The Impact of COVID-19 on the U.S. Defense Industrial Base

By Nayantara D. Hensel

The COVID-19 pandemic has imposed a number of challenges on countries and industries, some of which have been partially mitigated by government efforts, medical developments, and corporate strategies. Nevertheless, COVID-19, which, in March 2020, was identified as a pandemic by the World Health Organization and was declared by the U.S. government as a national emergency,[1] will likely continue to have after-effects in the coming years.

The defense sector, as has been the case with many other sectors, has faced challenges in declining production at manufacturing plants, difficulties with key inputs from sole source suppliers, concerns regarding the financial viability of small businesses within the supply chains, and the impact of different variants of COVID-19 within the global supply chains. Companies which had diversified between commercial and military clients often faced a greater negative impact on their financial strength than companies with largely defense-focused products. This was partially due to the decline in demand within the commercial aerospace sector as a result of COVID-19.

The financial health of companies across industries suffered due to COVID-19; indeed, this was reflected in the almost 30 percent increase in commercial chapter 11 filings in 2020 compared to 2019, with bankruptcies reaching their highest levels since 2012.[2] The sectors with the greatest number of bankruptcies in 2020 were real estate, oil and gas, restaurants, entertainment, and retail.[3] While bankruptcies were lower among firms in the defense sector due to stability in multi-year contracts with the government, as well as support of smaller suppliers by larger suppliers and by the government, defense firms with a greater focus on commercial clients suffered more. Consequently, although funding from the federal government under the $2.2 trillion Coronavirus Aid, Relief, and Economic Security (CARES) Act, as well as funding from the Department of Defense (DOD), provided support for companies within the defense sector and other sectors, defense firms continue to face challenges in the short-term and, potentially, in the longer-term. Moreover, the impact of COVID-19 relief funding could have long-term effects on government deficits and debt, which may reduce defense spending in future years. Indeed, the potential atrophy in the defense industrial base due to the impact of COVID-19 on the financial health of defense companies and on future government spending could

Dr. Nayantara D. Hensel is the former Chief Economist for the U.S. Department of the Navy and is the author of The Defense Industrial Base: Strategies for a Changing World (Ashgate, 2015).

lead to national security risks. Production of key defense products—aircraft, ships, tanks, cybersecurity technology, etc.—is vital in supporting national security strategies in various regions and through various types of warfare.

This article discusses key issues related to COVID-19 which impact the defense industrial base, including: (a) the challenges facing companies that have diversified between commercial and military sectors relative to companies that have focused more on the defense sector; (b) the challenges facing domestic and global supply chains, including concerns regarding small businesses and sole-sourcing of certain suppliers; and (c) the role of funding in supporting the defense industry. The article then provides case studies of four of the largest U.S. defense contractors—Lockheed Martin, Raytheon, Boeing, and General Dynamics—and assesses their specific challenges due to COVID-19, their overall business segments and linkages of these segments to the financial viability of each defense contractor, the ways in which the defense contractors handled COVID-19, the role of global defense sales on their financial viability, and, finally, the overall financial performance of each contractor in the COVID-19 world.

The article concludes with perspectives on the potential impact of COVID-19 on defense contractors in the coming years. The sections discussing current COVID-19 challenges, as well as the case studies section, suggest that while diversification between the commercial and military sectors can increase risks related to COVID-19 in the short-term, greater diversification across the sectors can reduce risks in the long-term. This can be achieved as companies re-design products for both commercial and military audiences and develop interchangeable product parts. In addition, reshoring overseas defense industrial manufacturing to the domestic arena and developing domestic sources of critical supplies can reduce the overseas risks from both the COVID-19 pandemic and potential future pandemics. Finally, greater diversification of products between the U.S. and overseas markets can help to mitigate risks from changes in the spending of specific countries due to current funding for COVID-19 or future funding for other potential pandemics.

Challenges Facing Companies with a Diversified Portfolio of Defense and Commercial Products

The diversification of the product portfolios of companies between different types of products that are focused on both commercial and military clients has often reduced risk in previous years. Indeed, traditional finance theory suggests that diversification can reduce risk in the long-term, Nevertheless, within the short-term context of the COVID-19 pandemic, companies that have had a greater focus on products for defense clients have exhibited greater financial stability compared to companies that developed products for both commercial and defense clients. As will be discussed throughout the article, especially in the case studies, many of the defense contractors involved in the commercial sector focused on the aerospace industry (through production and design of aircraft, engines, and related parts). The decline in the usage of commercial aircraft, the reduction in cash flows for airline companies, and the reduced need for new aircraft due to COVID-19 negatively impacted the financial strength of defense contractors involved in the commercial sector. Indeed, the International Air Transport Association (IATA) suggested that passenger traffic had declined 60 percent between 2019 and 2020 and that the net losses for the airline industry in 2020 would be $118 billion, which is a significant decline from net profits in 2019 of $26 billion. The decline in demand for air travel due to COVID-19 resulted in 7,300 commercial jets (29.4 percent of the world fleet) parked at the end of 2020.

This could impact the demand for future aircraft, as well as aircraft values and lease rates, both of which are influenced by the number and type of aircraft that are currently out of service. In comparison, 8.5 percent of commercial jet aircraft built by Western manufacturers were parked in 2019.[4]

The role of defense companies in developing commercial aircraft and products has increased their risk in the current COVID-19 world, due to lower demand for these products. This was particularly evident in the first half of 2020, although the second half showed improvement for some companies. Companies which manufacture business jets, such as Textron, Bombardier, and General Dynamics, showed an improvement in deliveries during the last quarter of 2020.[5]

As will be discussed in the case study section of the article, Boeing, which has a significant share of its work in the commercial arena, was hit hard by the COVID-19 pandemic. Indeed, Boeing entered the COVID-19 era in a difficult position due to the grounding of its 737-MAX jets and, as a result of this and the weaker demand in commercial aircraft due to COVID-19, Boeing tripled its debt in 2020.[6] Boeing announced in the third quarter of 2020 that it had a net loss of -$466 million and planned to reduce its employees from 160,000 in 2020 to 130,000 by the end of 2021.[7]

Similarly, Textron exhibited an 11 percent drop in revenue from the previous year, which was driven by its significant role in manufacturing business aircraft; the aviation sector was the source of 80 percent of the decline in revenue from the previous year. Nevertheless, Textron also provides defense products and manufactures V-22 tiltrotor aircraft through its Bell subsidiary, as well as manufactures the Navy's Ship-to-Shore Connector. The Bell subsidiary's revenue grew, mainly due to strong revenue from defense products.[8]

On the other hand, Lockheed Martin is less diversified between the commercial and defense sectors and, instead, is heavily focused on the defense sector (only 1 percent of its revenue are from U.S. commercial sales).[9] Despite challenges in the F-35 global supply chain (which will be discussed in the case study section), Lockheed recorded the third quarter of 2020 as its best quarter ever with 8.7 percent growth from the second quarter and record sales of $16.5 billion. This, in turn, enabled it to increase $1.8 billion in funds to firms in its supply chain.[10] Despite the negative impact of COVID-19 in some areas, Lockheed Martin hired almost 1,000 people in the second half of March 2020 and announced in April 2020 that it would hire 5,000 additional personnel to assist in the increasing orders for military equipment.[11]

Other firms which were key in the defense supply chain and that were also key in the supply chains for commercial products, were heavily hit by the impact of COVID-19 in the commercial arena. One example is Impresa Aerospace, which made sheet metal parts and assemblies for military aircraft constructed by Boeing and Lockheed. Nevertheless, they also provided a significant amount of work for Boeing's commercial 737 MAX aircraft, as well as for Boeing's 747, 777, and 787 aircraft, Gulfstream's G550 and G650 aircraft, and the Airbus A380 aircraft. Partially due to the grounding of the 737 MAX and the lack of demand for parts for commercial aircraft from Impresa, Impresa Aerospace declared bankruptcy.[12] Another example is Spirit Aerosystems, which, in addition to serving as a Tier 1 supplier for the Air Force's B-21 Raider program, also manufactures components for the Boeing 737 fleet. As a result of the impact of COVID-19 and the grounding of the 737 MAX, Spirit extended furloughs.[13]

The helicopter sector is an example of an industrial base subsector which experienced declines both in the commercial and the military arena. While helicopter manufacturers with both commercial and military aircraft had faced challenges prior to

COVID-19 due to the impact of the 2011 Budget Control Act, production of commercial rotocrafts in 2020 declined 19 percent from the prior year, while military rotocrafts declined by 16 percent. Many of the production declines were driven by issues in obtaining key materials in the supply chain. Nevertheless, diversified rotocraft companies with both civilian and military clients were negatively impacted by COVID-19 to a greater degree than contractors that focused primarily on defense, especially second and third tier suppliers in the supply chain with cash flow concerns from their commercial clients. Rapid obligation of funds to businesses for product manufacturing and sustainment was helpful in supporting financial stability.[14]

In summary, companies with portfolios diversified between the commercial and the defense sectors faced significant challenges due to COVID-19 in the short-term. While some of these firms had difficulty surviving, others showed some improvement during the second half of 2020 in the commercial sector. On the other hand, companies that placed a greater emphasis on the defense sector experienced fewer COVID-19 challenges over the past year that impacted their financial strength.

Challenges Facing Domestic and Global Supply Chains

The domestic and global supply chains of defense companies faced a variety of COVID-19-related issues involving closure and/or re-design of manufacturing facilities, development of "working from home" capabilities in certain cases, and provision of support for smaller businesses in the supply chain. Concerns regarding COVID-19 also contributed to greater consideration of reshoring and moving international production back into domestic locations, as well as greater development of domestic sources for critical input materials. Both of these strategies may help to mitigate the risk of COVID-19 and other pandemics in the longer-term.

In response to the COVID-19 pandemic in the spring of 2020, Boeing temporarily ceased production at its Seattle–area and Philadelphia plants and on products such as the V-22 tilt rotor aircraft, the KC-46 tanker, the H-47 cargo helicopter, the P-8 maritime aircraft, and the MH-139 helicopter. Textron placed 7,000 staff on furlough, and CAE laid off employees and reduced pay. Some of the defense companies ultimately experienced some impacts on the scheduling and delivery of programs, as well as on costs. Indeed, due to slowing down the production line, Lockheed Martin delivered 120 F-35's, which was less than its initial goal of delivering 141.[15] Nevertheless, as of early May 2020, data from the Defense Logistics Agency and the Defense Contract Management Agency suggested that a significant number of companies that closed when the pandemic was strong in the spring of 2020 had already re-opened: 106 of the 10,509 prime vendors had closed and 68 of the 106 had already opened. Similarly, 427 out of the overall 11,413 vendor businesses had closed, but 147 of the 427 had already re-opened.[16] Furthermore, segments which faced the most significant COVID-19 challenges during the spring and summer of 2020—small space launch, military aviation, and shipbuilding—had shown strong recovery by mid-October 2020, despite some delays in product deliveries.[17]

During 2020, half of the major defense acquisition programs experienced some delay due to COVID-19, although the larger defense contracts recovered with significant programs largely on track. The Defense Contract Management Agency has suggested that between June 2020 and February 2021, 94 Pentagon programs indicated at least one delay due to COVID-19, of which 48 were Major Defense Acquisition Programs (MDAPs). Of the 40 programs that still had a delay as of February 2021 (median delay was 2 months), 22 were MDAPs. About 20 of the 54 programs with a delay that recovered received schedule relief for at least three

months.[18]

There were also a number of issues in the global supply chain. One example was the COVID-19-related production disruptions in India in manufacturing the U.S. Army's Apache fuselage and the challenges of construction of generators in Mexico. The disruptions were eased through the efforts of the State Department and the Pentagon.[19] A second example was the temporary closure in the spring of 2020 of production sites for the F-35 in Italy and Japan.[20]

The impact of COVID-19 on global supply chains has provided greater support toward onshoring or reshoring production of U.S. defense equipment within the United States, and away from overseas locations. The impetus toward reshoring is also partially driven by cybersecurity issues, the need to support the U.S. defense industrial base, and concerns regarding China.[21] In addition, the need for key inputs, such as rare earth minerals and microelectronics, has also faced offshoring challenges. Indeed, only 12 percent of microelectronics (such as semiconductors) are produced in the United States and a smaller portion (3 percent) are tested and/or packaged within the United States, although over half of the intellectual property used in the production and creation of microelectronics products has been developed within the United States.[22]

As will be discussed in the next section, both federal funding and defense funding helped to support the global supply chain. Nevertheless, companies have continued to exhibit concerns.

Dozens of container ships waiting at sea to unload at the Port of Los Angeles. (Photo by MSPhotographic for shutterstock (2059221722) Los Angeles, CA USA - July 16, 2021)

A membership survey conducted by the National Defense Industry Association (NDIA) suggested that 70 percent of the members had experienced a negative impact of COVID-19 on their financial conditions (including a number of small companies) and 30 percent were concerned about a potential decline in reliability of their supply chain relative to the prior year.[23] Furthermore, not surprisingly, NDIA's September 2020 survey found that over half (52 percent) of the 1,100 respondents believed that their companies would take six months or more to recover from the COVID-19 challenges, while 12 percent did not think that their companies would recover.[24] The findings of an Interos survey in the fall of 2020 across corporate senior staff also suggested that 98 percent experienced challenges in their supply chain due to COVID-19, 90 percent believed that additional COVID-19 infections would similarly impact them in the future, and 75 percent planned a greater degree of reshoring their global supply chain back to the United States in the long term.[25]

The concerns of small businesses were reflected in a National Defense Industrial Association survey conducted in the spring of 2020 which involved 770 small firms, of which 550 had fewer than 50 staff. Access to capital and difficulties in timely product deliveries under contract were significant concerns for small businesses. About 60 percent of the respondents noted that COVID-19 negatively affected their cash flow and 60 percent also noted that they expected to experience long- term cash flow challenges due to COVID-19.[26]

The DOD also helped to indirectly support supply chains in both the defense and the commercial world through their efforts in expanding medical supplies, which would help the U.S. workforce in a variety of areas. DOD invested $215 million in funding through the CARES Act to increase the volume and strength of the domestic healthcare supply chain and, between March and October 2020, it invested $640 million to increase manufacturing of products to aid in COVID-19 detection, treatment, and prevention. DOD also created the Joint Acquisition Task Force (JATF) to provide skills in contracting and program management from the DOD services and agencies to respond to demands from the U.S. Department of Health and Human Services and the Federal Emergency Management Agency.[27]

One example of the collaboration of DOD with other federal agencies in providing more medical supplies for COVID-19 was the role of the U.S. Air Force in helping to increase the manufacturing of medical protective gear and supplies. The Department of Health and Human Services and the White House needed more COVID-19 test swabs, which were manufactured by Puritan Medical Products, a small firm in Maine—the only approved manufacturer of swabs for certain tests. Consequently, the Air Force reached out to Bath Iron Works, a major shipbuilder for the U.S. Navy in Maine, which "had the ability to fabricate the machines Puritan needed at a new plant." As a result, Puritan's second manufacturing plant, which opened in May 2020, used machines constructed by Bath Iron Works to provide an additional monthly increase of 20-40 million swabs under a $75.5 million contract.[28] In January 2021, Puritan Medical Products received a $110 million contract to purchase more equipment to manufacture more foam tip swabs for use in COVID-19 diagnostic tests.[29] Puritan Medical Products also received a $146.77 million contract in late March 2021 "from the Department of Defense (DOD) on behalf of and in coordination with the Department of Health and Human Services… to increase domestic production capability of foam tip swabs used in critical COVID-19 diagnostic tests."[30]

Defense companies also worked to directly provide support for medical equipment, which would assist not only their workforce, but also the broader

U.S. population. For example, Lockheed manufactured protective materials for medical staff working with COVID-19 patients, including 97,000 gowns and 57,000 face shields, many of which were donated to 300 locations across 20 states. In addition, Lockheed provided $22 million in donations to help non-profit organizations (including public schools) handle the challenges of COVID-19.[31] A second example is Raytheon: over 50 corporate locations globally produced and delivered 25,000 medical face shields for medical staff in 23 days using 3D printers, while the Phoenix, Arizona location produced over 16,000 washable medical gowns. Raytheon also provided extensive food donations to various groups, and assisted small business through providing $2.2 billion in accelerated payments (indeed, 700 of these businesses applied for support from the CARES Act).[32]

In summary, companies faced COVID-19 challenges in producing both defense and commercial products in their domestic and global supply chains. Manufacturing facilities were temporarily closed in certain areas and layoffs or temporary furloughs occurred. Companies, including small businesses, were concerned about the COVID-19 impact on their financial condition, although some of the companies and their programs recovered in production capacity as the year progressed. The COVID-19 pandemic led to collaboration between the defense sector and other sectors in producing medical equipment. Moreover, COVID-19 challenges heightened support for reshoring overseas production back into the United States, as well as in mitigating the risks of sole-source suppliers in the supply chain. Indeed, the financial viability of sole-source suppliers in the supply chain was previously highlighted in the DOD October 2018 report on the defense industrial base and is likely to be examined by "the House Armed Services Committee's new Defense Critical Supply Chain Task Force, which was created in March 2021."[33] These strategies of increased domestic production and domestic development of key critical resources may help mitigate risks from COVID-19 and other potential future pandemics.

The Role of Federal and Defense Financial Support in Facing COVID-19 Challenges

The federal government, including the Department of Defense, provided funds to businesses to ensure greater financial stability. Stabilizing cash flows and providing loans helped some of the companies to sustain their productivity.

Of the $2 trillion in the CARES Act, $17 billion was included for the DOD, as well as "$80 billion in loans for the broader aerospace industry." The combination of the accelerated payments for small companies, as well as the progress payment increases from 80 percent to 90 percent for large companies and from 90 percent to 95 percent for small companies, totaled over $2 billion, which helped to support the financial stability of the supply chain.[34] In December 2020, Congress provided a $900 billion relief package for COVID-19.[35]

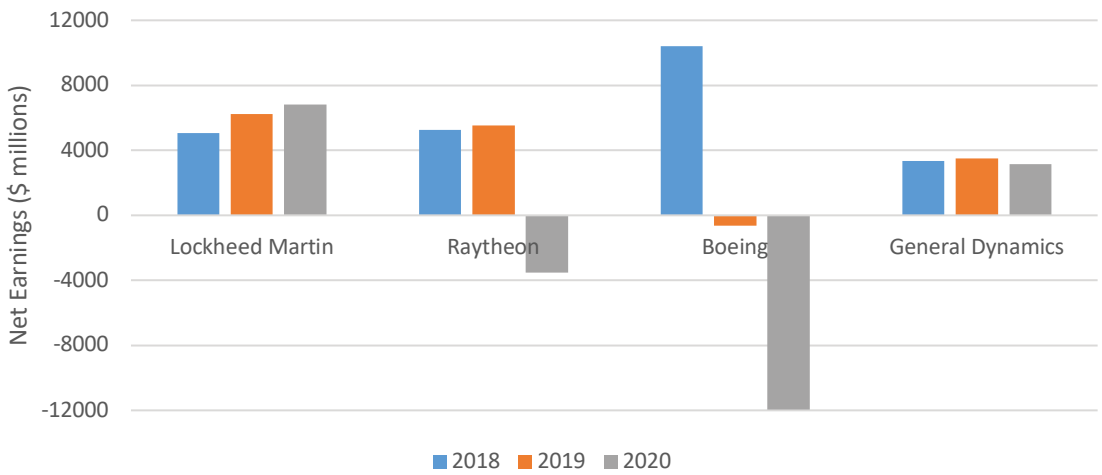
DOD provided $4.6 billion in funding to support the defense industrial base between the spring of 2020 (the beginning of the COVID-19 pandemic in the United States) and the end of January 2021, which was comprised of increases in progress payments ($4 billion), funds from the Defense Production Act ($700 million), and funds to reimburse companies ($73.2 million).[36] Payments from the CARES Act and the Defense Production Act Title III for companies helped to support the COVID-19 recovery and response strategies, and included small loans focused on businesses in space ($35.5 million), shipbuilding ($236 million), aircraft ($252.1 million), body armor/uniforms/survivability equipment ($20.9 million), and electronics ($79.1 million), as well as growing areas, such as hypersonics ($39.8 million).[37] DOD also provided funding to a number of defense companies in December 2020.[38]

Concerns continued to increase throughout 2020 regarding the financial strength of small companies. Indeed, by the fall of 2020, the Defense Logistics Agency (DLA) indicated that there was a reduction in small suppliers engaged in defense contracts. Larger defense companies were strongly encouraged to push their extra cash down to lower tier, small companies on the supply chain to reduce their likelihood of bankruptcy.[39] For example, companies such as Lockheed Martin increased supply chain payments to sustain financial stability.[40] As of the end of March 2021, Lockheed Martin had increased payments to 10,750 suppliers in 47 nations and across 50 states, of which 6,700 were small businesses.[41]

While DOD was given the authority to provide reimbursement to companies for their efforts in maintaining open production lines under Section 3610 of the CARES Act, Congress had not appropriated the funds as of the end of 2020, which left the companies to handle an additional $10 billion in costs. This could result in amortization of the costs by the companies over time, which could increase the costs of products and services for DOD, unless the funds are appropriated to DOD by Congress. The rising costs of the programs, in turn, could lead to greater Congressional oversight and additional administrative requirements if a Nunn-McCurdy breach is triggered. Full funding still remains unclear, despite the extension of Section 3610 authorities on March 10, 2021 through passage of the $1.9 trillion COVID-19 relief bill.[42]

In summary, both the CARES Act and the Defense Production Act provided support for various defense companies in mitigating the financial challenges from the COVID-19 pandemic in the short-term. While federal funding helped to support supply chains and small businesses with cash flow issues, defense contractors also accelerated payments through supply chains to ensure greater stability. Some companies, however, continue to exhibit financial difficulties. Nevertheless, the government support in the United States and other countries for COVID-19 risks may be difficult to sustain in the long-term, due to the increase in debt. Moreover, spending in the defense sector

Exhibit 1: Net Earnings of Four Largest Defense Contractors: 2018-2020



Sources: Lockheed Martin's 2020 Annual Report, p. 38; Raytheon's 2020 Annual Report, p. 96; Boeing's 2020 Annual Report, pp. 43, 50; and General Dynamics' 2020 Annual Report, p. 40.

could decline as spending in other pandemic-related sectors increases, which could impact demand for defense products in the long-term, suggesting that while diversification across defense and commercial clients increases risks in the short-term, it could reduce risks in the long-term.

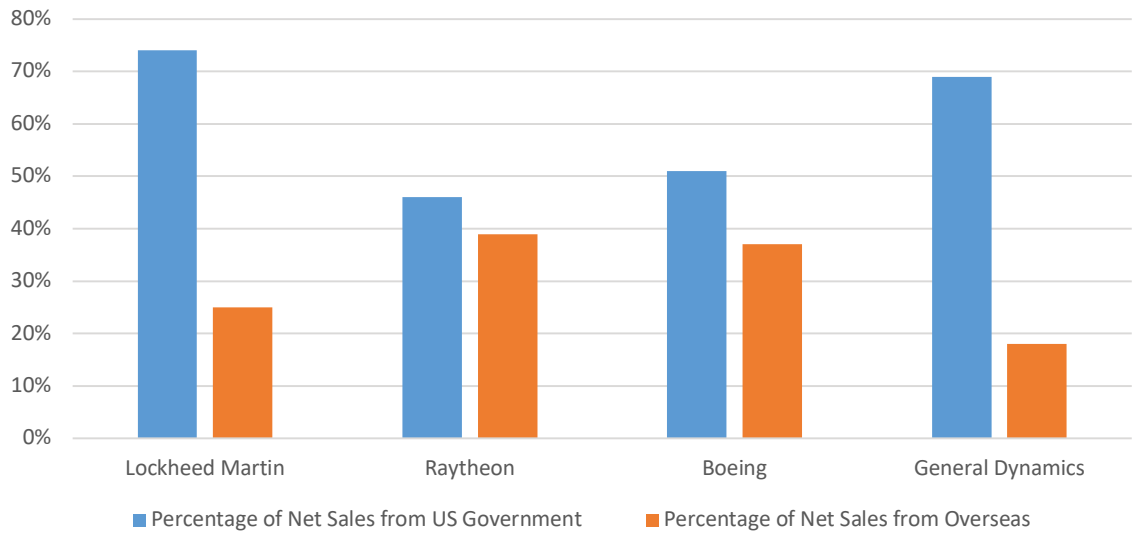
Case Studies of the Impact of COVID-19 on Defense Contractors: A Tale of Four Defense Contractors

This section of the article focuses on in-depth analyses of the impact of COVID-19 on four of the largest U.S. defense contractors.[43] It explores the challenges of these firms, as well as their successes, over the past year, which can provide broader perspectives for future strategies related to COVID-19 or any future pandemic.

The selection of these four defense contractors for more in-depth analyses highlights the variance among defense firms in diversifying between defense and civilian markets and provides insights on the impact of COVID-19 on the current financial health of defense firms resulting from diversification. Each of these defense companies faced challenges from COVID-19 due to closures of manufacturing facilities, difficulties within the supply chain, lack of demand for commercial products, and declines in delivery of military products. Nevertheless, while diversification reduces risk in the long-term, it can increase risk in the short-term, as reflected in the case studies, which suggest that the financial health of defense firms which have been more diversified between defense and commercial markets were more negatively impacted by COVID-19 than defense firms which have been more strongly focused on defense markets.

Exhibit 1 shows the change in net earnings of the four largest defense contractors, while Exhibit 2 shows the degree of diversification of these firms in terms of their percentage of sales to the U.S. government and to overseas customers. Exhibit 1 highlights the significant decline in net earnings in

Exhibit 2: Percentage of Net Sales from the US Government and from Overseas: 2018-2020



Lockheed Martin's 2020 Annual Report, p. 11; Raytheon's 2020 Annual Report, p. 33; Boeing's 2020 Annual Report, pp. 33, 35; and General Dynamics' 2020 Annual Report, p. 25-26.

2020 for Boeing and, to a lesser extent, for Raytheon, relative to prior years. Exhibit 2 highlights the greater diversification of Boeing and Raytheon, as is evident in the lower share of revenue in 2020 from U.S. government contracts compared to Lockheed and General Dynamics. This contributed to higher risks from COVID-19 in the short-term for Boeing and Raytheon due to weakness in the commercial sector, although it may reduce risks in the long-term. Boeing and Raytheon also had greater diversification between U.S. and overseas markets as reflected by their higher share of revenue from overseas sales than the other two defense contractors. This diversification across global markets can also lead to lower risks from COVID-19 and other pandemics over time by diversifying away from the decline in defense spending in particular countries due to their respective increases in funds to combat specific viruses.

Lockheed Martin

Despite COVID-19 challenges, Lockheed Martin had a very strong financial performance in 2020. Of the four defense contractors highlighted in these case studies, Lockheed exhibited the least diversification between the commercial and the defense sectors. Indeed, almost ¾ of its net sales of $65.4 billion in 2020 were from the U.S. government (64 percent of the net sales were from DOD), while 25 percent were from international customers, (including foreign military sales [FMS] contracted through the U.S. government)) and only 1 percent were from U.S. commercial customers.[44] Nevertheless, Lockheed was highly diversified in its global supply chain for the F-35 and faced significant challenges in its production of the F-35 in both the domestic and global supply chains, as was the case for companies in other industries with global and domestic supply chains.

Despite the COVID-19 challenges, Lockheed's net sales in 2020 grew by 10 percent from the previous year. Lockheed Martin is comprised of four segments: the Aeronautics segment; the Missiles and Fire Control (MFC) segment; the Rotary and Missions segment; and the Space segment. All four of the business segments showed growth in 2020 relative to the prior year in net sales and operating profit, with the Aeronautics segment and MFC segment showing 11 percent growth in net sales, respectively, from the prior year, the Rotary and Missions systems segment showing 6 percent growth in net sales, and the Space segment exhibiting 9 percent growth in net sales. Indeed, $2 billion of the $4.9 billion increase in Lockheed's product sales (which also grew 10 percent in 2020) was driven by the Aeronautics segment's increase in net sales of $1.8 billion for the F-35.[45]

The Aeronautics segment comprised 40 percent of 2020 net sales of $26.3 billion, of which 69 percent came from the U.S. government and 31 percent came from foreign customers. The F-35 program (Lockheed's largest program) comprises almost 70 percent of the net sales in the Aeronautics division and comprises 28 percent of Lockheed's total consolidated net sales.[46] Lockheed did well in non F-35 programs in the Aeronautics segment, such as in the development, production and delivery of F-16s, and C-130's.[47] The F-35 program, however, faced a number of COVID-19 challenges. These challenges included temporary closures of the F-35 production facilities in Texas, as well as in Italy and Japan. As already noted, Lockheed did not meet its original target of 141 aircraft in 2020 and delivered 120 aircraft, largely due to the impact of COVID-19 on production. Schedules in 2020 were temporarily adjusted for the F-35 workers in Fort Worth, Texas. These schedules did not resume the pre-COVID-19 work schedule until the third quarter of 2020. Indeed, protective equipment and social distancing procedures were implemented in many of the production facilities, as well as through alternative work schedules and teleworking for some types of

workers.[48]

Fortunately, Lockheed's overall direct workforce has been more sheltered from other mutations of COVID-19 in other countries in that 93 percent of the workforce is located in the United States and, despite COVID-19 challenges, 11,000 additional employees were hired in 2020. Nevertheless, Lockheed's extensive global and domestic supply chains involve a number of suppliers. To handle COVID-19 issues, for example, during the fourth quarter of 2020, Lockheed accelerated $2.1 billion in payments that were due in 2021 to small and medium size firms in its supply chain, including those that had been negatively affected by the decline in the commercial aviation sector.[49]

Lockheed's Missiles and Fire Control segment provided 17 percent ($11.3 billion) of the 2020 total consolidated net sales, of which ¾ were from U.S. government contracts and ¼ were from international contracts and did well in this sector.[50] Lockheed's Rotary and Mission Systems segment provided ¼ ($16 billion) of 2020 total consolidated net sales, of which 72 percent were from U.S. government contracts, ¼ were from international contracts, and 3 percent were from U.S. commercial contracts and contracts from other customers. The largest program within this segment is the Sikorsky helicopter program, which was stable in its share of consolidated net sales despite the COVID-19 challenges.[51]

Finally, Lockheed's Space business segment provided 18 percent ($11.9 billion) of its total consolidated net sales in 2020. This segment is heavily based on U.S. government customers, which comprise 87 percent of net sales, while international customers comprised the remainder. The largest program within this segment has been satellite products and services which has been stable in comprising 11 percent of Lockheed's total consolidated net sales over the past three years.[52]

In the long-term, diversification of sales across countries can mitigate risks from shortages in government contracts in specific countries. Some countries could continue to exhibit strain in their budgets in the coming years as they provide funds to support their population in the COVID-19 and post-COVID-19 environment. This could lead to declines in their defense budgets and a reduction in overseas sales for U.S. defense contractors. About ¼ of Lockheed Martin's total net sales came from overseas in 2020, of which 67 percent occurred through foreign military sales contracted through the U.S. government by purchasing the products on behalf of the foreign clients, and 33 percent were contracted through direct commercial sales to foreign clients.[53]

About 31 percent of the net sales of the Aeronautics business segment were from international sales; 25 percent of sales in the Missiles and Fire Control business segment and Rotary and Mission Systems, respectively, were from international sales; and 13 percent of space sales were from international sales. International aeronautic sales were driven by the F-35, F-16, and C-130J programs in 2020.[54] Indeed, despite the decline in F-35 deliveries, overseas interest in the F-35 remained strong. The F-35 deliveries in 2020 included 46 aircraft to foreign countries.[55] Within the Missiles and Fire Control segment for example, the Patriot Advanced Capability-3 (PAC-3) Cost Reduction Initiative (CRI) and the PAC-3 Missile Segment Enhancement (MSE) have been chosen by 14 countries.[56] Within the Rotary and Mission Systems segment, work to develop and modernize the Aegis Ballistic Missile Defense System has been provided to Japan, Spain, Republic of Korea, and Australia.[57] The segment also provides support to Australia, Chile, Taiwan, Denmark, Greece, Colombia, and Saudi Arabia for the MH-60 Seahawk aircraft and the S-70i Black Hawk aircraft. Within the Space segment, a large portion of the international sales were related to Lockheed's "majority share of AWE Management Limited (AWE), which operates the United

Kingdom's nuclear deterrent program."[58]

In summary, Lockheed did well in 2020 due to its concentration on the defense sector across its four segments, although, in the long-term, greater diversity across both commercial and defense clients could reduce risk as U.S defense spending could be limited by expenditures on COVID-19 and possible future pandemics. Diversification in sales across countries can help to mitigate the risk of declining defense spending in certain countries. The high domestic concentration of Lockheed's workforce helped to mitigate risks from other COVID-19 mutations, although the global supply chain (as well as the domestic supply chain) for the F-35 was impacted by COVID-19 in 2020.

Raytheon

Raytheon faced COVID-19-related challenges in 2020 due to its greater diversification of sales between the commercial sector and the defense sector, although this could help to reduce risk in the long-term. Raytheon's increased involvement in the commercial sector was the result of the merger between the Raytheon Company and United Technologies Corporation (UTC) in April 2020. The new Raytheon Technologies Corporation had 39 percent of its net sales in the commercial sector.[59] This was partially due to the acquisition of Collins Aerospace and Pratt &Whitney in the merger with United Technologies. Raytheon also had greater diversification across countries due to its extensive international sales (39 percent of sales in 2020), which can help with declines in future defense spending in particular countries due to current or future spending on COVID-19 or other potential future pandemics.

In 2020, Raytheon showed an operating loss of -$1,889 million, with an operating margin of -3.3 percent–a significant change from 2018 and 2019 results. This was largely due to the impact of the decline in the commercial aerospace industry on Collins Aerospace and Pratt & Whitney's commercial segments. Raytheon's defense-related segments–the Missiles and Defense segment and the Intelligence and Space segment—did well.[60]

As a result of COVID-19's impact on the commercial aerospace sector, Raytheon reduced capital expenditures, R&D spending, and discretionary spending; suspended the share buyback program; implemented temporary reductions in pay; deferred merit increases; and furloughed and/or reduced personnel. Indeed, 11 percent of the employees at Collins Aerospace and 13 percent of the employees at Pratt &Whitney were affected by workforce declines. Raytheon recorded total restructuring charges of $777 million largely due to reductions in the workforce at Collins Aerospace and Pratt & Whitney. By the second quarter of 2020, several airline clients had declared bankruptcy, various OEM production schedules had to be revised, and airlines delayed/canceled aircraft acquisitions, which led to declining revenue at Collins Aerospace and Pratt & Whitney. As a result, in the second quarter of 2020, Raytheon recorded a goodwill impairment charge of $3.2 billion. Raytheon also provided loans and lease financing to commercial aerospace customers.[61]

Collins Aerospace Systems net sales declined by 26 percent between 2019 and 2020, and its operating profit declined by 67 percent. Much of this was due to the impact of COVID-19 on aircraft usage and a decline in commercial OEM sales.[62] Collins' largest customers in commercial aerospace sales have been Boeing and Airbus, with commercial sales ranging between 31 percent of total aerospace segment sales in 2018 to 21 percent in 2020.[63]

Pratt & Whitney also showed a 20 percent decline in net sales in 2020 relative to 2019 and its operating profit declined by 131 percent, such that it experienced an operating loss of -$564 million in 2020 compared to a profit of $1,801 million in 2019. Pratt & Whitney's decline in sales was due to a decline in commercial OEM sales (especially a

decline in commercial engine deliveries) due to less usage of aircraft in the COVID-19 environment, although declines in commercial sales were partially offset by increases in defense sales (partially an increase in F135 engine sales).[64] The largest source of sales for Pratt & Whitney has been the commercial customer Airbus, ranging from 36 percent of sales in 2018 to 30 percent in 2020. Pratt & Whitney's Geared Turbofan (GTF) engines support over 900 aircraft across 50 airlines and three aircraft platforms: the Airbus A320neo family, the Airbus A220, and the Embraer E-Jets E2 family.[65] On the military side, Pratt & Whitney produces and supports the F135 engine, which is used in Lockheed Martin's F-35, builds engines for the U.S. Air Force's B-21 long-range strike bomber, and is creating the next-generation adaptive engines for the U.S. Air Force.[66]

Raytheon's defense segments did well: the Raytheon Missiles & Defense segment focuses largely on defense customers—the U.S. Navy, the U.S. Army, the Missile Defense Agency, the U.S. Air Force, and international customers.[67] Raytheon's Intelligence and Space segment also largely supports government customers: DOD, NASA, the U.S. Intelligence Community, the Department of Homeland Security, and the FAA.[68]

Raytheon's diversification across overseas markets could reduce risks in the long term from specific countries due to declines in their defense spending which would be partially driven by increases in potential future spending on COVID-19 or other pandemics. With the merger between Raytheon and United Technologies, as of 2020, U.S. government sales were 46 percent of total net sales, and international sales were 39 percent of total net sales. [69] Raytheon's clients in the commercial aerospace sector are located in "Argentina, Brazil, China, India, Indonesia, Mexico, Morocco, Poland, Russia, South Africa, Turkey, Ukraine ,and countries in the Middle East and Central Asia."[70]

Unlike Lockheed, Raytheon has greater geographic diversification of its workforce and could be at a greater risk of various COVID-19 mutations in different countries. Out of 181,000 employees, only 71 percent of Raytheon's employees are located in the United States. The non-U.S. employees are located largely in Europe (14 percent), Asia Pacific (9 percent), Canada (4 percent), and Middle East/North Africa (1 percent).[71] This suggests a greater need for reshoring of defense manufacturing.

In summary, Raytheon's role in the commercial sector has been impacted more by COVID-19 than its role in the military sector due to the declining demand in commercial aircraft as a result of COVID-19's limitations on travel, which highlights the challenges of diversification in the short-term. Nevertheless, in the long-term, diversification could reduce risk, especially if defense spending stabilizes or declines due to spending on COVID-19 or other pandemics. Raytheon's significant overseas presence suggests that diversification across countries may reduce the risk of the impact of defense spending in specific countries. Nevertheless, diversification of the workforce across countries puts employees at greater risk of various COVID-19 mutations.

Boeing

Boeing's financial challenges also highlight the risk of diversification toward the commercial sector in the short-term during the COVID-19 pandemic. Boeing was significantly impacted by COVID-19 due to its substantive role in the commercial aerospace sector, which declined due to extensive travel limitations. This affected its financial strength, as deliveries declined and Boeing's workforce downsized. Moreover, Boeing was also significantly impacted by the grounding of the 737 MAX from 2019 to the fourth quarter of 2020, which was unrelated to COVID-19. Fortunately, Boeing was not entirely focused on the commercial sector: about half (51 percent) of Boeing's overall 2020 revenue came

from U.S. government contracts (including FMS through the U.S. government)[72] and diversification between the government sector and the commercial sector could potentially reduce risks in the long-term. Moreover, Boeing has greater diversification between domestic and overseas markets than Lockheed. Boeing's substantive portfolio of international customers could reduce Boeing's risks in the long-term since diversification across countries limits the impact of potential declining defense spending due to COVID-19 expenditures in specific countries, as well as limits the impact of possible changes in commercial aircraft travel in specific countries.

Boeing has several key segments, which include: the Commercial Airplanes segment; the Defense, Space and Security segment; and the Global Services segment. Due to the steep declines in the Commercial Airplanes segment in 2020, partially due to the impact of COVID-19 on 787 production and the grounding of the 737 MAX, Boeing's overall debt levels more than doubled from $27.3 billion at December 31, 2019 to $63.6 billion at December 31, 2020, which led to credit downgrades. Moreover, Boeing's overall revenue declined from $101,127 million in 2018 to $76,559 million in 2019 to $58,158 million in 2020, and its operating cash flow became negative, declining from $15,322 million in 2018 to -$2,446 million in 2019 to -$18,410 million in 2020.[73]

Multiple Boeing 737 MAX and NG parked outside the company factory at Renton Airport. (Photo by Thiago B. Trevisan for Shutterstock (1516984382) Renton, Washington, USA - September 09, 2018)

Boeing faced COVID-19 operational challenges in a number of ways. First, it temporarily suspended production and operations for manufacturing commercial aircraft in March and April 2020 in the Puget Sound area and Philadelphia (both of which resumed operations during the week of April 20), and in South Carolina (which resumed operations on May 3). Boeing also engaged in procedures involving more staff working from home, adjusted schedules, greater cleaning, etc., which increased operating costs. Boeing consolidated the production of 787s in South Carolina and forecasted further office space reductions of 30 percent. Moreover, it downsized its workforce by 26,000 employees, of which 18,000 had already separated as of December 2020 and reduced its R&D and capital expenditures for 2020 by $1.3 billion.[74] Boeing unfortunately also faced supply chain disruptions from suppliers who had reduced or suspended their operations. The greater concentration of Boeing's workforce in the United States (only 11 percent of Boeing's workforce is located outside the United States), however, reduced the risk to employees regarding various COVID-19 mutations.[75]

The Commercial Aircraft segment showed sharp declines in revenue from $57,499 million in 2018 to $32,255 million in 2019 to $16,162 million in 2020, largely due to COVID-19 challenges in 787 production and the grounding of the 737 MAX. The lack of demand for commercial aircraft, as well as the impact of COVID-19, negatively affected the

production and deliveries for the 787, the 777, and the 737 commercial aircraft. The impact of COVID-19 on the production of the 777X, as well as on the supply chain, led to the delays to Boeing's first 777X delivery which was subsequently rescheduled to occur in late 2023. COVID-19 also led to declines in deliveries of the 787 in 2020. During the fourth quarter of 2020, Boeing delivered only four 787 aircraft. Prior to COVID-19, Boeing produced fourteen 787 planes per month. Similar sharp declines were seen in the deliveries of the 737 commercial aircraft.[76]

The grounding of Boeing's 737 MAX was unrelated to COVID-19 but also substantially weakened Boeing's financial strength. Boeing was ordered by the Federal Aviation Administration (FAA) in March 2019 to suspend 737 MAX aircraft operations due to two prior serious 737 MAX accidents. Nevertheless, FAA rescinded the grounding for the 737 MAX and it restarted its deliveries in the fourth quarter of 2020.[77]

About 83 percent of the Boeing Defense, Space & Security Segment's 2020 net revenue was from the U.S. DOD (including foreign military sales through the U.S. government), while other customers included NASA. The Defense, Space, and Security segment remained stable at $26,257 million in revenue in 2020 (compared to $26,095 million in 2019 and $26,300 million in 2018) due to increases in volume of fighter aircraft, but offset by unfavorable contract catch-up adjustments for the KC-46A tanker.[78] Indeed, a portion of the KC-46A tanker reach-forward loss of $1,320 million was partially due to COVID-19 disruption in production, as was the $168 million reach-forward loss on VC-25B, which contributed to engineering inefficiencies.[79]

The revenue of the Boeing Global Services segment declined slightly to $15,543 million in 2020, from $18,468 million in 2019 and $17,056 million in 2018, as a result of the decline in commercial service revenue, which was partially due to COVID-19. These effects were also evident in its decline in earnings from operations relative to 2019, some of which was driven by contract termination and facility impairment changes, as well as credit losses due to liquidity constraints of commercial airline customers.[80]

Boeing's substantive portfolio of international customers can reduce Boeing's risks in the long-term since diversification across countries could limit the potential impact of declining defense spending due to COVID-19 expenditures in specific countries, as well as could limit the potential impact of changes in commercial aircraft travel in specific countries. About 37 percent of Boeing's revenue are derived from overseas clients (including foreign military sales).[81]

In conclusion, Boeing's diversification between the commercial sector and the defense sector has led to greater COVID-19 risks in the short-term. Indeed, it has faced a number of challenges in the commercial aircraft sector due to the impact of COVID-19 on demand for commercial aircraft, as well as its impact on aircraft assembly lines. Nevertheless, in the long-term, demand for defense products could weaken due to the increased expenditures on COVID-19 and, potentially, on other pandemics. Boeing's diversification across international defense and commercial markets could limit its exposure to potential reductions in defense spending in specific countries, as well as could limit exposure to potential declines in commercial aircraft travel in specific countries. In the short-term, however, Boeing has faced significant challenges due to the impact of COVID-19 in the commercial sector which has weakened Boeing's financial strength through declining revenue and tripling levels of debt.

General Dynamics

General Dynamics, as was the case for the defense contractors in the previous case studies, was also negatively affected by COVID-19. Nevertheless, it did not

experience the significant issues faced by Boeing on the commercial front nor the impact of recent mergers (as was faced by Raytheon in its merger which expanded its commercial business exposure). General Dynamics' portfolio is diversified between the commercial sector and the military sector, with less emphasis on the commercial sector than Boeing or Raytheon. Almost 70 percent of General Dynamics' revenue came from the U.S. government in 2020; commercial revenue comprised an additional 13 percent of sales and focused on Gulfstream's business jets, which initially declined in 2020, but which recovered in the third and fourth quarters of the year. General Dynamics was also exposed to overseas markets,[82] but had less diversification between domestic and overseas markets than Lockheed, Raytheon, or Boeing, which could increase its risk in the long-run relative to the other three defense firms.

General Dynamics is composed of several segments: the Aerospace segment, the Marine Segment, the Combat Systems segment, and the Technologies segment. General Dynamics's overall revenue declined slightly in 2020 to $37,925 million from $39,350 million in 2019 and its operating earnings declined in 2020 to $4,133 million from $4,570 million in 2019. Much of this decline in overall revenue was driven by declines in the Aerospace segment due to less demand for aircraft and services, as well as by lower demand for services from the Technologies segment due to COVID-19. The growth in revenue in the Marine systems through the Columbia-class and Virginia-class submarine programs helped to balance the decline in revenue from the other segments. COVID-19 also impacted General Dynamics through some closures of customer sites, reduction in key inputs, and lower hours on domestic production sites, while some of the overseas facilities were temporarily closed.[83]

The Aerospace segment, which was 21 percent of overall revenue in 2020, declined from $9,801 million in 2019 to $8,075 million in 2020) and its operating earnings declined from $1,532 million in 2019 to $1,083 million in 2020. During this time, deliveries of Gulfstream aircraft fell from 147 aircraft in 2019 to 127 aircraft in 2020. Indeed, due to the impact of COVID-19 on travel, General Dynamics reduced its delivery rates and production of aircraft in April, such that the decline in aircraft manufacturing revenue was due to fewer deliveries of G650 aircraft (with some offset by more deliveries for other G500 and G600 aircraft). Reduction in flights also led to less demand for maintenance and R&D expenses declined.[84]

Nevertheless, while Aerospace was strongly impacted by COVID-19 disruptions in the second quarter, its revenue grew by 23 percent between the third and fourth quarter, and its operating earnings increased by 42 percent over the period due to greater deliveries of Gulfstream aircraft and greater demand for aircraft services. Some of this increased demand was driven by the new G700 aircraft, which is scheduled for completion in the fourth quarter of 2022.[85]

General Dynamics Marine segment accounted for 26 percent of total revenue in 2020. The bulk of the $9,979 million in revenue for the Marine segment in 2020 was driven by nuclear powered submarines ($6,938 million). The revenue of the Marine segment has been stable over the past few years ($8,502 million in 2018 and $9,183 million in 2019), as has the nuclear-powered submarines sector (from $5,712 million in 2018 and $6,254 million in 2019).[86] The slight increase in revenue in 2020 relative to the prior year was driven by greater engineering and construction work on the increasing number of Columbia-class submarines, as well as greater construction on an increasing number of Virginia-class submarines and Expeditionary Sea Base (ESB) auxiliary support ships. General Dynamics has three significant ship manufacturers-- General Dynamics Electric Boat, General Dynamics Bath Iron Works, and General Dynamics NASSCO. Some

of these facilities, were impacted by closures due to COVID-19, including Bath Iron Works which also had a strike in 2020.[87]

Similar to the Marine Systems segment, the Combat Systems segment's revenue (19 percent of consolidated revenue) and operating earnings were stable with slight growth between 2019 and 2020, with revenue reaching $7,223 million in 2020 and operating earnings reaching $1,041 million, despite disruptions from COVID-19 during the first half of 2020. The Combat Systems segment is comprised of Land Systems, European Land Systems, and Ordnance and Tactical Systems.[88] The increase in revenue was largely driven by weapons systems and munitions due to increased manufacturing of subcomponents for missiles and artillery. Revenue from international military vehicles grew due to greater product manufacturing for armored combat support vehicles (ACSVs) for the Canadian government, and the British Army's AJAX armored fighting vehicle program, despite less production on Piranha wheeled armored vehicle programs. Finally, the greater production of main battle tanks for the U.S. Army led to modest growth in revenue for U.S. military vehicles.[89]

The Technologies segment showed a slight decline in financial metrics in 2020: its revenue of $12,648 million in 2020 (34 percent of consolidated revenue) was less than its revenue of $13,309 million in 2019; its operating earnings of $1,211 million in 2020 were lower than operating earnings of $1,311 million in 2019. This decline was due to the partial closure of some customer sites to all but mission critical personnel and a lower level of customer and program activity as a result of the COVID-19 pandemic. The decline was largely seen in the IT services segment in 2020, partially due to the splitting off of several non-core lines of business in 2019. The decline in C4ISR revenue contributed to a lesser degree to the overall decline in the revenue.[90]

General Dynamics' diversification between domestic and overseas markets was less than that of Lockheed, Raytheon or Boeing. In the long-term, it may have greater risk exposure to the impact of spending on COVID-19 on defense funding in specific countries. Indeed, only 18 percent of its revenue in 2020 ($6.7 billion) came from overseas, and was evenly split between government and commercial clients. Most of the overseas commercial revenue was driven by business jet aircraft exports which comprised 60 percent of the backlog in aircraft for the Aerospace segment; indeed, non-U.S. customers had almost half (45 percent) of the orders for Gulfstream in 2020. Nevertheless, General Dynamics' workforce was more diversified across countries than the workforces of Lockheed Martin or Boeing which could also increase the exposure of General Dynamics' workforce to overseas mutations of the COVID-19 virus. Indeed, 15 percent of General Dynamics' workforce is located outside the United States, in over 65 countries.[91] This suggests a greater need for reshoring of defense manufacturing.

In summary, General Dynamics faced challenges from COVID-19 over the past year resulting from its negative impact on the demand for commercial aircraft, however, it was less diversified toward the commercial sector than Boeing or Raytheon. COVID-19 impacted its Gulfstream production facilities, however production improved for the Gulfstream business jets in the second half of 2020. General Dynamics had some diversification between domestic clients and international clients, however it was more exposed to the potential risks of specific countries than more diversified firms such as Boeing. Various sectors of General Dynamics' defense segments, including Land Systems, had some exposure to overseas governments, while the commercial focus of the Aerospace segment had some exposure to overseas commercial clients. In the long-term, General Dynamics' increased diversification between the commercial and the defense sectors, as well as between the domestic and overseas

marketss, may help to mitigate risks of COVID-19 or other future pandemics.

Conclusions

While the overall global impact of the COVID-19 virus on the fiscal strength and economic stability of countries, as well as on the financial viability of companies across various industries in the long-term is unclear, its impact in the short-term in 2020 provides potential insights for the long-term.

Developments in the short-term which may impact product demand and industrial base operations in the longer term include; the movement away from domestic and overseas airline travel with greater emphasis on "virtual" meetings; greater emphasis on working "virtually" or working at different times from other staff and "social distancing" in manufacturing facilities; greater emphasis on reshoring the supply chains toward the domestic arena to minimize the impact of COVID-19 mutations; and increasing fiscal efforts to handle COVID-19 medical challenges and to support companies across industries, including small businesses. The greater collaboration of companies in different industries (e.g. defense companies working with firms in other industries in developing medical products) has been a bright spot over the past year, as has the development of new ways in the "virtual" arena to work productively on some products and services, and the greater emphasis on developing strategies to obtain access to key inputs (such as rare earths) domestically, rather than through international purchases.

Despite similarities in supply chain manufacturing challenges due to COVID-19, companies which are diversified between the commercial sector and the defense sector have experienced greater financial challenges compared to firms which focus more on the defense sector over the past year. This was largely due to unforeseen declines in the demand for commercial aerospace travel, which has impacted aircraft and parts production, maintenance, and future orders. Unfortunately, the resulting layoffs and furloughs in the short-term may impact the ability to develop and sustain employees with specific skillsets in the long-term.

In addition, while a greater emphasis on U.S. government defense contracts relative to commercial contracts has provided less financial risk to companies in the short-term, in the longer-term, fiscal deficits and debt could rise due to COVID-19 mitigation efforts. This could lead to future defense budget cuts, as well as greater use of continuing resolutions, possible future U.S. government shutdowns, and issues with the federal debt ceiling, which could lead to potential cancellations of defense programs as debt levels rise and interest rates increase. Companies with substantive exposure to federal defense spending could be impacted in the long-term, however companies with greater diversification into the commercial sector could potentially mitigate the risk.

Despite the peak in global defense spending of $1.9 trillion in 2019, the increased government spending across nations on COVID-19 challenges may also reduce global defense spending in future years due to rising debts and deficits across countries. Indeed, for NATO members, although they may be able to meet the 2 percent target for defense spending as a share of GDP, their actual defense spending may be less and may decline in concert with the overall GDP.[92] This could lead to declines in the financial strength of defense contractors with exposure to some of these specific countries. On the other hand, the need for defense spending, despite fiscal constraints, could increase due to the partial and indirect impact of COVID-19 on global stability.[93] Consequently, potential weakness in the financial health of defense firms due to COVID-19, as well as changes in the degree of defense spending, may lead to national security risks. COVID-19's role in reducing the financial strength of supply chains

in manufacturing ships, aircraft, tanks, etc. can ultimately impact defense capabilities in particular regions and in particular types of warfare.

The stronger negative impact of COVID-19 on the financial strength of companies that diversify between the defense sector and the commercial sector highlights short-term risks from diversification. Nevertheless, while companies which are less diversified and which are largely focused on the defense sector have experienced less risk from COVID-19 in the short-term, they may face greater long-term risks if defense spending flattens out or declines due to the impact of COVID-19 mitigation efforts on other areas of the budget and rising government debt. Similarly, in the long-term, firms which focus largely on the commercial sector (aircraft and parts, etc.) may also face greater long-term risks if the COVID-19 legacy towards "virtual" meetings rather than traveling to/from meetings leads to permanent declines in air travel. Traditional finance theory has suggested that diversification can reduce risk in the long-term; this may be supported in the post-COVID-19 world in the long-term for companies that diversify and provide related products in both the defense and commercial sectors. In an effort to reduce risk, more companies can develop equipment with interchangeable parts based on both commercial and military uses and re-evaluate designs of particular products for multiple audiences. Moreover, a greater focus on developing sources of critical materials within the United States for the supply chains (such as rare earths) lessens the current risks in importing materials from countries impacted by COVID-19. This is also important for risk reduction in the long-term since other pandemics or national security challenges may emerge. Furthermore, a greater emphasis on reshoring defense production to the United States and reducing the share of the overseas workforce s of defense companies may also reduce COVID-19 risks for companies in the short-term, as well as the potential risks of other pandemics in the long-term. Finally, diversification of products across domestic and international clients can help to mitigate risks from changes in the spending of various countries due to current funding for COVID-19 or future funding for other pandemics.

In conclusion, the overall impact of COVID-19 on various countries, industries, and firms remains unclear, especially due to the potential for future COVID-19 virus mutations and other possible pandemics. Nevertheless, the insights and experiences in 2020 regarding the financial strength of the defense industrial base and the role of diversification provide new concepts for supply chains and manufacturing, as well as for various methods for sustaining financial viability in the coming months and years both within the defense sector and for other industries outside the defense sector. PRISM

Notes

Dr. Nayantara D. Hensel is the former Chief Economist for the US Department of the Navy and is the author of The Defense Industrial Base: Strategies for a Changing World *(Ashgate, 2015). The views expressed in this article are solely those of the author and do not necessarily represent the views of the US government or any other company or institution with which the author is or has been affiliated.*

[1] *Lockheed 2020 Annual Report,* p. 40.

[2] American Bankruptcy Institute, "Total Bankruptcy Filings Drop 30 Percent in Calendar Year 2020, Commercial Chapter 11s up 29 Percent", January 6, 2021.

[3] O'Connell, Jonathan and Anu Narayanswamy, "The Wave of COVID-19 Bankruptcies Has Begun", *Washington Post*, February 26, 2021; New Generation Research suggested that bankruptcies in 2020 increased almost 300 percent in the entertainment sector, over 230 percent in the oil and gas sector, and between 55 percent and 65 percent in the real estate, restaurant and retail sectors.

[4] *Boeing 2020 Annual Report*, pp. 45, 64.

[5] Reuters Staff, "Global business jet deliveries decline 20 percent in 2020 due to COVID-19-19", February 24, 2021.

[6] Gregg, Aaron. "Coronavirus opens a stark divide in America's aerospace industry," *Washington Post*, November 3, 2020; *Boeing 2020 Annual Report*, p. 22.

[7] Lee, Connie. "Future Uncertain for Industrial Base as Pandemic Spreads," *National Defense Magazine*, February 3, 2021.

[8] Werner, Ben. "Defense Industry Weathering COVID-19-19 Economic Slowdown", *USNI News*, May 1, 2020.

[9] *Lockheed 2020 Annual Report,* p. 40.

[10] Gregg, Aaron. "Coronavirus opens a stark divide in America's aerospace industry," *Washington Post*, November 3, 2020.

[11] Tirpak, John A. "The Defense Industry After COVID-19-19," *Air Force Magazine*, May 1, 2020; *Lockheed 2020 Annual Report,* p. 40.

[12] Di Mascio, Jen. "How COVID-19-19 Is Affecting the Defense Industrial Base," *Aviation Week*, November 3, 2020; Sullivan, Vince. "Boeing Supplier Hits Chapter 11 Citing COVID-19-19 and 737 Max," *Law 360*, September 24, 2020.

[13] Tadjdeh, Yasmin. "COVID-19-19 NEWS: Coronavirus Impacting B-21 Bomber Program," *National Defense Magazine*, August 13, 2020.

[14] Tadjeh, Yasmin, "US Rotorcraft Industry Trying to Regain Footing," *National Defense Magazine*, March 26, 2021.

[15] Mehta, Aaron. "Chaos, cash and COVID-19-19: How the defense industry survived — and thrived — during the pandemic", *Defense News*, March 15, 2021.

[16] Mayfield, Mandy. "COVID-19-19 Pandemic Delaying Some Defense Programs," *National Defense Magazine*, May 11, 2020.

[17] Edgar, Bill. "COVID-19-19 Impacts on Defense Supply Chains and the Defense Industrial Base: Understanding the Real Impacts," *Real Clear Defense*, March 13, 2021.

[18] Mehta, Aaron. "Chaos, cash and COVID-19-19: How the defense industry survived — and thrived — during the pandemic", *Defense News*, March 15, 2021.

[19] Di Mascio, Jen. "How COVID-19-19 Is Affecting the Defense Industrial Base," *Aviation Week*, November 3, 2020.

[20] Mehta, Aaron. "Chaos, cash and COVID-19-19: How the defense industry survived — and thrived — during the pandemic", *Defense News*, March 15, 2021.

[21] Di Mascio, Jen. "How COVID-19-19 Is Affecting the Defense Industrial Base," *Aviation Week*, November 3, 2020.

[22] Lopez, C. Todd. "COVID-19-19 Response Sparks Efforts to Strengthen Supply Chain," *DOD News*, September 29, 2020.

[23] Mehta, Aaron. "Chaos, cash and COVID-19-19: How the defense industry survived — and thrived — during the pandemic," *Defense News*, March 15, 2021.

[24] Lee, Connie. "Future Uncertain for Industrial Base as Pandemic Spreads," *National Defense Magazine*, February 3, 2021.

[25] Interos News Release. "New Report Illustrates Severity of COVID-19-19 Impact on Global Supply Chains, Risk of Further Disruption," October 1, 2020.

[26] Mayfield, Mandy. "COVID-19-19 Pandemic Delaying Some Defense Programs," *National Defense Magazine*, May 11, 2020.

[27] Lopez, C. Todd. "COVID-19-19 Response Sparks Efforts to Strengthen Supply Chain," *DOD News*, September 29, 2020.

[28] Mehta, Aaron. "Chaos, cash and COVID-19-19: How the defense industry survived — and thrived — during the pandemic," *Defense News*, March 15, 2021.

[29] Department of Defense Press Release. "DOD Awards $110 Million Firm Fixed Price Contract Action to Puritan Medical Products to Increase Domestic Production Capacity of Foam Tip Swabs," January 8, 2021.

[30] Department of Defense Press Release. "DOD Awards $146.77 Million Contract to Puritan Medical Products to Increase Domestic Production Capacity of Foam Tip Swabs," March 29, 2021.

[31] Lockheed Martin Press Release, "Lockheed Martin Supports Suppliers and Improves Vaccine Access," April 8, 2021.

[32] *Raytheon 2020 Annual Report,* p. 22.

[33] Mehta, Aaron. "Chaos, cash and COVID-19-19: How the defense industry survived — and thrived — during the pandemic," *Defense News*, March 15, 2021.

[34] Edgar, Bill. "COVID-19-19 Impacts on Defense Supply Chains and the Defense Industrial Base: Understanding the Real Impacts," *Real Clear Defense*, March 13, 2021.

[35] Taylor, Andrew. "Congress seals agreement on $900 billion COVID-19 relief bill," *Defense News*, December 20, 2020.

[36] Mehta, Aaron. "Chaos, cash and COVID-19-19: How the defense industry survived — and thrived — during the pandemic," *Defense News*, March 15, 2021.

[37] Edgar, Bill. "COVID-19-19 Impacts on Defense Supply Chains and the Defense Industrial Base: Understanding the Real Impacts," *Real Clear Defense*, March 13, 2021.

[38] Indeed, eight companies in December 2020 were supported under the Defense Production Act Title III: Boeing ($63 million), IDEAL Fastener Corp. ($5.1 million), Bernard Cap and Aurora Industries ($3 million), NCA Solutions ($2.3 million), and Bender CCP ($1.5 million). Lee, Connie, "Future Uncertain for Industrial Base as Pandemic Spreads," *National Defense Magazine*, February 3, 2021.

[39] Mehta, Aaron. "Chaos, cash and COVID-19-19: How the defense industry survived — and thrived — during the pandemic," *Defense News*, March 15, 2021.

[40] Tirpak, John A. "The Defense Industry After COVID-19-19," Air Force Magazine, May 1, 2020

[41] Lockheed averaged $430 million on a weekly basis in accelerated payments to companies in the supply chain during the first quarter of 2021 and, at the end of March, 2021 had increased invoices for $1.4 billion to be paid in the second quarter of 2021 and subsequent quarters to firms in the supply chain. Lockheed Martin Press Release, "Lockheed Martin Supports Suppliers and Improves Vaccine Access", April 8, 2021.

[42] Mehta, Aaron. "Chaos, cash and COVID-19-19: How the defense industry survived — and thrived — during the pandemic," *Defense News*, March 15, 2021.

[43] These four defense contractors have been ranked in the top five global defense contractors, as measured by revenue ,for the past two years in the list of *Defense News*' *Top 100 Defense Companies* (https://people.defense-news.com/top-100/), as well as ranked as the top four US defense contractors in Bloomberg Government's list for 2020, which was released on June 10, 2021 (https://about.bgov.com/top-defense-contractors/).

[44] *Lockheed 2020 Annual Report,* p. 40.

[45] Moreover, $1.4 billion of the increase was driven by the MFC segment, through "increased volume for integrated air and missile defense programs (primarily PAC-3 and THAAD) and tactical and strike missile programs (primarily Guided Multiple Launch Rocket Systems (GMLRS) and High Mobility Artillery Rocket System (HIMARS))". *Lockheed 2020 Annual Report,* pp. 47, 51, 54-56.

[46] *Lockheed 2020 Annual Report,* p. 11.

[47] Lockheed Martin's Skunk Works received a contract from USAF to further develop U-2's. Lockheed received a USAF contract worth $62 billion over ten years to provide F-16s to international allies (including a $4.9 billion initial delivery to two countries for 90 F-16s), as well as a $15 billion production and sustainment contract from the USAF for C-130s and a $1.4 billion Indefinite Delivery Requirement over ten years to sustain C-130's for international allies. In addition, Lockheed delivered 22 C-130J aircraft in 2020 and received contracts to produce F-16s for Taiwan (66 aircraft) and Bulgaria (8 aircraft). *Lockheed 2020 Annual Report*, p. 4, 12.

[48] *Lockheed 2020 Annual Report*, p. 41; Mehta, Aaron, "Chaos, cash and COVID-19-19: How the defense industry survived — and thrived — during the pandemic," *Defense News*, March 15, 2021.

[49] *Lockheed 2020 Annual Report*, pp. 3, 16.

[50] This segment includes: the Patriot Advanced Capability-3 (PAC-3) and Terminal High Altitude Area Defense (THAAD) air and missile defense programs, as well as the Multiple Launch Rocket System (MLRS), Hellfire, Joint Air-to-Surface Standoff Missile (JASSM) and Javelin tactical missile programs. In 2020; it received a $1 billion Guided Multiple Launch Rocket Systems (GMLRS) contract from the US Army, as well as a USAF $824 million Joint Air-to-Surface Standoff Missile (JASSM) Lots 17 and 18 production contract. *Lockheed 2020 Annual Report*, pp. 4, 12.

[51] The Sikorsky's helicopter programs include: Black Hawk and Seahawk helicopters,, the CH-53K King Stallion heavy lift helicopter, the Combat Rescue Helicopter , and the VH-92A helicopter. Other significant program within the segment include the integrated warfare systems and sensors (IWSS) programs (e.g. Aegis Combat System programs). Lockheed Martin's Rotary and Mission System was also awarded several contracts in 2020. Sikorsky received from the US Navy a $2 billion sustainment contract for the MH-60 SEAHAWK® platform, a $500 million contract for a Low-Rate Initial Production (LRIP) lot of 12 Combat Rescue Helicopters, as well as a $470 million contract for LRIP lot of presidential helicopters. It also received overseas orders of over $1 billion from Indian and Greece for MH-60 helicopters, in addition to previous contracts with Australia, Denmark, and Saudi Arabia. *Lockheed 2020 Annual Report*, pp. 5, 13.

[52] Key programs within this business segment include: the Trident II D5 Fleet Ballistic Missile program; the Space Based Infrared System (SBIRS) and Next Generation Overhead Persistent Infrared (Next Gen OPIR) system programs, which provide the US Air Force with enhanced worldwide missile warning capabilities; the Orion Multi-Purpose Crew Vehicle for NASA; and the Global Positioning System (GPS) III, hypersonics programs, and the Advanced Extremely High Frequency (AEHF) system. In 2020, Lockheed's space business expanded with the launch of the sixth and final Advanced Extremely High Frequency (AEHF) satellite, the launch of the JCSAT-17 satellite, the first Mobile Satellite Service (MSS) communications satellite), and other successes, including the issuance of an agreement to purchase aerospace and defense rocket engine manufacture Aerojet Rocketdyne Holdings, Inc., which would further grow Lockheed's presence in supply chains for tactical missiles, hypersonics, integrated air and missile defense, space exploration, and strategic systems. *Lockheed 2020 Annual Report*, pp. 6-7, 13.

[53] *Lockheed 2020 Annual Report*, p. 24.

[54] This included contracts from Bulgaria and Taiwan for F-16s and a C-130 Super Hercules aircraft contract from New Zealand. *Lockheed 2020 Annual Report,* p. 43.

[55] Poland and Singapore became partners in the program in 2020 and Lockheed, in November 2020, provided the Swiss government with a proposal to provide up to 40 F-35A aircraft, valued at up to $10.4 billion. Turkey, however, was removed from the F-35 program in 2019 and sanctions were imposed in December 2020 by the US government on the defense procurement agency (SSB) in Turkey. Turkish companies continue to work on the F-35 supply chain in producing component parts (some of which are single-sourced), While Lockheed has worked on finding non-Turkish suppliers, "[d]uring 2020, the DOD publicly confirmed that Turkish suppliers would be permitted to provide certain components for the F-35 through 2022." Turkish companies also provide component parts for the production of Black Hawk helicopters in the US *Lockheed 2020 Annual Report,* pp. 4, 44.

[56] Qatar has placed orders for Apache and Low Altitude Navigation and Targeting Infrared for Night (LANTIRN®) systems and Romania and Bulgaria have placed orders for precision fires systems. *Lockheed 2020 Annual Report,* p. 43.

[57] The Multi-Mission Surface Combatant (MMSC) program has included international customers, including Saudi Arabia. *Lockheed 2020 Annual Report,* p. 43.

[58] *Lockheed 2020 Annual Report,* pp. 43-44.

[59] *Raytheon 2020 Annual Report,* pp. 2-4.

[60] Ibid, p. 66.

[61] Ibid, pp. 33, 35, 60, 77.

[62] Ibid, p. 72.

[63] Some of its largest contracts in 2020 were for "Future Vertical Lift (FVL) platforms, the Next Generation Ejection Seat (the ACES 5), Ground Based Strategic Deterrent, Bell H-1 Tail Drive System, the Next-Gen APU. Fuel Nozzle, and the Mounted Assured Positioning, Navigation and Timing System (MAPS GenII)." The products were helpful for the Boeing 777X, as well as the Embraer Praetor 500 and 600. On the defense side, Collins Aerospace was chosen by the Army "to provide its Mounted Assured Positioning, Navigation and Timing System (MAPS) Gen II for next-generation manned and unmanned ground vehicles" and received a $700 million contract for upgrades for the Air Force's F-15 fleet with ACES 5 ejection seats. *Raytheon 2020 Annual Report,* p. 10, 30.

[64] *Raytheon 2020 Annual Report,* p. 73.

[65] The Airbus A320neo aircraft uses the PW1100G-JM engine; the Airbus A220 passenger aircraft and Embraer's E-Jet E2 aircraft (and the upcoming Irkut MC-21 passenger aircraft) use / will use PW1000G Geared Turbofan engines; and Gulfstream's new G500 and G 600 business jets (as well as Dassault's new Falcon 6X business jet) will be using the PW800 engine. The reduction in commercial airline capacity due to COVID-19 enabled Pratt & Whitney to focus more on upgrades to Geared Turbofan (GTF) engines. Deliveries in 2020 on the first GTF-powered A320neo family aircraft were made to international commercial customers: Swiss International Air Lines, Middle East Airlines, Aircalin, China Express Airlines, and Aegean Airlines, while Quantas Freight took delivery of the first A321 passenger-to-freighter conversion aircraft which uses Pratt & Whitney's IAE V2500 engine. *Raytheon 2020 Annual Report,* pp. 12, 31.

[66] In 2020, Pratt & Whitney received defense contracts--$1.6 billion in contracts for the F135 engine for the three types of the F-35 aircraft. *Raytheon 2020 Annual Report,* p. 11, 31.

[67] The Raytheon Missiles and Defense segment in 2020 provided delivery of the first AN/SPY-6(V)1 radar array for the Navy's first Flight III guided-missile destroyer, obtained a $2.4 million contract for AN/TPY-2 radars as part of the Terminal High Altitude Area Defense system from the US Missile Defense Agency, obtained a $126 million contract from the Navy for producing Enterprise Air Surveillance Radars, and had USAF approve the StormBreaker smart weapon for usage on the F-15E Strike Eagle aircraft, as well as approved continued development of the Long-Range Standoff Weapon (replacement for the Air-Launched Cruise Missile). *Raytheon 2020 Annual Report,* pp. 16-17, 32.

[68] In 2020, the segment obtained a USAF contract to develop "a ground-based data processing system to generate missile warnings." The Raytheon Intelligence and Space segment provided the F-35 with its first production unit of the Joint Precision Approach and Landing Systemahead of schedule, as well as the updated High-Energy Laser Weapon System to the Air Force, obtained a USAF $950 million contract for the Advanced Battle Management System and a contract for constructing prototype sensor payloads for DARPA's Blackjack program, and bought Blue Canyon Technologies which provides components for spacecraft, as well as small satellites. *Raytheon 2020 Annual Report,* pp. 14, 31-32.

[69] *Raytheon 2020 Annual Report,* p. 33

[70] Ibid, p. 42.

[71] Ibid, p. 34.

[72] *Boeing 2020 Annual Report,* p. 35.

[73] Ibid, p. 27, 43.

[74] Ibid, pp. 27, 46.

[75] Ibid, p. 22.

[76] Indeed, the deliveries of the 787 declined to 53 in 2020, down from 158 in 2019 and 145 in 2018, The deliveries of the 737 were only 43 in 2020, down from 137 in 2019 and 580 in 2018. Deliveries of the 777 similarly declined to 26 in 2020, down from 45 in 2019 and 48 in 2018. *Boeing 2020 Annual Report,* pp. 47, 55, 58.

[77] *Boeing 2020 Annual Report,* p. 29.

[78] This segment produces and sustains rotorcraft and rotary-wing programs (CH-47 Chinook, AH-64 Apache, and V-22 Osprey); fixed-wing military aircraft (F/A-18E/F Super Hornet, F-15 programs, P-8 programs, KC-46A Tanker, and T-7A Red Hawk); unmanned vehicles (the MQ-25, QF-16, and Insitu's Scan Eagle aircraft) and space and missile systems (government and commercial satellites, NASA's Space Launch System (SLS), the International Space Station, Commercial Crew, missile defense and weapons programs, and Joint Direct Attack Munition) and is involved in the United Launch Alliance joint venture. *Boeing 2020 Annual Report,* pp. 21, 47.

[79] Boeing experienced increased revenue from B-52 upgrades, fighter aircraft, Space Launch System, and MQ-25 work. *Boeing 2020 Annual Report,* p. 61.

[80] *Boeing 2020 Annual Report,* pp. 47, 64.

[81] Ibid, p. 33.

[82] *General Dynamics 2020 Annual Report,* pp. 25-26, 46.

[83] Ibid, pp. 42, 44-45.

[84] Ibid, pp. 18, 45-46.

[85] Ibid, pp. 46, 50.

[86] Ibid, p. 20.

[87] General Dynamics Electric Boat manufactures the Navy's nuclear-powered submarines – the Virginia-class attack submarine and the Columbia-class ballistic-missile submarine. The supply chain of 3000 companies, as well as the modernization and expansion of Electric Boat (expenditures peaked in 2020) has helped to support the program. General Dynamics' Bath Iron Works manufactures and supports the Arleigh Burke-class (DDG-51) guided-missile destroyers program. In addition, Bath also produces and supports the Zumwalt-class (DDG-1000) guided-missile destroyer program, with the completion of the final ship (the third ship) occurring in 2020. Finally, General Dynamics' NASSCO manufactures Navy auxiliary and support ships and constructs the Expeditionary Sea Base (ESB) and the John Lewis-class (T-AO-205) fleet replenishment oiler. The shipyard also builds oil and product tankers and container / cargo ships for non-defense clients, per the Jones Act requirements that cargo ships sailing between US ports be constructed in US shipyards. Both NASSCO and Electric Boat provides maintenance and repair in several locations. *General Dynamics 2020 Annual Report,* pp. 20, 46-47.

[88] The primary client of Land Systems is the US Army, for which it produces the M1A2 Abrams battle tank and the Stryker wheeled combat vehicle. Land Systems received a $4.3 million contract for developing upgrades to the Abrams tank, as well as received a $2.5 million contract to upgrade the new Stryker to the double V-hull configuration. Moreover, GC's Land Systems group is manufacturing the AJAX armored vehicle for the British Army, as well as light armored vehicles (LAVs) for the Canadian Army. The European Land Systems group plays a role in the global defense arena through production and delivery of the Piranha V armored combat vehicles to Spain, Denmark, and Romania and received an $870 million contract in 2020 from Spain for delivering and supporting 348 Piranha combat vehicles. The European Land Systems also received contracts in 2020 to manufacture and deliver Eagle vehicles to Germany and Denmark, as well as to provide Pandur armed vehicles to Austria. The ELS also offers various versions of the tracked combat vehicle ASCOD to other countries—the Spanish Pizarro, the Austrian Ulan, etc. – and provides various versions of Duro and Eagle tactical vehicles to Denmark, Switzerland and Germany. The Ordnance and Tactical Systems group provides a variety of weapons systems for naval, ground, and air forces, including the M2/M2-A1 heavy machine guns and MK19/MK47 grenade launchers for ground forces, as well as weapons systems for shipboard and airborne applications, such as the high-speed Gatling guns for US fighter aircraft (such as the F-35). *General Dynamics 2020 Annual Report,* pp. 9, 21, 47.

[89] *General Dynamics 2020 Annual Report,* p. 47.

[90] The Technology segment received contracts in 2020 to support visa applications for the State Department and other US embassies, as well as an $885 million contract to modernize the Army's training programs, a $355 million contract from the Army for technology under the Common Hardware Systems-5 (CHS-5) program, a $760 million contract from DOD for cybersecurity services, $400 million to support accounting systems for Medicare and Medicade, a $305 million contract for claims processing for the Veterans Administration, a $105 million contract for fire control systems on Navy submarines, etc. *General Dynamics 2020 Annual Report,* pp. 11, 25, 48.

[91] *General Dynamics 2020 Annual Report,* pp. 25-26, 28, 51.

[92] Mevlutoglu, Arda. "The Impact of COVID-19-19 on the Aerospace & Defense Sector and the Road Ahead." *Defence Turkey.*

[93] Tirpak, John A. "The Defense Industry After COVID-19-19," *Air Force Magazine*, May 1, 2020.