeing the current airline fleet is about 20,900 airplanes, limited to LCAs and regional jets. In addition, there are also thousands of business aircraft, turboprops, helicopters, and military aircraft. As these aircraft age and go out of production there will be increasing opportunities for OEM suppliers. (International Trade Administration, 2015)

As of 2014 the combined backlog between Airbus and Boeing is more than 10,000. Major suppliers for these OEMs such as Precision Castparts, SAFRAN, Rolls-Royce, and Zodiac are also seeing significant growth.

EADS changed its name to Airbus Group in 2013 to reflect the fact that the majority of revenues for this company now come from the civil aerospace industry. This reflects a broad trend in decreasing defense spending in the U.S. and Western Europe, forcing an overall shift in focus to alternative commercial markets. (International Trade Administration, 2015)

Global Air Fleet Growth Projections

The global fleet of aircraft is expected to experience strong growth over the next 20 years. Deloitte, Airbus, Boeing, and CAVOK all project strong growth particularly in the Asia Pacific market. Over the next 20 years the Asia Pacific fleet is projected to eclipse 11,000 aircraft.

Global aircraft deliveries totaled just under 1,400 in 2015. By 2025, Deloitte anticipates that number to increase to just under 1,800 (Deloitte, 2016). Boeing estimates that over the next 20 years, the global market for commercial aircraft will shift to the Asia Pacific. Boeing forecasts that the Pacific market will represent roughly 40% of demand, followed by Europe and North America at 20% each, with the remaining markets composing the last fifth of demand.

Airbus projects that between 2016 and 2035, an estimated 33,074 new aircraft will be delivered across the globe in the 100+ and freight classes. By value, these orders are estimated to total more than $5.2 trillion, of which more than $5.0 trillion will be in the form of passenger aircraft (**Exhibit 6**).

A major driver of this will be among emerging economies, whose discretionary spending is forecasted to double in just the next years; this increase in spending will in part translate into new demand on air travel, both for business and leisure, helping to drive overall market projections. Among major market regions, the Asia Pacific region is expected to represent approximately 41% of all orders, driven by continued middle class growth in China, India, and other emerging economies. (Airbus Group, 2015).

As the current fleet, especially in the Asia-Pacific region expands, so too will demand for MRO services throughout the globe. MRO is an important market for both OEM parts manufacturers and aftermarket parts manufacturers. Key MRO markets include Singapore, China, and the Middle East (Clearwater International, 2014).

Exhibit 6. Projected Global Demand for New Passenger and Freight Aircraft, 2016-2035, by Region

Region	Passenger Units		Freight Units		Total	
	Units	*Value (bils $US)*	*Units*	*Value (bils $US)*	*Units*	*Value (bils $US)*
Africa	991	140.3	9	2.3	1,000	143
Asia/Pacific	13,239	2,188.3	219	67.0	13,458	2,255
CIS	1,201	156.3	25	7.2	1,226	164
Europe	6,508	959.4	79	23.6	6,587	983
Latin America	2,545	341.2	22	4.6	2,567	346
Middle East	2,365	554.4	64	20.4	2,429	575
North America	5,579	700.3	228	59.7	5,807	760
Total	**32,428**	**5,040.1**	**646**	**184.8**	**33,074**	**5,225**

Sources: Airbus Group, 2016; Community Attributes Inc., 2016.

According to CAVOK, a global aviation services and consulting firm, the global air transportation system fleet will grow by more than 10,000 aircraft by 2025, growing annually by 3.7%, with the passenger fleet growing 3.8%. This growth is fueled by increases in sales of narrow body aircraft. All regions are expected to see expansion of their air transportation fleets (Macrontell, 2015). CAVOK's analytics suggest that Asia Pacific fleets, including China and India, will grow at a compound annual growth rate (CAGR) of 6.1% between 2015 and 2025—an absolute increase of more than 5,200 aircraft—far outpacing North America (0.9%, +722 aircraft) and Europe (2.8%, +1,965 aircraft). Asia Pacific's total fleet will increase to nearly 11,700 aircraft by 2025, making it the largest regional fleet (compared with 8,142 aircraft in North America).

The Asia-Pacific region is one of the largest potential markets for aerospace defense aircraft and services. This region is particularly interested in fighter jets and multi-purpose fighters that can be used both for internal and external security uses. Long-term cost efficiencies are a key factor for defense suppliers to work toward for this market. (The

Dwight D. Eisenhower School for National Security and Resource Strategy, 2015)

MRO Market Growth Projections

Analytics by CAVOK suggest that the composition of the global air fleet will be much newer by 2025, with a period (already underway) of significant air fleet replacement; an estimated 43% of all deliveries will be constructed to replace existing aircraft, with the remainder driven by overall fleet growth. This growth may have important implications for the MRO market. By 2025, the MRO industry is projected to reach more than $100 billion, of which nearly half (47%, up from 42% in 2015) will be tied to engine maintenance and related work (Macrontell, 2015, p. 9). The Asia Pacific MRO market is projected to reach more than one-third of this total market, or about $34.8 billion (at a growth rate of 6.6%).

Clearwater International's (2014) Global Aerospace Report notes that "with the civil air transport fleet doubling to more than 50,000 aircraft within 15 years, there are significant opportunities in the MRO market as airlines increasingly outsource their maintenance operations, while aircraft OEMs are also extending their reach into the MRO business."

The modernization of aging equipment will be a driver of the MRO market for defense in the Asia-Pacific region. Many of these markets are expected to hold-off on purchases of defense aircraft until the next generation of equipment is available, which means that current fleets will continue to need MRO services. Among the current fleet the F-16 is projected to generate 31% of MRO demand over the next 10 years as it currently operates in 25 nations. (The Dwight D. Eisenhower School for National Security and Resource Strategy, 2015)

Boeing has received orders for its new P-8 Poseidon submarine-hunting aircraft from Australia and India. In the coming years, these aircraft will require maintenance and repair, representing an opportunity for Washington maintenance and repair companies. Australia has ITAR exemptions that would make this market the easier to enter of the two.

The U.S. is realigning its defense assets toward East Asia. Opportunities for existing contractors may grow in the region among U.S. partner countries such as Australia.

Planned and potential new aircraft models—Defense and Space

While the following programs are funded by arms of the U.S. government, there may exist opportunities for Washington suppliers to

provide sub-tier support for overseas firms participating in these bids, e.g., Saab, Korea Aerospace Industries, Leonardo, BAE Systems.

U.S. Air Force T-X next generation training aircraft

The U.S. Air Force released a draft RFP for the T-X next-generation training aircraft. This RFP includes incentives for submittals that exceed the threshold limits for specific performance features, including high-g maneuvering, high angle-of-attack maneuvering and aerial refueling (Seligman, 2016).

Teams that are expected to compete, and are already developing their prototypes include: Boeing/Saab; a Northrop Grumman led coalition including BAE Systems and L-3; a team of Korean Aerospace Industries and Lockheed Martin; Raytheon teamed with Leonardo and CAE. Each of these teams already has a plan for the prototype that they will submit to the Air Force, some are based on existing platforms and others are "clean sheet" designs (Seligman, 2016).

Although the teams are already in place for these programs, aerospace manufacturers should keep track of how this RFP process moves forward. The RFP is expected to be released in December of 2016 for 350 training aircraft, which will trigger a year-long competitive process (Drew, Boeing Offers Sneak Peak of Clean-Sheet T-X Design, 2016). It is possible that, depending on the selection of the program, there may be openings and needs in the supply chain for this updated training aircraft. Teams submitting proposals include the following:

- Lockheed Martin and Korean Aerospace Industries are expected to submit a variation of KAI's T-50, called the T-50A
- Raytheon, Leonardo (formerly Finmeccanica) and CAE are expected to submit their T-100
- Boeing and Saab have not released much information about their program, but it will be a completely new platform not based on an existing plane
- Northrop Grumman, BAE Systems and L-3 have released information on their program, but it, like Boeing, is a new platform and concept (Seligman, 2016)

Potential replacement for the A-10 Warthog

The U.S. Air Force is exploring ideas for revamping its close-air support mission. The mission currently uses the A-10 Warthog, but the Air Force has expressed concern that there is decreasing use for "slow, unstealthy aircraft" because advances and proliferation of surface-to-air missiles make them much more vulnerable (Seligman, 2016). The Air Force has

considered both a low-end OA-X fighter to support the A-10, as well as an enhanced replacement for the A-10 (Seligman, 2016).

This potential program is a direction that aerospace manufacturers should watch, and those that have the capability to offer a low-cost, efficient solution to the Air Force could benefit.

NASA X-plane

NASA is seeking concepts for X-planes. NASA wants X-planes that can demonstrate technologies for "ultra-efficient subsonic transports," capable of reducing CO2 emissions, reducing noise and landing and takeoff NOx emissions. The primes that are expected to submit proposals for the X-plane include Aurora Flight Sciences, Boeing, Lockheed Martin Skunk Works, and Empirical Systems Aerospace (ESAero). (Warwick, 2016)

Army T700 Engine

Another program defense contractors are expecting is an Army preliminary design project to replace the T700 engine. GE, Honeywell, and Pratt & Whitney are all expected to submit designs. This replacement engine will be used for 2,135 Army aircraft, including Sikorsky H-60 Black Hawks and Boeing AH-64 Apaches (First Take, 2016).

Program Improvements

Established programs are continually working to develop improvements. Both GE and Rolls-Royce are both exploring upgrades to the engines they provide for the Boeing 787. GE is working on upgrades to their GEnx-1B engine, by using technology that they developed for the 777X GE9X. Rolls-Royce is also testing upgrades to their Trent 1000 TEN, incorporating technology from their Advance3 demonstrator. (Norris, 2016)

Research and Development

OEMs across the globe are working both separately and together to conduct research and development that advances the aerospace industry. One such example is a collaboration between Boeing and Embraer on a variety of research and development projects. Most recently they are conducting flight tests of the latest EcoDemonstrator on an Embraer 170 prototype in Brazil. Some of the research the two OEMs have been collaborating on includes boundary layer data systems, ice-phobic paint, flight safety, energy management, advanced lidar (light-detection and ranging) laser systems, as well as airframe designs to reduce noise. The collaboration has also included the establishment of a joint biofuel research center in Soa Jose dos Campos in Brazil. (Norris, 2016)

Space is an emerging field in the aerospace industry. Although space has been an important piece of the industry for a long time, advances and renewed interest in passenger travel to outer space have re-energized the space travel market. Aerojet Rocketdyne is looking into manufacturing and design projects in the space field. Their current focus in on developing a new engine for the United States focused on national security. OEMs and aerospace manufacturers interested in the space field are currently focused on a contest to provide engines for the United Launch Alliance (ULA) which is looking for a successor to the Atlas V and Delta IV from U.S. manufacturers, ending the reliance on Russian RD-180 rockets. (Norris, 2016)

Emergence of New Global Competitors

Emerging competition in the regional jet market is putting pressure on traditional manufacturers. Mitsubishi, Comac and Sukhoi are all developing or have recently released regional jets. Mitsubishi is developing one jet, the MRJ90 to serve the 90-seat market, expected delivery in 2018, and one jet, the MRJ70 to serve the 70-seat market, with expected delivery in 2019. Although neither of these jets have been released yet, Mitsubishi already has more than 400 orders as of July 2016.

In 2016 Mitsubishi signed letters of intent with MRO Japan, the maintenance subsidiary of All Nippon Airways (ANA), HAECO Americas, and PEMCO World Air Services to provide MRO and customer support services across the globe (Pozzi, Mitsubishi Aircraft Ramps Up MRO Network, 2016). In July of 2016, Mitsubishi announced that its next major milestone was to transfer four aircraft to their Moses Lake, Washington facility for flight testing (Flottau, Mitsubishi Aims for MRJ Credibility, ARJ21 Enters Indonesia, 2016).

Another competitor in the regional jet market is the Sukhoi SuperJet 100 (SSJ100). The SSJ100 is primarily used in the Russian/CIS market, but as of 2016 also has jets with Interjet of Mexico and CityJet of Ireland, both of which are satisfied enough with the aircraft to agree to promote it (Dubois, 2016). In May of 2015 Sukhoi's parent company the United Aircraft Corporation (UAC) signed an agreement with Xixian New Area Administrative Committee and New Century International Leasing's joint venture, expected to purchases as many as 100 SSJ100s in the Chinese market (Pyadushkin, 2015).

As of 2015 Sukhoi's backlog of SSJ100s was more than 190 (Pyadushkin, 2015), and in 2016 Sukhoi announced that they are starting development of a stretched version of the SSJ100 that will increase capacity by 20. Their plans do not include a major redesign in order to keep the costs of

the stretched aircraft down (Dubois, Sukhoi Developing 120-Seat Superjet, 2016).

In China, the Commercial Aircraft Corporation of China (Comac) is also emerging as a global competitor in both the narrow-body and regional jet markets. In June of 2016, Comac's ARJ21 entered service with Comac's in-house operator, Chengdu Airlines. Just one ARJ21 was in service, but this slow introduction is intended to allow Comac to address any issues before releasing the aircraft into the competitive market. Additionally, the experience with the ARJ21 will help prepare Comac for the release of the C919, a narrow-body aircraft that is designed as a competitor with the Boeing 737 and Airbus A320. (Perrett, 2016) Comac and the Civil Aviation Administration of China (CAAC) are being cautious with the release of both the ARJ21 and the C919. This care led Comac to announce in April of 2016 a delay in the target release of the C919 to 2019, partially due to an extension of the flight testing for the jet (Perrett, 2016)

Technology Trends

Aircraft and parts technology trends

The commercial aerospace market is currently moving away from large aircraft like the A380, though this trend may reverse. An example of this trend is Singapore Airlines, which is already moving away from the A380 after making a large investment in the aircraft (Flottau, 2016).

Another example of the market responding to this trend is the announcement by Airbus that they will decrease production of the A380, and Boeing's announcement that they will reduce production and may even close the line for the 747 (Norris & Flottau, 2016). Fuel costs and changing travel patterns will determine which models airlines determine are most cost effective, and these decisions will have long-range impacts on the production and creation of specific aircraft lines.

Global OEMs are always working to improve the function and operation of their aircraft. Bombardier is working at the London City Airport to make their C-series airplane more competitive and increase its range (Flottau, 2016). As Bombardier works to make their C-series jets more competitive, the company becomes a stronger potential option for suppliers to look toward in order to join their list of approved suppliers.

The aerospace industry is increasingly integrating technology into its products. This is in particular focused on increasing communication between aircraft systems and between aircraft (Abrams, 2016). As wearable technologies have become more common in personal use, they are also starting to appear in the aerospace industry, particularly in the

form of updated controls and gauges. These advances have especially important applications in defense with the use of touchscreens and speech recognition (Warwick, 2016).

Safety is an arena in which the aerospace industry is working on advancing. Some of these advances and innovations were shared at the 2016 EAA AirVenture show. LAM Aviation shared their new Columbia Volant, a Lancair Columbia 300 with a modification of an electro-mechanical aileron and flat system design with the purpose of preventing loss-of-control issues. Additionally, the FAA is working on rules to require new aircraft designs to be "departure-resistant," meaning that new aircraft must "avoid a departure from controlled flight in roll or other axes, a nod to a spin- or stall/spin-resistant design" (Morris, McMillin, George, Degimann, & Croft, 2016).

Fuel efficiency, composites, and clean technology

Increasing efficiency is a major focus in the aerospace industry. A variety of technology and innovation is being explored relating to efficiency. One technology that services this are turbo fans, which are bigger, better and more efficient, and these fans in addition to increasing fuel efficiency, could also result in changes to overall aircraft design. Laminar-flow wings are a design innovation that requires precision manufacturing, but presents amazing increases in aerodynamics and fuel efficiency. (Warwick, 2016)

Alternative fuel sources are another area of innovation that the aerospace industry is exploring. Among these alternative sources are electric and hybrid-electric options. One example of this is Airbus's work on their E-fan, a proof of concept electric engine fan (Warwick, 2016). Additionally, the government is looking into alternative fuel sources. The U.S. National Academy of Sciences convened a group to look at strategies to decrease carbon emission from the aviation industry, most of which are generated by large aircraft. The group expressed skepticism about the viability of hybrid-electric engines for large aircraft. However, they did provide four recommendations of areas for the industry to focus on: "propulsion-airframe integration, gas turbines, sustainable alternate jet fuels and turbo-electric propulsion" (Warwick, 2016).

Advances in manufacturing processes and materials are also important innovations in the aerospace industry, contributing to increasing efficiency across the industry. New trends include 3D printing and additive manufacturing. The industry has historically been cautious in the use of these technologies due to concerns about safety. However, these manufacturing capabilities present opportunities in prototyping, the use of

polymers and more importantly the use of metal additive manufacturing processes. (Bruno, 2016; Warwick, 2016)

Renewed interest in turboprop aircraft

In 2013 the turboprop market started to see a strong resurgence in demand, which is partially credited to the high cost of fuel in 2013 and the fuel-efficiency of the aircraft (Perrett, 2013). The turboprop market seeing the greatest resurgence at the time was the 90-seat market, dominated by ATR and Bombardier, and experts projected that more than 480 aircraft in service in 2013 would need to be replaced (Air Insight, 2013). A wide range of manufacturers explored the 90-seat market in 2013, including AVIC, Regional Transport Aircraft (RTA) of India's Hindustan Aeronautics Ltd., Bombardier and Korea Aerospace Industries (Perrett, 2013).

Although the resurgence started in 2013, the turboprop remains a strong market, despite decreases in fuel costs. Interest has also extended beyond the 90-seat market, including small aircraft seating less than 10 to the 30-seat market and the 90-seat market. GE is working on a new advanced turboprop engine for Textron in their new single-engine turboprop. The engine will compete with the PT6 manufactured by Pratt & Whitney Canada, the dominant engine in the market to dates (Norris, 2015). Aerospace manufacturers across the globe are releasing new turboprops, including Aircraft Industries of the Czech Republic, ASI Aviation, CAIGA, Diamond, Epic, Evektor, Piper, and Tecnam are just a few releasing new or upgraded turboprops (Jackson, 2016).

ATR—jointly owned by Italian aircraft manufacturer Finmeccanica and Airbus—is a particularly strong competitor in the turboprop market. ATR is looking to sell their aircraft (the ATR 42 and the ATR 72) to markets in Japan, China and India. Overall, ATR expects that routes served by turboprops will grow 4% over the next 20 years. This equates to demand for 3,900 aircraft in 2035 compared to 2,100 currently, and a large part of the demand will be for replacement aircraft (Osborne, ATR Projects Strong Demand, 2016). ATR is looking in particular at Japan, with a predicted demand for 100 turboprops through 2025. In 2015 Amakusa Airlines took delivery of the first ATR 42 in the country, and Japan Air Commuter ordered 8 ATR 42s, plus one option and 14 purchase rights. ATR is hopeful they will be able to capture a large share of the market, replacing the current fleet of Bombardier, Embraer, and Saab aircraft (Schofield, 2016).

ATR is also interested in adding a new 100-seat aircraft to their offerings. One shareholder Leonardo is interested in the project, while Airbus Group is not as interested. As a result, ATR is taking a two-step approach

to their new offerings. Their first step is to re-engine the ATR 72, following the trend set by Airbus with the A320neo and Boeing with the 737 MAX. They are exploring the new engine with both Pratt & Whitney Canada and GE, and are specifically looking to increase fuel efficiency and reduce maintenance costs. After some years they will embark on the second step and launch a 100-seat turboprop program. As of 2016, ATR has a three-year backlog on production. (Flottau & Norris, 2016)

Intelligence, surveillance, and reconnaissance and continued demand for UAVs

A growing trend, accelerated with the U.S. aerial combat needs in the Middle East, is for greater unmanned aerial intelligence gathering. Currently, the U.S. Air Force relies on the U-2, scheduled to be retired in 2019 (the SR-71 has been retired since 1998) and the Global Hawk UAV.

Recent trends suggest that future intelligence, surveillance, and reconnaissance (ISR) platforms will be unmanned and include hypersonic, stratosphere orbital capabilities. Lockheed Martin, for example, is proposing two unmanned models for high altitude ISR: 1) the SR-72, successor to the SR-71 and capable of reaching Mach 6; and 2) the TR-X. The latter model is being advertised as a replacement for both the U-2 and Global Hawk, able to reach an altitude of 70,000 feet and able to stay in the air for 24 hours, and much longer with air refueling (Seligman, 2016).

The DOD is also exploring the use of laser systems on UAVs to stop ballistic missiles. The program is known as the Laser Demonstration Program, and Lockheed Martin, Boeing, Northrop Grumman, Raytheon and General Atomics Aeronautical Systems are all expected to compete for these programs. (Drew, 2016)

Another important trending innovation in the drone market for defense is teams or swarms. This technology would allow drones to interact cooperatively, creating teams or swarms, and has important applications for the defense industry. (Warwick, 2016)

Drones and UAVs are also an important tend in the commercial aviation market. Many federal agencies are exploring the use of drones, including the FAA, the Department of the Interior, the U.S. Postal Service, NOAA and NASA. All of these departments are working on testing drone use in cargo delivery and data collection where manned vehicles are currently required. The FAA is also convening stakeholder panels to address issues related to drone safety and regulation. (Warwick, 2016)

The FAA is working to develop regulations to address UAVs and drones use in the U.S. The lack of regulations to this point has been a depressive influence on the market for UAVs and drones in the commercial market. Once the FAA finalizes its policies it is possible that there may be a boom in the UAV market. (Warwick, 2016)

The potential for the use of drones in the commercial market is exemplified by Airbus. Airbus is researching air taxis and autonomous air vehicles for passengers. The research is known as Project Vahana, located at Airbus's Silicon Valley location A3. It is exploring concepts and designs for air taxis and plans to have a prototype for demonstration by the end of 2017. Airbus is also exploring autonomous drone delivery services and has designs for batteries, motors, and avionics. (Warwick, 2016)

REGULATORY AND INSTITUTIONAL FACTORS

This section provides an overview of domestic and overseas factors shaping exporting opportunities for Washington aerospace suppliers.

Aerospace Certifications

Aerospace-related certifications are a valuable signal to potential international trade partners: they demonstrate that a company has a level of quality sufficient for their respective fields.

ISO 9000 is a family of quality management systems for aerospace companies that requires third-party certification. There are more than 1 million certified companies across the globe.

AS9100 is a quality management system for the aerospace industry developed by the Society of Automotive Engineers and the European Association of Aerospace Industries. This replaced the earlier AS9000 and fully incorporates ISO 9000. Major aerospace manufacturers and suppliers require compliance or registration to AS9100 as a condition of doing business.

There are 189 certified AS9100 producers in Washington. Out of these, 32 had contracts with the DOD or Coast Guard. These certified contractors represent 27% of all Washington aerospace defense contractors in 2015.

AS9110 is a quality management system based on AS9100, but is targeted to maintenance companies. AS9120 is also based on AS9100, but is specific to aerospace distributors. Another certification, the 14 CFR Part 145 is an FAA certification that ensures that programs, systems and methods of compliance are reviewed, evaluated and tested. The 14 CFR Part 145 is specific to repair stations.

Export Controls

Aerospace defense exports are often subject to export controls. These regulations on the overseas sales of aerospace products and services help shape potential markets for Washington aerospace defense contractors. Details on the rules and specific implications for aerospace defense firms are discussed below.

International Traffic in Arms Regulations

The International Traffic in Arms Regulations (ITAR) control the import and export of defense articles and defense services. The U.S. Munitions List (USML) is a list of defense articles and services controlled under the ITAR. The USML is divided into 21 categories. USML Category VIII (Aircraft and Related Articles), USML Category XI (Military Electronics), Category XV (Spacecraft and Related Articles), and USML Category XIX (Gas Turbine Engines and Associated Equipment) are the most relevant to the aerospace industry.

For example, aircraft capable of being refueled in flight may fall under USML Category VIII, ground control systems specifically designed for telemetry, tracking, and control of spacecraft may fall under USML Category XV and a turbojet engine capable of 15,000 lbf of thrust or greater may fall under USML Category XIX.

The ITAR has strict licensing requirements and exports of defense articles and defense services to most all countries and in most all circumstances require an export license from the U.S. State Department's Directorate of Defense Trade Controls (DDTC). Certain articles and services may, however, be exported to Australia, Canada, and the United Kingdom, without DDTC licensing if certain requirements are met. Nevertheless, Washington defense contractors must carefully review the ITAR's licensing requirements and exceptions to avoid inadvertently violating ITAR.

Export Administration Regulations

The U.S. Commerce Department's Bureau of Industry and Security (BIS) administers and enforces the EAR. Aerospace companies must consider compliance with the EAR when providing non-military use products to, or technology with, customers outside of the United States.

The CCL is divided into ten categories. CCL Category 6 (Sensors and Lasers), CCL Category 7 (Navigation and Avionics), and CCL Category 9 (Aerospace and Propulsion) are the most relevant to the aerospace industry. For example, radar systems fall under CCL Category 6, certain global positioning systems (GPS) fall under CCL Category 7, and non-military Unmanned Aerial Vehicles (UAVs) fall under Category 9. In some

cases, a product for export including all of these items may be subject to the licensing requirements under each of the categories.

Unlike the ITAR, which requires DDTC licensing for nearly all exports, a potential aerospace industry exporter with items controlled on the CCL first would review the CCL to determine the precise Export Control Classification Number (ECCN) that controls the item for export. It is important to note that the EAR controls products, design/testing/production equipment, materials, software and technology. Accordingly, the email of detailed blueprints controlled under a specific ECCN might require an export license from the BIS just as an export of the end-item produced using those blueprints.

Many items previously listed on the USML that are now listed on the CCL are assigned ECCNs in the 600 series (e.g., equipment for testing certain engines is now covered under ECCN 9B619.b). Items in the ECCN 600 series are generally subject to a policy of denial by the BIS for export to China, Cuba, Iran, North Korea, Sudan, and Syria.

Each ECCN includes a list of the reasons for control. Once the exporter has located the ECCN and the reasons for control, the exporter can then refer to the EAR's Commerce Country Chart (Country Chart). The Country Chart provides rows listing all countries of the world and columns listing the various reasons for control.

By reviewing the reasons for control and the country, an exporter can determine if a BIS export license is needed. If the reason for control column includes an "X" next to a country, then the exporter must apply to the BIS for an export license to export the item to that particular country unless a license exception is applicable. Each ECCN includes information on special license requirements and any licensing exceptions that apply. When an export license is required, the exporter can apply using the BIS's online system known as "SNAP-R."

Export Control Reforms

Through the Obama Administration's export control reform effort (ECR), the USML has undergone major revisions that have greatly reduced the number of products that fall under ITAR controls. As a result, Washington's aerospace industry may see new market opportunities available because DDTC licensing may no longer be required for certain items that previously were under ITAR controls.

Although certain systems and major components have been removed from ITAR controls, the products affected generally have been parts, components, attachments and accessories that were only nominally adapted for military use and that have both military and civilian uses, so

called "dual-use items." For example, certain helicopters, small craft, and electronic components that were previously considered ITAR-controlled but that can be used for either civilian or military purposes have shifted from the USML to the Commerce Control List (CCL) of the Export Administration Regulations (EAR).

A detailed example of an export compliance review came be found in the **Appendix**.

Case study—Esterline civil penalty in 2014

In 2014 Esterline paid a $20 million civil penalty for alleged ITAR violations. Kirkhill-TA Co, one of Esterline's U.S. subsidiaries, transferred ITAR-controlled technical data to foreign employees without authorization.

Korry, another Esterline subsidiary, submitted a Manufacturing License Agreement to authorize the foreign manufacture of optical filters used in night vision imaging systems. However, Korry began exporting technical data before the agreement was executed. Korry was also charged with exporting items that were not originally in the scope of the company's approved agreements.

Esterline's Mason Electric Company subsidiary allegedly failed to report fees and commissions paid to one of its Brazil sales agents as require in ITAR § 130.9. After acquiring a company called Memtron, Esterline continued to submit its annual DDTC registration from 2007 to 2010 without including Memtron on its registration renewal paperwork. (Export Solutions, 2014)

GLOBAL MARKETS

Major Market Trends

Several major trends will define future opportunities for Washington's aerospace defense suppliers. These trends, discussed in earlier sections of this report, can be summarized as the following:

- **Asia as a major source of current and future civilian aircraft demand**. Projected growth in airline traffic in China and other developing economies will drive orders.
- **The continued shift to an integrated supply chain, with greater control and development among a select number of tier I suppliers**. The industry experienced a modest retreat from the integrated supply chain in response to complications arising in the 787 program. However, research indicates that future aircraft programs will continue to move to a more globalized supply chain,

with large segments of R&D and manufactured outsourced to tier I suppliers, including many overseas firms.

- **New and evolving OEMs**. In the past, the large-body commercial aircraft space was dominated by Boeing and Airbus. In recent years, manufacturers of smaller aircraft and business jets—notably Bombardier and Embraer—as well as new manufacturers in China and elsewhere will erode this duopolistic industry orientation. New competitors range from Comac (a subsidiary of the Aviation Industry of China, or "AVIC") and Mitsubishi, among several others. Yet despite the emergence of these new mid- and large-body aircraft competitors, a significant share of component work is—and will continue to be—imported from foreign firms, presenting an opportunity for Washington defense contractors.
- **New aircraft models**. Accessing contracting opportunities for existing models—either as parts suppliers or in the MRO space—is extremely difficult and unlikely to bear fruit for many firms. The best opportunity for Washington aerospace defense contractors is to look forward and cultivate relationships with existing OEMs and tier I suppliers competing or planning to compete on new models, both civilian and military in use. Even among U.S. Air Force and Navy aircraft manufactured by U.S.-based OEMs, foreign contractors often perform significant work on these programs. United Kingdom-based BAE Systems, for example, is among the largest defense contractors in the world, a subcontractor on the F-35, and a member of a team bidding on future U.S. defense programs.

United Kingdom

Overview

The United Kingdom is one of the largest aerospace markets in the world, and also is a large producer of defense technologies. This aerospace industry has many areas of specialization, including: "design and manufacture of large aircraft wings; production of aircraft engines; design and manufacture of helicopters; building landing gear systems; and creating advanced aircraft systems." (Department for International Trade, 2014)

As home to the headquarters of Rolls-Royce, the UK is a major hub for aircraft engine manufacturing. This specialization creates opportunities for domestic and foreign manufacturers of engine components, as well as firms working in aircraft engine maintenance. (Department for International Trade, 2014)

Notable aerospace companies headquartered in the United Kingdom include:

- Rolls-Royce
- BAE Systems
- GKN
- Meggitt
- Ultra Electronics

Many foreign firms also have locations in the UK, including:

- Airbus
- Finmeccanica
- Thales
- Boeing
- Bombardier

In addition to being one of the largest aerospace industries in the world, it is the second largest export destination for U.S. aerospace exports. In 2015 the U.S. exported almost $9.7 billion in aerospace parts to the United Kingdom. The country is also an important destination for Washington state aerospace companies, which sent more than $1.7 billion to the country in 2015.

BAE Systems is one notable example of a UK defense company. Working in electronics, aerospace, maritime, land-based defense vehicles, and cyber security, BAE Systems works across sectors in the defense industry. In addition to providing defense services for the United Kingdom, BAE Systems is also an important contractor in U.S. defense contracts, and also works in Australia among other export destinations.

BAE Systems was selected to provide key components for the B-21, or the "long-range strike bomber." Much of the project is still classified, but experts speculate that BAE Systems likely will be building the electronic-warfare equipment for the project. The Nashua, New Hampshire headquarters of BAE Systems electronic-warfare arm has a strong history in the field, having built electronic-warfare equipment for 80% of the U.S. military's fixed-wing aircraft. (Thompson, 2016)

The company is also part of a team with Northrop Grumman and L-3 competing for a contract with the U.S. Air Force to develop the T-X advanced pilot trainer (Drew, Boeing Offers Sneak Peak of Clean-Sheet T-X Design, 2016).

One of BAE Systems recent successes is a kit that converts a conventional rocket into a laser-guided weapon. Known as an advanced precision kill weapons system, this kit is more affordable and more sophisticated than a Hellfire, according to BAE Systems, and is also more capable than the Hydra rocket. Recently the United States approved the sale of these kits to Iraq, Jordan, Lebanon, Australia and the Netherlands, and an additional 19 countries have expressed interest. (Bach, 2016)

In 2016 BAE Systems was awarded a contract with the U.S. Army Intelligence and Security Command to help with the development of their next-generation geospatial intelligence capabilities (Tomkins, 2016). Another recent contract win for BAE Systems was a contract extension for $200 million with the Royal Australian Air Force to continue their support of the Hawk Lead-In Fighter through 2020 (Contract Extensions for Raytheon and BAE Systems at Williamstown, 2016). BAE Systems was also part of a recent agreement signed by the United Kingdom, known as the Typhoon Total Availability eNterprise (TyTAN) agreement to provide maintenance to the Royal Air Force for 10 years and also includes provisions to reinvest cost savings on maintenance into upgrades of the Typhoon (Lancashire Evening Post, 2016).

BAE Systems also works in the civil aircraft field, exemplified by a recent solicitation for feedback about a passenger-to-freighter conversion for the Avro RJ, particularly for the RJ100 as they come out of passenger service (MRO-Network.com, 2016). BAE Systems was also selected in 2014 by Boeing to provide the fly-by-wire flight control system for the 777X (Norris, BAE-Rockwell Wins 777X Deal, 2014). Additionally, BAE Systems is also looking to the space industry as a strong future market for their services, their expertise in electronic warfare puts them in a strong position to offer security and electronic systems for space systems (Wall, 2016).

Market Barriers and Access

The United Kingdom's strong relationship with the United States makes it an attractive trade destination due to lower barriers to entry. The U.S. and the UK have the Defense Trade Cooperation Treaty, which is implemented through the Arms Export Control Act and ITAR. This treaty's aim is to ease the export of defense articles between both counties, and allow greater access between the defense industries of both countries. These aims are achieved by creating a community of approved government entities and contractors who can export approved articles without an export license. (U.S. Department of State, 2015)

The recent vote by UK citizens to leave the UK, known as Brexit has created some uncertainty in the global aerospace market. These

uncertainties center around market fluctuations affecting UK aerospace firms, the changing relationship between the UK and the EU, changes in the value of the pound, continued defense spending in the UK, and funding for UK aerospace research. (Reid, 2016)

Post Brexit, it is unclear how the UK and the EU will work out trade relationships into the future. Europe is a major market for UK aerospace firms, and they do not know if their level of access will continue in the European open market. The short-term uncertainty is expected to impact the UK aerospace market, and the long-term impacts are dependent on the future deals. (Derber, 2016)

Immediately post-referendum the shares for airlines in the UK went down significantly. It is unknown if this decline will continue. Additionally, a decline in the value of the pound because of Brexit could negatively impact the demand for travel from UK citizens. This could have negative impacts on the demand for aerospace. However, a weakened pound could have positive impacts for UK aerospace manufacturers as their products become more competitive against stronger currencies (Derber, 2016).

Brexit is also creating uncertainty about public funding sources for UK aerospace research. In 2016, after Brexit, the UK government and aerospace industry announced almost $480 million in aerospace research projects. However, the funding comes from sources committed prior to Brexit, and the announcement did not include any plan to replace funding from European Programs. (Warwick, U.K. Backs Aerospace R&D Projects, But Not Replacing EU Funds Yet, 2016)

Projects funded include the Large Landing Gear of the Future project, which is led by Safran Landing Systems; the Wing Design Methodology Validation (WINDY) project led by the Airbus Center for Excellence for Wing Design; the iCore project working to reduce engine fuel burn led by Rolls-Royce; among many other research and development projects. (Warwick, U.K. Backs Aerospace R&D Projects, But Not Replacing EU Funds Yet, 2016)

China

Market Overview

China is already both a major market for Washington state—for aerospace and non-aerospace products and services—and one of largest and fastest growing aerospace sectors in the world. Below are notable trends and findings:

China's aerospace sector is led by two state-owned OEMs: 1) the Aviation Industry Corporation of China (AVIC); and 2) the Commercial Aircraft

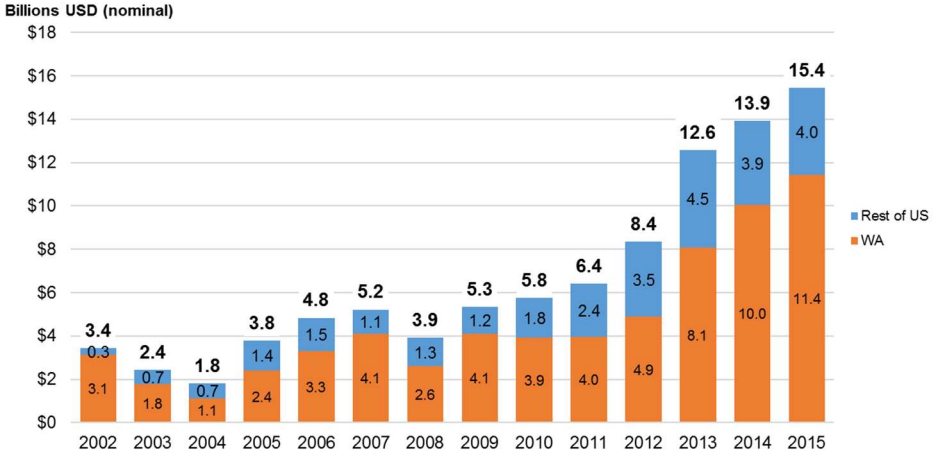
Corporation of China (Comac). China's two leading commercial aircraft programs, both under Comac, are the ARJ-21 regional jet and the C919 narrow-body aircraft.

Working in the Chinese aerospace sector inherently entails engagement with state enterprises, which constitute the vast majority of China's aerospace sector.

In 2015, China imported more than $2.15 billion in aircraft parts and components, of which one third came from the U.S. (U.S. International Trade Administation, 2016). In the coming years, due to overall economic growth and demand on the aviation sector, China's continued movement up the value-added chain into systems integration and assemblage, and state industrial policies supporting the continued development of the aerospace sector, China will be an important market for Washington aerospace firms to explore and seek opportunities.

China is already a major market for U.S. aerospace exports. In 2015, U.S. aerospace exports to China totaled more than $15.4 billion (**Exhibit 7**). The majority of these sales were in the form of Boeing aircraft from Washington state, though in recent years an increasing number of components and related hardware has been sold to China in support of final assembly of China's two major commercial aircraft, discussed further below.

Exhibit 7. U.S. and Washington State Aerospace Exports to China, 2002-2015



Sources: U.S. Census Bureau, 2016; Community Attributes Inc., 2016.

China's Aerospace Sector

AVIC is the largest of the two state-owned aerospace OEMs, and is responsible for all of China's military aircraft production. The company

was established in 1993, due to the consolidation of several older state enterprises engaged in the manufacture of aircraft and related parts. The company employs more than 500,000 workers in across more than 200 subsidiaries, and in 2015 generated $58.1 billion in revenues, though down 3.5% year-over-year (Grevatt, 2016; Crane, et al., 2014; Fortune Global 500, 2016).

Some of AVIC's flagship units include Shenyang Aircraft and Chengdu Aircraft—both produce fighter jets for the Chinese military, including China's new fifth generation stealth fighter, the J-20, which is expected to be combat ready by 2019 (Defense Update, 2016). While much of AVIC's aerospace work (a large share the company's holds are of non-aviation industrial assets) is defense oriented, the above subsidiaries have in turn established additional subsidiaries to produce commercial components—the Chengdu Commercial Aircraft Company and Shenyang Commercial Aircraft Company, responsible for the nose section and tail assembly for the ARJ-21 regional jet (Crane, et al., 2014, p. 12).

Another AVIC subsidiary, the AVIC Aircraft Corporation, produces large civilian and military transport aircraft. An additional subsidiary under this unit, Xi'an Aircraft Industrial Corporation, is a subcontractor for Boeing and Airbus, including the wing assembles for the A320, and manufacturers the wings and fuselage for the ARJ-21.

Comac was formed in 2008 out of assets held under AVIC I and AVIC II, before the remaining parts of each were re-merged to form the AVIC of today. Comac is exclusively focused on commercial work and has no involvement in military articles. Its two flagship aircraft are the ARJ-21 regional jet and the C919 narrow-body aircraft, intended to compete against the Airbus A320 and Boeing 737. The ARJ-21, fourteen years after development started, entered into service in June 2016. The first customer, Chengdu Airlines, is a subsidiary of Comac, reflecting a broader state strategy to incubate the domestic aircraft industry through use of state enterprises as initial customers. The entry of the regional jet will also give Comac three years of experience managing customer relations prior to the entry into service of its more ambitious aircraft, the C919 (Perrett, Comac ARJ21 Enters Service 14 Years After Project Launch, 2016).

One of Comac's subsidiaries, the Shanghai Aircraft Manufacturing Corporation, Ltd., is responsible for final assembly and systems integration for both commercial models, and also serves as a subcontractor for Boeing and Airbus.

However, despite China's broader ambitions to spur a robust, technology advanced indigenous commercial aviation sector, commentators have noted the C919's extensive reliance on foreign components, constituting

the largest share of intellectual property. According to the Rand Corporation, "China's industry continues to struggle with systems integration…[i]n short, COMAC has yet to show that it will be able to produce commercially viable aircraft, much less show that it can become commercially competitive" (Crane, et al., 2014, p. xiii).

Washington's current aerospace linkages with China

Several Washington state aerospace suppliers already sell components and tooling equipment to Comac, AVIC, and their subsidiaries. These sales help evidence the opportunities for aerospace defense suppliers to access the Chinese market, and the high value-added products Comac and AVIC desire from foreign suppliers. One example is Electroimpact, a Mukilteo-based tooling company that manufacturers a fuselage riveter used by Xi'an Aircraft Corporation to drill and install rivets and interface bolts into the panels of the ARJ-21 fuselage (Electroimpact, 2016).

Market Barriers and Access

- As in other sectors, companies aiming to sell into China must develop a strategy for protecting their **intellectual property**. While China's intellectual property rights regime enforcing, there remain sizable risks for foreign firms.
- Companies will face significant **competition from European suppliers**, many of whom have already established presences in the China market. In many cases, these firms have agreed to technology transfers as part of their negotiated contracts with Chinese customers, including state enterprises (U.S. Commercial Service, 2016).
- For defense firms especially, complying with EAR rules on dual-use technology.
- Developing relationships in-country with Chinese state enterprises in the aerospace sector can be a very resource-intensive endeavor.

Continental Europe

Market Overview

Continental Europe is another global leader in the aerospace industry. Major aerospace clusters exist in Germany, France and Italy. Some of the world's largest aerospace OEMs are based in Continental Europe including:

- Airbus
- Airbus Defence & Space
- Airbus Group
- Airbus Helicopters
- Dassault Aviation

- Fokker Technologies (purchased by GKN, a UK company, in 2015)
- Leonardo (formerly Finmeccanica)
- MBDA Missile Systems (jointly owned by Airbus Group, BAE Systems and Leonardo Finmeccanica)
- SAAB
- Safran
- Thales

In 2015 France and Germany were among the top export destinations for U.S. aerospace products. The U.S. exported more than $9.6 billion in aerospace products to France in 2015 and more than $6.7 billion to Germany. Both countries are also important destinations for Washington-based aerospace products, with France receiving more than $1billion and Germany almost $1.2 billion in 2015.

Germany is one of the European countries with the greatest potential as an export destination. Home to Airbus and the production of the A380 and A320 in Hamburg, Germany's aerospace manufacturing industry has been experiencing strong growth, between 2014 and 2015 the industry grew by 4.9%. Among the almost 750 approved Airbus suppliers from the U.S., more than 40 of these are based in Washington. Among these suppliers are ELDEC Corporation and Triumph Composite Systems. Beyond Airbus, other German aerospace manufacturers that are potential prospects for U.S.-made parts include:

- Diehl Aerosystems
- Liebherr-Aerospace Lindenberg
- MTU AeroEngines
- Premium AEROTEC
- Lufthansa Tecnik (International Trade Administration, 2015)

Throughout Europe, OEMs and tier I suppliers are introducing new aircraft platforms and technology. Dassault announced the production of its new Falcon 5X in 2015, and plans to start deliveries of the new midsize aircraft to 2020 (Jackon, 2016). Safran and Air France Industries announced in June a joint venture to conduct engine-compressor blade-repair services in France, this joint venture will begin operations in late 2017 and will service engines on Airbus A320s and Boeing 737-family aircraft (Pozzi, 2016).

Additionally, Safran was selected as a participant in the GE9X program developing the engine for the 777X (Pozzi, 2016). Safran and Latécoère are the two top suppliers of electrical systems in the global aerospace industry (Osborne, 2016). European companies are working on advances

in electric aircraft, Pipistrel, Aero Electric Aircraft Crop., and Airbus Group are all working on developing light electric aircraft (Dubois, 2016). European OEMs are also exploring the emerging market for space craft, Airbus and Safran were approved to move forward with their Airbus Safran Launchers Ariane 6 development. The Ariane 6 is a next-generation rocket, designed to compete with SpaceX (Svitak, 2016).

Market Barriers and Access

An important barrier to accessing the European aerospace market are strong subsidies from European countries to their aerospace manufacturers. The Belgian government provides subsidies to their aerospace manufacturers that are Airbus suppliers. Additionally, in France, OSEO a state-backed company provides reimbursable advances to their manufacturers, in 2010 these advances totaled $95 million. (International Trade Administration, 2015)

There are also some challenges created by the European Safety Administration (EASA) regulatory environment for U.S. companies looking to export to Europe. EASA is the European regulatory body equivalent to the FAA. This administration provides airworthiness certifications for foreign aircraft parts, and the process can be lengthy. Additionally, EASA fees can be a barrier for some U.S. firms. EASA charges fees to validate the FAA's airworthiness certification, and can cost almost as much as the certification for European-made parts. (International Trade Administration, 2015)

Overall the European market has low barriers to entry. The WTO Agreement on Trade in Civil Aircraft requires that European countries and the U.S. both must provide duty-free entry to about 250 civil aircraft parts. Additionally, the EU has a temporary duty suspension for the U.S., which provides duty-free entry of aircraft parts for U.S. suppliers. The 2009 Bilateral Aviation Safety Agreement (BASA) also provides a positive regulatory environment for aerospace between the U.S. and European countries. BASA institutionalized safety standards between U.S. and EU aircraft parts, which allows for the export of some U.S.-made parts to be exported to Europe with no EASA approval. (International Trade Administration, 2015)

Canada

Market Overview

Canada has been in the top five export destinations for aerospace over the past five years. Canada is the fifth-largest export destination for U.S. aerospace products. In the past ten years more than 61% of U.S. aerospace exports to Canada were aircraft parts. Additionally, 53% of

aircraft imports to Canada were from the U.S. (International Trade Administration, 2015). Washington firms are strong exporters to Canada, **65** Washington companies are listed as approved suppliers to the Canadian OEM Bombardier. Overall in 2015, Washington state exported nearly $1.6 billion in aerospace products, including finished aircraft and parts, to Canada.

Additionally, Canada has production in every aerospace subsector. The Canadian market is broken into four subsectors:

- Aircraft and aircraft components—represent 42% of the market
- Maintenance, repair and overhaul (MRO)—represent 31% of the market
- Engines and engine parts—represent 11% of the market
- Avionics and electrical systems—represent 7% of the market (International Trade Administration, 2015)

The Canadian market focuses primarily on civil aircraft manufacturing. It also invests in research; approximately $1.5 billion per year. Research and development in Canada is focused on new technologies, including improvements in de-icing, noise reduction, enhanced fuel efficiency, and extreme weather capable engines. The industry is also focusing on implementing LEAN manufacturing and supply chain principles. Canadian OEMs are working with fewer suppliers, becoming larger systems integrators. This is a strategy to offset risk, protect against business cycle volatility, and manage the cost of large aircraft platforms. (International Trade Administration, 2015)

Potential OEM and Market Opportunities

The top 19 aerospace companies in Canada account for 87% of aerospace production in Canada, including the following firms:

- Bombardier
- Pratt & Whitney Canada
- Bell Helicopter Textron
- Vector Aerospace
- European Canada Ltd (International Trade Administration, 2015)

There is increasing demand for unmanned aircraft systems or UAs. In fact, Transport Canada has authorized use of UAs for some law enforcement and commercial applications. (International Trade Administration, 2015)

Canada also has a strong commercial aircraft fleet, which creates demand for parts for the required MRO activities. The fleet includes:

- 279 Boeing aircraft
- 116 Airbus aircraft
- 106 Bombardier aircraft
- 66 Embraer aircraft

In total, Canada has 567 aircraft in service. (International Trade Administration, 2015)

Market Barriers and Access

There are almost no specific barriers to market entry because of strong bilateral agreements between the U.S. and Canada. Specific bilateral agreements that eliminate barriers to entry include:

- NAFTA
- North American Defense Production Sharing Agreement
- ITAR Exemption
- U.S.-Canada Bilateral Aviation Safety Agreement
- Canada is a signatory on the WTO agreement on Trade in Civil Aircraft, which promotes free trade for civil aircraft and parts (International Trade Administration, 2015)

However, the strength of Canada's aerospace industry creates challenges for new entrants into the market, whether foreign or domestic. There is stiff competition from current U.S. exporters, European exporters and local Canadian manufacturers. The maturity of Canada's market poses a challenge for entry into the market. Suppliers interested in entering the Canadian market need to embrace LEAN supply chain manufacturing principles and will also need to be able to integrate into the supply chains of larger systems integrators. (International Trade Administration, 2015)

RECOMMENDATIONS AND ACTION STEPS

Focus on the future—build relationships with overseas OEMs and tier I suppliers

Great barriers to entry into established supply chains—for both manufacturing and MRO activities—are prevalent, and entry into existing supply chains may be an unrealistic objective for most defense contractors. Instead, Commerce should help firms cultivate relationships with OEMs and tier I suppliers to bolster competitiveness for future programs. To do this, the following actions are recommended:

- **Lead a domestic delegation to U.S.-based offices of European, Asian, and South American OEMs and tier I suppliers**. Many overseas OEMs have offices in the U.S. and

actively seek opportunities to build relationships with domestic suppliers. Part of this is political—Airbus and other OEMs see benefits in Washington D.C. from having an extensive list of U.S. companies among their suppliers. Commerce should lead a delegation help firms take advantage of this environment.

- **Convene events in Washington**. Organize special sessions at future industry supplier conferences to convene defense contractors and overseas OEM representatives.
- **Lead an annual outbound delegation of defense contractors to meet with overseas OEMs in Europe and Asia, including BAE Systems in the U.K.** Help cultivate and sustain these relationships to increase the possibility that one or more defense contractors may be invited to be part of a bidding team for a future civilian or defense project.
- **Recruit defense contractors for the Paris, Dubai, and Farnborough Airshows**. Commerce already leads annual delegations to these international aerospace trade shows. For Paris in 2017, Commerce should actively engage small-and medium-sized (SME) aerospace defense contractors to join these delegations, and organize seminars and work sessions at the show to showcase the defense sector's aerospace capabilities.
- **Take advantage of overseas firms already located in Washington**. Many overseas aerospace tier I suppliers, such as Thales Avionics Inc., already have a presence in Washington, in part due to their work for Boeing. Commerce should convene meetings between defense contractors in Washington and these overseas offices to discuss opportunities for future supply chain work.

Support innovation among local suppliers

Trends in the aerospace sector point to incremental innovation among: existing civilian large-body models; military emphasis on unmanned platforms; and fuel efficiency. In order to survive and thrive in a potential environment of reduced U.S. defense spending, aerospace defense contractors must continue to enhance technological capabilities across these areas. Commerce can assist innovation through the following:

- **Help firms access DARPA, SBIR, and other grant-supported research**. For many smaller contractors, awareness and capacity to track and apply for research funding can be limited. Commerce can work with existing organizations in Washington, including the University of Washington, Washington State University, and other four-year colleges, to foster contractor-university partnerships. Some of this work can occur through WSU Extension programs,

while in other cases companies can apply for joint research grants with university faculty.

Stay aware of new programs and opportunities

For many smaller aerospace firms reliant on DOD funding, it can be a challenge to devote resources to business development. Commerce and the Washington Military Alliance together should serve as a clearinghouse for news and information related to new programs, specifically, Commerce should:

- **Expand the Washington Military & Defense Economic Impact Tool to include current information on aerospace defense trends.** The WMA can be broadened to provide information on aerospace defense contractors in Washington through regular newsfeeds, website content, and communication with registered subscribers.
- **Consider hiring a position to focus on technical outreach in the defense market.** This position would act as an ombudsperson for aerospace (and other sectors) by liaising with technical contacts at DOD and related agencies, and connecting companies to the right resources and contacts.
- **Disseminate information**. Build out and update the aerospace sector section of the Commerce website with information and data on target markets, regulations, financing information, trends, and contact information for the aerospace sector lead. A shared knowledge database for aerospace defense contractors can also include basic information on exporting, logistics, shipping, customs and more. Furthermore, Commerce should create a database of defense contractors willing to talk with each other and share experiences, tips and ideas. They may be selling different products and services but much of the export basics and challenges will be the same and they can learn from each other's experiences.

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APPENDIX

Methodology for Developing Recommendations

The table below delineates key considerations that help shape development of strategy development for the aerospace sector.

Exhibit A-1. Framework for Developing Strategies for Supporting Aerospace Defense Contractors

Strategic Considerations	Description	Examples
Firm characteristics	• Firm size • Experience exporting	• Small firm vs. large firm economies of scale • Ability and/or desire to export • Resources to invest in exporting effort
Domestic conditions	• Health of U.S. economy • Regulatory issues • U.S. government programs supporting exporting	• Strength of U.S. market versus overseas opportunities • ITAR, EAR, FCPA, compliance challenges and access to necessary information • U.S. Foreign Military Sales Program and U.S. foreign military aid (e.g., Egypt, Israel) • Excess Defense Articles program • ITAR exemption status among certain allies, including Australia
Foreign market/ government conditions	• State policies supporting local industries • Weak/limited IPR enforcement • Cultural barriers	• Taiwan's recent plan to support more domestic production of maritime vessels • China's weak record on IPR protection • Offset requirements • Relationship building • Finding overseas distributors • Foreign governments often demand for same hardware as U.S. military.
Firm characteristics	• Firm size • Experience exporting	• Small firm vs. large firm economies of scale • Ability and/or desire to export • Resources to invest in exporting effort
Domestic conditions	• Health of U.S. economy • Regulatory issues • U.S. government programs supporting exporting	• Strength of U.S. market versus overseas opportunities • ITAR, EAR, FCPA, compliance challenges and access to necessary information • U.S. Foreign Military Sales Program and U.S. foreign military aid (e.g., Egypt, Israel) • Excess Defense Articles program • ITAR exemption status among certain allies, including Australia
Foreign market/ government conditions	• State policies supporting local industries • Weak/limited IPR enforcement • Cultural barriers	• Taiwan's recent plan to support more domestic production of maritime vessels • China's weak record on IPR protection • Offset requirements • Relationship building • Finding overseas distributors • Foreign governments often demand for same hardware as U.S. military.

A-2. Categories of Current Assistance and Support from the Washington State Department of Commerce

Type of Assistance	Examples
Education and Training	• Seminars on exporting opportunities, how to find market opportunities • Seminars on legal and trade barriers and issues • Trade delegations to learn about new markets, including trips to DC to meet with embassy officials. • Add info and links to existing website on resources
Technical and Legal Assistance	• Proper paperwork • Export finance • Export control compliance
Market Research	• Identifying overseas opportunities (defense and civilian) • Finding distributors and/or overseas representatives • Helping develop connections with the Foreign Military Sales program
Advocacy	• Helping firms dealing with trade disputes and IPR infringement cases and other barriers • Commerce as a first point of contact for defense contractors

Example of Aerospace Defense Export Controls Compliance

As an example, suppose that Company A is interested in selling a non-military UAV that can stay in the air for over an hour to Company B in Canada and also to Company C in Brazil. Company A would search the CCL Category 9 to determine that such UAVs are listed under ECCN 9A012. More specifically, UAVs with a maximum 'endurance' of one hour or greater are listed under ECCN 9A012.a.2. ECCN 9A012.a.2 notes that such UAVs are controlled for reasons of national security (NS), anti-terrorism (AT), and missile technology (MT) if the UAV has a maximum range of 300 km or greater. The ECCN also indicates that on the Country Chart, for NS, column 1 applies, for AT, column 1 applies, and for MT, column 1 applies. *See* **Exhibit A-3**.

Exhibit A-3. ECCN Reasons for Control Entry for 9A012

License Requirements

Reason for Control: NS, MT, AT

Control(s)	*Country Chart (see sup No. 1 to part 738)*
NS applies to entire entry	NS Column 1
MT applies to non-military Unmanned Air Vehicle (UAVs) and Remotely Piloted Vehicles (RPVs) that are capable of a maximum range of at least 300 kilometers (km), regardless of payload, and 9A012.b.5.	MT Column 1
AT applies to entire entry	AT Column 1

Company A can then look at the country entries for Companies B and C on the Country Chart. Canada does not have an "X" in the NS, MT, or AT columns. *See* **Exhibit A-4**. Accordingly, Company A likely does not need a BIS license to export the UAV to Canada. (The EAR contains a list of ten general prohibitions that must be reviewed in connection with any international transaction. If one of those prohibitions applies, then a BIS license is required regardless of the determination under the Country Chart analysis.)

However, Brazil has an "X" under NS and MT. *See* **Exhibit A-5**. According to the Country Chart, a BIS license may be required to send the UAV to Company C, even if the UAV has a maximum range of less than 300 km.

Exhibit A-4. Commerce Country Chart for Canada

Countries	Chemical & Biological Weapons			Nuclear Nonproliferation		National Security		Missile Tech	Regional Stability		Firearms Convention	Crime Control			Anti-Terrorism	
	CB 1	CB 2	CB 3	NP 1	NP 2	NS 1	NS 2	MT 1	RS 1	RS 2	FC 1	CC 1	CC 2	CC 3	AT 1	AT 2
Bulgaria[3]	X					X		X	X							
Burkina Faso	X	X		X		X	X	X	X	X		X		X		
Burma	X	X	X	X		X	X	X	X	X		X		X		
Burundi	X	X		X		X	X	X	X	X		X		X		
Cambodia	X	X		X		X	X	X	X	X		X	X			
Cameroon	X	X		X		X	X	X	X	X		X		X		
Canada	X										X					
Cape Verde	X	X		X		X	X	X	X	X		X		X		

Exhibit A-5. Commerce Country Chart for Brazil

Countries	Chemical & Biological Weapons			Nuclear Nonproliferation		National Security		Missile Tech	Regional Stability		Firearms Convention	Crime Control			Anti-Terrorism	
	CB 1	CB 2	CB 3	NP 1	NP 2	NS 1	NS 2	MT 1	RS 1	RS 2	FC 1	CC 1	CC 2	CC 3	AT 1	AT 2
Bahrain	X	X	X	X		X	X	X	X	X		X		X		
Bangladesh	X	X		X		X	X	X	X	X		X		X		
Barbados	X	X		X		X	X	X	X	X	X	X		X		
Belarus	X	X	X			X	X	X	X	X		X	X			
Belgium[3]	X					X		X	X							
Belize	X	X		X		X	X	X	X	X	X	X		X		
Benin	X	X		X		X	X	X	X	X		X		X		
Bhutan	X	X		X		X	X	X	X	X		X		X		
Bolivia	X	X		X		X	X	X	X	X	X	X		X		
Bosnia & Herzegovina	X	X		X		X	X	X	X	X		X		X		
Botswana	X	X		X		X	X	X	X	X		X		X		
Brazil	X	X				X	X	X	X	X	X	X		X		
Brunei	X	X		X		X	X	X	X	X		X		X		

Company A may refer back to the ECCN to see if it qualifies for any license exceptions. *See* **Exhibit A-6**. However, for UAVs, no license exceptions are available.

Exhibit A-6. ECCN License Exceptions Entry for 9A012

List Based License Exceptions (See Part 740 for a description of all license exceptions)

LVS: N/A
GBS: N/A
CIV: N/A

There are also a number of country-specific export regulations under the EAR that may apply to other products. As referenced above, the EAR has ten general prohibitions. For example, exports of most items to countries currently embargoed by the United States are generally prohibited.

In addition to restrictions on the destination country, U.S. companies exporting controlled products must ensure their products do not pass through certain countries during transit to the final destination. These countries include Armenia, Azerbaijan, Belarus, Cambodia, Cuba, Georgia, Kazakhstan, Kyrgyzstan, Laos, Mongolia, North Korea, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, and Vietnam. If a product must pass through one of these countries during transit, a company must apply for a BIS license.

Additionally, U.S. companies that import products may need a BIS license to re-export the products if they are modified to have more than a *de minimis* amount of controlled content. For example, if a Washington aerospace equipment provider retrofits a foreign aircraft to include upgraded software, navigation equipment, or propulsion systems, the equipment provider may need to apply for a BIS license to re-export the aircraft.

In addition to the CCL, the BIS also maintains lists that designate certain persons, companies, or organizations that are restricted from receiving certain exports. Companies that receive export requests from unfamiliar organizations or individuals should consult these resources as part of their due diligence.