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AY 2019-2020 Industry Study

Final Report *Air Domain*



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Abstract

The Air Domain is a critical National Security industry driving a broad spectrum of technology development. Air Domain is a technology integrator of capabilities from other industry studies such as munitions, information technology, and electronic warfare. Therefore, the Air Domain drives economic growth across multiple business sectors. Research in the shifting of strategic priorities revealed the Air Domain is not positioned to maintain the U.S. technical superiority. Policymakers should focus on increasing research and development, improving technology protection, and revise restrictive regulations enabling rapid development and fielding. The 2020 Air Domain Industry Study for the Eisenhower School of National Security and Resources Strategy consists of the following students:

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In the development of this report, the Air Domain Industry Study Seminar (henceforth Seminar 1) met and interviewed experts from the public and private sectors, including the Department of Defense, Federal Aviation Administration, Boeing Corporation, Bell Textron, Elbit USA and numerous other sources. Air Domain also had the benefit of receiving guest lectures from domain experts from the Teal Group, the Aerospace Industry Association, the Defense Counterintelligence and Security Agency, Joint Staff/J8, AF/A5, and AFWIC.

Seminar 1 focused its study on major aviation manufacturers in the U.S., significant U.S. Government interaction with those manufacturers, and the worldwide environment in which Air Domain industries participate, including U.S. Great Power competition with China and Russia.

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Introduction

Domain Definition

The Air Domain Industry consists of all products and services related to aviation, in particular as they may relate to the national security of the United States of America. This is a broad field, including manned and unmanned aircraft, systems for operating aircraft such as avionics and sensors, munitions that may be fired or dropped from aircraft, and the facilities, materials, and manpower used to manufacture, support, and repair aircraft. It is not restricted to purely military products, as commercial and general aviation products are often dual-use or can be repurposed.

National Security Capabilities

The first recorded use of aircraft for military purposes was in 1793, when the French employed a hydrogen balloon to observe enemy troop movements.¹ The use of aviation for national security purposes has broadened significantly since then, especially after the advent of heavier-than-air flight in 1903. Intelligence, surveillance, and reconnaissance (ISR) has been a staple capability since that first balloon but has expanded recently with the introduction of unmanned aerial systems (UAS). The delivery of ordnance onto enemy positions on land and ships on water became prevalent during World War One and developed into tactical and strategic bombing through World War Two and beyond. The ability of aircraft to attack other aircraft to prevent reconnaissance or bombing also developed during World War One and has continued to advance to the point of discussion of Sixth Generation fighter aircraft and/or systems. Aircraft can transport troops and material virtually anywhere around the world more quickly than any other transportation method, allowing global power projection.

Thesis

The U.S. is the world's leader in Air Domain technology innovation and manufacturing and has been at the forefront of flight for over a century. Over the last two decades, the Air Domain adapted to economic fluctuations marked by civil market expansion and shrinking defense budgets as well as continued rigid regulatory and acquisition policies. This has reduced the Defense Industrial Base (DIB) through mergers and acquisitions, supply chain globalization, and off-shoring of manufacturing capability. This has left the air domain industry ill-prepared to support the National Security Strategy (NSS) transition to great power competition. This paper depicts the state of the Air Domain industry today and identifies emerging technologies and processes, concluding with policy recommendations to maintain U.S. national security through military, economic, and industrial power.

Research Methodology

Seminar 1 used a combination of literature review, site visits, in-person interviews, and remote conferencing to conduct research on the Air Domain Industry. Due to the COVID-19 crisis, site visits were limited but comprehensive electronic conferencing overcame the limitations. Seminar 1 spoke with representatives from the Department of Defense, industry, and relevant industry observers to gain multiple viewpoints on issues. Through extensive discussion and debate among the seminar, consensus on conclusions was achieved.

Disclaimer

The views expressed in this paper are those of the seminar members and do not reflect the official policy or position of the National Defense University, the Department of Defense, or the U.S. Government.

Strategic Environment

Security Situation

The global security situation facing the U.S. has evolved in recent years from the focus on less-developed rogue states and violent extremist groups to one where we have identified the technologically advanced revisionist powers of China and Russia as the primary threats to American security and prosperity. The most recent National Defense Strategy (NDS) also calls out “rapid technological advancements and the changing character of war” as major challenges to our security.² For example, both Russia and China have employed advanced Anti-Access/Area Denial (A2/AD) capabilities, specifically designed to thwart American air superiority. The U.S. strategy seeks to capitalize on cooperative efforts with allies such as security commitments and arm sales to address great power competition with China and Russia.

Security Commitments

The U.S. has legal security commitments to other nations around the world. In Europe, the U.S. is a signatory to and leading power in the North Atlantic Treaty Organization (NATO), which states that the members acknowledge, “that an armed attack against one or more of them ... shall be considered an attack against them all and ... will assist the Party or Parties so attacked by taking ... such action as it deems necessary, including the use of armed force, to restore and maintain the security of the North Atlantic area.”³ NATO members include several countries that border and are potentially threatened by Russia, including the Baltic and Nordic states. In Asia, the U.S. has treaty alliances with Japan, the Republic of Korea, Australia, and the Philippines. The U.S. also has a defensive relationship with Taiwan declaring the U.S. has a policy to “to provide Taiwan with arms of a defensive character” and “to maintain the capacity of the U.S. to resist any resort to force or other forms of coercion that would jeopardize the security, or the social or economic system, of the people on Taiwan.”⁴ This does not mandate the U.S. would go to war to defend Taiwan, but does indicate a higher likelihood if Taiwan was threatened by its long-time opponent China. In the Near East, the U.S. has a long defensive relationship with Israel though no formal alliance commitment. However, it is currently likely that the U.S. would support Israel’s defense, especially if Israel came under attack from Iran.⁵

Arms Sales

Arms sales are an important component of strengthening U.S. alliances, particularly by deepening interoperability.⁶ If the U.S. operates the same systems as our allies, it can operate together more effectively to secure common objectives. Out of \$56.2 billion in announced foreign military sales in 2019, two of the largest sales were of F-16 fighters (\$14.5 billion) and air-to-air missiles (\$2 billion). These sales can also help to support domestic industry when U.S. arms purchases slow.⁷ During a Seminar 1 visit to a major American aerospace manufacturing facility in February 2020, it was noted several major production lines were currently being kept in operation solely by foreign sales.

The U.S. does not import significant numbers of finished Air Domain products from abroad as it focuses on domestic producers. However, major Air Domain Industry manufacturers in the U.S. do rely on numerous global suppliers for systems and materials.

Economic Strength

At the end of 2019, the U.S. economy, as measured by Gross Domestic Product growth, was stable but slowing with the final two quarters of 2019 showing 2.1% growth.⁸ However, the current COVID-19 crisis has significantly affected the U.S. economic strength as a whole. The Congressional Budget Office (CBO) predicts a sharp contraction in the second quarter based on a number of factors, including “more than 24 million new unemployment insurance claims reported since mid-March.”⁹ Follow on effects of this economic contraction include a significant increase in the federal deficit and federal debt held by the public.¹⁰ This trajectory suggests the possibility of future decreases in discretionary U.S. Government spending, to include defense spending.

Defense Budgets

Prior to the COVID-19 crisis, Department of Defense (DoD) budgets for procuring aircraft have generally trended downwards since a high of \$34 billion in 2010.¹¹ In a 30 year forward projection of one-for-one replacement, CBO estimates that “costs for procuring aircraft increase steadily through the mid-2030s and peak at \$44 billion in 2038. DoD’s costs would exceed the peak appropriation of the past 20 years (\$34 billion in 2010) every year between 2030 and 2043, CBO estimates, and would exceed the 2000–2018 average (\$26 billion) every year between 2021 and 2047.”¹²

Defense Industrial Base

The U.S. Defense Industrial Base for the Air Domain is dominated by three major corporations: Boeing, Lockheed Martin, and Northrop Grumman. These corporations are supported by a global supply chain consisting of hundreds of companies ranging from large corporations to local small businesses. Airbus is the predominant player in the rest of the world, though Russia and China have industrial capacity at a lower level. Presentations detailing these corporations’ strategies, strengths, and weaknesses are included as Appendices A – D.

Products

Three major product lines dominate the future of Air Domain in the U.S. They are Future Vertical Lift, Sixth Generation Fighters, and Unmanned Aerial Systems. These products will perform nearly the entirety of the mission sets assigned to Air Domain platforms and could revolutionize the conduct of military action in the air.

Future Vertical Lift (FVL)

The DoD has over 5,700 helicopters in service today.¹³ All of these aircraft will “reach the end of their expected useful life starting in the mid-2020s.”¹⁴ In order to replace this fleet, DoD decided to implement a joint effort called “Future Vertical Lift” encompassing the next generation replacements for all sizes, or “capability sets”, of vertical lift aircraft in the DoD’s inventory.¹⁵ The first FVL system being developed is the Medium Lift Capability Set Three aircraft, which will replace such aircraft as the UH-60, UH-1, and V-22. As the lead FVL agency, the Army designated it the Future Long Range Assault Aircraft (FLRAA). The competition for FLRAA has come down to two designs, the Sikorsky-Boeing SB>1 Defiant, a compound helicopter with two counter-rotating main rotors and a pusher-propeller at the back of the aircraft for increased speed, and the Bell V-280 Valor, a tilt-rotor aircraft that improves on the technology of the current V-22 Osprey. The next competition will be for the Capability Set One aircraft, designated the Future Attack Reconnaissance Aircraft (FARA). As of March 2020, the Army selected the Sikorsky Raider X and Bell A360 Invictus designs to compete for the contract award.¹⁶ See Appendix E for more detail.

While the FVL concept is to procure the same aircraft in each capability set for all the services, lessons learned from the F-35 program indicate trying to have one platform meet the varying service needs will not meet expectations. It is recommended that each service is allowed the option to field either of the final two competing designs within each FVL capability set in order to better meet differing service requirements (e.g. shipboard compatibility) and service history and culture (e.g. the Army has no tilt-rotor experience and would likely transition to another helicopter more easily). As the FVL program continues, future capability sets will ostensibly be derived from these designs, which are scalable. This will also improve DIB resilience by increasing and diversifying the manufacturers available.

Sixth Generation Fighter

The U.S. maintains its air supremacy advantage over its competition through integrating several advanced capabilities to create new generations of fighters. The current U.S. 5th Generation fighters, the F-22 Raptor and F-35 Lightning II, incorporated advancements in stealth, composite material manufacturing, and advanced data links, which Russia and China are still trying to match. As the F-35 progresses towards full operational capability, the U.S. is defining 6th Generation fighter technologies. The literature review indicates 6th Generation fighters may include upgrades in data fusion improving situational awareness, directed energy weapons,¹⁷ cooperative unmanned systems (loyal wingmen),¹⁸ artificial intelligence to conduct and defend against kinetic and cyber-attacks, and advanced multi-use materials (e.g. structural components that double as sensors).¹⁹ However, there are mission questions on the future operational environment,²⁰ such as should 6th Generation fighters be manned or remotely piloted

like UAS, and to what extent should artificial intelligence be used to control systems. Given the long development times, to ensure air dominance, the U.S. must first define the future mission environment and then direct the necessary 6th Generation advanced technology development.

Unmanned Aerial Systems

In the U.S., technology advancements enabled the DoD to expand the missions assigned to UASs meeting the new and challenging mission environments not suited for manned missions. UAS has given “the military the ability to conduct persistent surveillance and strike quickly,”²¹ that is more cost-effective²² and reduces combat personnel losses. As the DoD continues to expand its use of and research in UASs, the civil and commercial UAS use have exploded using the same technology to support a wide array of missions to include surveillance, surveying, agriculture, and freight delivery.²³ As a result of commercial and civil growth, the U.S. has become the largest UAS market across all sectors. However, U.S. UAS manufacturing has not kept up with demand, especially in the commercial market.

In the U.S., the UAS manufacturing capability is dominated by military systems and primarily produced by the large air domain companies such as General Atomics and Northrup Grumman²⁴ Although AeroVironment, a small/medium manufacturer, has successfully competed for DoD UAS business.²⁵ The commercial market is dominated by a single Chinese firm, Da-Jiang Innovations (DJI), providing 70% of global non-military UAS sales and 76.8% of all sales in North America.²⁶ This gap is further supported in a recent innovation base assessment where the Council for Foreign Relations Task Force 77 stated there was no major U.S. commercial UAS manufacturer.²⁷

As UASs continue to grow in capability supporting more national security and commercial requirements, the U.S. needs to invest in expanding manufacturing capabilities to meet commercial requirements. With the large air domain firms focused on military solutions, commercial manufacturing should emphasize growth in small and medium UASs, which represent 84% of U.S. manufacturing.²⁸

Innovation Policy Environment

The ability to innovate in the Air Domain has been critical to the U.S. since World War II, in such areas as supersonic flight, use of rotorcraft, stealth, and use of new materials like composites in manufacturing. Strong foundational policies regarding education and workforce development will be critical to continue this lead in innovation in addition to the innovative developments themselves.

Leading Air Domain Innovation

Through a robust National Security Innovation Base (NSIB) consisting of interlinked relationships between private industry, academic institutions, and government entities, the U.S. continues to be the world leader in aviation-based innovation. The U.S. Government spurs a large amount of Research and Development (R&D) directly through organizations such as the Defense Advanced Research Projects Agency (DARPA) and the National Aeronautics and Space Administration (NASA), indirectly by setting requirements for new acquisitions and encouraging private sector R&D to find new solutions for those requirements. The U.S. Government is also the largest funder of basic research in the country, accounting for 42% in 2017.²⁹

China, potentially the greatest competitor to the U.S., focuses significantly on innovation and R&D, but still lags behind the U.S. in the Air Domain. China relies on purchasing or licensing foreign technology. For example, China continues to import a significant number of helicopters from Russia due to limitations in their ability to produce helicopter engines, rotors, and transmissions.³⁰ Chinese firms also have a history of intellectual property theft and the Chinese government “has implemented a whole-of-government campaign to recruit talent and foreign experts from around the world.”³¹

In order to maintain U.S. dominance in Air Domain innovation, the U.S. Government must continue or increase its investment in basic and applied research. At the same time, the U.S. should strengthen efforts and penalties to limit Chinese access to U.S. higher education facilities³² while continuing to block their acquisition of critical businesses and intellectual property either through purchase or theft.

Workforce Development

The innovation and industrial bases’ success is reliant on having workforce development programs providing access to education and training programs focused on filling critical human capital gaps. Despite the acknowledgment of its importance, human capital educational gaps, especially trade skills, is a constant theme in numerous assessments and reports on the industrial base health.³³ The gaps’ impact are felt throughout the Air Domain industry but they are greater in the midsize and small companies that do not have the resources or access to help.³⁴ In the last decade, the government enacted several programs revising the nation's training infrastructure through hands-on job skill programs and increasing apprenticeship³⁵ only to have the same concerns arise in subsequent assessments and new reprogramming efforts³⁶.

Reports indicate some localized success, mainly with the Air Domain prime contractors. However, these successes have not transitioned equally to small and midsize enterprises. The Air Domain industry's health is only as strong as the supply chain's health, and to ensure overall

industry health, the nation must focus on building up the workforce's strength for the midsize and small companies. The U.S. government must establish a human capital strategy and consolidate all educational programs under a single lead. The strategy needs to emphasize improving small and midsize companies access to the program and encourage prime contractors to lead in strengthening supply chain health through investment in programs where its suppliers are located. Finally, the strategy must address the negative opinion regarding trade skills and manufacturing jobs as low paying, no opportunity for advancement and growth, and constantly under the threat of layoffs.³⁷

Trade, Tax and Regulatory Environments

The civilian and defense portions of the Air Domain are not separate. The two largest global aerospace manufacturers (Boeing and Airbus) derive much of their income from commercial aircraft while still being heavily invested in their defense divisions. Innovation in commercial UAS technology can translate into defense requirements. Thus, the U.S. can ensure strength in the Air Domain industry by focusing on domestic and international legal structures affecting commercial markets.

Regulatory Environment

Governance in the democratic world is a social contract balancing freedom and control. This is as true for the economy and specific markets as it is for individuals. The Air Domain has been heavily regulated since its inception. Enacted in the U.S. by the Federal Aviation Administration (FAA), this regulation has induced inevitable market inefficiencies and it is arguable that the Air Domain innovation environment has been stunted as a result. To improve this environment, some degree of deregulation should be undertaken. Three options include relatively small actions such as eliminating FAA subsidization and control of airports. A more significant option would be the privatization of the FAA's Air Traffic Control function. The most drastic option would be to redefine the FAA's role, removing all regulatory authority and making it a coordinating entity for formal standards as agreed upon by the Air Domain industry. A graduated implementation of all three options starting with the easiest and ending with full civilian Air Domain industry deregulation would likely spur further innovation in the Air Domain, though it may be politically implausible to move towards full deregulation in the near future.

Trade and Tax Environment

Many nations have used subsidies, local content requirements in procurements, tax holidays, infrastructure enhancements, R&D credits, and university partnerships to attract Air Domain industry investment. China has been especially aggressive in attracting investments and has made technology transfer a requirement to access the market (projected at 7,500 new aircraft over the next 20 years).³⁸ In adapting to this environment, American and European Air Domain companies have made acquisitions, formed joint ventures, and established research partnerships around the world, in the process diversifying and making more resilient the global supply chain. Despite agreements like the Plurilateral Agreement on Trade in Civil Aircraft, the U.S., and European Union (EU) have waged a sixteen year battle of claims and counterclaims on subsidies for the aerospace industry. In October 2019, the World Trade Organization (WTO) made the largest arbitration award in its history allowing the U.S. the right to impose \$7.5 billion in punitive tariffs and rejected claims that the EU no longer provides subsidies to Airbus.³⁹ Effective March 13, 2020 the U.S. imposed a 15% tariff on aircraft imported from the EU, though not on aircraft parts.⁴⁰ These tariffs will raise prices for U.S. airlines purchasing Airbus aircraft and for passengers.

The U.S. should leverage the punitive tariffs to force an end to EU subsidies for the civil aircraft industry and gain European support for an aggressive effort against subsidies by other parties. Working together to curb the practice would enable the U.S. and the EU to

maximize the benefits of their economies of scale and efficiency of production in the manufacture of aircraft. Furthermore, the U.S. and EU should give preferential treatment to Trade in Civil Aircraft Agreement signatory countries in their Air Domain supply chains and target investments in those economies. The U.S. and Europe should act in concert to challenge China to end its practice of forced technology transfer and joint ventures as a precondition to access in its civil aircraft market, imposing further technology transfer restrictions should they not do so.

Equipping Allies in the Air Domain

A primary NDS tenet is to “Strengthen Alliances and Attract New Partners.”⁴¹ The U.S. superiority in Air Domain products and systems can be leveraged with friendly countries supporting “our interests, maintaining favorable balances of power that deter aggression and support the stability that generates economic growth.”⁴² There are several methods allied countries can obtain U.S. Air Domain materiel, each with strengths and weaknesses. Foreign Military Sales (FMS) is a system where the U.S. Government facilitates sales of U.S. defense articles to friendly countries supporting interoperability and generating more strength for the U.S. industrial base. FMS sales includes additional support including spares, maintenance assistance, and training under the Total Package Approach (TPA) rubric⁴³. However, some technological upgrades are withheld from foreign users, leaving them to resort to intermediaries to keep their equipment relevant. Direct Commercial Sales (DCS) is where U.S. defense industries sell directly to foreign militaries, as approved by the Department of State. Allies can obtain aircraft much cheaper through DCS but cannot utilize TPA resources to maintain materiel obtained through DCS.⁴⁴ For allies with more limited budgets, this can make the sustainment costs unaffordable. The U.S. should work to elevate the value of FMS to allies by ensuring adequate upgrade plans for items supplied in this manner or allow allies to better use TPA resources for items procured via DCS. Either, or both, will ensure U.S. allies continue to operate U.S. manufactured systems and prevent our allies from looking to Russia or China for alternative support.

Ukraine as an Air Domain Partner

As the U.S. seeks new partnerships, Ukraine provides opportunity to establish new support capabilities strengthening the European theater. The Air Force of the Armed Forces of Ukraine must recapitalize its force soon to replace an aging fleet of Soviet-made aircraft, as their prospects for maintenance and modernization diminish. The youngest aircraft in the Ukrainian Air Force date back to the 1991 Ukrainian independence and have passed into their fourth decade of service.

The Ukrainian Air Force transition to U.S. fighter jets is an option increasing its combat capability and moving closer to NATO standards. Today, seven European NATO countries successfully operate different models of F-16 fighter jets (Portugal, Netherlands, Belgium, Denmark, Slovakia, Poland, Turkey). Ukraine could join this club by purchasing surplus U.S. F-16 fighters or seek buying former Polish/Dutch/Belgian F-16 fighters that will soon be replaced with newly acquired F-35s. Either of these options could be beneficial to all parties. Ukraine could become a more valuable partner to the U.S. and NATO and a long-term operator of U.S. fighter jets. Furthermore, given the technical capabilities of Ukrainian aerospace companies, the U.S. Defense Industrial Base could create valuable partnerships and leverage new sources of knowledge and innovation and NATO can establish new sources of maintenance, overhaul, and supply.

Acquisition

The process by which the DoD procures new systems has become so rigid that acquisition professionals now intentionally avoid new procurement efforts. Instead, they tend to choose to execute costly Service Life Extension Programs (SLEPs) resulting in updated capabilities for old and limited platforms. This tendency has resulted in excessively aged inventories, and an overall failure to modernize Air Domain assets. Additionally, past and current procurement decisions have resulted in a “High-Low” mix of aircraft. The High-side of this mix includes very expensive but extremely capable assets paired with the Low-side featuring more affordable aircraft bought in higher quantities.⁴⁵ The problem in the U.S. is the DoD is planning to buy too many High aircraft (e.g. F-35/B-21/FLRAA) and the Low aircraft versions are not really affordable (F-16/A-10/AH-1) when the costs of SLEPs and modifications are taken into account.

This model is no longer affordable with diminishing resources post COVID-19, and no longer agile enough for the U.S. to keep pace with competitors in 21st Century Great Power competition. A first step to solving this problem is to maximize the production of High-side products, such as the F-35, to minimize the number of expensive Low-side products needed. For example, Air Force acquisition executive Dr. Will Roper has proposed a system of multiple manufacturing lines producing a new “century series” of highly modular high-performance aircraft, each fitted with a wide array of capabilities.⁴⁶ The constant low rate production of different aircraft would provide a constant stream of new more capable aircraft to replenish active aircraft inventories.⁴⁷ The next step would include limiting the expense of maintaining the Low-side inventory. The emerging fiscal reality of decreasing defense spending will mandate aircraft inventories maintain a lower number of High-side aircraft and consist of more affordable Low-side aircraft that are much more affordable.

Mobilization and Supply Chain

The ability to mobilize people and materiel in times of conflict and ensure a robust supply chain are critical to future U.S. success in the Air Domain.

Defense Industrial Supply Chain

In 2018 a presidentially directed assessment revealed the Defense Industrial Supply Chain (DISC) faces unprecedented challenges that are eroding capabilities and threatening the Department of Defense's ability to equip the nation's armed services for great power competition. During the 1990s a dramatic decline in aircraft procurement led to market consolidation.⁴⁸ Dozens of companies in the sector merged, resulting in a decline from 51 aerospace defense companies to the large prime contractors dominating today's market, resulting in less competition, driving up costs, and dampening innovation.

Strategic market analysis suggests a few variables in current defense manufacturing drive market diversification. Firms creating situations driving new rules in the markets or product differentiation are two strategic variables increasing diversity, but both require research, testing, and extensive evaluation, a luxury new firms simply do not have. Furthermore, discretionary defense budget forecasts make the prospect of new firms competing in the markets unlikely.

Public policy could impact the strategy of existing defense firms while reducing barriers to entry for burgeoning firms anxious to introduce new rules into the old game. Economic, legislative, and industrial factors can contribute to the formation and maintenance, or dissolution, of oligopolies. However, the disparate regulatory guidance currently regulating the DISC appears as a tactical response to a strategic problem. A national DISC strategy that considers the known rules of the game and leverages them against the constricting market serves it and the nation. Government regulations are more likely to improve rather than impede the DISC performance when they adhere to broad economic principles rather than impose narrow statutory rules. Principle-based regulatory approaches have the advantage of being more adaptable to changes in economic conditions opportunities, as new rules develop in the game. As the DISC is continually adjusting to the global and domestic economic conditions so must a national DISC strategy. Formal and continuous monitoring of a broad strategy encourages agile regulatory energy that can ebb and flow as the politics and economy move the DISC toward diversification and agility.

Conclusion

Implications for Security and Defense

The U.S. lead in the Air Domain is not insurmountable. Renewed Great Power competition leads to questions of whether the United States can deter near-peer rivals in aerospace conflict or industrial capability. To remain competitive, it is clear that the U.S. needs to innovate in Air Domain products, policies, and innovation itself. The U.S. also needs to continue strengthening its allies and partners and ensuring its ability to manufacture and acquire materiel is efficient and effective.

Policy Recommendations

No U.S. ground troop has been killed in an attack by an enemy aircraft since 1953. This is due in large part to the massive advantage the US has enjoyed in the air domain for decades. This advantage has deteriorated significantly in the last two decades, as adversaries have made substantial technological developments in both mil and civil aviation. If the U.S. is to regain and secure the advantage in the Air Domain, it must implement the following recommendations:

Strengthen Defense Industrial Base

- Increase federal investments in basic and applied research and development and advanced manufacturing methods such as the American Manufacturing Institutes with the intent of reinvigorating manufacturing in the U.S.
- The U.S. should work to elevate the value of FMS to allies by ensuring adequate upgrade plans for items supplied in this manner or allow allies to better use TPA resources for items procured via DCS.
- Work with NTIB countries and close NATO and Indo-Pacific region allies to better protect dual-use technologies and ensure a diverse and secure supply chain.

Dominate the Future of Air Domain

- The U.S. should invest R&D dollars for Sixth Generation Fighters, Unmanned Aerial Systems, and Future Vertical Lift (in priority order) in combination with middle tier acquisition reform to streamline the acquisition process. Within the context of the Advanced Battle Management System (ABMS) for multi-domain joint service communication, these products will perform nearly the entirety of the mission sets designed for Air Domain platforms and will revolutionize the conduct of military action in the air.
- To ensure air dominance, the U.S. must first define the future mission environment and then direct development of the necessary 6th Generation advanced technology.
- Accelerate production of the F-35 and reduce investments in aging platforms.

Trade, Tax and Regulatory Environments

- The U.S. should leverage the punitive tariffs to force an end to EU subsidies for the civil aircraft industry and gain European support for an aggressive effort against subsidies by other parties.
- The U.S. and Europe should act in concert to challenge China to end its practice of forced technology transfer and joint ventures as a precondition to access in its civil aircraft market, imposing further technology transfer restrictions should they not do so.
- Some degree of deregulation in the civil aviation market should be undertaken. Three options include relatively small actions such as eliminating FAA subsidization and control of airports. A more significant option would be the privatization of the Air Traffic Control function of the FAA. The most drastic option would be to redefine the role of the FAA, removing all regulatory authority and making it a coordinating entity for formal standards as agreed upon by the Air Domain industry. A graduated implementation of all three options starting with the easiest and ending with full deregulation of the civilian air domain industry would likely spur further innovation in the Air Domain.

Mobilization and Supply Chain

- The U.S. and EU should give preferential treatment to Trade in Civil Aircraft Agreement signatory countries in their Air Domain supply chains and target investments in those economies.
- The U.S. should strengthen efforts and penalties to limit Chinese access to U.S. higher education facilities while continuing to block their acquisition of critical businesses and intellectual property either through purchase or theft.
- The U.S. government must establish a human capital strategy. One option is to consolidate all educational programs under a single lead agency. The strategy needs to emphasize improving small and midsized company access to the program and encourage prime contractors to lead in strengthening supply chain health by investing in programs where its suppliers are located.

Impact of COVID-19 on Air Domain Moving Forward

This paper was informed by research and analysis conducted during the early stages of the COVID pandemic. COVID-19 is expected to have the most substantial impact on personal services, hospitality/travel, manufacturing, and government.⁴⁹ The Air Domain is impacted by three of the top four. COVID-19 has cascading effects; airlines will face cash-flow liquidity challenges and difficulty managing debt obligations, resulting in canceled aircraft orders that will directly impact original equipment manufacturers and related suppliers.⁵⁰ Demand for U.S. defense companies will likely experience supply chain disruptions, resulting from the financial impact requiring suppliers to halt production.⁵¹ Two F-35 facilities in Italy and Japan have already paused production.⁵² This exogenous event will have a significant economic impact on the health of the Air Domain.

The full impact of COVID-19 on the Air Domain will not be fully realized for a while. The impacts to large companies like Boeing are already being felt, the impact on the related small and medium commercial and defense companies is inevitable. As the U.S. deficit increases, it is clear that all aspects of the government will need to examine and prioritize current and future spending. Recovery will take a year or longer. The impact of COVID-19 may result in dual use airframes supporting both commercial passenger and cargo flights. Future aviation will continue to play an essential role in both the commercial and defense industries; however, the near-term impact of COVID-19 will directly impact the evolution and growth of all aspects of the Air Domain.

¹ Murphy, *Military Aircraft, Origins to 1918: An Illustrated History of Their Impact.*, 8.

² Mattis, “Summary of the 2018 National Defense Strategy,” 2.

³ NATO, “The North Atlantic Treaty.”

⁴ 22 USC Ch. 48: Taiwan Relations.

⁵ Simon, “Should the United States and Israel Make It Official?”

⁶ Mattis, “Summary of the 2018 National Defense Strategy,” 9.

⁷ Tiron and Levinson, “Raytheon Missile, Lockheed F-16 Jet Top Foreign Military Sales.”

⁸ “Gross Domestic Product, Fourth Quarter and Year 2019 (Third Estimate); Corporate Profits, Fourth Quarter and Year 2019.”

⁹ Swagel, “CBO’s Current Projections of Output, Employment, and Interest Rates and a Preliminary Look at Federal Deficits for 2020 and 2021.”

¹⁰ Swagel.

¹¹ “The Cost of Replacing the Department of Defense’s Current Aviation Fleet,” 1.

¹² “The Cost of Replacing the Department of Defense’s Current Aviation Fleet,” 2.

¹³ “Helicopter Fleet Strength.”

¹⁴ Campbell, “Initial Capabilities Document for Future Vertical Lift (FVL) Family of Systems,” 2.

¹⁵ Coll, Hunter, and Karlen, “Beating the Air into Submission.”

¹⁶ Judson, “Lockheed and Bell Will Compete Head-to-Head to Build US Army’s Future Attack Recon Aircraft.”

¹⁷ Tirpak, “The Sixth Generation Fighter.”

¹⁸ Stevenson, “‘Loyal Wingman’ Part of the Future of Air Combat.”

¹⁹ Tirpak, “The Sixth Generation Fighter.”

²⁰ Harper, “What to Expect from Sixth-Gen Aircraft.”

²¹ Benjamin, *Drone Warfare: Killing by Remote Control.*, 18.

²² McLean, “Drones Are Cheap, Soldiers Are Not.”

²³ Hiner, “Unmanned Aerial Vehicle (UAV) Manufacturing in the US.”

²⁴ Hiner, 6.

²⁵ Hiner, 25.

²⁶ Ferek, “Interior Department Adopts Restrictions Aimed at Chinese Drones.”

²⁷ Manyika and McRaven, “Innovation and National Security: Keeping Our Edge,” 52.

²⁸ Levinson, “Job Creation in the Manufacturing Revival,” 15, 16.

²⁹ Sargent Jr. et al., “Federal Research and Development (R&D) Funding: FY2020,” 6.

³⁰ Wezeman, “China, Russia and the Shifting Landscape of Arms Sales.”

³¹ Portman and Carper, “Threats to the U.S. Research Enterprise: China’s Talent Recruitment Plans,” 1.

³² White House, “National Security Strategy of the United States of America,” 22.

³³ “Annual Report to Congress, Fiscal Year 2018: Industrial Capabilities.”

³⁴ Ramaswamy et al., “Making It in America: Revitalizing US Manufacturing.”

³⁵ “Ready to Work: Job-Driven Training and American Opportunity.”

-
- ³⁶ “Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States: Report to President Donald J. Trump by the Interagency Task Force in Fulfillment of Executive Order 13806,” 42.
- ³⁷ Gross and Marcus, “High-Paying Trade Jobs Sit Empty, While High School Grads Line Up for University.”
- ³⁸ Magnusson, “COMAC Rising.”
- ³⁹ Shalal and Hopher, “Timeline: Highlights of the 16-Year Airbus, Boeing Trade War.”
- ⁴⁰ Wolfstellar, “USA Raises Tariffs on EU Aircraft to 15%.”
- ⁴¹ Mattis, “Summary of the 2018 National Defense Strategy,” 8.
- ⁴² Mattis, 8.
- ⁴³ Farnen, “Foreign Military Sales: Building Readiness through Partner Capacity.”
- ⁴⁴ Clark and Hindin, “Viewpoint.”
- ⁴⁵ Cancian, “U.S. Military Forces in FY 2020,” 1.
- ⁴⁶ Insinna, “The US Air Force’s Radical Plan for a Future Fighter Could Field a Jet in 5 Years.”
- ⁴⁷ Insinna.
- ⁴⁸ “Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States: Report to President Donald J. Trump by the Interagency Task Force in Fulfillment of Executive Order 13806.”
- ⁴⁹ Price, “Impact of Coronavirus on Small Businesses - Where Is It Worst?”
- ⁵⁰ “COVID-19.”
- ⁵¹ “COVID-19.”
- ⁵² “COVID-19.”

Bibliography

- 22 USC Ch. 48: Taiwan Relations, Pub. L. No. 96–8, 22 Foreign Relations and Intercourse (1979).
<https://uscode.house.gov/view.xhtml?path=/prelim@title22/chapter48&edition=prelim>.
- “Annual Report to Congress, Fiscal Year 2018: Industrial Capabilities.” Office of the Under Secretary of Defense for Acquisition and Sustainment and the Office of the Deputy Assistant Secretary of Defense for Industrial Policy, May 2019.
<https://www.businessdefense.gov/Portals/51/Documents/Resources/2018%20AIC%20RTC%2005-23-2019%20-%20Public%20Release.pdf?ver=2019-06-07-111121-457>.
- “Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States: Report to President Donald J. Trump by the Interagency Task Force in Fulfillment of Executive Order 13806.” Washington, DC: Office of the Under Secretary of Defense for Acquisition and Sustainment and the Office of the Deputy Assistant Secretary of Defense for Industrial Policy, September 2018.
<http://defense.gov/StrengtheningDefenseIndustrialBase>.
- Benjamin, Medea. *Drone Warfare: Killing by Remote Control*. Updated edition. Verso, 2013.
<https://nduezproxy.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,url,uid&db=cat04199a&AN=ndu.550815&site=eds-live&scope=site>.
- Campbell, LTG John F. “Initial Capabilities Document for Future Vertical Lift (FVL) Family of Systems.” Department of Defense, April 8, 2013.
- Cancian, Mark F. “U.S. Military Forces in FY 2020.” Washington, DC: Center for Strategic and International Studies, October 2019.
- Clark, Samantha, and Doron Hindin. “Security Assistance Programs - A Guide for the Perplexed.” *National Defense* (blog), September 27, 2019.
<https://www.nationaldefensemagazine.org/articles/2019/9/27/viewpoint-security-assistance-programs---a-guide-for-the-perplexed>.
- Coll, Gabriel, Andrew Hunter, and Robert Karlen. “Beating the Air into Submission: Investing in Vertical Lift Modernization (Part II).” Washington, DC: Center for Strategic and International Studies, May 10, 2019. <https://www.csis.org/analysis/beating-air-submission-investing-vertical-lift-modernization-part-ii-0>.
- PricewaterhouseCoopers US. “COVID-19: What It Means for the Aerospace and Defense Industry.” Accessed May 13, 2020. <https://www.pwc.com/us/en/library/covid-19/coronavirus-impacts-aerospace-and-defense.html>.
- Farmen, MG Stephen. “Foreign Military Sales: Building Readiness through Partner Capacity.” Presented at the AUSA 2017 Annual Meeting, October 2017.
<https://www.ausa.org/sites/default/files/ausa-unstreamed-event-slides/foreign-military-sales.pdf>.
- Ferek, Katy Stech. “Interior Department Adopts Restrictions Aimed at Chinese Drones.” *Wall Street Journal*, January 29, 2020, sec. Politics. <https://www.wsj.com/articles/interior-department-adopts-restrictions-aimed-at-chinese-drones-11580295602>.
- Gross, Ashley, and Jon Marcus. “High-Paying Trade Jobs Sit Empty, While High School Grads Line Up for University.” *All Things Considered*. NPR, April 25, 2018.
<https://www.npr.org/sections/ed/2018/04/25/605092520/high-paying-trade-jobs-sit-empty-while-high-school-grads-line-up-for-university>.

- U.S. Bureau of Economic Analysis (BEA). "Gross Domestic Product, Fourth Quarter and Year 2019 (Third Estimate); Corporate Profits, Fourth Quarter and Year 2019," March 26, 2020. <https://www.bea.gov/news/2020/gross-domestic-product-fourth-quarter-and-year-2019-third-estimate-corporate-profits>.
- Harper, Jon. "What to Expect from Sixth-Gen Aircraft." *National Defense Magazine*, September 16, 2019. <https://www.nationaldefensemagazine.org/articles/2019/9/16/what-to-expect-from-sixth-gen-aircraft>.
- Global Firepower. "Helicopter Fleet Strength," 2020. <https://www.globalfirepower.com/aircraft-helicopters-total.asp>.
- Hiner, Jacqueline. "Unmanned Aerial Vehicle (UAV) Manufacturing in the US." IBISWorld Industry Report. Melbourne, Australia: IBISWorld Services, December 2019. <http://clients1.ibisworld.com/reports/us/industry/default.aspx?entid=4424>.
- Insinna, Valerie. "The US Air Force's Radical Plan for a Future Fighter Could Field a Jet in 5 Years." *Defense News*, September 16, 2019. <https://www.defensenews.com/digital-show-dailies/2019/09/16/the-us-air-forces-radical-plan-for-a-future-fighter-could-field-a-jet-in-5-years/>.
- Judson, Jen. "Lockheed and Bell Will Compete Head-to-Head to Build US Army's Future Attack Recon Aircraft." *Defense News* (blog), March 25, 2020. <https://www.defensenews.com/smr/army-modernization/2020/03/25/lockheed-and-bell-will-compete-head-to-head-to-build-us-armys-future-attack-recon-aircraft/>.
- Levinson, Marc. "Job Creation in the Manufacturing Revival." Washington, DC: Congressional Research Service, July 19, 2019. <https://fas.org/sgp/crs/misc/R41898.pdf>.
- Magnusson, Ari. "COMAC Rising: China's State-Owned Aerospace Manufacturer Aims High." APEX | Airline Passenger Experience, January 23, 2019. <https://apex.aero/2019/01/23/comac-aims-high>.
- Manyika, James, and William McRaven. "Innovation and National Security: Keeping Our Edge." Washington, DC: Council on Foreign Relations, September 2019. <https://www.cfr.org/report/keeping-our-edge/>.
- Mattis, Jim. "Summary of the 2018 National Defense Strategy," n.d., 14.
- McLean, Wayne. "Drones Are Cheap, Soldiers Are Not: A Cost-Benefit Analysis of War." *The Conversation* (blog), June 25, 2014. <http://theconversation.com/drones-are-cheap-soldiers-are-not-a-cost-benefit-analysis-of-war-27924>.
- Murphy, Justin D. *Military Aircraft, Origins to 1918: An Illustrated History of Their Impact*. Weapons and Warfare Series. ABC-CLIO, 2005.
- NATO. "The North Atlantic Treaty," April 4, 1949. http://www.nato.int/cps/en/natohq/official_texts_17120.htm.
- Portman, Senator Rob, and Senator Tom Carper. "Threats to the U.S. Research Enterprise: China's Talent Recruitment Plans." Staff Report. Washington, DC: United States Senate Permanent Subcommittee on Investigations, November 18, 2019. <https://www.hsgac.senate.gov/imo/media/doc/2019-11-18%20PSI%20Staff%20Report%20-%20China's%20Talent%20Recruitment%20Plans.pdf>.
- Price, Lisa. "Impact of Coronavirus on Small Businesses - Where Is It Worst?" *Small Business Trends* (blog), April 29, 2020. <https://smallbiztrends.com/2020/04/impact-of-coronavirus-on-small-businesses.html>.

- Ramaswamy, Sree, James Manyika, Gary Pinkus, Katy George, Jonathan Law, Tony Gambell, and Andrea Serafino. "Making It in America: Revitalizing US Manufacturing." Washington, DC: McKinsey Global Institute, November 2017.
<https://www.mckinsey.com/~media/McKinsey/Featured%20Insights/Americas/Making%20it%20in%20America%20Revitalizing%20US%20manufacturing/Making-it-in-America-Revitalizing-US-manufacturing-Full-report.ashx>.
- "Ready to Work: Job-Driven Training and American Opportunity." Washington, DC: Executive Office of the White House, July 2014.
https://obamawhitehouse.archives.gov/sites/default/files/docs/skills_report.pdf.
- Sargent Jr., John F, Tadlock Cowan, Robert Esworthy, Marcy E Gallo, Laurie A Harris, Eva Lipiec, Daniel Morgan, and Kavya Sekar. "Federal Research and Development (R&D) Funding: FY2020." Washington, DC: Congressional Research Service, n.d.
<https://crsreports.congress.gov/product/pdf/R/R45715>.
- Shalal, Andrea, and Tim Hepher. "Timeline: Highlights of the 16-Year Airbus, Boeing Trade War." Reuters, February 14, 2020. <https://www.reuters.com/article/us-wto-aircraft-timeline/timeline-highlights-of-the-16-year-airbus-boeing-trade-war-idUSKBN20901R>.
- Simon, Steven. "Should the United States and Israel Make It Official?" *Foreign Policy* (blog). Accessed April 24, 2020. <https://foreignpolicy.com/2019/12/20/united-states-israel-allies-formal-defense-treaty-trump-netanyahu/>.
- Stevenson, Beth. "'Loyal Wingman' Part of the Future of Air Combat." *Aviation International News* (blog), June 13, 2019. <https://www.ainonline.com/aviation-news/defense/2019-06-13/loyal-wingman-part-future-air-combat>.
- Swagel, Phill. "CBO's Current Projections of Output, Employment, and Interest Rates and a Preliminary Look at Federal Deficits for 2020 and 2021." Congressional Budget Office, April 24, 2020. <https://www.cbo.gov/publication/56335>.
- "The Cost of Replacing the Department of Defense's Current Aviation Fleet." Washington, DC: Congressional Budget Office, January 2020.
- Tiron, Roxana, and Robert Levinson. "Raytheon Missile, Lockheed F-16 Jet Top Foreign Military Sales." *Bloomberg Government* (blog). Accessed April 24, 2020.
<https://about.bgov.com/news/raytheon-missile-lockheed-f-16-jet-top-foreign-military-sales/>.
- Tirpak, John. "The Sixth Generation Fighter." *Air Force Magazine* (blog), October 1, 2009.
<https://www.airforcemag.com/article/1009fighter/>.
- Wezeman, Siemon. "China, Russia and the Shifting Landscape of Arms Sales." Stockholm International Peace Research Institute, July 5, 2017.
<https://www.sipri.org/commentary/topical-backgroundunder/2017/china-russia-and-shifting-landscape-arms-sales>.
- White House. "National Security Strategy of the United States of America," December 2017.
<https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905-2.pdf>.
- Wolfstellar, Pilar. "USA Raises Tariffs on EU Aircraft to 15%." *Flight Global* (blog), February 14, 2020. <https://www.flightglobal.com/aerospace/usa-raises-tariffs-on-eu-aircraft-to-15/136776.article>.

Appendix A – Boeing

5/6/2020

AY 2019-2020
Boeing
Air Domain
Industry Analysis Firm Brief

SPRING SEMINAR #1
10 March 2020

The Dwight D. Eisenhower School
for National Security and Resource Strategy
National Defense University
Fort McNair, Washington, D.C. 20319-5062

1

Agenda

- Raison D'Etra
- Universe
- Success
- Strategy
- Opportunity

2

5/6/2020



RAISON D'ETRE

Purpose and Mission: Connect, Protect, Explore and Inspire the World through Aerospace Innovation

Aspiration: Best in Aerospace and Enduring Global Industrial Champion

Enduring Values

Integrity / Quality / Safety / Diversity & Inclusion / Trust & Respect / Corporate Citizenship / Stakeholder Success

3



THE BOEING COMPANY

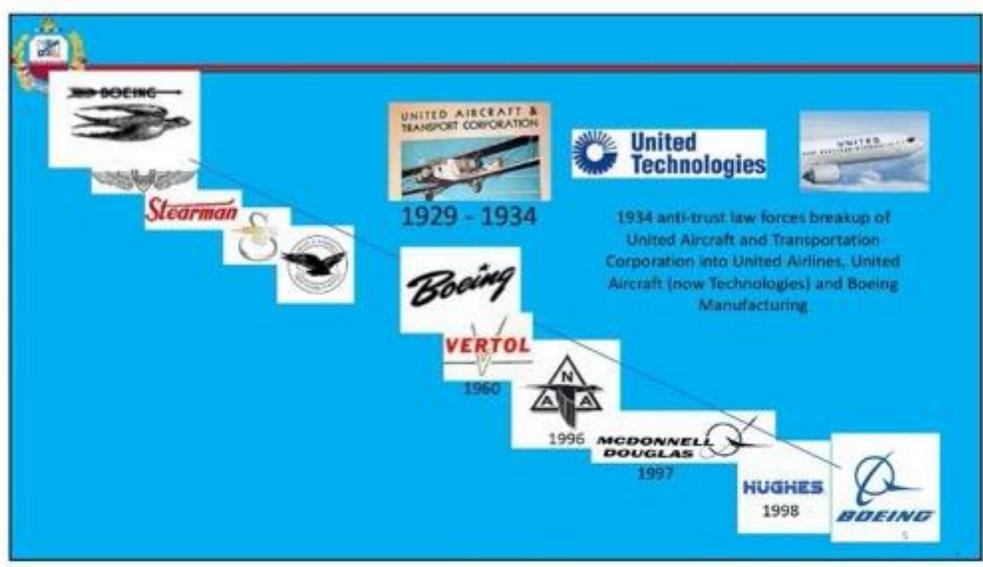
Founded: 1916 Founder: William "Bill" Boeing

Early History

- 1917 - Produced 50 Aircraft for the US Navy in World War I
- 1919 - Began first international mail service between Seattle and Victoria, British Columbia
- 1927 – launched Chicago – San Francisco route and established an airline subsidiary, Boeing Air Transport
- 1929 Renamed company United Aircraft and Transportation (Boeing + Rentschler)
- 1933 - First air-cooled engine in Boeing Model 40A and First all metal airliner
- 1934 anti-trust rules force United Aircraft and Transportation to sell portions of its operations as United Air Lines and United Aircraft (later United Technologies).

4

5/6/2020



5

...to connect, protect, explore and inspire the world through aerospace innovation

COMMERCIAL AIRPLANES

premier manufacturer of commercial jetliners

HQ: Seattle, WA	Employees: 64,529
Major Facilities: Everett, WA; Renton, WA; North Charleston, SC	
Revenues: \$32.255B	
Earnings from Operations: \$6.657B	
Major Products: 737, 747, 767, 777, 787	
Backlog: 5400 aircraft, \$177B value	

DEFENSE, SPACE & SECURITY

unparalleled aftermarket support

HQ: Arlington, VA	Employees: 33,757
Major Facilities: St. Louis, MO; Huntsville, AL; Mesa, AZ; El Segundo, CA; Palmdale, CA; Philadelphia, PA; Cape Canaveral, FL	
Revenues: \$26.227B	
Earnings from Operations: \$2.908B	
Products Delivered in 2019: AH-64, G-17, C-40A, CH-47, F-15, F/A-18, KC-46, P-8A, Satellites	

GLOBAL SERVICES

HQ: Dallas, TX	Employees: 24,585
Operations: 300 Countries; 40 States	
Revenues: \$18.680B	
Earnings from Operations: \$2.697B	

2019 Revenues

6

5/6/2020



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Boeing Commercial Airplanes in the News

Boeing to cut 787 production at its North Charleston plant amid trade war with China
By John M. McDermott and David M. Weis, authors of Boeing's 2019 Commercial Airplane Industry Outlook Report

Boeing Faces Deeper Antitrust Probe of Embraer Deal in Europe
A so-called "Phase II" investigation from the EU often raises risks that companies must sell part of their business to eliminate antitrust concerns.

Boeing posts negative commercial airplane orders in 2019 for first time in decades
PUBLISHED TUE, JAN 14 2020 12:45 AM EST | UPDATED TUE, JAN 14 2020 12:00 PM EST

Merger Creates One of World's Biggest Aerospace and Defense Suppliers
Woodward to combine with Hexcel in all-stock transaction.

Boeing will halt production of troubled 737 Max airplane
It's unclear how long the suspension will last.

8

5/6/2020



Boeing Commercial Airplanes in the News

Boeing Raises 20-Year Demand Forecast to \$6.8T

Global market's need for new commercial aircraft pegged at 44,040 new jets through 2038, 3% higher than last year's outlook.

American Machinist Staff
JUN 18, 2019

BOEING FORECASTS MASSIVE GROWTH OVER 20 YEARS REQUIRING 44,000 JETS.

By Geoffrey Thomas June 17, 2019

9



IMPORTANT INDUSTRY TRENDS

- # of Passenger Airline Miles CAGR – 4.6%
- Global Air Freight CAGR – 4%
- Global Aircraft Leasing CAGR – 5%
- Consolidation within supplier network
- Net Profits of Airlines at \$26 Billion in 2019
- Boeing built 90% of freight aircraft flying
- 10,000 aircraft in airline fleets

CUSTOMERS –

- Airlines
- Aircraft Leasing Companies
- Freight Airlines
- Business Jets

IMPLICATIONS FOR FIVE FORCES

- Increasing demand for aircraft benefits Boeing
- Consolidation among suppliers benefits Boeing
- Existing fleet of aircraft benefits Boeing (familiarity with maintenance systems)
- Intense competition within a duopoly
- 737 MAX grounding has allowed Airbus to pick up orders from Boeing, reputational harm
- Expands opening for new competitors
- Corona virus could slow demand for aircraft

COMPETITORS

Airbus

United Aircraft Corp.
COMAC



Commercial Airplanes

COMPLEMENTERS

- Entertainment Systems
- Gaming
- Movie Industries
- Satellite Communications
- Airport Services

SUPPLIERS

Spirit AeroSystems	United Technologies	General Electric	Safran SA	Dassault Systems
Honeywell	Arcam	Mitsubishi Heavy Industries	Titanium Group	Bell Helicopter
Leonardo	Skanska	Kniveshell Heavy Industries	Thales	Toray Industries
PPG Industries	BAE Systems	TransDigm Group	Sankhya Corp.	Midea Group

10

Boeing Space, Defense, and Security in the News

Science Jeff Donald

Boeing Starliner Completes Successful Landing, Gets The New Name 'Calypso'

New NDIA study gives defense industrial base health a 'C' grade

By Jared Serbu | @jserbu/WFED
February 6, 2020 7:51 am 5 min read

Boeing Continues Investing in Defense R&D Even With 2019 Losses

By Ben Warner
January 29, 2020 2:18 PM • Updated: January 29, 2020 3:57 PM

Boeing first-quarter defense revenue increases 2% on higher volume

STAFF WRITER | APRIL 24, 2019

The Incredibly Shrinking Defense Industry

Fewer contractors mean less competition and innovation

BY MARK THOMPSON | FILED UNDER ANALYSIS | AUGUST 9, 2019

11

IMPORTANT INDUSTRY TRENDS

- Global Aerospace/Defense CAGR – 3.5%
- Commercial and Military Satellite CAGR – 76.6%
- Boeing #2 Defense Contractor to DOD
- Continued Consolidation within ranks of suppliers and Competitors

SALES

- U.S. Department of Defense - DOD
- AEC & Commercial Satellite Operations - CSO

IMPLICATIONS FOR FIVE FORCES

- Monopsony purchaser in DOD for defense items
- Consolidation among suppliers benefits Boeing
- Consolidation among competitors reduces options for DOD, but strengthens competitors hand versus Boeing, putting both price and differentiation pressure on Boeing
- Boeing partnerships with complementors' adds value to Boeing offering

COMPETITORS

- Lockheed Martin
- Airbus
- General Dynamics
- United Technologies
- Northrop Grumman
- Space X
- Raytheon
- Textron
- BAE Systems

CUSTOMERS

Space, Defense & Security

COMPLEMENTERS

- Artificial Intelligence
- Cloud Computing
- Electronic Sensors
- Satellite Systems
- Remotely Piloted Vehicles

SUPPLIERS

Spire Aerospystems	United Technologies	General Electric	Safarim SA	Dassault Systems
Honeywell	Arcam	Mitsubishi Heavy Industries	Tishman Group	Bells Royce Holdings
Leonardo	Skanska	Kniveshell Heavy Industries	Thales	Toray Industries
PPG Industries	BAE System	TransDigm Group	Sankhya Corp.	Midea Group

12



Boeing Global Services in the News

Boeing Global Services On Track For \$50 Billion Goal

November 17, 2019

By Marie Hullett FEB 05, 2020

Aircraft Maintenance, Repair Industry Is Latest to Form Blockchain Alliance

Global Digital MRO Market Outlook (2018-2027): MRO Market Forecast to Reach \$3.39 billion by 2027 - ResearchAndMarkets.com

January 16, 2020

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IMPORTANT INDUSTRY TRENDS

- Global Digital MRO CAGR – 16.5%
- Global Aircraft MRO CAGR – 4.6%
- Business Jet MRO CAGR – 4%
- Growing Demand for Aircraft
- 10,000 Boeing aircraft in airline fleets

CUSTOMERS –

- Airlines
- Business Jets
- Freight Airlines
- Defense Aviation
- MRO



SUPPLIERS

IMPLICATIONS FOR FIVE FORCES

- Boeing familiarity with and data on its own planes gives Boeing Global Services a potential advantage over other MRO providers
- Sales relationship with airlines allows Boeing to differentiate services
- Existing manufacturing relationship with suppliers allows services unit to garner discounted prices on spares

COMPETITORS					COMPLEMENTERS
AAR Corp.					Data Analytics
Barnes Group Inc.					Cloud computing
Collins Aerospace					Remote Sensing
Delta TechOps					Additive Manufacturing
FL Technics	Spirit AeroSystems	United Technologies	General Electric	Safran SA	Dassault Systems
GE Aviation	Honeywell	Airbus	Mitsubishi Heavy Industries	Tiempo Group	Rolls Royce Holdings
Lufthansa Technik	Leonardo	Skanska	Kawasaki Heavy Industries	Thales	Toray Industries
Rolls Royce	PPG Industries	BAE System	TransDigm Group	Sankhya Corp.	Midea Group
Singapore Technologies					

14

Hedge fund interest in Boeing is above average

What have hedge funds been doing with The Boeing Company (NYSE:BA)?

Heading into the first quarter of 2020, a total of 82 of the hedge funds tracked by Insider Monkey were bullish on this stock, a change of -1% from the third quarter of 2019. The graph below displays the number of hedge funds with bullish position in BA over the last 18 quarters. With the smart money's sentiment shifting, there exists a few key hedge fund managers who were boosting their holdings significantly (or already accumulated large positions).

Of the funds tracked by Insider Monkey, Ken Griffin's Citadel Investment Group has the biggest call position in The Boeing Company (NYSE:BA), worth close to \$651.7 million, amounting to 0.3% of its total 13F portfolio. The second largest stake is held by Citadel Investment Group, led by Ken Griffin, holding a \$318.5 million position; the fund has 0.1% of its 13F portfolio invested in the stock. Some other professional money managers with similar optimism consist of Andrew Immerman and Jeremy Schiffman's *Paradise Capital Management*, Phil Gross and Robert Atchinson's *Adage Capital Management* and Panayotis Taka Sparagga's *Aikeon Capital Management*. In terms of the portfolio weights assigned to each position *Hedgebury Investment Partners* allocated the biggest weight to The Boeing Company (NYSE:BA), around 14.74% of its 13F portfolio. *Mountaineer Partners Management* is also relatively very bullish on the stock, designating 7.8 percent of its 13F equity portfolio to BA.

INSIDER MONKEY No of Hedge Funds with BA Positions

— No of Hedge Funds with BA Positions

Quarter	No of Hedge Funds with BA Positions
Q3 2018	40
Q4 2018	42
Q1 2019	45
Q2 2019	48
Q3 2019	52
Q4 2019	55
Q1 2020	82

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Boeing 2019 10-K

Boeing is assuming the 737-Max will be returned to service mid year 2020

Five-Year Summary (Unaudited)					
(Dollars in millions, except per share data)	2019	2018	2017	2016	2015
Revenues	\$76,939	\$101,127	\$94,055	\$97,496	\$96,114
Net (loss)/earnings	(\$636)	\$15,480	\$6,454	\$5,024	\$5,176
Basic (loss)/earnings per share	(\$1.12)	\$13.05	\$14.25	\$7.92	\$7.82
Diluted (loss)/earnings per share	(1.12)	12.65	13.65	7.83	7.44
Dividends declared per share ⁽¹⁾	6.22	7.19	5.97	4.69	3.82
Cash and cash equivalents	\$9,485	\$7,437	\$8,613	\$8,804	\$11,302
Short-term and other investments	545	927	1,174	1,328	791
Total assets	133,625	117,359	112,362	108,076	94,408
Total debt	27,392	13,847	11,117	8,362	9,364
Operating cash flow	(\$2,448)	\$15,322	\$13,348	\$15,496	\$9,561
Total backlog	\$463,402	\$492,481	\$474,643	\$473,492	\$459,289
Year-end nonfines	161,198	153,000	140,800	150,500	161,400

⁽¹⁾ Cash dividends have been paid on common stock every year since 1962.

⁽²⁾ Amounts prior to 2016, along with 2016 Backlog, do not reflect impact of the adoption of ASU No. 2014-09, Revenue from Contracts with Customers (Topic 606); ASU No. 2017-07, Compensation - Retirement Benefits (Topic 718); Improving the Presentation of Net Periodic Pension Cost and Net Periodic Postretirement Benefit Cost; ASU 2016-18 Statement of Cash Flows (Topic 230); Restricted Cash, in the first quarter of 2019.

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5/6/2020

Balance Sheet Analysis 2019 (\$M)



Current Assets	\$ 102,229.00
Non-Current Assets	\$ 31,396.00
Total Assets	\$ 133,625.00
Net Sales	\$ 76,559.00
EBIT	\$ (3,345.00)
Tax	\$ (1,623.00)
Net Income	\$ (636.00)
Current Liab.	\$ 97,312.00
Non Current Liab.	\$ 44,613.00
Owners Equity	\$ (8,300.00)
Liab + O. E.	\$ 133,625.00

Jan. 24, 2020: 100,750 Shareholders of record

17

Boeing Financial Performance Over Time

	2019	2018	2017	2016	2015
Liquidity					
Current Ratio	1.05	1.08	1.14	1.25	1.35
Quick Ratio	0.14	0.16	0.18	0.38	0.42
Altman Z	1.98	3.07	3.54	2.91	2.93
Long Term Solvency					
Total Debt Ratio	21.35	11.8	9.89	11.06	10.55
Profitability					
Profit Margin	5.83	19.42	18.5	15.48	14.59
Earnings per Share (EPS)	-1.12	18.05	14.03	7.92	7.52
EPS: 1 Yr Growth		28.65	77.17	5.32	0.67
ROIC	-4.4	70.35	64.57	36.94	33.51
WACC	7.36	10.89	9.48	8.54	9.07
Activity Analysis					
Asset Turnover Ratio	0.61	0.88	0.93	1.01	1.03
Inventory Turnover Ratio	1.06	1.36	1.70	2.48	2.46
Capital Market Analysis					
Price to Earning Ratio	-	20.12	27.56	14.68	15.71
Dividend Payout Ratio	-	39.21	42.04	57.65	49.75

• "Our debt balances increased significantly in 2019, and we expect further increases in 2020, in order to manage liquidity impacts related to the 737 MAX grounding. This has also resulted in downgrades to our credit rating. If we require additional funding in order to fund outstanding financing commitments, address further 737 Max impacts, or meet other business requirements, our market liquidity may not be sufficient." 10 K pg 13.

Boeing secures \$13B in loans over 737 Max jet crisis: Report

Boeing secures \$13B in loans over 737 Max jet crisis: Report

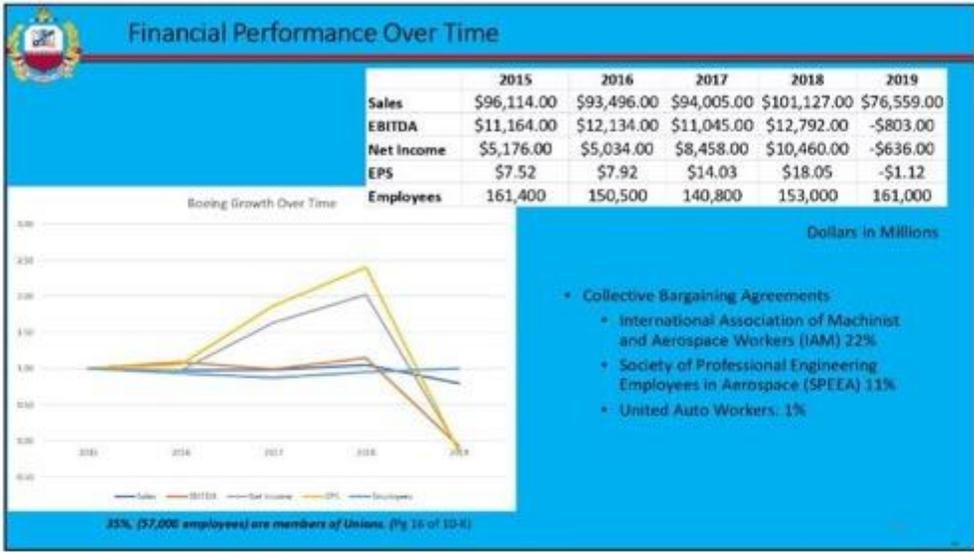
Technology

Boeing Sells \$3.5 Billion of Bonds as 737 Max Scrutiny Deepens

3/30/2019

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5/6/2020



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5/6/2020

Financial Performance Comparison

	Boeing	Lockheed Martin	Northrup Grumman	Airbus-SE	Industry 2018	Market 2018
Liquidity						
Current Ratio	1.05	1.22	1.13	0.91	1.41	1.37
Quick Ratio	0.23	0.28	0.38	0.32	0.66	0.88
Long Term Solvency						
Total Debt Ratio	21.35	28.94	37.5	10.16		
Total Debt / Total Capital	341.07	81.26	63.66	65.98		
Profitability						
ROIC	-4.4	40.69	19.32	-6.48	0.16	0.08
Profit Margin	5.83	13.99	21.45	14.91	20.98	35.26
Effective Tax Rate	EBT < 0	13.96	11.77	29.73	26.73	22.42
Activity Analysis						
Total Asset Turnover	0.61	1.29	0.86	0.61	0.8	0.6
Inventory Turnover	1.06	15.55	37	1.89	3.3	6.2
Capital Structure Analysis						
Total Debt to Equity	Equity < 0	4.05	1.45	0.92	1.22	0.94
Interest Coverage		13.09	7.52	20.34	10.19	4.82

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Business Segment Breakdown

Revenues	Dec-19 %Rev	Oper Marg	Dec-18 %Rev	Oper Marg	Dec-17 %Rev	Oper Marg
BCA-Commercial Airlines	32,255.00	42%	57,499.00	57%	54,612.00	58%
DSS-Defense Space/Security	26,227.00	34%	26,392.00	26%	23,938.00	25%
Global Services	18,468.00	24%	17,056.00	14%	14,611.00	16%
Boeing Capital	244.00	11.0%	274.00	29.0%	307.00	37.0%

Global: Approximately 80% of Commercial Airplanes' total backlog, in dollar terms, is with non-U.S. airlines.

DDC: 70% of revenues from fixed-price contracts
 DDS: 73% of revenues from fixed-price contracts

DDC: We expect the market to grow by around 2.5% annually. Non-U.S. Customers including FMS: 55% of revenues (pg. 12, 10Q)

2019 Business Segment Breakout

737 Max Impact

* Q4 2019 * Q1 2019 * Q1 2019

2018 Business Segment Breakout

* Q4 2018 * Q1 2018 * Q1 2018

2017 Business Segment Breakout

* Q4 2017 * Q1 2017 * Q1 2017

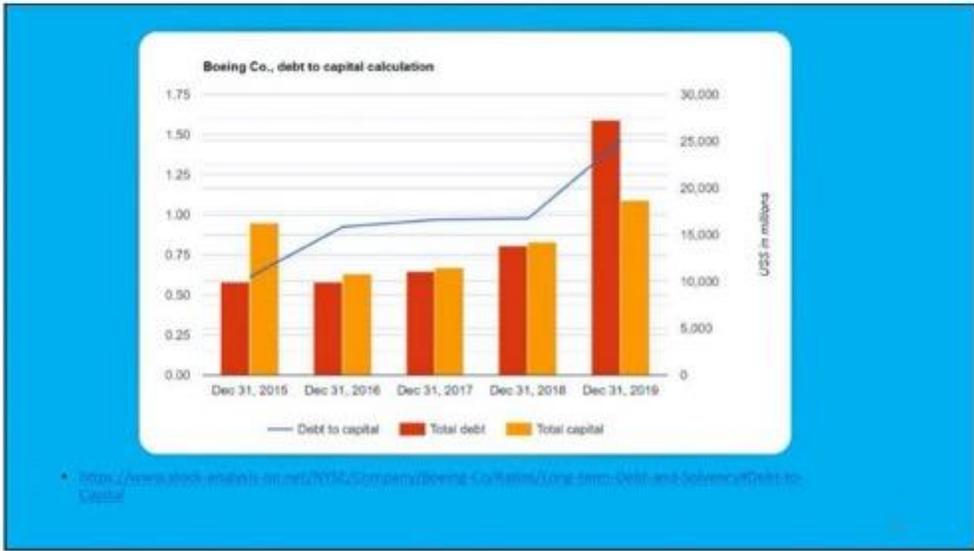
DDC lists 20% of revenues related to U. S. government contracts - includes Foreign Military Sales

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<https://www.secdatabase.com/SEC-1332/Company/Boeing-Corporation/Long-Term-Debt-and-Interest/Debt-to-Capital>

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Commercial Market

737 Max Issue: 10K

- March 2019 FAA issues order to suspend operations of all 737 MAX aircraft in the US following two fatal accidents
- Deliveries suspended until clearance is granted by FAA and other regulatory agencies
- 2nd Quarter 2019: Boeing reduced production from 52 aircraft per month to 42 aircraft per month
- 4th Quarter: Boeing announced plans to temporarily suspend production of 737 MAX starting Jan 2020.

On March 13, 2019, the Federal Aviation Administration (FAA) issued an order to suspend operations of all 737 MAX aircraft in the U.S. and by U.S. aircraft operators following two fatal 737 MAX accidents. Non-U.S. civil aviation authorities have issued directives to the same effect. Deliveries of the 737 MAX have been suspended until clearance is granted by the appropriate regulatory authorities. The grounding is having a significant adverse impact on our operations and creates significant uncertainty. We are focused on safely returning the 737 MAX to service. (10K pg 18)

Commercial Airplane deliveries as of December 31 were as follows:

	737 ^a	767 ^b	787 ^c	777 ^d	350 ^e	Total
2019						
Cumulative deliveries	7,439	1,865	1,176	1,627	939	12,046
Deliveries	127 ^(f)	7	43 ^(g)	48 ^(h)	156	281
2018						
Cumulative deliveries	7,312	1,848	1,133	1,582	781	11,656
Deliveries	180 ^(f)	6	27 ^(g)	49	142	304
2017						
Cumulative deliveries	6,732	1,842	1,106	1,533	639	11,252
Deliveries	525 ^(f)	14 ^(f)	12	74	136	769

^a Preliminary deliveries identified by parentheses
^b Aircraft accounted for no revenue by BGA and as operating leases in consolidation identified by parentheses

Commercial Aircraft Deliveries (pg 29 of 10K)

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Strategic Gameboard

- Commercial: Single Aisle Aircraft Make up 63% of Market (Ibis World)
 - Boeing and Airbus: Duopoly
- Boeing competes in all Classes—737 Max is their product line that feeds the dominant sector of the commercial market
- Global Services: Commercial and Defense
 - Full Spectrum MRO
 - Engineering
 - Supply Chain Services
 - Logistics Management
- Defense: "We also expect the U.S. DoD to continue to emphasize affordability, innovation, cybersecurity and delivery of technical data and software in its procurement process. If we can no longer adjust successfully to these changing acquisition policies, our revenues and market share could be impacted"
- Defense: "We anticipate that the effects of defense industry consolidation, fewer large and new programs and new priorities, including near and long term cost competitiveness of our US DoD and non US customers will intensify competition for many of our BDS products." (pg 11, 10K)
- "Our Strategy is centered on successful execution in healthy core businesses"

Products and services segmentation

Category	Percentage
Commercial	63%
Global Services	24%
Defense	13%

Defense Business increased as a function of revenue by 31% in 2019

Based on long-term global economic growth projections of 2.7% average annual GDP growth, we project a \$6.8 trillion market for approximately 44,000 new airplanes over the next 20 years. The industry remains vulnerable to exogenous developments including fuel price spikes, credit market shocks, acts of terrorism, natural disasters, conflicts, epidemics and increased global environmental regulations. (10K pg 25)

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Backlog and Inventory

Orders, Deliveries and Backlog | October 2019

	A200	A200	A300	A300	A300	TOTAL
Deliveries						
Orders	4	58	6	8	0	76
Deliveries	737	747.8	767	777	787	TOTAL
Backlog	1	1	3	2	12	19
Net Orders						
Orders	5	308	12	0	0	415
Deliveries	737	747.8	767	777	787	TOTAL
Backlog	-18	0	0	2	5	-11
Gross Orders						
Orders	5	308	12	0	0	415
Deliveries	737	747.8	767	777	787	TOTAL
Backlog	0	0	0	2	6	8
Backlog						
Orders	1	300	6	-8	0	308
Deliveries	737	747.8	767	777	787	TOTAL
Backlog	-19	-1	-3	0	-2	-30

Backlog

Our backlog at December 31 was as follows:

Orders in backlog	2019	2018
Year ended December 31		
Commercial airplanes	\$176,888	\$408,142
Defense, Space & Security	\$3,908	\$1,277
Global Services	22,862	21,984
Total Backlog	\$483,658	\$431,403
Contractual backlog	\$476,473	\$423,376
Unobligated backlog	28,836	\$28,411
Total Backlog	\$483,658	\$431,403

Commercial backlog of unfilled orders includes purchase orders, awarded orders for which delivery contracts have not been executed, and unawarded U.S. and non-U.S. government contract funding. The increase in contractual backlog during 2019 was primarily due to BCA, increases in backlog of new orders and a reduction in backlog related to orders from a customer that experienced liquidity issues, partially offset by BDS. Unobligated backlog includes U.S. and non-U.S. government defense contracts for which funding has not been authorized. The decrease in unobligated backlog in 2019 was primarily due to reallocations to contractual backlog related to BDS and BGS contracts partially offset by contract awards.

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Where to Compete?

Strategy - *focused on execution, productivity, and competitiveness*

- RETURN THE 737 MAX TO SERVICE SAFELY
- REBUILD TRUST
- FOCUS ON OUR VALUES
- OPERATE WITH EXCELLENCE
- RESTORE PRODUCTION HEALTH
- INVEST IN OUR FUTURE

- Strategy is centered on successful execution in healthy core businesses – Commercial Airplanes (BCA), Defense, Space & Security (BDS), and Global Services (BGS), enables investment in new products and services. Focus on producing the products that the market demands, improve efficiency and quality.
- BCA goal to offer airplanes and services that deliver superior design, safety, efficiency and value
- BDS delivers capability-driven solutions at reduced costs, strategy is to leverage core businesses to capture key next-generation programs
- BGS provides innovative, comprehensive, and cost-competitive product and service solutions.

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How to compete?

FOCUS ON OUR VALUES

Enduring Values

- Committed to core values that not only define who we are, but also serve as guideposts to help us become the company we would like to be.
- **Integrity** - Take the high road by practicing the highest ethical standards and honoring our commitments, take personal responsibility for our own actions.
- **Quality** - Strive for first-time quality and continuous improvement in all that we do to meet or exceed the standards of excellence.
- **Safety** – Value human life and well-being above all else and take action accordingly be personally accountable for our own safety and collectively responsible for the safety of our teammates and workplaces, our products and services, and the customers who depend on them.
- **Trust & Respect** - Act with integrity, consistency, and honesty in all that we do.

2025 Goals:

- Market Leadership
- Top-quartile Performance and Returns
- Growth Fueled by Productivity
- Design, Manufacturing, Services Excellence
- Accelerated Innovation
- Global Scale and Depth
- Best Team, Talent and Leaders

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OPERATE WITH EXCELLENCE

- Susan Donix joins Boeing as CIO / SVP IT and Data Analytics - *"She brings deep insight and skills to digital transformation, data analytics and artificial intelligence – all essential to our long-term growth strategy as well as our continuous drive for operational and safety excellence. She brings as well a passion for STEM education and diversity and inclusion."*
- *Company must focus on quality and excellence in the business lines that are not commercial aviation.*

https://www.boeing.com/resources/boeing/resources/susan_donix_enr_story.cfm?information=officer
<https://www.cnbc.com/2020/11/11/the-boeing-cio-joins-the-company-and-what-it-for.html>

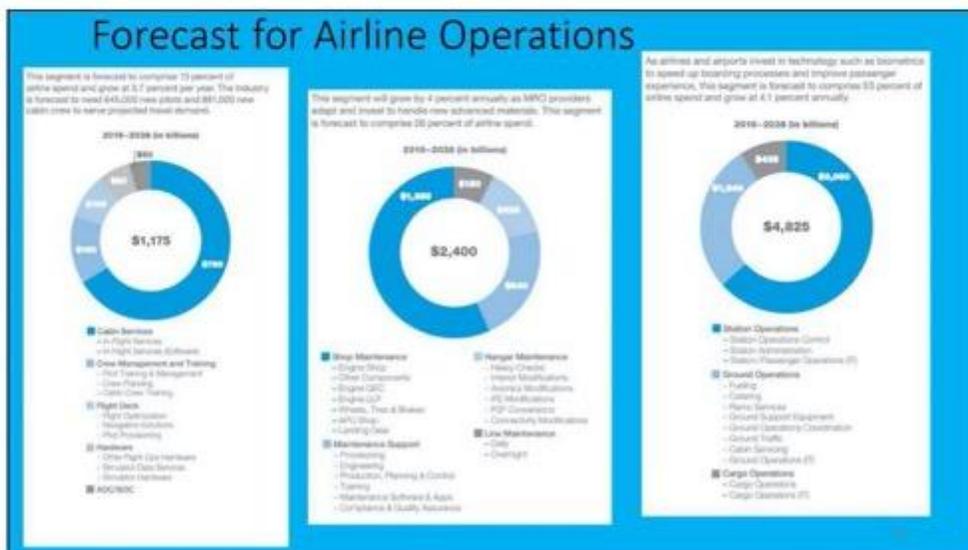
INVEST IN OUR FUTURE

- Boeing Global Services is looking to take over parts of the market where Boeing has not traditionally played, for example is flight simulator training.
- Focused on fuel efficient aircraft and alternate energy sources for aviation and aerospace industry.
- "Demand growth for their higher-priced wide-body jets that can fly longer distances has slowed the most, as carriers opt for nimbler, fuel-saving planes that can fly travelers on ever-longer nonstop flights."

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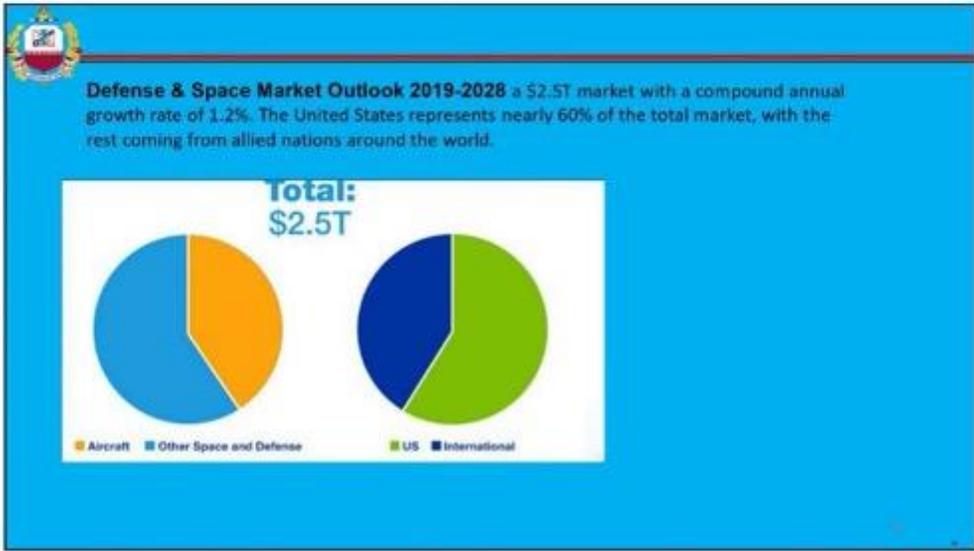
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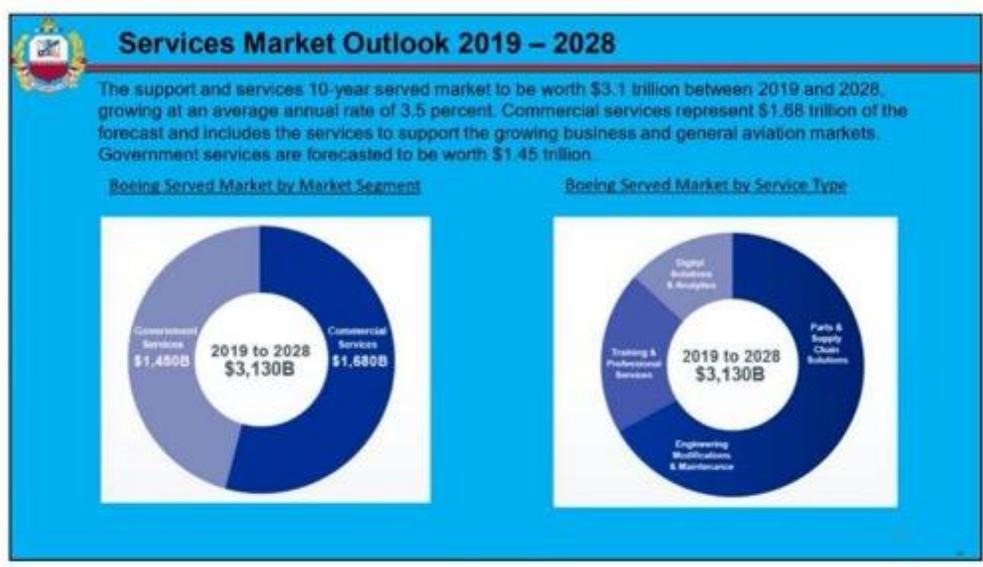


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Funding for Key Aviation Programs

	FY19	FY20	FY21	FY22
F-35	\$ 11,743	\$ 12,612	\$ 11,400	\$
CH-53K	1,619	1,622	1,492	
Combat Rescue	1,183	1,124	1,255	
F-22	822	776	1,059	
Black Hawk	1,447	1,691	1,014	
Pres. Helicopter	906	826	738	
C-130	2,546	2,413	1,232	
KC-46A	\$ 2,377	\$ 2,205	\$ 2,981	\$
F-15	985	1,952	2,414	
F/A-18	2,094	1,994	2,062	
AH-64E	1,566	1,074	1,226	
Pres. Aircraft	714	758	801	
B-21	\$ 2,190	\$ 2,983	\$ 2,848	\$
E-2D	1,479	1,443	1,048	
MQ-4C/RQ-4	1,342	986	863	
Bomber sust.	966	790	884	

Source: Boeing Intelligence

Defense Investment Near Term

- Boeing Programs
 - F-15
 - F/A-18
 - AH-64E
 - KC-46A
 - Presidential Helicopter

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Opportunity

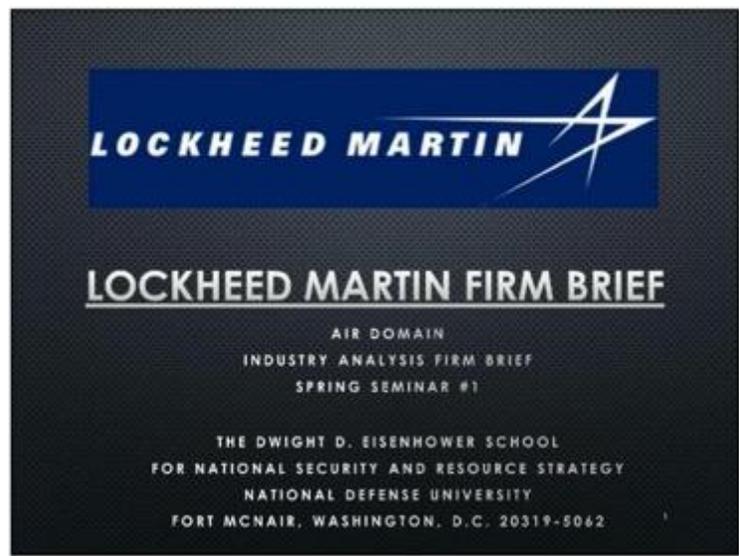
- Long-term commercial airline traffic growth is directly tied to sustained economic growth and political stability both in developed and emerging markets. Demand for our commercial aircraft is further influenced by world trade and epidemics.
- With the restrictions being placed on international travel the number of global flights and a willingness of individuals to travel reduces significantly. This reduction in travel will benefit Boeing, buying them time to get 737 Max back in service.
- Boeing is concentrating on their defense market to help promote stability while the focus on fixing the 737 Max issues.
- In 2019 39% of Boeing revenues were earned pursuant to U.S. government contracts of that 39% - 84% was DoD remainder was NASA
- Only one real competitor Airbus
- Long-term Boeing should continue their relationship with China finishing the interior of 737's it will help ensure long term market share for Boeing

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Questions?

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Appendix B – Lockheed Martin



1



2

RAISON D'ETRE

- MISSION: SOLVE COMPLEX CHALLENGES, ADVANCE SCIENTIFIC DISCOVERY AND DELIVER INNOVATIVE SOLUTIONS TO HELP CUSTOMERS KEEP PEOPLE SAFE.
- VISION: BE THE GLOBAL LEADER IN SUPPORTING OUR CUSTOMER'S MISSION, STRENGTHENING SECURITY AND ADVANCING SCIENTIFIC DISCOVERY
- VALUES: DO WHAT'S RIGHT, RESPECT OTHERS, PERFORM WITH EXCELLENCE

3

RAISON D'ETRE - HISTORY

- 1912-1920 – LOUGHEAD AIRCRAFT MANUFACTURING COMPANY
 - FOUNDED BY ALLAN AND MALCOLM LOUGHEAD
- 1926 – LOCKHEED AIRCRAFT COMPANY
 - ALLAN LOCKHEED RESIGNED IN 1929
- 1929 – SOLD TO DETROIT AIRCRAFT CORP
- 1934 – BOUGHT OUT OF BANKRUPTCY IN 1934 AS LOCKHEED AIRCRAFT CORPORATION
- 1985 – ACQUISITION OF METIER MANAGEMENT SYSTEMS
- 1986 – ACQUISITION OF SANDERS ASSOCIATES ELECTRONICS
- 1993 – ACQUISITION OF GENERAL DYNAMICS FT WORTH AIRCRAFT DIV
- 1995 – MERGE WITH MARTIN MARIETTA, SPIN-OFF MARTIN-MARIETTA MATERIALS, FORM LOCKHEED-MARTIN CORPORATION

4

RAISON D'ETRE – PEOPLE MOVERS



5

RAISON D'ETRE – TACTICAL AIRCRAFT



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LOCKHEED MARTIN BUSINESS SEGMENTS

Aeronautics



Missiles and Fire Control



Rotary and Mission Systems



Space



Financial Overview (2018)

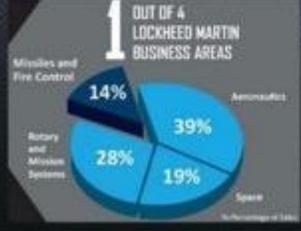
- \$53.8B sales (8% increase from 2017)
- \$130B backlog
- \$5B Net earnings
- \$17.59 Diluted earnings/share

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MISSILES AND FIRE CONTROL RAISON D'ETRE

Primary: Increase LMT shareholder value
Secondary: MFC is a recognized **designer, developer and manufacturer** of **precision engagement aerospace and defense systems** for the U.S. and allied militaries. MFC **develops, manufactures and supports** advanced combat, missile, rocket, **manned and unmanned systems** for military customers that include the U.S. Army, Navy, Air Force, Marine Corps, NASA and dozens of foreign allies. MFC also offers a wide range of **products and services** for the **global civil nuclear power industry and the military's green power initiatives.**

1 OUT OF 4 LOCKHEED MARTIN BUSINESS AREAS



Business Area	Percentage of Sales
Aeronautics	39%
Rotary and Mission Systems	28%
Space	19%
Missiles and Fire Control	14%

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STRATEGIC GAMEBOARD

How: Traditional rules required in highly regulated defense industry, push boundaries in recent USG attempts at rapid acquisition models

When: Deliver on current commitments to maintain industry leading reputation, remain vigilant to opportunities to broaden or divest in technology segments

Where: Maintain broad defense industry presence, continue to innovate and acquire new technology as new segments present themselves

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MISSILES AND FIRE CONTROL \$UCCESS

	CY16	CY17	CY18
Net Sales	\$6,789M	\$7,282M	\$8,462M
Operating Profit	\$1,004M	\$1,034M	\$1,248M
Operating Margin	14.8%	14.2%	14.7%
Backlog	\$14,204M	\$17,729M	\$21,363M

3-Year Trends:

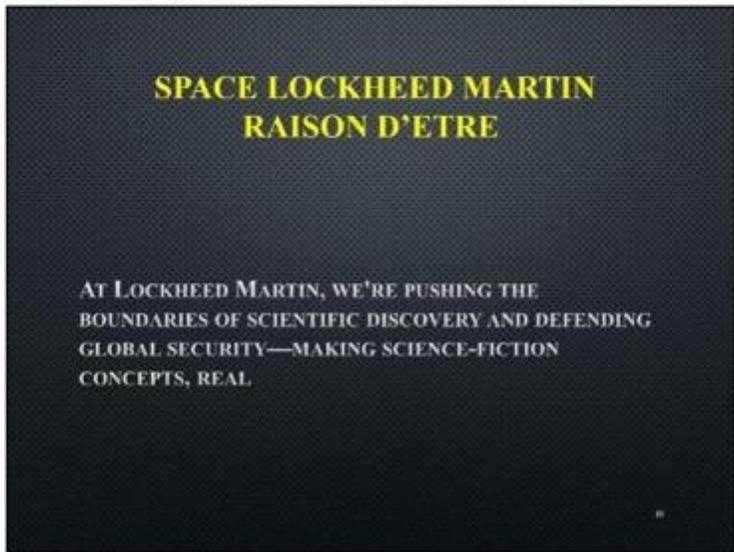
- Increasing sales, profit, and backlog show healthy growth – primarily classified and precision fires programs, as well as increased volume in LANTIRN, SNIPER, Apache
- Both CY17 and CY18 benefited from previous year production holdover (production costs in 1 yr, sale/payment in next year)

* \$925M from increased volume in tactical and strike missile programs in 2018 (JAGM, Hellfire)
 * \$205M – primarily PAC-3, +\$135M – primarily SOF QLSS, LANTIRN, SNIPER (2018)
 - \$120M – tactical strike missile programs (precision fires and Hellfire) in 2017 – lower volume and establishing a program reserve

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SPACE LOCKHEED MARTIN RAISON D'ETRE

Who

- Engaged in research, design, development, engineering and production of satellites, space transportation systems, and strategic, advanced strike, and defensive systems
- Provide network-enabled situational awareness and integrates complex space and ground global systems to help our customers gather, analyze and securely distribute critical intelligence data
- Responsible for various classified systems and services in support of vital national security

Why

- Provide a network-enabled situational awareness and integrate complex space and ground global systems to help customers gather, analyze and securely distribute critical intelligence data and in charge of various classified systems and services in support of vital national security systems

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UNIVERSE - SPACE PROGRAMS



Trident II D5 Fleet
Ballistic Missile



Space-Based Infrared
System



GPS Block III Satellite



Advanced Extremely High
Frequency - US main client
others are UK, Australia,
Netherlands & recently Japan,
Vietnam & KSA contracted LM



-Design, manufacture and
support nuclear warheads
weapons for UK - deterrent

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SPACE PROGRAMS

Airbus made Service capsule



Orion for transporting astronauts/supplies to deep space



Crew capsule produced by Lockheed Martin

Firms collaborate to satisfy customer

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SPACE PROGRAMS

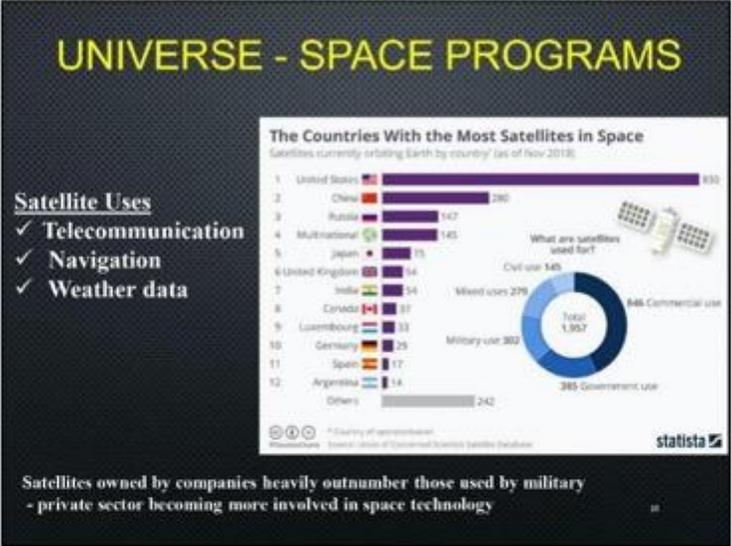
United Launch Alliance

- Facility co-owned with Boeing for manufacture and launch of rocket vehicles

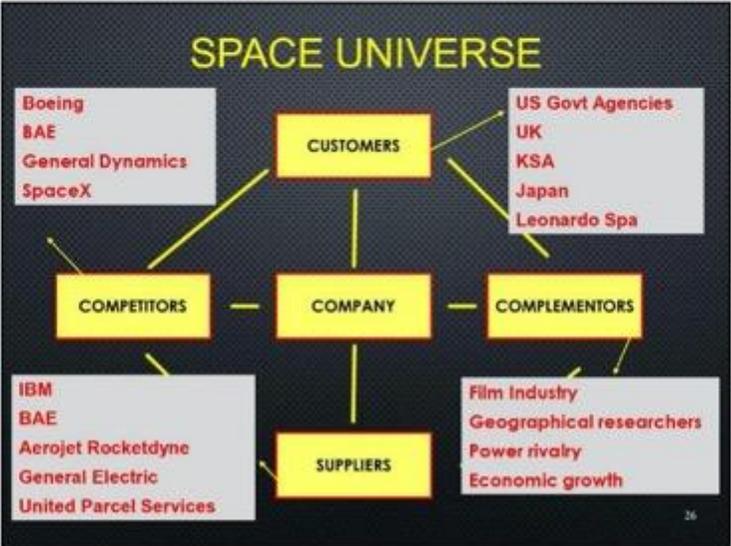


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STRATEGIC GAMEBOARD

When: All the time monitor market trends

Where: Seek market domestically and internationally with governments and commercial sectors

How: Technological Advancement via R&D, collaboration, investment abroad through acquisition

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LOCKHEED MARTIN SPACE \$UCCESS

	2018	2017	2016
Net sales	\$ 9,808	\$ 9,605	\$ 9,613
Operating profit	1,055	980	1,288
Operating margin	10.8 %	10.2 %	13.4 %
Backlog at year-end	\$ 22,184	\$ 22,042	\$ 25,224

- ✓ Investment in modernization e.g. A2100 to LM2100 Satellite with delay in development, integration and deployment to 2x Sat program caused losses, 2017-2108 – profit (1x launched)
- ✓ Future looks better for LM Space as backlog is further reduced (2018 is better 2017)

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ROTARY & MISSION SYSTEMS

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ROTARY & MISSION SYSTEMS BUSINESS UNIT

BUSINESS
Lockheed Martin to Buy Sikorsky for \$9 Billion
- November 2015

2016: Realigned Mission Systems and Training into a new business area named Rotary and Mission Systems (RMS).

RMS business segment ~ 25% of LM revenue
Sikorsky Helicopter sales ~ 10-12% of LM revenue

LM Strategy: "Expand its core business into the growing areas of helicopter production and sustainment. Sikorsky's ability to leverage Lockheed Martin's scale will ensure it remains a technology leader at the forefront of vertical lift."

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ROTARY & MISSION SYSTEMS RAISON D'ETRE

Primary: Increase shareholder value

Secondary: Support US military services, principally the U.S. Navy / Marine Corps and Army, and various government agencies of the U.S. In 2018, U.S. Government customers totaled 71% of RMS sales.

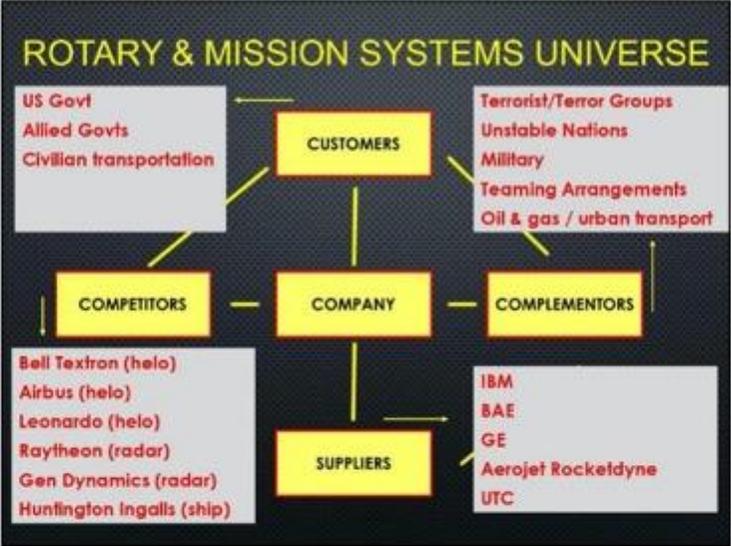


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ROTARY & MISSION SYSTEMS MAJOR PROGRAMS

- The Black Hawk® and Seahawk® helicopters manufactured for U.S. and foreign governments
- The CH-53K King Stallion helicopter delivering the next generation heavy lift helicopter for the U.S. Marine Corps
- The VH-92A helicopter manufactured for the U.S. Marine One transport mission
- The Aegis Combat System (Aegis) serves as an air and missile defense system for the U.S. Navy and international customers and is also a sea and land-based element of the U.S. missile defense system
- The Advanced Hawkeye Radar System, an airborne early warning radar, which RMS provides for the E2-C/E2-D aircraft produced for the U.S. Navy and international customers
- Command, Control, Battle Management and Communications (C2BMC) contract, a program to provide an air operations center for the Ballistic Missile Defense System for the U.S. Government
- The LCS, a surface combatant ship for the U.S. Navy designed to operate in shallow waters and the open ocean

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STRATEGIC GAMEBOARD

When: Now and the future with cutting edge air, land, sea technology

Where: Maintain US govt as primary customer and also maintain a broad, global presence to aggressively compete in the international markets

- Ex: Sikorsky Blackhawk in DoD, DHS, and 28 foreign militaries
- Subject to government regulation (US and foreign)

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STRATEGIC GAMEBOARD

How: Leverage reputation of LM / Sikorsky products & the worldwide relationships and structure to secure new business

1. Superior Radar and C2 technologies
2. "Next Gen Vertical"

Step 1: CH-53K
Step 2: FVL (F-35 business model)




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ROTARY & MISSION SYSTEMS \$UCCESS

	CY16	CY17	CY18
Net Sales	\$13.60 B	\$13.67B	\$14.25B
Operating Profit	\$0.85B	\$0.90B	\$1.30B
Operating Margin	6.2%	6.6%	9.1%
Backlog	\$29.03B	\$30.03B	\$31.32B

3-Year Trend:

1. Increase in volume for command, control, communications, computers, cyber, combat systems, intelligence, surveillance, and reconnaissance (C6ISR) and integrated warfare systems and sensors (IWSS) programs driving the growth in sales / profit.
2. Sikorsky helicopter total revenue flat / decreasing with Blackhawk sales slow down / ending. Will not grow until CH-53K FRP contracts begin in 2025 timeframe (LRIP / IOC until 2023/24). CH-53K program ~ \$31B.

+ \$525 million for IWSS programs due to higher volume (primarily radar surveillance systems programs and Multi Mission Surface Combatant)
 + \$250 million for C6ISR programs due to higher volume on multiple programs.
 - \$270 million for Sikorsky helicopter programs, which reflect lower volume for Black Hawk production, partially offset by higher volume for CH-53K King Stallion development and for mission systems programs.

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AERONAUTICS

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AERONAUTICS RAISON D'ETRE

Primary: Increase shareholder value

Secondary: LM Aeronautics has existed for over 100 years and has a workforce of 25,000+. LM Aeronautics, delivers breakthrough capabilities and landmark aircraft that continually redefine flight. LM plays an important role in the national security of the United States and more than 70 other countries, ensuring peace and stability around the world. LM Aeronautics is committed to the relentless research and development of high-performance aircraft, seeking innovative, low-cost design and manufacturing strategies, and delivering operational readiness for our customers' missions to ensure continued relevancy for the life cycle of our products.

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AERONAUTICS BUSINESS UNITS

Skunk Works: Advances technical capabilities and explores new venues for developing next generation air dominance air platforms as well as potential enhancements to current platforms.

Advanced Aeronautics: The research labs focused on tomorrow

Aeronautics Sustainment: Delivering integrated sustainment capabilities to ensure our customers' aircraft are mission ready anytime and anywhere.

Aeronautics Procurement: Is responsible for \$11.2 billion annually flowing through our supply chain, 1,500 production suppliers and 900 non-production suppliers worldwide.

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AERONAUTICS BUSINESS UNITS

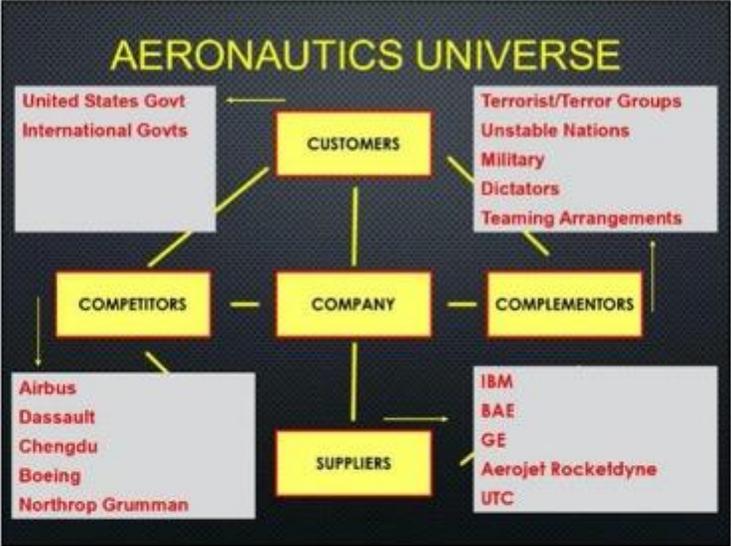
F-35 Lightning II: 5th Generation Fighter Jet, 491+ aircraft delivered, 258K flight hours, 21 bases worldwide

F-22 Raptor: 5th Generation Fighter Jet, 195 delivered, increment 3.2 upgrade, and AF plans to use until 2040

F-16 Fighting Falcon: International Multi Role Fighter, 4,588 delivered, 19M flight hours, 29 countries

C-130J Super Hercules: International Tactical Airlifter, 400 Delivered, 1.7M flight hours, 18 Countries

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STRATEGIC GAMEBOARD

When: Constantly, cutting edge aeronautics platforms

Where: Maintain broad, global presence, but aggressively go after the international market

How: Technological Advantage, superior human capital and R&D strategies

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AERONAUTICS \$UCCESS

	CY16	CY17	CY18
Net Sales	\$17.293B	\$19.410B	\$21.242B
Operating Profit	\$1.845B	\$2.176B	\$2.272B
Operating Margin	10.7%	11.2%	10.7%
Backlog	\$34.999B	\$35.692B	\$55.106B

Aeronautics Success driven by F-35 program

43

LOCKHEED MARTIN CORPORATION SUMMARY

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45

LM \$UCCESS

Current Assets \$17.1 B	Current Liabilities \$ 14.0B
Non-Curr. Assets \$30.4B	Non-Curr. Liabilities (LT Debt) \$30.4 B
Total Assets \$47.5B	Owners' Equity \$3.1 B
	Liabilities + O.E. \$47.5 B
Net Sales \$59.81 B	
EBIT \$8.34 B	* End of year Report: December 31, 2019
Tax \$1.01 B	
Net Income \$7.20 B	

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LM \$UCCESS

	Lockheed Martin	Raytheon	General Dynamics	Huntington Ingalls
Current Ratio	1.22	1.54	1.11	1.04
LT Debt / Equity	3.6	0.42	1.12	1.01
Total Debt	0.93	0.65	0.72	0.77
ROE	226.90%	27.57%	26.72%	37.15%
ROIC	14.62%	26.90%	14.36%	19.89%
WACC	8.10%	6.89%	7.45%	8.52%

* December 31, 2019

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LM \$UCCESS

	2013	2014	2015	2016	2017	2018	2019
Sales \$B	45.36	39.95	40.54	47.29	49.96	53.72	59.81
EBITDA \$B	5.83	5.94	6.02	8.35	9.54	10.50	11.94
Net Income \$B	3.21	3.21	3.26	4.25	4.46	5.85	7.20
EPS \$	9.85	9.96	10.36	14.01	15.33	20.40	25.37
# Employees	115,000	112,000	126,000	97,000	100,000	105,000	110,000

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LM SWOT

<u>Strengths</u>	<u>Weakness</u>
<ul style="list-style-type: none">* Financial Performance.* Market Leading Position* Order Backlog	<ul style="list-style-type: none">* Inability to Manage Cost Overruns
<u>Opportunities</u>	<u>Threats</u>
<ul style="list-style-type: none">* Expanding UAV Market* Focus on Cybersecurity* Initiative to Expand* International Presence	<ul style="list-style-type: none">* Government Contract* Compliance and Regulations* Federal Defense Budget Sequestration* Growing Geo-Political Conflicts with Russia

*MarketLine Oct 2019

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CONCLUSION

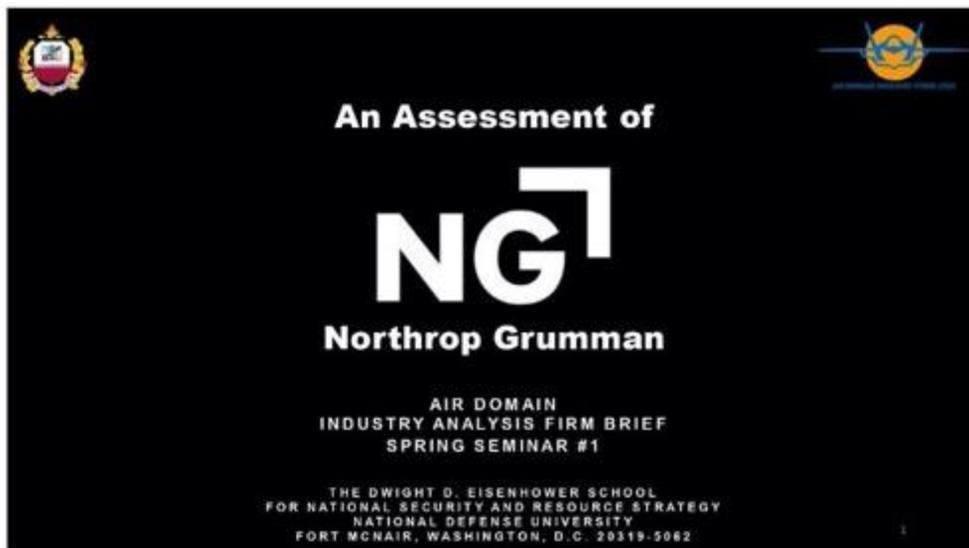
LM will continue to increase shareholder value by maintaining its US market Share and increasing international market share in all four business segments

- Aggressively expand UAV and cybersecurity markets
- F-35 multi trillion-dollar international program will anchor revenue
- FVL potential to follow F-35 model (multi-service, multi-national)

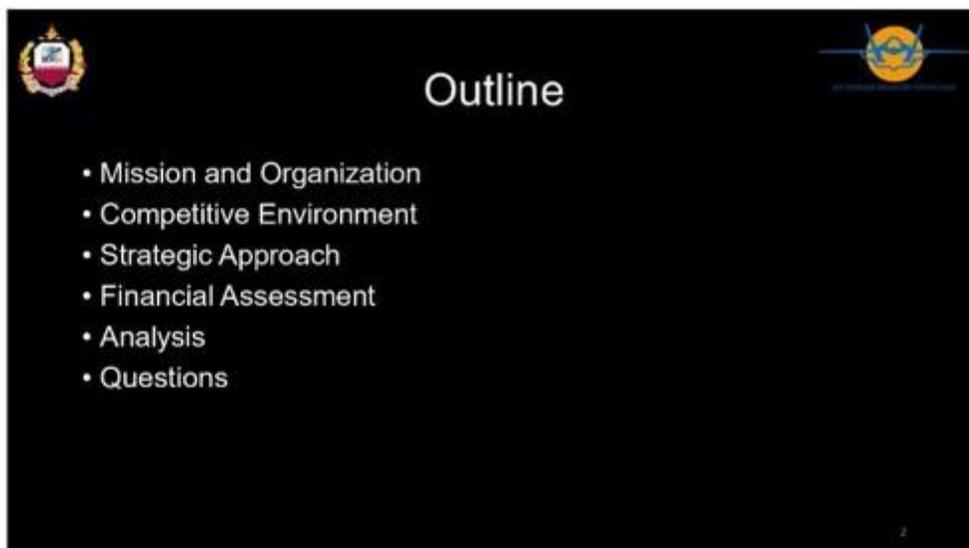
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Appendix C– Northrop Grumman

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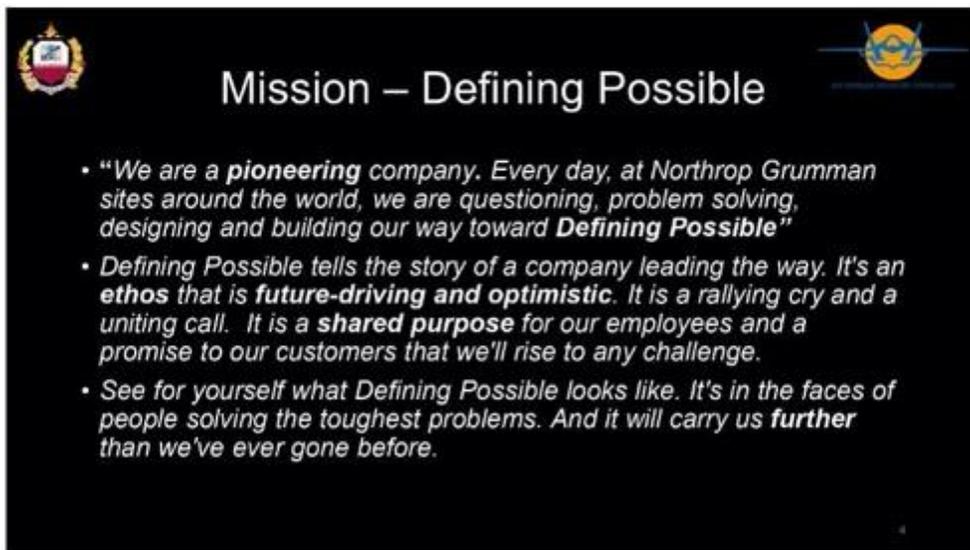


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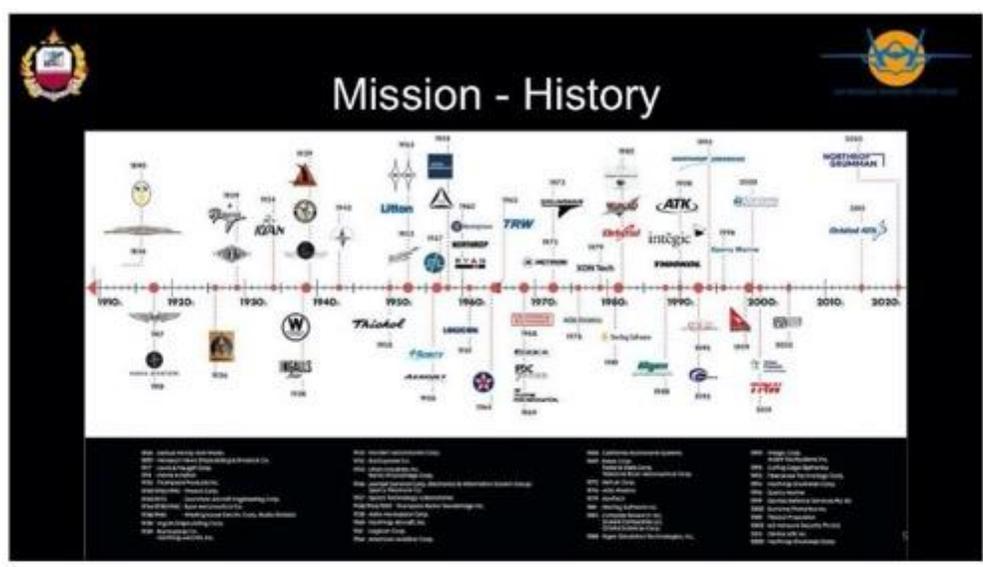


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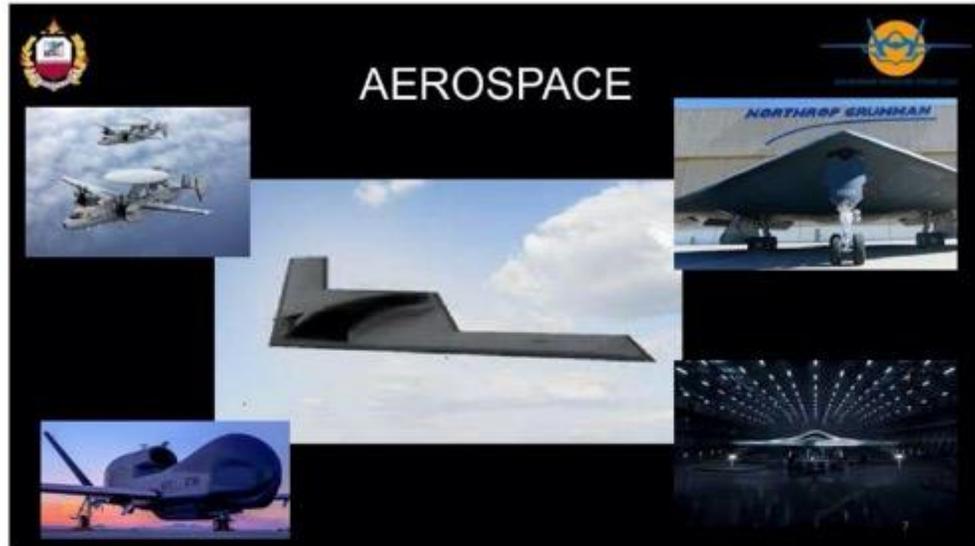


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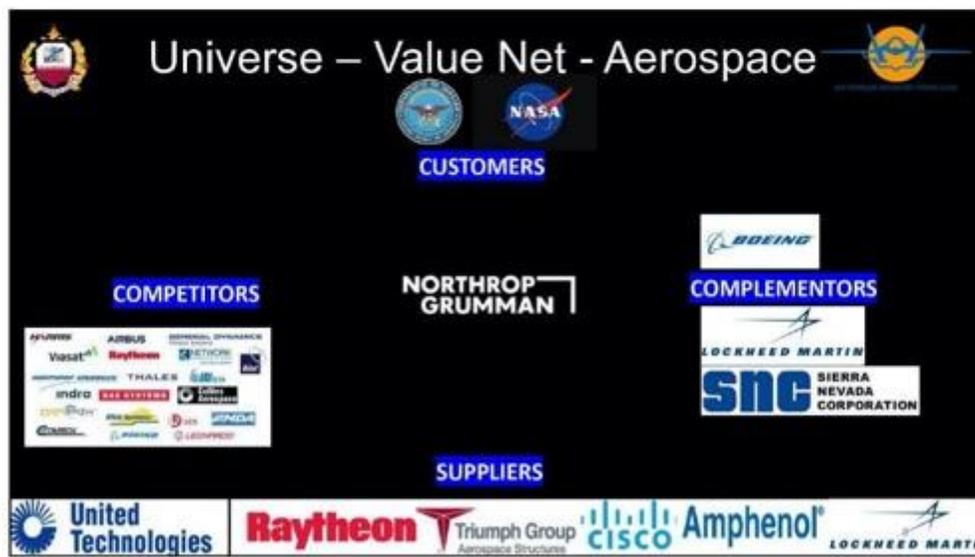


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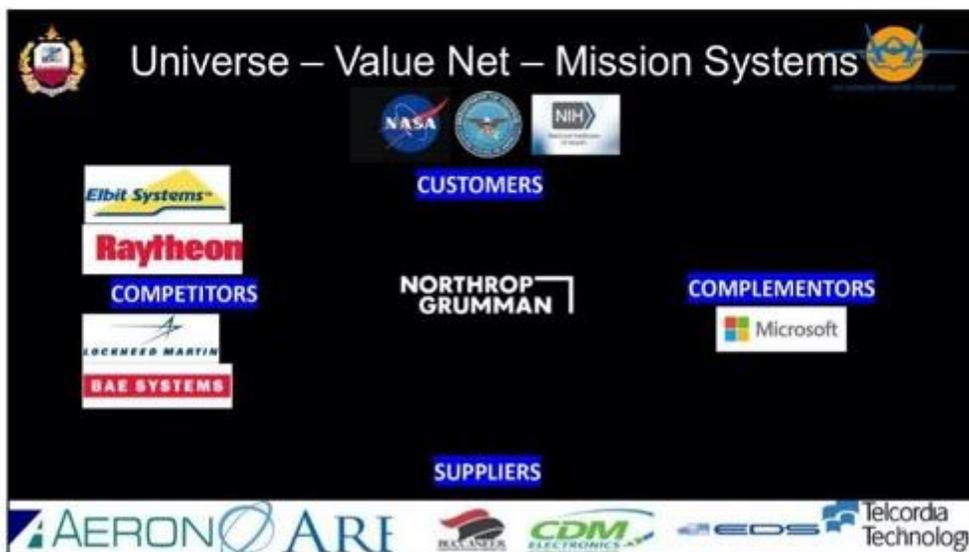


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5/6/2020



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INNOVATION SYSTEMS











The Utah Rocket Development Cluster is a partnership with Northrop Grumman Innovation Systems directly across the hall to make you a workshop. **May 12, 2020** www.northropgrumman.com

The University of Utah's Space and Astronautics Center is seeking qualified candidates for a position. Please apply at www.northropgrumman.com.

For more information, please visit www.northropgrumman.com.

Northrop Grumman Innovation Systems is an Equal Opportunity Employer. Minorities and women are encouraged to apply.

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Universe – Value Net – Innovation Systems








COMPETITORS

- BLUE ORIGIN
- SPACEX
Space Exploration Technologies
- BOEING
- LOCKHEED MARTIN
- ULA
United Launch Alliance

CUSTOMERS

NORTHROP GRUMMAN

SUPPLIERS

COMPLEMENTORS

- BOEING

- AMORIM
- AMPO
- QUALITY SERVICES

JABIL

LEESON

AEROJET

- ROCKET DYNAMICS

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TECHNOLOGY SERVICES

The slide features a central graphic with the text "REALM Research in Applications for Learning Machines" and a brain-like structure. Surrounding this are several smaller images: a large eye, a server room, a person in a futuristic environment, and a control room. Logos for the organization are in the top corners.

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Universe – Value Net – Technology Services

CUSTOMERS: NASA, [UK Royal Coat of Arms]

COMPETITORS: CACI, Raytheon, LOCKHEED MARTIN

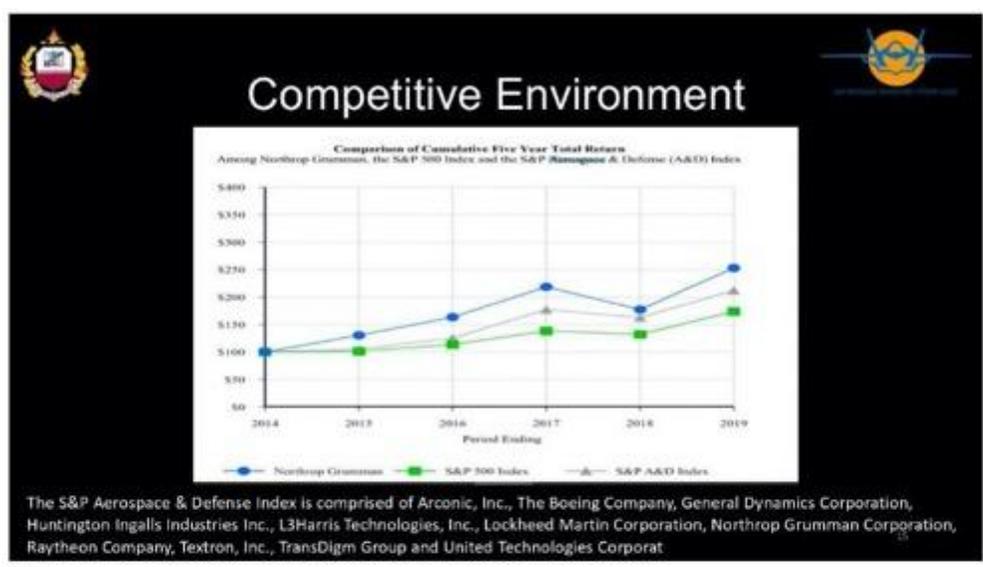
COMPLEMENTORS: L3, Rockwell Collins

SUPPLIERS: Tech, ARI, BAKKER, LEE, MY MACHINE, INC.

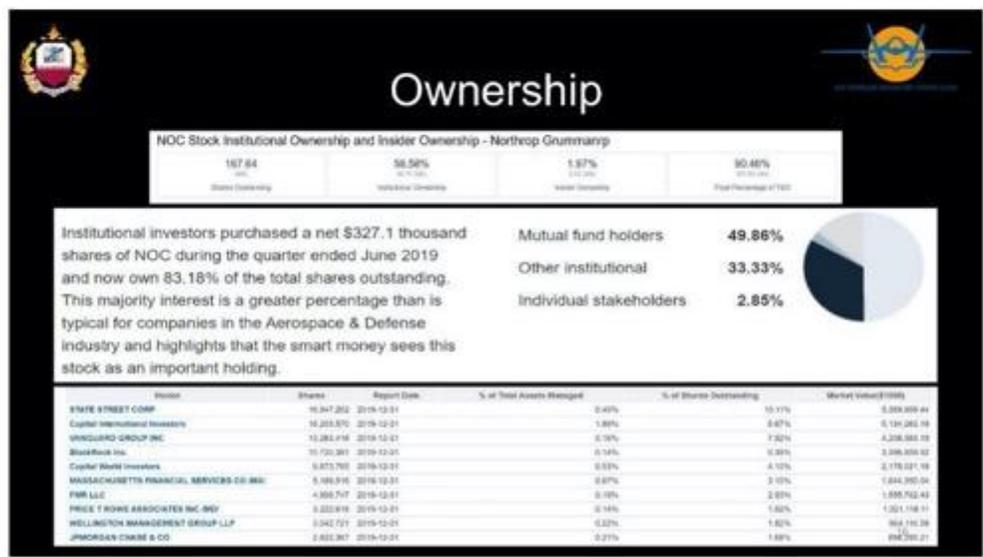
The slide displays a value network diagram with various company logos categorized into Customers, Competitors, Complementors, and Suppliers. Logos include NASA, Lockheed Martin, Raytheon, CACI, Northrop Grumman, Rockwell Collins, L3, Tech, ARI, BAKKER, LEE, and MY MACHINE, INC.

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Overall Firm Strategy

DEFINING POSSIBLE™

- ◆ Defining Possible also represents THEIR place at the forefront of technology and innovation, working at the edge of what is, always pushing to what could be. Leading across the world. (globalization)
- ◆ The general strategy of the company is to complete the satisfaction of the customer through the application of science, and engineering developing new technologies that allow them to push the limits further than possible.
- ◆ The firm conducts its strategy through diversification. The company was subdivided into four new segments since January 2020, looking to project the company closer to the needs of its customers.
- ◆ Long Term Strategy
 - ◆ To fuel organic growth, Northrop Grumman is focused on the future frontiers of warfighting, space exploration, and information technologies.
 - ◆ NG is only bidding on projects that the company believes will generate the best financial returns on its investments.

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Strategic Game Board






Where to Compete








How to Compete

- Innovation:** Design, develop, integrate, and produce flight, weapons, and space systems to enable national security, civil government, and commercial customers to accomplish their critical missions
- Global Provider:** provides global logistics support, sustainment, operations and modernization for air, sea and ground systems and weapon system components

When to Compete

- 1939- 1985 Northrop Corporation: principal developer of flying wing technology, including the B-2 Spirit bomber, DoD contractors
- 1994 Acquired Grumman Corporation, Space Development
- 1996 Westinghouse Electric Corporation, Radar, Electronic Sys.
- 2001 Litton Industries, global electronics and information technology; and Newport News Shipbuilding
- 2002 TRW Inc, military and civil space systems,
- 2011 Huntington Ingalls Industries, Inc, Shipbuilding business.
- 2018 Orbital ATK, Inc, the "Merger date"

Ref: 2019 NCC 10X

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Key Means & Distinct Activities.






To align the company's broad portfolio to serve its customers

Effective January 1, 2020,

The four new sectors

Aeronautic Systems.

- Manned Aircraft: B-21, F-35 Lightning II center fuselage and F/A-18 Super Hornet center/aft fuselage sections, E-20, (JSTARS)
- Autonomous Systems key programs: high-altitude long-endurance (HALE) systems, such as the Global Hawk system, TRITON SYS, AGS

Mission Systems

- **Advanced Capabilities** key programs: the Integrated Air and Missile Defense Battle Command System (IBCS)
- **Cyber and ISR** key programs: exploitation and cyber programs; operational services to the United States Computer Emergency Readiness Team (US-CERT)
- **Sensors and Processing** key programs: Airborne Early Warning & Control (AEW&C) and air-to-ground sensors; Battlefield Airborne Communications Node (BACN); F-35 fire control radar; Distributed Aperture System (DAS)

Space Systems

- Designs, develops, manufactures and integrates spacecraft, systems, subsystems, sensors and communications payloads in support of space C4ISR and science missions.
- James Webb Space Telescope (JWST), Advanced Extremely High Frequency (AEHF), Enhanced Polar System (EPS)
- Next-Gen: Overhead Persistent Infrared Program (OPIR) Space-Based Infrared System (SBIRS)

Defense Systems

- Develops and produces small-medium and large-caliber ammunition, precision weapons and munitions; high-performance gun systems; and propellant and energetic materials.

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Firm Strategy in Each Market



Profitability



=

Sector	Sales	Operating Margin
Aerospace Systems	Mid to High \$11B	Low to Mid 10%
Defense Systems	Mid \$7B	Mid 10%
Mission Systems	High \$9B	Low 14%
Space Systems	Low \$8B	Low to Mid 10%

<http://investor.northropgrumman.com/static-files/bc9eadd7-2c4e-4357-83be-2c21042ef4af>
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Financial Assessment



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Current Year Financial Data

Balance Sheet (in millions)*

Assets	2019
Current	\$10,685
Non-Current	\$30,404
Total	\$41,089
Liabilities	
Current	\$9,434
Non-Current	\$22,836
Owners Equity	\$8,819
Liabilities + Equity	\$41,089

Income Statement (in millions)*

Income	2019	
Aerospace Systems	\$13,862	38.1%
Mission Systems	\$12,263	33.7%
Innovation Systems	\$6,119	16.8%
Technology Services	\$4,110	11.3%
Costs		
Cost of Product Sales	\$22,621	
Cost of Service Sales	\$9,532	
R&D	\$953	
Net Earnings	\$2,248	

* All information as reported by 2019 Northrop Grumman Annual Report dated 31 December 2019

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Earnings

	2015	2016	2017	2018	2019
Total Sales	23,526	24,706	26,004	30,095	33,841
EBITDA	3,558	3,438	5,064	5,104	4,094
Earnings	1,990	2,043	2,869	3,229	2,248
EPS	10.5	11.4	16.5	18.6	13.3

Earnings Trends

Year	Total Sales	EBITDA	Earnings	EPS
2015	23,526	3,558	1,990	10.5
2016	24,706	3,438	2,043	11.4
2017	26,004	5,064	2,869	16.5
2018	30,095	5,104	3,229	18.6
2019	33,841	4,094	2,248	13.3

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Significant Financial Issues

- Pension fund challenges
 - Underfunded
 - \$36.91 billion in obligations
 - \$30.65 billion in assets
 - Fund has been consistently 80-85% funded
 - Have been contributing additional funds each year to catch up
 - Lawsuit settled in 2017 alleging failure to uphold fiduciary duties
 - Excessive plan manager compensation
 - Unwarranted administrative expenses

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Analysis

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SWOT Analysis

<p style="text-align: center;">Strengths</p> <ul style="list-style-type: none"> • Culture of innovation across all sectors (electromagnetic, microelectronics, aeronautics, info tech, space launch, data analytics, sensor fusion) • Committed to R&D. \$764M (FY 18), strategic partnerships with research labs and universities • Business diversification (cash flows) from four unique sectors 	<p style="text-align: center;">Weaknesses</p> <ul style="list-style-type: none"> • Underfunded pension and benefits packages pressurizes liquidity stance • U.S. Govt makes up 83% of customer base • Legal/Geo-Pol/Regulation exposure domestically and internationally
<p style="text-align: center;">Opportunities</p> <ul style="list-style-type: none"> • Aggressive pursuit of new contracts (existing platforms/services, new growth areas) • Growing global aerospace & defense markets (2023: \$1.514T, 2018: \$1.273T, CAGR 3.5%) • Increased cyber threats = increased cash flows in cyber security products/services 	<p style="text-align: center;">Threats</p> <ul style="list-style-type: none"> • Fierce market competition (remain relevant with product differentiation, preserve human capital) • Nuclear weapon regulatory environment and incident avoidance • Rapidly evolving technology can make current efforts obsolete

Source: NOC MarketLine SWOT Analysis. Published 26 Jan 2020
Source: 2019 NOC 19K

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Corporate Reorganization - 2020

AERONAUTICS
SYSTEMS

DEFENSE
SYSTEMS

MISSION
SYSTEMS

SPACE
SYSTEMS

© 2019 NOC 10X Report

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Future Growth Area – Doomsday

Ground Based Strategic Deterrence (GBSD):

- Original competition between Northrop Grumman & Boeing. Sole-source after Boeing dropped out in Dec19'
- Total contract estimated between \$60B-\$85B over 20+ years for MM III replacement
- MM III requires replacement to maintain TRIAD. SLEP not a viable option from cost/benefit analysis

Primary Enabler (Strategic Foresight from NOC):

- Orbital ATK acquisition in 2018
 - Critical advantage in Solid Rocket Motors (SRM)
 - SRMs ~50% of the price of ballistic missiles

The Future:
War is changing. The GBSD missile will keep Total War a concept of the past. However, imagine the change in TTPs conventional weapons based off of hypersonic/GBSD tech advancements will facilitate

Sources: <https://spacenews.com/northrop-grumman-ems-competition-to-build-future-icbm-by-default/> & <https://www.defenseone.com/business/2019/12/boeing-declines-led-icbm-leaving-northrop-side-contender/161898/>

MINUTEMAN II Lance Vandenburg AF mil Photo

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Future Growth Area - Cyber

Cyber Growth Potential: Unlimited in a Networked World

Unified Platform: Program suite for core offensive & defensive cyber operations, along with cyber ISR functions

LYNXeon: "Cyber Pattern Analysis Program." Data Fusion, Big Data Analytics. Data is the new currency in the world market

Artificial Intelligence, Machine Learning, Cognitive Learning: Joint partnerships with research laboratories, universities, and silicon valley IT firms offers huge military capability and profit potential for the first to market

- First to market owns the architecture/data standards
- Authority to Operate (ATO) timeline/process improvements can lessen barriers
- Huge applications in commercial markets

Source: <https://www.northropgrumman.com/cyber/>

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Future Growth Area – Space

- Space: Still the Final Frontier
 - Delivery systems
 - Weapon Systems
 - Detection Systems
 - SBIRS
 - STSS

Signaled their intent to compete heavily in this domain with acquisition of Orbital ATK

Huge potential cash flow opportunities with creation of the Space Force and DoD focus on the domain

Source:
<https://www.northropgrumman.com/space/>

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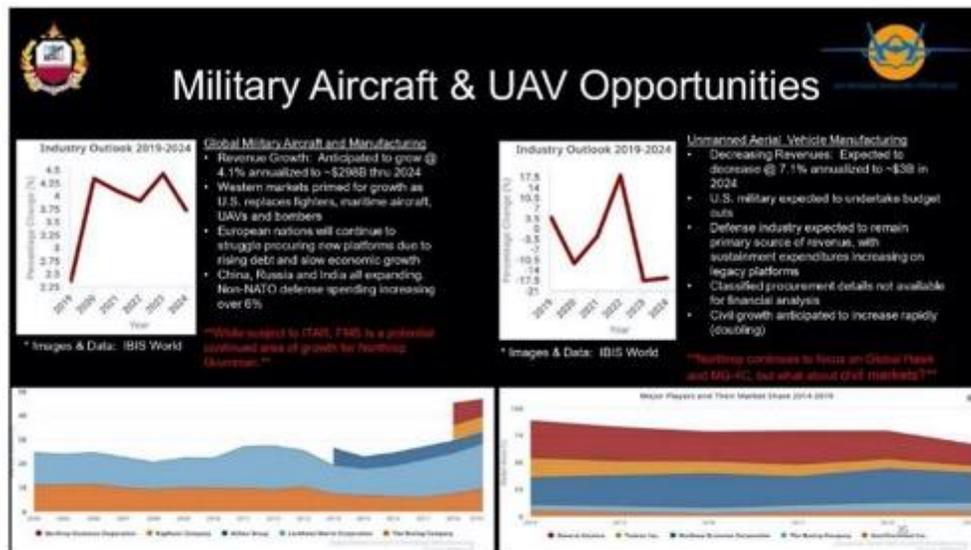
Maintain Market Leading Positions

Strategic Strike, Advanced Tactical Radars, UAVs (autonomous and remote), and Advanced Weapons DON'T GO AWAY.

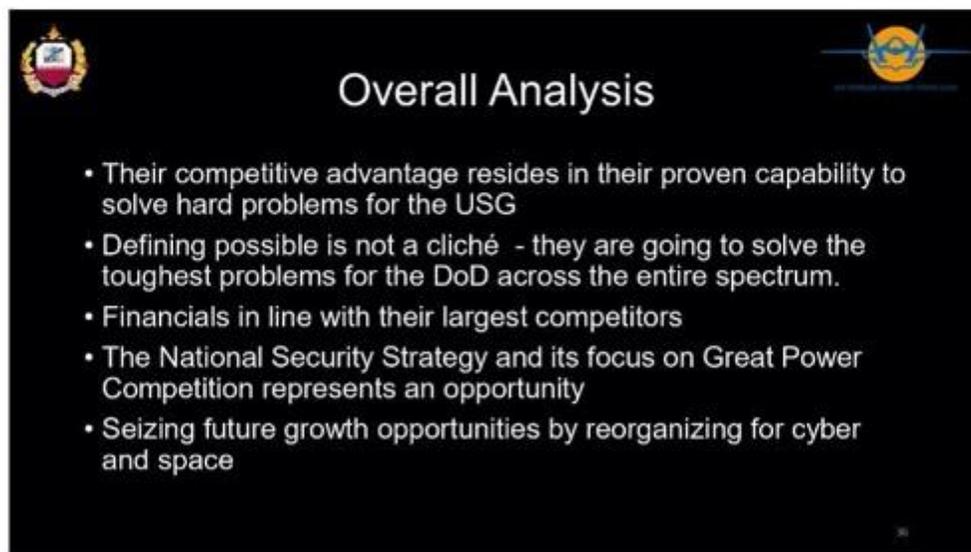
Photos: Northrop Grumman Website

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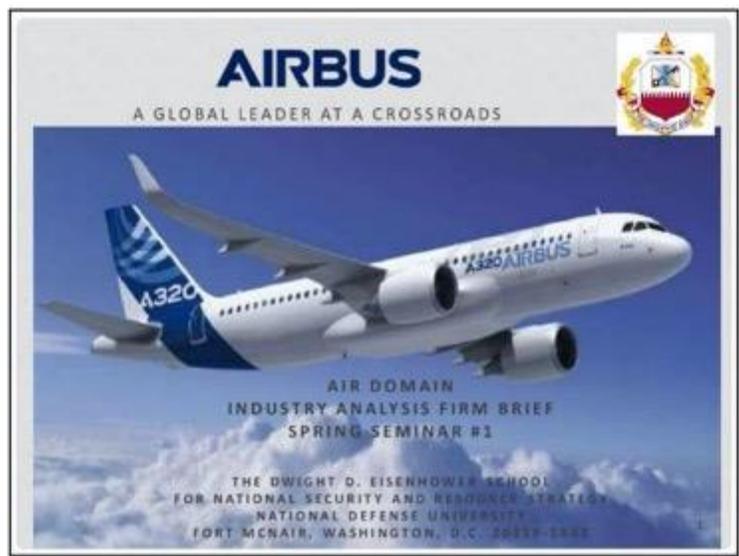
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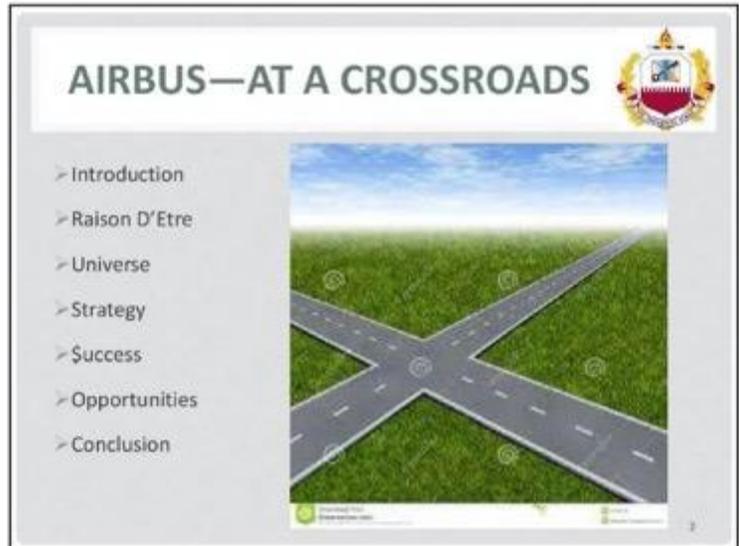
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Appendix D – Airbus

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RAISON D'ETRE



"Airbus is an international reference in the aerospace sector. We **design, manufacture and deliver** industry-leading **commercial aircraft, helicopters, military transports, satellites and launch vehicles**, as well as **providing data services, navigation, secure communications, urban mobility and other solutions** for customers on a **global scale**."

AIRBUS

Explore our products and services

Commercial Aircraft	Helicopters	Space	Defence
---------------------	-------------	-------	---------



1

3

RAISON D'ETRE - ORIGINS





France



Germany



Spain



United Kingdom



Italy



Turkey



Finland



Poland



Ireland

Airbus is a primarily European Corporation

4

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5/6/2021

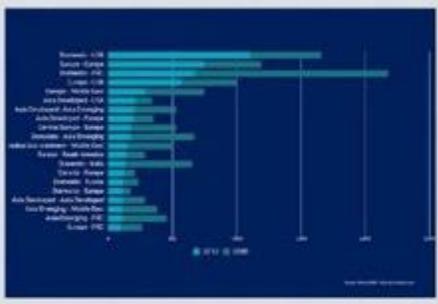
RAISON D'ETRE - FUTURE



Projected traffic flows to 2038 in Billion Revenue Passenger Kilometers

NB:

- Domestic PRC
- Domestic Asia
- Emerging
- India – Middle East
- Domestic India
- Europe – Middle East



5

5

RAISON D'ETRE – HISTORY



- Post WW2, U.S. aviation industry dominant
 - European aircraft manufacturers feared they couldn't compete
- 1967 – France, Germany, UK sign agreement for aerospace development
 - Includes clause "to take appropriate measures for the joint development and production of an airbus."
 - UK subsequently drops out - Hawker Siddeley remains subcontractor
- May 29, 1969 – France and Germany sign agreement to form consortium to produce/market A300
 - Formation of Airbus GIE (*Groupement d'intérêt Economique*)
- 1972 – A300 maiden flight
 - Orders are initially slow, but in 1978 Eastern Airlines orders 23
- By 1979, Airbus "had achieved 26 per cent market share in dollar value"
- 1980's – A320 family cements Airbus as commercial aviation player



<https://www.airbus.com/company/history/aircraft-history/2977-1379.html#bettingonairbus>

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RAISON D'ETRE – HISTORY

- 1990's - European aerospace defense companies feeling the pinch
 - British Aerospace Director in 1997: "Europe, with defense spending of \$125 billion a year, is supporting three times the number of contractors on less than half the budget of the U.S."
- July 10, 2000 - DaimlerChrysler Aerospace, Construcciones Aeronáuticas SA, Aerospatiale-Matra combine to form European Aeronautic Defence and Space Company (EADS)
- Airbus GIE becomes Airbus SAS (conventional company)
 - GIE was ostensibly a temporary agreement to build one plane type
- 2007 - EADS buys out BAE share of Airbus SAS
- 2014 - Reorganization from EADS to Airbus SE with three divisions: Commercial, Defence and Space, Helicopters

Kerzman, Andrea; Lanzberg, Reed (2007-06-25). "European Defense Firms Feel Pressure to Unite". The Seattle Times. 7

7

UNIVERSE – COMPETITION

- Commercial:
 - **BOEING**
 - COMAC
 - UAC
 - Embraer
- Helicopters
 - Leonardo
 - Bell
- Defense & Space
 - Boeing
 - Lockheed Martin
 - Northrop Grumman
 - Thales









Kerzman, Andrea; Lanzberg, Reed (2007-06-25). "European Defense, Comps Feel Pressure to Unite". The Seattle Times. 8

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UNIVERSE – COMPLEMENTORS



- Bombardier (A220)
- Leonardo (ATR)
- Boeing (737MAX)
- Globalization
- Hostile militaries
- Publics demanding emergency services




Rothman, Andrea; Lanzberg, Reed (1997-06-25). "Global Orders From First Presence to Ushak". The Seattle Times.

9

UNIVERSE – CUSTOMERS



- Airlines
- Militaries
 - Germany, Spain, UK, Italy
 - Indonesia, Saudi Arabia
- Parapublic institutions
- Petroleum companies
- European Space Agency (ESA)

Customers

All of 31 December 2019, Airbus had 414 customers and a total of 13,342 Airbus aircraft had been ordered, of which 11,252 aircraft had been delivered to operators worldwide. The table below shows Airbus' signed commitments in terms of firm global firm orders by customer for the year 2019.

Customer	Firm orders**
Airbus	100
Jalisco Airways	60
Maly	80
Wajaj Air	30
Iranian Air Force	34
Lufthansa	32
Angkor Airlines	30
Delta Air Lines	25
Sabah Airlines	20
Viet Airbus	20

* Figures are not included in orders backlog or firm backlog.
 ** Figures are global firm orders.

Rothman, Andrea; Lanzberg, Reed (1997-06-25). "Global Orders From First Presence to Ushak". The Seattle Times.

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UNIVERSE – SUPPLIERS



Supplier	%
United Technologies	15.45
Sopra Steria	11.75
Atos SE	3.39
Safran SA	3.16
General Electric Corp	2.85
International Business Machines	2.56
Anconic Inc.	2.1
Rolls-Royce Holdings PLC	2.08
Spirit Aerosystems	2.01
Honeywell	1.98
Solvay SA	1.74
Hexcel Corp	1.36
Dassault Systems	1.27
AVIC	1.04
PPG Industries	0.92
Leonardo SpA	0.81
Berkshire Hathaway Inc	0.73
Bio Tinto PLC	0.68
TransDigm Group Inc	0.67
Toray Industries	0.63

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UNIVERSE – OVERVIEW



- > Future:
 - > Competitors – COMAC?
 - > Complementors – AI, Networked capabilities, Electric engines
 - > Customers – Globalizing: China/India domestic, Asia short -haul, Middle East
 - > Suppliers – Broadly diverse supply chain




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AIRBUS STRATEGY--BLUF

- **Committed to Global Expansion through Sustained Performance, Innovation & Smart Investment**
- Airbus at a Crossroads – Committing to Globalization
- New President Oct '19 – Guillaume Faury
 - Strong Values & International Mindset
- Developed Short & Long Term strategies that address public improprieties & internal friction
- New leadership intended to focus on globalization & modernization




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SHORT TERM STRATEGY

- Ramp up A321 production
 - Improve industrial flow thru vertical integration & investment in supply chain partners
 - A321 is sold out through 2024 the current production rate of 60/mo – Cash flow for other interests
- Continue to increase R&D investment in emerging markets
- Emphasize on-time deliveries 2020—continue to address programmed backorders to facilitate cash flow
 - Unprecedented deals featuring low down payments, fully refundable within a year of production start
- Capitalize on working in the seams between aircraft categories - beginning with A320 - 95% commonality w/options
 - New Engine Options, Cabin Flex Additional Center Tanks
 - Increase in design complexity has pushed ramp-up into 2023—engineering design and supply chain capability slowed timeline
- Improve A350 margins—smooth production flow
- Strategic Partnering to increase market share in Space/Defense and MRO Services sectors

"We see no quick fix to the A321neo's production problems, but we are confident the issues have been stabilized as we manages the ramp-up in output." Guillaume Faury

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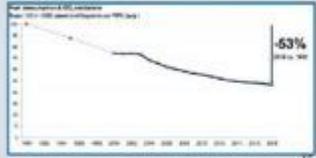
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LONG TERM STRATEGY

"Cities, Airports, & Aircraft" Airbus 2038 → Presumes 4.3% annual growth requiring 39,200 aircraft to support growth

- Commercial segment focused on categories S, M, L acft
 - Forward Looking Strategy plans to exploit the space between the categories further
 - Beginning w/A320 moving to larger acft
 - Passenger Amenities comfort/tech conveniences
 - Mechanical/Digital Innovations
 - Investing in Emerging Markets
 - Not winning market share—earning it
 - Global Innovation Centers
 - Hardware Innovation
 - Live ware Innovations
 - Clean Ops 2040
 - Reducing Carbon Emissions
 - Clean Fuel Research



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STRATEGIC IMPERATIVES

- 5 Strategic Imperatives – to realize strategy
 - Remain a leader in commercial aerospace, strengthen market position and profitability through global expansion
 - Gain market share in European Defense, Space, & Government markets by providing military platforms, space assets, & associated services
 - Pursue incremental innovation potential w/existing products & pioneer disruptive innovation— foster skilled engineers/artisans for future comp
 - Adapt with globalization, attract & retain global talent & customer base
 - Strengthen the Value Chain—focus on profitability and value creation



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COMPETITIVE ADVANTAGE

MARKET SHARE
Airbus = 59.4%
Boeing = 40.6%

- Airbus' Competitive Advantage
 - Innovative products, successful acquisition and mergers and demonstrated superb performance in production & service
 - Willingness to INTEGRATE with emerging markets, investing in human capital and EARNING vs winning global expansion in the market
 - Public impropriety behind us, accepted responsibility—behavior and fines were 2019's news—"...we are forward looking and anxious to invest."



Investment in R&D Adapted from Airbus.com

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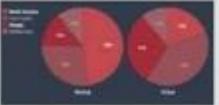
STRATEGIC GAME BOARD

Rortman, Andrea; Lundberg, Reid (2007-06-15). "Airbus Delivers Firm First Pressure to Strike." The Seattle Times

- Where to compete:
 - Started European/Asian deliberately expanding in the global market
 - Boeing main competitor
 - Other competitors include Bombardier and Embraer, Comac, Mitsubishi in Japan and UAC in Russia.
 - Primarily competing in commercial aircraft production—70% revenue, however...
 - Strategy foretells expansion of Services (MRO)
 - Work to gain market share in Defence & Space Segments—Strategic Partnering



Segment Competition



Geographic Diversity

Graphs adapted from Airbus.com

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STRATEGIC GAME BOARD

➤ How to compete

- Focus on Differentiation (all digital cockpit, fleet commonality, not American)
- ATR—Strategic Partnership enables Airbus to move more aggressively into Defense Segment—risk reduced through Leonardo's mature & proven technology
- Global expansion through integration and ATR Partnership
- R&D—Innovations targeting existing products & enables more desirable future design—innovating in the seams of S, M, & L production lines
 - Live ware Innovations



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STRATEGIC GAME BOARD

•When to compete

- Airbus has retooled their management to remove the perception of impropriety—stated the sins of the past are "them." New faces
 - Ready to compete in 2020—globally
- Setting conditions for global expansion—investing in human capital and technical architecture now
- Future competition
 - Asia Pacific, Space & Defense, & Services
 - Leverage partnerships (ATR & Supply Chain)

Strong momentum in commercial acft production & a competitive portfolio, validated by strong backlog encourages competition in this segment NOW!

Increased investment in R&D & integration into emerging markets posture Airbus to compete well in the future—sustaining commercial acft production & adding Space/Defense & MRO Services Segments to a profitable future

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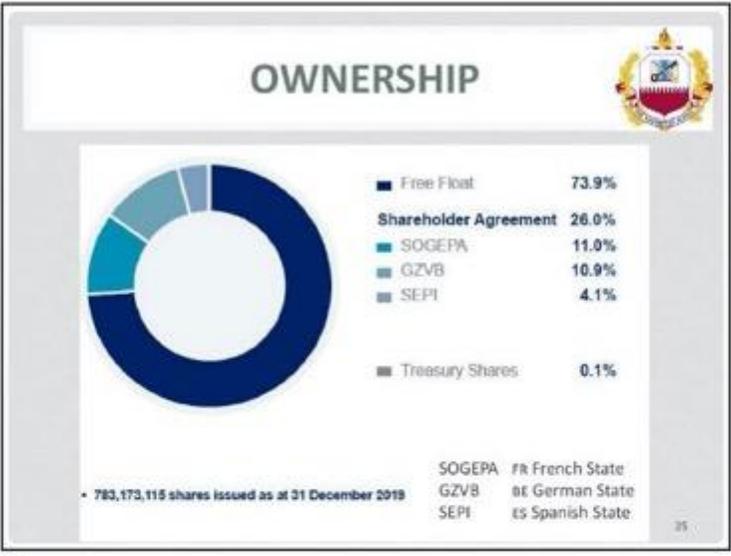
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OPPORTUNITIES vs CHALLENGES

Opportunities



2 Main Lines of Efforts

- Market expansion = competition with Boeing
- Innovation & technology = competition with Boeing

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OPPORTUNITIES vs CHALLENGES

Challenges

- \$3.9 Billion in Global Penalties (1 Qt 2020)
(UK – \$2,2, France – \$1,1, US – \$0,6)
- Coronavirus Supply Chain Disruption
(2 weeks Airbus Final Assembly Line (FAL) in Tianjin)
- 15% US import tariff rates from March 18, 2020
(old WTO dispute with Boeing)
- Defense and Space Restructuration
(Lack of new orders)

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OPPORTUNITIES vs CHALLENGES 

Commercial Aircrafts
Strategy Revision for Long-Haul Air Travel

LOE 1
Market
Expansion



Hub-to-Hub concept 🍷

A-380
A-350, A-320, A-220 –
window of opportunities



Multiple Connections 🍷

B787 Dreamliner
737 MAX

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OPPORTUNITIES vs CHALLENGES 

LOE 2
Innovation and
technology

- Airbus: in search of technological revolutionaries (robotization, 3-D printing)
- Acceleration program BizLab (4 offices - Toulouse, Hamburg, Madrid and Bangalore)

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AIRBUS MOBILIZATION



- Despite developing more toward globalization, Airbus is not focused nor centered on/in the U.S.
 - Boeing presenters, "Boeing abides by U.S. Policy" -- repeated claims
 - Not so with Airbus
- What is Airbus' role in American mobilization
 - If mobilization is driven by a NATO adversary -- it is likely Airbus is mobilizing at the same rate as Boeing, Northrop, Lockheed: Ref. NATO Article 5
 - In this case--prioritizing supply chain is prudent
- If mobilization only occurred in the U.S
 - Airbus could contribute by slowing production
 - Freeing resources for American production
- Prudent to ask, "What type of mobilization?"
 - Assumes aerospace industry will be a priority producer--if maritime assets or "space assets" are prioritized before traditional aircraft, Airbus may be asked to free supplies for shipbuilding or satellites



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AIRBUS CONCLUSION



- As Airbus departs the crossroads of increased regional competition or global competition--the strategic choice is clear--increased Global competition--they are all in!
- Airbus started as result of European desire to compete with the U.S. in aerospace markets. Through commercial and defense consolidation, it finds itself as a market leader with few competitors, many customers, and a large pool of suppliers. It is well situated to lead into the future on a global scale.
- Sustainable Global expansion through responsible investment to earn increased global market share--Clean Ops and Live Ware--A strategic approach to growth
- Financially, 2019's loss is not considered a downturn, just a one-time adjustment. Airbus has maintained consistent growth in the past 5 years with a growing share of the market. Airbus plans to learn from this and focus on strengths to continue global reach and growth in existing and new markets
- We are likely to witness a heightened competition between Airbus and Boeing in the next years. The main catalyst for such competition will be the revision of tariff plans under a future comprehensive US-EU trade agreement. Airbus will lobby the idea to introduce so-called "mirror" tariffs for Boeing at the EU market for compensation its losses caused by US tariffs

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Appendix E – Future Vertical Lift

Future Vertical Lift FoS				
Light	Medium			Heavy
<ul style="list-style-type: none"> Cockpit FACE/JCA Training 	<ul style="list-style-type: none"> Requirements Reduced overhead Mission flexibility 	All Air Vehicles have common...		<ul style="list-style-type: none"> Sustaining Maintaining Repair parts and components
Missions: <ul style="list-style-type: none"> Reconnaissance CAS/Attack DA Maritime Interdiction Ops MEDEVAC Urban Assault/Security 	Missions: <ul style="list-style-type: none"> Reconnaissance Urban Assault/Security CAS/Attack SuW/ASW/MCM DA Maritime Interdiction Ops MEDEVAC HA/DR CSAR Rotary Wing Intercept SAR Counter Drug 	Missions: <ul style="list-style-type: none"> Air Assault Urban Assault/Security Amphibious Assault CAS/Attack HA/DR Tactical Resupply DA Maritime Interdiction Ops MEDEVAC NEO CSAR 	Missions: <ul style="list-style-type: none"> Air Assault Urban Assault/Security Amphibious Assault HA/DR Tactical Resupply DA Maritime Interdiction Ops MEDEVAC NEO CSAR Aerial Refuel Donor 	Missions: <ul style="list-style-type: none"> Air Assault Amphibious Assault HA/DR Tactical Resupply DA Maritime Inter Ops MEDEVAC NEO CSAR Aerial Refuel Donor
NOTE: 6K/95 HOGE at Objective (midpoint) minimum required, 6K/95 HOGE Throughout desired, unless stated otherwise				
Capability Set 1 <ul style="list-style-type: none"> Speed 200-250kts Radius 170-229nm Pax 6 Crew 2 Int Payload 2-2.5k Ext Payload TBD DDG compatible Self Deployment Endurance 30min-2 hrs @170nm 	Capability Set 2 <ul style="list-style-type: none"> Speed 170-270kts Radius 300-437nm Pax 8-10 (@285lbs) Crew 4-2 Int Payload 3.5-4.5k Ext Payload 6-8k DDG compatible HOGE SL/103* Self Deployment Endurance 4.5 hrs @ 50nm 	Capability Set 3 <ul style="list-style-type: none"> Speed 230-350kts Radius 300-450nm Pax 10-12 (@335lbs) Crew 4-2 (@250lbs) Int Payload 4.0-5.5k Ext Payload 6-8k LPD/LHD compatible Self Deployment Endurance 30min @ 300nm 	Capability Set 4 <ul style="list-style-type: none"> Speed 270-350kts Radius 300-450nm Pax 24-32 Crew 4-2 Int Payload 12-20k Ext Payload 15-20k HOGE SL/103* LPD/LHD compatible Self Deployment Endurance 30 min @324nm 	Capability Set 5 <ul style="list-style-type: none"> Speed 270-350kts Radius 750-1200nm Pax 45-54 Crew 4-2 Int Payload 25-30k Ext Payload 30+k HOGE 6K/95 Throughout LPD/LHD capable Self Deployment Endurance 30 min @750nm

Figure 1: The five established capability sets defined across FVL Light, Medium, and Heavy weight classes. FVL Medium Capability Set 3 (highlighted in red) is identified to be the first FVL aircraft in the development / fielding sequence [Table courtesy of FVL ICRD 2016 p.2]

FVL Current Status Summary

Development Sequence	FVL Class / Cap Set	Aircraft Designs	Fielding Date	Aircraft Being Replaced
First	Medium Cap Set 3	Bell V-280 Valor Sikorsky-Boeing SB>1 Defiant	2030	UH-60, UH-1, V-22, AH-64*, AH-1*
Second	Light Cap Set 1	Bell A360 Invictus Sikorsky Raider X	Early 2030s	OH-58, AH-6, AH-64*, AH-1* *Cap Set 1/2/3 characteristics

FLRAA – Competing Designs – Bell V-280 Valor and Sikorsky-Boeing SB>1 Defiant



Bell V-280 Valor (Photo courtesy of Bell)



Sikorsky-Boeing SB>1 Defiant (photo courtesy of Boeing)

FARA – Competing Designs – Bell A360 Invictus and Sikorsky Raider X



(Photo courtesy of Bell)

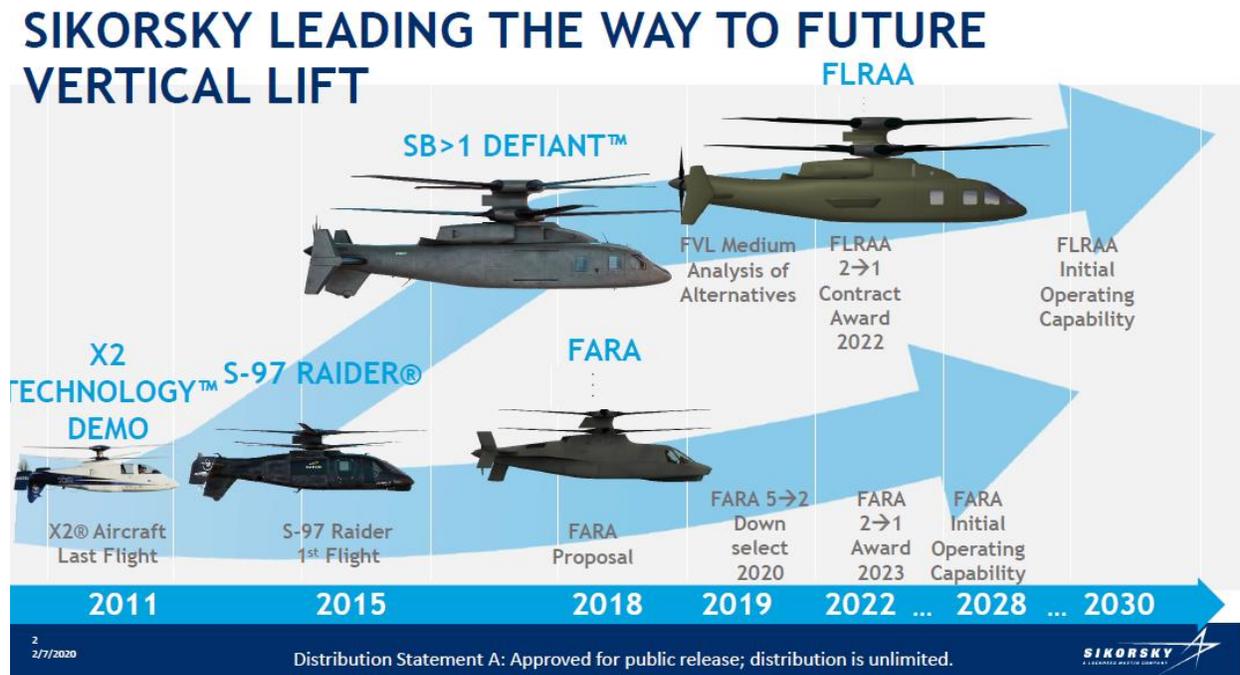
An artist rendering of the Bell 360 Invictus, the company's design for the Army's Future Attack Reconnaissance Aircraft (FARA). Bell is competing to build a prototype for the service and plans to fly the aircraft in 2022.



(Photo courtesy of Lockheed Martin)

An artist rendering of Lockheed Martin's Raider X, which the company has been chosen to build as a prototype as part of the US Army's Future Attack Reconnaissance Aircraft competition.

Scalable FVL Technologies



(Photo Courtesy of Sikorsky)