NDIA

# VITAL SIGNS 2020

## The Health and Readiness of the Defense Industrial Base

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# ABOUT NDIA

The National Defense Industrial Association (NDIA) drives strategic dialogue in national security by identifying key issues and leveraging the knowledge and experience of its military, government, industry, and academic members to address them. NDIA, comprised of its Affiliates, Chapters, Divisions, and 1,700 corporate and 70,000 individual members, is a non-partisan, non-profit, educational association that has been designated by the IRS as a 501(c)3 nonprofit organization—not a lobby firm—and was founded to educate its constituencies on all aspects of national security.

# DISCLAIMER

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# FOREWORD

## General Hawk Carlisle, USAF (Ret), NDIA President and CEO

For nearly 40 years, I had the honor to serve in the U.S. Air Force and fly some of the greatest machines built by human hands. Those aircraft were superior in every way to those of our adversaries and competitors. In fact, the U.S. defense industrial base has developed and produced the innovative, advanced, game-changing technologies and services enabling our armed forces to enjoy significant capability advantages for over 80 years. Such superiority, however, is not a birthright. It takes long-term investments in people, research, ideas, infrastructure, and—yes—companies.

Those investments are the result of trade-offs with investments in other priorities and, when done right, are the result of deliberate strategies. Strategy comes from determining an endstate, identifying available resource means, and choosing various ways in which those resources can be brought to bear… ends, ways, and means.

The 2018 National Defense Strategy has done just that by including a call for leveraging the defense industrial base to enable a more lethal force. However, knowing where to invest in that base requires an understanding of its health and readiness to respond to warfighter needs. To that end, the National Defense Industrial Association (NDIA) has completed this pilot of an annual report we call *Vital Signs*.

As the non-partisan industry association representing all sectors of all sizes within the defense industrial base and chartered with educating the national security community on industrial base issues, we are uniquely called upon to provide this report. I believe it will serve as both an annual baseline for discussion and provide for trend analysis over time.

We hope and expect this report to be of value every year as the national security community debates the investments (means) and policies (ways) to ensure our warfighters maintain and extend their qualitative advantages over any adversaries or competitors while our nation remains strong and secure in the years and decades to come.

## Tara Murphy Dougherty, Govini CEO

The defense industrial base has long underpinned the United States' military strength. In World War II, America was the "arsenal of democracy," forging the armaments the Allies used to defeat the forces of fascism and militarism.[i] Technological advantage enabled the U.S. and Allied militaries to offset superior Soviet numbers during the Cold War. Likewise, U.S. global military dominance over the past 30 years has rested on innovations pioneered by U.S. industry. As America enters a new era of great power competition, the defense industrial base remains essential to its security.

Harnessing technological innovations for application in warfare will be crucial—and may prove decisive—in the battle for military advantage. China and Russia continue to modernize their militaries. In response, the Department of Defense (DoD) must modernize to build a more lethal force. As the National Defense Strategy states, "We cannot expect success fighting tomorrow's conflicts with yesterday's weapons or equipment."[ii]

The United States, however, faces a different innovation landscape than it has in the past. Unlike the Soviet Union, China is a rival economic power and is rapidly closing the gap in technological progress. DoD will not be able to simply spend its way to technological preeminence and military dominance. Moreover, China's efforts to exploit technological advancements made by others for its own benefit threaten the security of the defense industrial base. At the same time, many of the leading innovators in critical technology areas reside outside DoD's traditional vendor base. As a result, DoD must expand the defense industrial base and employ more nimble contracting mechanisms better suited for engaging with non-traditional defense partners.

Maintaining military advantage in an era of renewed strategic competition requires a healthy and vibrant defense industrial base. *Vital Signs 2020: The Health and Readiness of the Defense Industrial Base* is an essential step towards ensuring that is the case. Its holistic, data-driven approach to assessing the health of the industrial base replaces anecdotes with evidence while providing a model for regular monitoring and assessment. In so doing, *Vital Signs 2020* offers a necessary baseline of the current health of the defense industrial base while also pointing the way forward.

# EXECUTIVE SUMMARY

2018's Executive Order 13806 report on production risks to critical defense industrial supply chains starkly framed the health of the U.S. defense industrial base as key to the readiness of U.S. armed forces to confront near-term threats and compete long-term against strategic adversaries. Despite its high-resolution snapshot of the defense industrial base's "unprecedented set of challenges," the report does not provide the public and the defense policy community either an unclassified summary measurement of the health and readiness of the defense industrial base or a simple way of tracking such a measurement over time.[iii]

To fill this gap, the National Defense Industrial Association (NDIA) has piloted what is intended to become an annual project by writing *Vital Signs 2020*. In order to provide a comprehensive assessment of the defense industrial base, our procedure involved standardizing and integrating different elements of both the defense sector and the business environment that shapes its performance.

2020's mediocre "C" grade reflects a business environment characterized by highly contrasting areas of concern and confidence. Deteriorating conditions for industrial security and for the availability and cost of skilled labor and materials emerge from our analysis as areas of clear concern. Favorable conditions for competition in the defense contracting market and a rising demand for defense goods and services reflect recent year-over-year growth in the defense budget. This first iteration of an expected annual study contributes to the debate about national defense acquisition strategy by offering a common set of indicators—vital signs—of what some have called America's "sixth service," the industrial partners who equip our warfighters with their capability advantages.

## Methodology

In order to complete this assessment, we conducted a months-long study of data related to eight different dimensions that shape the performance capabilities of defense contractors: market competition, cost and availability of skilled labor and critical materials, demand for defense goods and services, investment and productivity in the U.S. national innovation system, threats to industrial security, supply chain performance, political and regulatory activity, and industrial surge capacity. We analyzed over 40 longitudinal statistical indicators, converting each of them into an index score on a scale of 0 (bad) to 100 (excellent). By evaluating three years of data for these indicators, we obtained a three-year running average and controlled for data spikes such as the 2018-2019 government shutdown. Once we aggregated the individual indicator scores into scores for each dimension, we did so into an overall composite score for the defense industrial base, which turned out to be 77 out of 100 for this year—a passing C grade but with a worrying downward trend.

**COMPOSITE INDEX SCORES**

| DIB Health Dimension | 2017 | 2018 | 2019 | Change, 2017 – 2019 |
|---|---|---|---|---|
| Competition | 94 | 95 | 96 | +2 |
| Production Inputs | 70 | 68 | 68 | -2 |
| Demand | 78 | 84 | 94 | +16 |
| Innovation | 78 | 76 | 74 | -4 |
| Industrial Security | 69 | 65 | 63 | -6 |
| Supply Chain | 83 | 83 | 68 | -15 |
| Political and Regulatory | 92 | 89 | 79 | -13 |
| Productive Capacity and Surge Readiness | 68 | 70 | 77 | +9 |
| ***Overall Health and Readiness*** | ***79*** | ***79*** | ***77*** | -2 |

*Source: NDIA*

## Areas of Concern

Our analysis reveals a stressed defense industrial base that is trending negative. Composite scores for four of the eight dimensions eroded in 2019 since 2018. Meanwhile, six dimensions earned composite scores lower than 80 and three dimensions earned scores below 70, which are failing grades. These scores suggest that the defense industrial base is increasingly struggling to meet the 'unprecedented' challenges it faces.

Industrial security scored the lowest among the eight dimensions with a 63 for 2019. In fact, industrial security has gained prominence as massive data breaches and brazen acts of economic espionage by state and non-state actors plagued defense contractors in recent years. To assess industrial security conditions, we analyzed indicators of threats to information security and to intellectual property (IP) rights. The indicators of global information security threats were already failing in 2017 and scored even lower in 2019 given the rising annual average number of new cyber vulnerabilities documented by MITRE, which almost doubled between 2016 and 2018 when compared to the period between 2014 and 2016. The score also incorporates MITRE's annual average of the threat severity of the new cyber vulnerabilities, which improved slightly between 2016 and 2018 but remains high. In contrast, threats to IP rights scored 100 out of 100 for 2019 as the number of new FBI investigations into IP rights violations steadily declined since reaching an all-time high in 2011.

Defense industry production inputs also scored poorly in 2019 with a 68, exhibiting a decline from an already barely passing score of 70 for 2017. Major production inputs include the skilled labor, intermediate goods and services, and raw materials used to manufacture or develop end-products and services for Defense Department consumption. Relatively low 2019 index scores for defense industry workforce size contributed to this dimension's low score. Our estimate of the size of the defense industry workforce, currently about 1.1 million, falls substantially below its mid-1980s peak size of 3.2 million.

Security clearance process indicators also contributed to the low overall composite score for production inputs as backlogs shrink but persist. Onboarding new personnel in the defense industry often requires navigating the security clearance process. Defense contractors face a security clearance management process that became more complicated from 2017 to 2019. The index scores for the annual average number of pending security clearance investigations declined for 2019 with much of that decline due to issues with initial top secret clearances.

## Areas of Confidence

The state of defense contracting competition and the state of demand for defense goods and services offer the defense industrial base a favorable outlook. An analysis of the top 100 publicly traded Defense Department contractors demonstrates that competition conditions in the defense industrial base earned a composite index score of 96 for 2019. Several high-scoring indicators drove the strength of market competition conditions, including the availability of cash assets, the low level of market concentration of total contract award dollars, the relatively low share of total contract award dollars received by foreign contractors, and the high level of capital expenditures. Additionally, the defense industrial base earned a solid score of 88 for profitability for 2019 based on index scores for the average return on both sales and assets.

Demand for defense goods and services received a high score of 94 for 2019, which constitutes an increase of 16 points over the year 2017. This result comes from an increasing financial volume of contract obligations issued by DoD. In fact, total contract obligations issued by DoD grew from $306.7 billion in 2016 to $368.7 billion in 2018. Acquisition expenditures also grew in all categories, rising by 11% for aircraft, ships, and land vehicles; by 33% for electronic and communication equipment; by 35% for weapons and ammunition; by 39% for sustainment; and 23% for knowledge-based services. In the same way, foreign military sales (FMS) in aircraft, ships, and land vehicles grew by 113% between 2016 and 2018 while related services grew by 100%.

## Other Takeaways

Conditions in the other dimensions of the defense industrial base conform to the pattern of moderate but declining health and readiness. For example, innovation conditions within the defense industrial base received a score of 74 for 2019, two points down from its 2018 score. Accordingly, the U.S. share of international patent applications—a measure of innovation competitiveness—received an index score of 69 for 2019, four points down from its 2018 score. Similarly, the share of global research and development (R&D) comprised by U.S. R&D expenditures saw its index score decrease between 2018 and 2019 from 75 to 74.

Political and regulatory conditions earned an overall index score of 79 for 2019, dropping precipitously by 13 points from a 2017 index score of 92. Congressional defense budgeting process indicators contributed to this decline since their composite

index score decreased from 90 for 2017 to 77 for 2019. Congressional interest in major defense acquisition programs (MDAPs) decreased over this same period as mentions of MDAPs in congressional hearings decreased from 86 in Fiscal Year (FY) 2016 to 18 in FY 2018, which is echoed in an index score drop from 97 in 2017 to 54 in 2019. Regulatory conditions also eroded between 2018 and 2019; the index score for our "red tape ratio" of nonrestrictive rules to new restrictive rules decreased by 18 points from 100 to 82.

## Can the Defense Industrial Base Meet Surge Demand?

The capacity of the defense industrial base to grow its output and fulfill a surge in military demand stands as a key test of its health and readiness. Productive capacity and surge readiness earned an index score of 77 for 2019, a 9-point increase from its 2017 index score. Gains in output efficiency and stability in capacity utilization contributed to this rising trend. An assessment of the surge capacity of the defense industrial base using industrial input-output analysis uncovers fewer shortages in critical defense supplier industries than estimated for the defense industrial base of the early 1980s, which constitute the last era of great power competition. The defense industrial base of that time operated under a dramatic "buildup" in defense spending and force posture that began during the Carter Administration and accelerated throughout the Reagan Administration. The Carter-Reagan buildup involved a 31% surge in DoD expenditures; we estimate that the defense industrial base circa 1980 experienced shortages in the productive capacity of 54.5% (6 of 11) of critical defense supplier industries. Presently, 27.3% (3 of 11) of critical defense supplier industries would likely experience shortages in the event of a surge in demand for combat-essential defense programs equivalent to the Carter-Reagan buildup of the late 1970s through the mid-1980s. As a result, the industrial surge capacity indicator scored 100 for 2019.

The health and readiness of the defense industrial base pose a challenge to the defense acquisitions community. With the growing expectation of the defense industrial base to rise to unprecedented challenges, *Vital Signs 2020* highlights several hurdles that the defense industrial base will face in doing so. The overall defense industrial base's health score of 77 out of 100 suggests a satisfactory ability to meet current mission requirements. However, the fast-moving era of great power competition requires more, including the delivery of extraordinary capabilities to reverse the erosion of the capability advantages we hold over our competitors. Further, the vulnerabilities shown in this study—industrial security and production inputs to include workforce—indicate a need for urgent attention and action. It is fortunate that the areas of confidence highlighted herein should confirm that the fundamentals of America's defense industry remain a sound foundation on which to build.

# INTRODUCTION

President Dwight D. Eisenhower's 1961 farewell address famously warned against the creeping influence of the "military-industrial complex."[iv] Yet, a lesser known fact is that the same speech praises the important role of industry in keeping American military arms "mighty, ready for instant action."[v] The defense industrial base has provided the United States with a strategic advantage over adversaries since the runup to World War II. American industry heroically mobilized and performed during that global conflict, enabling the United States to supply the combined Allied forces by war's end and, thereby, create the legendary "Arsenal of Democracy."[vi] Despite the vital and historical role of the defense industrial base in supporting America's armed forces during wartime, U.S. defense policy has not always recognized it. For example, congressional panels on the defense industrial base convened by the House Armed Services Committee in 1980, 1992, and 2011 called attention to U.S. policy's persistent neglect of the defense industrial base and the potential tactical and strategic ramifications for the nation's armed forces in a conflict against a large, well-equipped, and determined adversary.[vii] Issued in 2017, Presidential Executive Order 13806 identified important structural changes to the U.S. manufacturing sector that "raise[d] concerns about the health of the manufacturing and defense industrial base" and called for a "comprehensive evaluation" to help guide future remedial policy actions.[viii] As the executive order suggests, a key obstacle to sound a defense industrial base strategy is a common baseline understanding of the overall health and readiness of the defense industrial base. Despite its high-resolution snapshot of the defense industrial base's present challenges, the subsequent Executive Order 13806 report released in 2018 fails to provide the public and the defense policy community either an unclassified summary measurement of the health and readiness of the defense industrial base or a simple way of tracking such a measurement over time.

The National Defense Industrial Association, in partnership with Govini, has completed a months-long pilot assessment of the health and readiness of the defense industrial base to address this gap. By analyzing select statistical indicators, NDIA developed a composite indicator that provides an integrated measure of the health and readiness of the U.S. defense industrial base to meet the demands of the National Defense Strategy (NDS) and the needs of our warfighters. Given that this synoptic indicator brings together data on multiple sets of factors affecting the defense industry, it facilitates a common, holistic understanding of the state of the defense industrial base and its "vital signs." In doing so, it will encourage conversations at all levels about how to adjust policies and make investments that maintain the superior readiness of the American defense industrial base while providing the advantages our nation and its warfighters have come to expect.

## WHAT IS THE DEFENSE INDUSTRIAL BASE?

The nation-wide defense industrial base partners with the Department of Defense (DoD) to ensure the U.S. armed forces enjoy decisive advantages. The defense industrial base encompasses manufacturers, systems integrators, service providers, technology innovators, labs and research organizations, and other suppliers linked to one another by contracts into regional, national, and global supply chains to provide America's warfighters with superior tools, capabilities, and resources.[ix] The defense industrial base includes more than just the producers of major capabilities vital for national defense.

In recent years, the U.S. domestic defense industrial base has declined in size despite growing demand for its output. The Defense Department issued $364 billion worth of contract obligations during Fiscal Year (FY) 2018, which demonstrates an increase of 10% over FY 2017. DoD currently manages approximately 350,000 active contracts.[x] However, it issued 9% fewer prime contract obligations in FY 2018 than in FY 2017. Between FY 2015 and FY 2018, the total value of contract obligations increased by 25% while the number of prime contract recipients decreased by 15%. In hindsight, these changes represent the combined effects of the reduction of forces in Afghanistan and Iraq along with the 2011 Budget Control Act—both of which contributed to the decline in the ranks of recipients of prime DoD contract awards from 78,500 to 61,700 between FY 2011 and FY 2017.

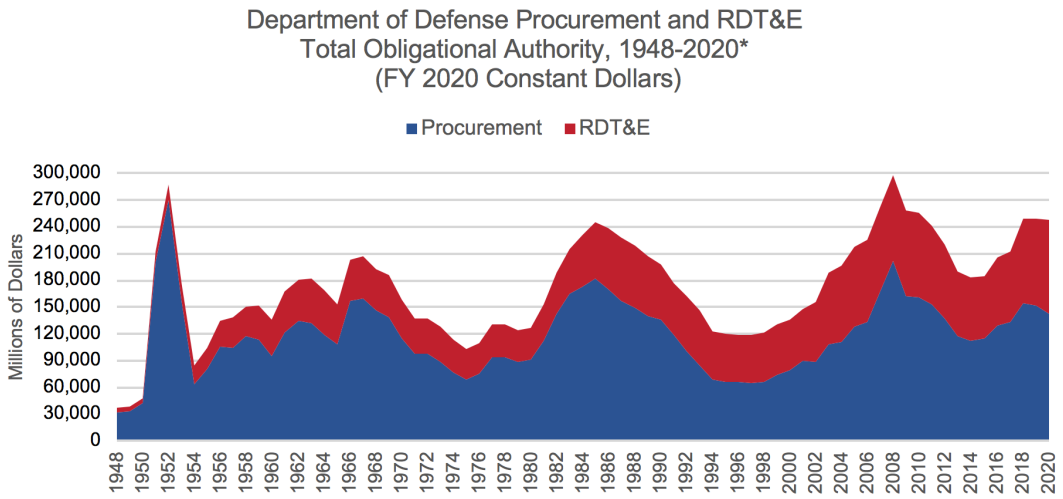
| TOP 10 DEFENSE CONTRACT SPENDING LOCATIONS | | |
|---|---|---|
| **County Name** | **Metropolitan Statistical Area** | **FY 2017 Defense Contracting Expenditures (billions of dollars)** |
| Fairfax County, VA | Washington-Arlington-Alexandria, DC-VA-MD-WV | 13.7 |
| Tarrant County, TX | Dallas-Fort Worth-Arlington, TX | 13.0 |
| San Diego County, CA | San Diego-Chula Vista-Carlsbad, CA | 9.2 |
| King County, WA | Seattle-Tacoma-Bellevue, WA | 8.1 |
| St. Louis County, MO | St. Louis, MO-IL | 7.2 |
| New London County, CT | Norwich-New London, CT | 7.0 |
| Madison County, AL | Huntsville, AL | 5.7 |
| Los Angeles County, CA | Los Angeles-Long Beach-Anaheim, CA | 5.3 |
| Middlesex County, MA | Boston-Cambridge-Newton, MA-NH | 5.1 |
| Santa Clara County, CA | San Jose-Sunnyvale-Santa Clara, CA | 4.8 |

*Source: Office of Economic Adjustment, 2019; NDIA*

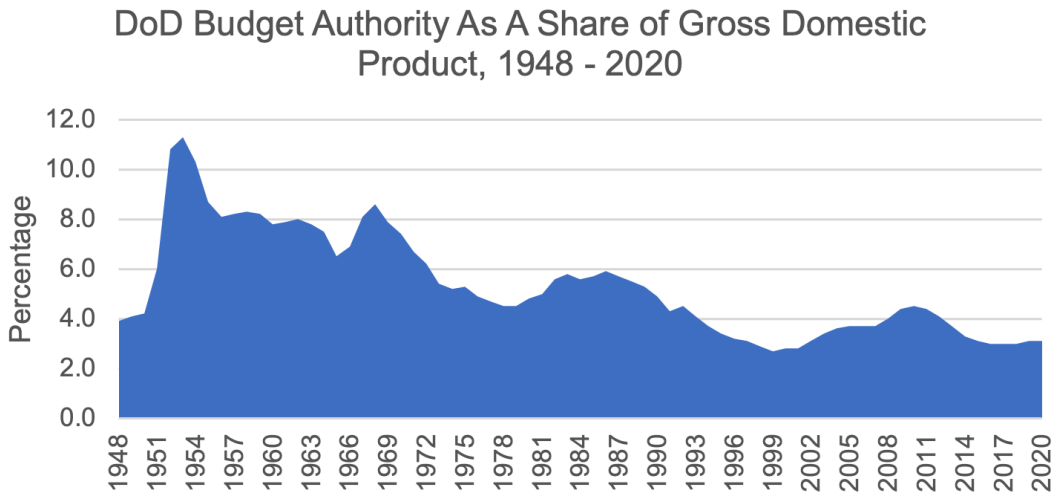
Defense supply chains touch every state in the Union. According to DoD's Office of Economic Adjustment data, defense contract spending in FY 2017 averaged over $5 billion per state although spending levels varied widely. For example, California receives the most of all states with $35 billion in defense contract spending while Wyoming receives the least at approximately $100 million. The concentration of defense contract spending in major metropolitan areas supports clusters of defense industry production, investment, and employment. Metropolitan areas such as Washington, DC, Dallas-Ft. Worth, San Diego, Seattle, St. Louis, Los Angeles, Silicon Valley, and Boston host the country's largest defense contracting clusters.

Historically, defense procurement has followed a decadal cyclical pattern, driven by events and policy change.[xi] The breakout of major military conflict has prompted defense spending peaks with a typical concentration in the high-volume procurement of major defense acquisition programs (MDAPs). Spending troughs have followed such peaks when military conflicts and tensions have deescalated, driving industry consolidation. For the U.S. defense industrial base, these cyclical changes reflect the challenges defense contractors have when maintaining thriving companies while also making critical investments in future capabilities. The globalization and internationalization of supply chains have only served to exacerbate those challenges while the increasing share of non-defense spending—especially that which is devoted to entitlements and interest on the debt—place increasing pressure on overall defense spending.

# THE EVOLVING DEFENSE INDUSTRIAL BASE: FROM THE COLD WAR TO TODAY




*Source: National Defense Budget Estimates For FY 2020, Office Of The Under Secretary Of Defense (Comptroller)*




*Source: National Defense Budget Estimates For FY 2020, Office Of The Under Secretary Of Defense (Comptroller)*

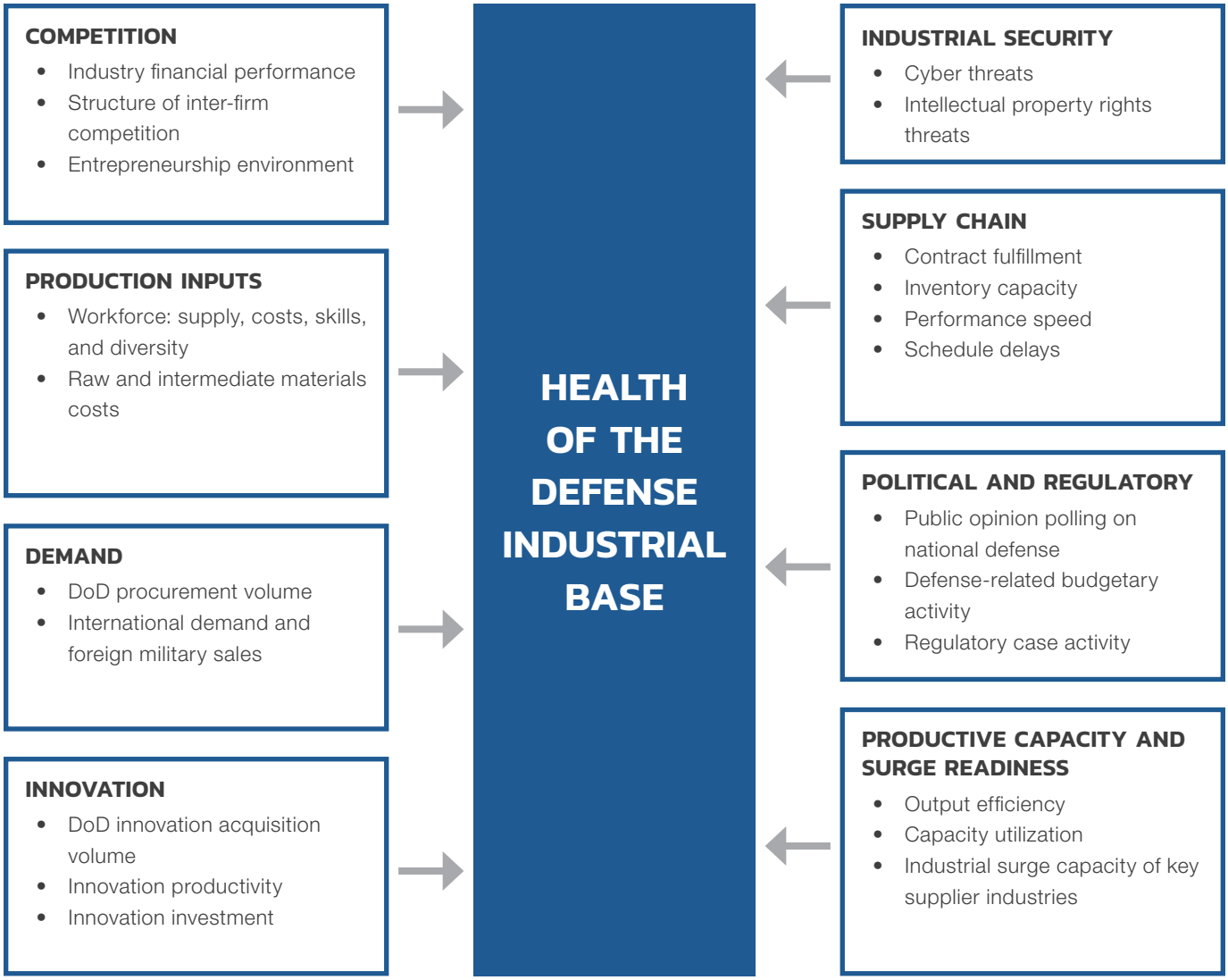
The 2018 National Defense Strategy's declaration of the re-emergence of an era of great power competition has held significant implications for the defense industrial base. The NDS called for reforms to defense acquisition systems to ensure the prompt delivery of important capabilities, services, and materials to U.S. warfighters in step with the changing strategic environment. This era of great power competition presents the challenge of a multi-dimensional competition with near-peer competitors, specifically China and Russia, the central dimension of which could be technology. Achieving decisive national advantages across emerging technologies—artificial intelligence, hypersonic aviation, quantum computing, autonomous vehicles, and human-machine teaming systems, etc.—will have significant implications for the future economic and strategic balances of power.

This new era also challenges industry to achieve high levels of readiness to rapidly scale-up the production and deployment of military hardware during a war against a competitor. Nevertheless, trends from previous eras will continue to affect the defense industrial base. Consolidation among prime contractors can be expected to continue as risks of budget instability and the pressure to deliver favorable quarterly returns lead companies seeking further competitive advantages to join forces. The pressure to reduce costs and exploit international talent will encourage a more comprehensive globalization of supply chains. Growing dangers to industrial security from cyber threats and traditional economic espionage will require defense contractors to implement new and often costly security procedures and systems. Such dynamic and uncertain business conditions of this emerging era will undoubtedly bring changes to both the organization and behavior of the defense industrial base.

## UNDERSTANDING THE HEALTH OF THE DEFENSE INDUSTRIAL BASE

Despite their importance in achieving the U.S. national defense mission, many assessments of national defense capacities, capabilities, and needs lack a broad consideration of the strengths and weaknesses of the defense industrial base. The Fiscal Year 2017 Annual Industrial Capabilities Report, authored by the Office of the Under Secretary of Defense for Acquisition and Sustainment, focused on cataloguing defense-related private manufacturing capabilities. Separately, the 2018 federal interagency task force report entitled "Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States," initiated by Presidential Executive Order 13806, highlighted emergent risks to industrial capabilities in various defense sub-sectors and weapons systems categories. Influential non-governmental analyses like those within The Center for Strategic and International Studies' annual "Acquisition Trends" reports tend to address the defense industrial base health question from the perspective of trends in demand-side defense contracting flows. Although these studies provide valuable insight into specific aspects of the health of the defense industrial base, they lack the breadth necessary to develop a holistic understanding of the position of the defense industrial base with respect to peak performance standards.

To understand the current business environment of the defense industrial base in empirical terms, NDIA has developed a composite index based on a diverse array of select statistical indicators. In general, statistical indicators provide summary representations of statistical data, typically revealing directional trends or relative positions. Statistical indicators also provide a structured and longitudinal manner of understanding the relative performance of the defense industrial base. The complexity and scale of the defense industrial base mean that an array of statistical indicators may be useful for performance analysis and interpretation. Composite index indicators simplify the challenge of interpreting multiple statistical indicators by combining and integrating various statistical indicators into "a single index on the basis of an underlying model."[xii] As a result, composite indicators offer a better value for capturing multi-dimensional concepts, like defense industrial base health, for which single indicators prove inadequate means of measurement. By enabling a simpler tracking of change over time, composite indicators render modeling and other forms of advanced statistical analysis easier. Beyond their analytical benefits, composite indicators facilitate broader, more inclusive public communication.




*Source: NDIA*

Descriptions of each of the eight dimensions follow below. The rest of *Vital Signs 2020* presents the overall composite index score and the underlying analysis for each dimension of the defense industrial base health model.

## Competition

The state of competition between firms within the defense industrial base exerts a powerful influence on the productive performance of firms within industry. A large population of firms of varying sizes, product and service specializations, and even national origins competes for the same defense contracts. While such competition occurs, trends in financial performance indicate the financial health of the involved firms. The competition between firms for contracts results in a pattern of market concentration that illustrates the extent to which relatively few firms dominate defense contracting dollars. The entry of firms into defense contracting provides insight into the openness of the defense contracting market to new sources of competition. This section of the report informs our understanding of the health of competitive dynamics within the defense industrial base, partially relying on the evaluation of financial data from the top 100 publicly traded defense contractors.

## Production Inputs

The cost and availability of the inputs used in the production of goods and services also shape the performance of the defense industrial base. Defense industry production relies heavily on inputs, including a wide variety of intermediate goods and services, highly skilled labor, and rare raw materials. Trends in the cost and availability of these resources shed light on the ability of defense contractors to acquire the inputs necessary for production.

## Demand

The scale of defense contracting opportunities shapes the defense industrial base's health. Companies in the defense contracting market compete to provide goods and services to defense agencies and the military services. These contracts are critical sources of capital for defense companies who use them to initiate R&D and production processes. The stability of this demand affects the ability of companies to commit to and plan for defense-related production. This section of the report shows trends in aggregate defense procurement and the distribution of contracting awards among different product categories.

## Innovation

For decades, the National Defense Strategy has looked to the defense industrial base as an important source of technological innovation. The manufacturing and services industries associated with the most technology-intensive goods and services acquired by the Defense Department provide significant amounts of capital for research and development. They also generate significant innovation productivity. Trends in industrial R&D investment and patenting activity help form a picture of the state of private sector defense innovation.

## Industrial Security

The security of industrial operations against information threats also contributes to a comprehensive portrait of the health of the defense industrial base. American industry faces persistent, increasing threats of intellectual property theft, economic espionage, cybercrime, and other forms of attacks to include the corruption of data necessary for production integrity or operational security. Trends in the scale and severity of these threats indicate the intensity of industrial security challenges.

## Supply Chain

The performance of the corporate supply chains that support industry's supplier networks also factors into assessments of the health of the defense industrial base. Defense supplier networks rely on well-functioning relationships among companies to deliver products and services to government clients. The overall competency of these networks comes from the combination of their track record of contract delivery, product flow, and speed of operation. This section of the report studies trends in industry's contract performance failures, inventory assets, program schedule integrity, and speed of operation.

## Political and Regulatory

More than most industries, legislative and regulatory processes have a direct impact on defense industry productivity. Public attitudes toward defense spending shape congressional interest in defense acquisition, ultimately affecting congressional budgets. The time that Congress takes to authorize a budget for national defense programs affects capital availability and the product delivery schedule of defense supply chains. Similarly, changes to defense acquisition regulations affect defense contractors' eligibility and administrative costs. In this way, policymakers can have a significant impact on the defense industry in terms of the demand for goods and services, availability of inputs, conditions in related and supporting industries, and structure of industry competition. This section of the report assesses political and regulatory trends that shape defense industrial productivity.

## Productive Capacity and Surge Readiness

Industrial productive capacity and surge readiness provide another important lens through which we can evaluate the health of the defense industrial base. Conflicts often start suddenly, leaving defense suppliers little time to prepare and fulfill a surge in demand for goods, services, or materials. Meeting surge demand requires leveraging the latent excess productive industrial capacity in the national economy. In manufacturing industries, firms must activate unused industrial capital assets to reach necessary levels of productivity. However, the complex structure of industrial supply chains means that flows of goods and services between industries will limit the extent to which an increase in demand for industrial end-products translates into an increase in industrial output. This section of the report analyzes trends in indicators of potential output, capacity utilization, and the output of major defense platforms and systems.

## HOW TO READ THIS REPORT

In the succeeding sections of this report, we present composite scores for each of the defense industrial base health dimensions described above.

Our scores follow a nested approach, combining quantitative scores for each dimension's conditions into an overall health score on a 0-to-100 scale. The score for each set of conditions is itself a composite of scores for variables that contribute to health and readiness in that area. To score each variable, we analyzed statistical indicators that serve as empirical proxies.

Indicator scores are calculated by comparing a three-year average of the indicator to a baseline value. Baseline values are either historical peak values (a prior value of the indicator that represents the best recent performance given available data) or, when conceptually appropriate, ideal standards. As a result, baseline values are chosen on a case-by-case basis, further depending on data availability. For each indicator, we provide an analysis that incorporates the influence of contemporary contextual events and forces that drive the indicator's performance.

In each section of *Vital Signs 2020*, graphs depicting the recent trend line in the scores accentuate the discussion of variables and indicators. Each section also includes a table detailing the current scores for each variable and indicator in addition to their net change over the two previous years.

The indicators that form the basis of our analysis were constructed from multiple data sources. Furthermore, we developed many indicators from public data sources. Our financial indicators are based on data obtained through the FTSE Russell Mergent Online database. Several indicators, including those presented in the Demand Conditions section, are derived from custom data provided by our research partner, Govini. Some indicators are based on estimates generated by NDIA. We reference indicator data sources throughout the report. Readers will find reference information related to these data sources in the Data Sources section of this report.

## FOR THE FUTURE

As stated at the beginning of this introduction, *Vital Signs 2020: The Health and Readiness of the Defense Industrial Base* is meant as a pilot of an annualized report. Of note, this project makes only conclusions on the overall health and readiness of the defense industrial base. In it, we purposely do not make any policy recommendations, support any specific legislative or regulatory changes, or advocate for any targeted investments. Our goal in this report is to provide a baseline reference for the national defense community.

We believe an unclassified report like this will serve as an important annual touchpoint at the beginning of the policy cycle by providing trend analyses that demonstrate the results of changes in the strategic environment, economy, policies, and investments while ensuring a discussion of industrial base issues at the national level. In this way, we will be able to identify what actions or decisions were successful and which ones were not. It will then be up to various stakeholders, organizations, and policymakers to interpret and advocate for what they believe is in the best interest of defense industrial base health and our overall national security posture.

As such, the National Defense Industrial Association looks forward to feedback from across the spectrum of thought leaders on our study model, its methods and measures, and ways of ensuring its usefulness to the national defense resourcing community.

# COMPETITION CONDITIONS

## INTRODUCTION

The defense industrial base consists of thousands of companies competing for and performing on contracts with the Department of Defense. The conditions that characterize and shape this competition help to determine the composition of the industry and its performance outcomes. These conditions pertain to profitability, cash availability, capital investment, market concentration, foreign ownership, and contract bidding intensity. By understanding the trends of these conditions, we can determine whether the dynamics of the defense contracting marketplace are evolving in a healthy direction.

> ***Indicator scores are determined by the ratio of an indicator's average value to a baseline value. Baseline values reflect historical peak values or ideal standard values, which means that they are unique for each indicator. Ultimately, the availability of data in the public domain constrained the selection of baseline values. The overall section score averages variable scores that, in turn, consist of averages of indicator scores, which are capped at 100 to allow for a 0-to-100 scoring scale.***

This section presents scores for indicators of the competitive dynamics within the defense industry. The indicators describe key attributes of industry competition, including average firm profitability, cash availability, capital expenditures, market concentration, extent of foreign ownership, and intensity of competitive bidding for defense contracts. NDIA calculated indicators of profitability, cash availability, capital expenditures, market concentration, and foreign ownership using financial data for the top 100 publicly traded DoD contractors, relying on data obtained from FTSE Russell's Mergent Online business intelligence database. NDIA calculated the score for competitive bidding with custom federal procurement data from Govini.

**Key takeaways:**

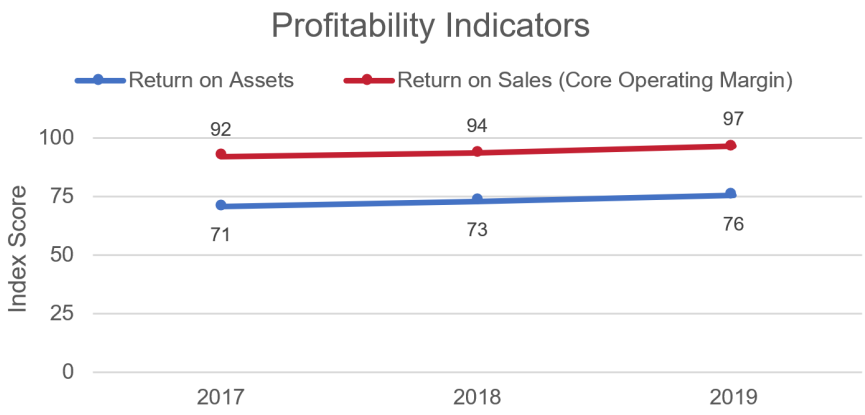
- Overall competition conditions scored a 96 for 2019
- Well-performing factors: profitability, cash availability, capital investment, overall market concentration, and low market share for foreign-owned companies
- Poor-performing factors: return on assets and contract offers per contract action

**COMPETITION SCORES**

| Factor | Indicator | 2019 Score | Change, 2017 – 2019 |
|---|---|---|---|
| Profitability | Core operating margin (return on sales), weighted average | 97 | 🟢 +5 |
| | Return on assets, weighted average | 76 | 🟢 +5 |
| ***Overall Profitability*** | | ***88*** | 🟡 ***+3*** |
| Cash Availability | Free cash flow, weighted average | 100 | 🟡 +4 |
| ***Overall Cash Availability*** | | ***100*** | 🟡 ***+4*** |
| Capital Investment | Capital expenditures, weighted average | 99 | 🟡 -1 |
| ***Overall Capital Investment*** | | ***99*** | 🟡 ***-1*** |
| Market Concentration | Level of market concentration (Herfindahl-Hirschman Index) | 100 | 🟡 +0 |
| ***Overall Market Concentration*** | | ***100*** | 🟡 ***+0*** |
| Foreign Ownership | Share of total contract obligations awarded to foreign-owned firms | 100 | 🟡 +0 |
| ***Overall Foreign Ownership*** | | ***100*** | 🟡 ***+0*** |
| Contract Competition | Offers received per contract action | 88 | 🟢 +5 |
| ***Overall Contract Competition*** | | 88 | 🟢 +5 |
| ***Overall Competition Score*** | | ***96*** | 🟡 ***+2*** |

*Source: NDIA*

## PROFITABILITY




*Source: NDIA*

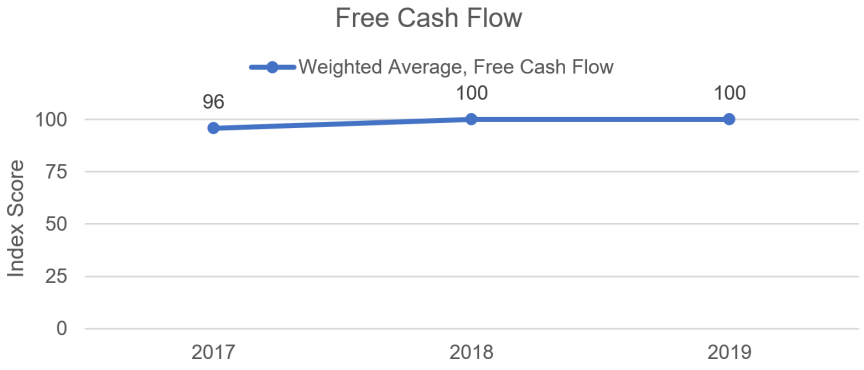
Industry's profitability trended upward in 2019, rising three points over 2017 to 88. This score is based on industry's achievement of an average return on sales of 10.1% and an average return on assets of 7.6% in 2018.

Profitability describes the ability of defense contractors—given existing business lines—to generate revenue in excess of their costs. Profitability matters because profits provide companies with the financial resources necessary to sustain and expand their business operations. Additionally, profitability lures new entrants into the sector, ensuring that new ideas, capabilities, and energy continue to revitalize it over time.

To assess industry profitability, NDIA estimated weighted averages of the return on both total sales and assets for a sample of the top 100 publicly traded defense contracting companies. While return on sales indicates the amount of profit generated per dollar of sales revenue, return on assets denotes the amount of profit earned per dollar value of business assets. These figures do not separate defense-related revenues and costs from those derived from other sources. However, they provide a picture of the average overall profitability of leading defense contractors. Return on assets was scored against a baseline value of 10%, the average return on assets for leading defense companies reported in the landmark 1985 Defense Financial and Investment Review (DFAIR) study.[xiii] On the other hand, return on sales was scored against a 2014 baseline value of 9.85%, the peak value available in a limited data set.

Industry's greater profitability reflects rising levels of corporate profitability throughout the national economy in 2018.[xiv] That year, corporate profits grew by 3.4% across the U.S. economy.[xv] With regards to the defense industry, DoD budget increases for both FY 2017 and FY 2018 boosted corporate returns.[xvi] Global accounting firm Price Waterhouse Coopers estimated record-breaking growth for aerospace and defense companies in 2017 and 2018.[xvii]

## CASH AVAILABILITY



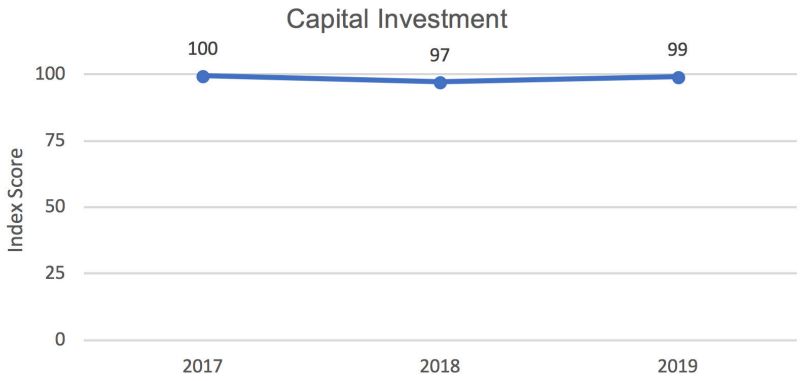

*Source: NDIA*

Increasing four points over 2017, free cash flow scored 100 for both 2018 and 2019. These scores are based on the average free cash flow of $3.5 billion and $2.9 billion for 2019 and 2017, respectively.

Free cash flow signifies the amount of the unobligated cash that is available for discretionary corporate use. Industry uses free cash flow to achieve business objectives such as reducing liabilities, making capital investments, paying dividends, or fortifying savings. The amount of cash assets held on hand can also indicate the quality of a company's fiscal management over time. To assess industry's free cash flow, NDIA estimated a weighted average of the free cash flow reported annually by the top 100 publicly traded defense contracting companies. Free cash flow was scored against industry's free cash flow level for FY 2014 of $3.1 billion.

Industry's rising level of free cash flow follows years of defense budget instability in the aftermath of the 2011 Budget Control Act. Defense contractors traditionally hold high free cash flow levels compared to contractors of other industries, making them more attractive to investors.[xviii] The boost to contractor revenues from the Tax Cuts and Jobs Act of 2017 legislation and recent increases in defense spending have enhanced free cash flow levels. Additionally, in the face of uncertainty about future interest rates, industry has had an incentive to borrow before the Federal Reserve Board increases rates.

## CAPITAL INVESTMENT



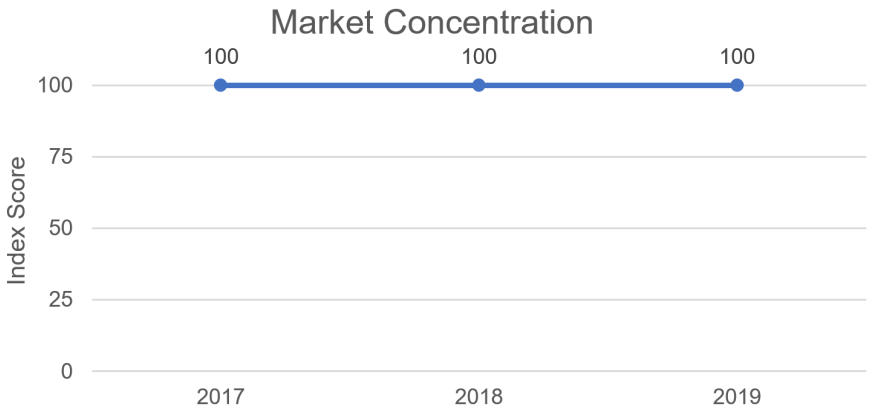

*Source: NDIA*

Industry's capital investment achieved a score of 99 for 2019, which is one point less than its score for 2017. This score is based on the average capital expenditures that were estimated at $1.3 billion.

Capital expenditures describe the amount of money spent on acquiring new plant facilities, durable property, and new capital equipment. Companies procure new capital equipment in order to expand or sustain their productive capacity. As a result, capital expenditure trends reflect evolving expectations about future demand for goods and services such as physical property, equipment, physical plant infrastructure, software, and intangible intellectual property. Capital expenditures were scored against a baseline of $1.34 billion—industry's average capital expenditures for FY 2014.

Average capital expenditures have remained largely stable since FY 2014 despite expectations of an increase in defense spending.[xix] Industry is divided in terms of how firms are to best spend greater cash assets. Although a few prominent firms have targeted capital investment, others seek investment in research and development while some peg extra cash for dividends to investors.[xx]

## MARKET CONCENTRATION



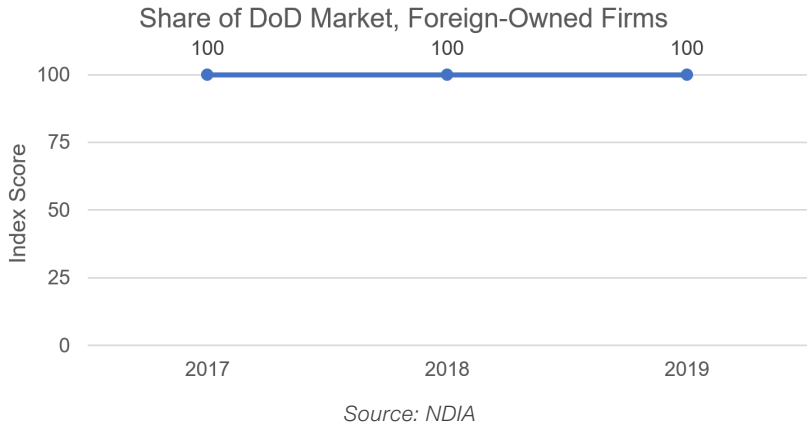

*Source: NDIA*

Industry's level of market concentration scored a 100 for 2019, maintaining its score for three consecutive years. The score is based on NDIA's calculation of the Herfindahl-Hirschman Index (HHI), which yields a relatively low value of 304 out of 10,000. The defense industry score is far below the standard moderate-concentration threshold of 1500 defined by the HHI.

Market concentration delineates the degree to which an industry's business activity is dominated by a few firms. Low market concentration is generally preferable to high market concentration because low-concentration markets feature more competition, leading to lower prices and more frequent innovation. Since the HHI is the standard statistical measure of market concentration, it is widely used among federal policymakers.[xxi] NDIA calculated the HHI using the distribution of total contract obligation dollars between FY 2015 and FY 2019 among the top 100 publicly traded defense contractors.

The steady trend in the score for market concentration indicates that total contract obligation dollars remain widely allocated among contractors despite the large combined market share held by the "Big 6" defense contractors (36%). The high score also suggests a high degree of competition for defense contracting business. With that being said, the outlook on market concentration will differ by sector, sub-sector, industry, and specific industry category.[xxii] Calculating the HHI for companies among the top 100 that specialize in manufacturing results in an HHI value of approximately 800. Limiting the HHI calculation to companies that specialize in aerospace contracts results in an HHI value of nearly 1800. Thus, while the overall market concentration indicates a competitive defense sector, concentration in critical subsectors merit concern.

## FOREIGN OWNERSHIP




*Source: NDIA*

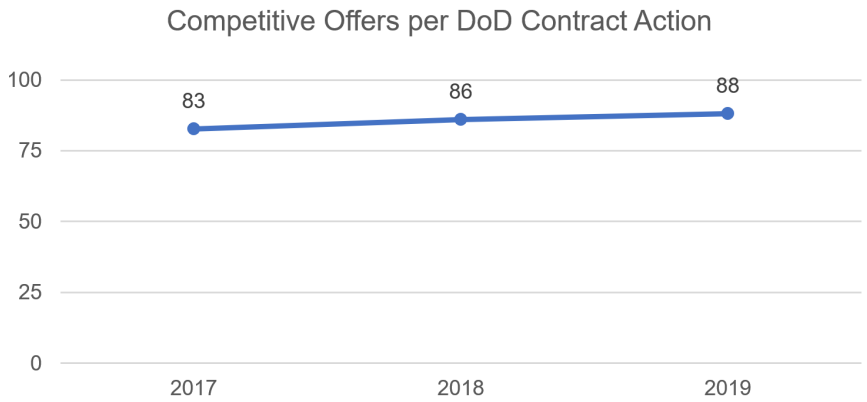
Industry's level of foreign ownership earned a high score of 100 for 2019, equaling its score for 2017 and 2018. This score is based on estimates finding foreign-owned firms receive 2% of the total contract obligation dollars awarded to the top 100 publicly traded contractors.

Foreign-owned defense contracting market share indicates lost economic opportunity for American-owned firms. Defense contracting operates under a set of domestic content restrictions that plainly intend to provide American-owned firms with an

advantage in source selection decisions. Chief among these restrictions, the Buy American Act obligates contracting officials to select domestic end-products for purchases exceeding the micro-purchase threshold. Federal statute 10 USC §2533b requires that specialty metals used in military platforms and weapons systems must have a domestic manufacturing origin. Nevertheless, contracts held by foreign-owned firms indicate a deficit among U.S.-based suppliers, presenting a security vulnerability in defense supply chains because of the greater risk of improper foreign influence or control in the handling of sensitive information. Notwithstanding, foreign-owned firms play an important part in the National Technology and Industrial Base, unifying the productive capabilities of the United States, Canada, Australia, and the United Kingdom. NDIA calculated the score for foreign-ownership based on a historical average of 9.4% reported by the Government Accountability Office in 1981 during the Carter-Reagan military buildup.

The consistent trend in the foreign ownership score among defense contractors indicates that foreign involvement in the U.S. defense industrial base is currently at a historic low. Although the number of contracts awarded to foreign-owned firms may still be historically low, the potential for foreign involvement in supply chains only grows.

## CONTRACT COMPETITION



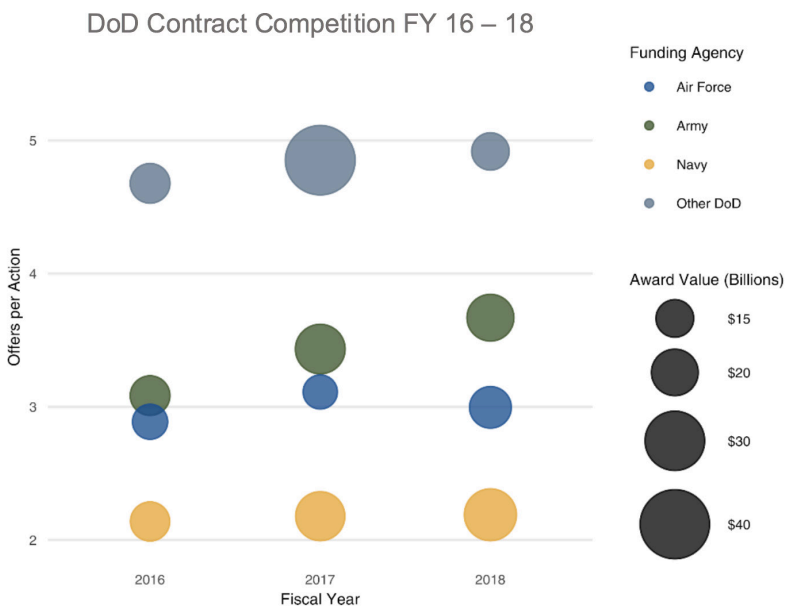

*Source: NDIA*

The intensity of industry competition for defense contracts earned a score of 88 for 2019, which marks a five-point increase over 2017. This score is based on 4.57 competitive offers per DoD contract action submitted by industry.

The number of competitive offers per DoD contract demonstrates the intensity of competition among firms for defense contracts. Many defense contracts are issued without competitive bidding. For example, DoD has awarded 67% of Major Defense Acquisition Programs (MDAPs) on a non-competitive basis.[xxiii] Across the Department, agencies award just 51% of all contracts on a competitive basis.[xxiv] Competitive bidding for contracts helps to improve defense procurement by ensuring that contracting officials have the ability to make a comparative choice. The competitive bidding process can help the government to negotiate better terms and better contract delivery requirements. NDIA's data partner, Govini, analyzed federal procurement data from USASpending.gov to calculate the number of bids received per DoD contract action. The ratios for bids per contract action were scored against a recent peak in 2010 of 5.18 bids received per contract.

This upward trend in the number of bids per DoD contract action means that DoD's contracting processes are growing more competitive under the influence of several potential factors: government preferences, onerous requirements, or a haphazard and poorly constructed acquisition process. Research by the Government Accountability Office has found that service contracts receive more competitive interest on average than products (71% to 43%).[xxv]

With respect to contract competition, the difference per service department is noteworthy as the Department of the Army consistently receives the most bids per contract while the Department of the Navy receives the least. Even more interestingly, the so-called "fourth estate"—the portions of the DoD that are not the military services—received the most bids per contract likely due to the nature of their service.




*Source: Govini*

## CONCLUSION

2019's score of 96 for competition conditions indicates a favorable landscape for firms engaged in the defense contracting market. Competitive bidding improved to a score of 88, increasing five points above its 2017 score. Industry's profitability also scored an 88 on the strength of increasing profits relative to sales and assets. The availability of cash resources for industry gained four points, reaching a score of 100 after 2017's corporate tax cuts legislation and the rise of defense spending in National Defense Authorization Acts (NDAAs)—congressional legislation usually passed annually that establishes new policies and authorities for DoD and the military services—since FY 2016. Scores for capital investment, market concentration, and foreign ownership held constant at or near the scoring upper bound of 100. With additional defense spending increases expected for FY 2020, competition conditions within the defense industrial base are predisposed to continue ahead favorably.

# PRODUCTION INPUTS CONDITIONS

## INTRODUCTION

Defense contractors make use of a variety of goods, services, materials, and cleared skilled labor to deliver successfully on defense contracts. Subject to market and institutional forces, changes in the cost and availability of these production ingredients can have consequences for the final cost to the government, schedule of delivery, and quality of goods and services. This section of *Vital Signs 2020* analyzes statistical indicators that clarify the factors driving the supply side of defense production by presenting indicator scores for common inputs to defense production.

> ***Indicator scores are determined by the ratio of an indicator's average value to a baseline value. Baseline values reflect historical peak values or ideal standard values, which means that they are unique for each indicator. Ultimately, the availability of data in the public domain constrained the selection of baseline values. The overall section score averages variable scores that, in turn, consist of averages of indicator scores, which are capped at 100 to allow for a 0-to-100 scoring scale.***

Moreover, the indicators describe key attributes of defense production inputs, including costs of goods, services, and materials; workforce size, compensation, and diversity, and STEM talent; and security on-boarding capacity. The indicators of costs of goods, services, and materials rely on Producer Price Index (PPI) data from the U.S. Bureau of Labor Statistics. While data for the rare earth price indicator came from Yahoo Finance, data for the indicators of workforce attributes such as total employment, per-worker pay, compensation, diversity, and STEM talent comes from the U.S. Bureau of Labor Statistics and National Science Foundation. Then, indicators describing security on-boarding processes use security clearance process performance data published by the National Industrial Security Program Advisory Council.

**Key takeaways:**

- Overall production inputs conditions scored a 68 out of 100 for 2019
- Well-performing factors: cost of goods, services, and materials; workforce compensation; and STEM talent pool
- Poor-performing factors: workforce size, workforce diversity, and security on-boarding capacity

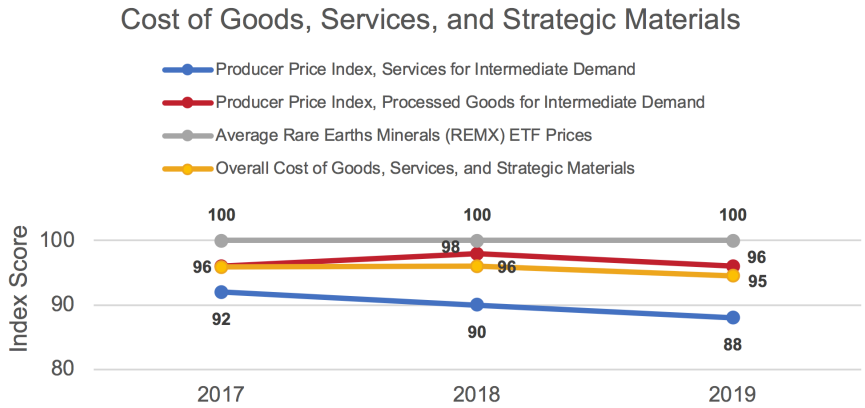
**PRODUCTION INPUTS SCORES**

| Factor | Indicator | 2019 Score | Change, 2017 – 2019 |
|---|---|---|---|
| Cost of Goods, Services, and Materials | Producer price index, services for intermediate demand | 88 | 🟠 -4 |
| | Producer price index, processed goods for intermediate demand | 96 | 🟠 +0 |
| | Average rare earths minerals (REMX) ETF prices | 100 | 🟠 +0 |
| ***Overall Costs of Goods, Services, and Materials*** | | ***95*** | 🟠 ***-1*** |
| Workforce Size | Estimated total defense-related direct employment | 34 | 🟠 +2 |
| ***Overall Workforce Size*** | | ***34*** | 🟠 ***+2*** |
| Workforce Compensation | Estimated average annual per-worker pay, for defense-related employment | 80 | 🟢 +5 |
| ***Overall Workforce Compensation*** | | ***80*** | 🟢 ***+5*** |
| Workforce Diversity | Gender diversity in employment in defense supplier industries | 85 | 🟠 +0 |
| | Racial diversity in employment in defense supplier industries | 75 | 🟢 +8 |
| | Latino ethnicity diversity in employment in defense supplier industries | 40 | 🟠 +0 |
| | Age diversity in employment in defense supplier industries | 100 | 🟠 +0 |

| | | | |
|---|---|---|---|
| ***Overall Workforce Diversity*** | | ***75*** | ***+2*** |
| Workforce STEM Talent Pool | STEM percentage of total U.S. occupational employment | 100 | +0 |
| | STEM degree awards as average share of total degree awards | 100 | +5 |
| ***Overall Workforce STEM Talent Pool*** | | ***100*** | ***+3*** |
| Security On-Boarding | Annual inventory of security clearance investigation cases | 24 | -19 |
| | Duration of initial top secret clearance reviews (days) | 20 | -14 |
| | Duration of periodic top secret clearance reinvestigations (days) | 27 | -28 |
| ***Overall Security On-Boarding*** | | ***24*** | ***-20*** |
| ***Overall Production Inputs Score*** | | ***68*** | ***-2*** |

*Source: NDIA*

## COST OF GOODS, SERVICES, AND STRATEGIC MATERIALS



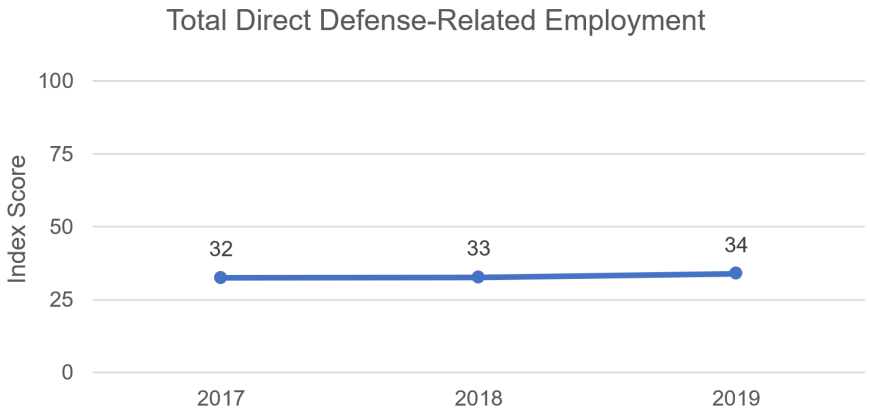

*Source: NDIA*

The cost of goods, services, and strategic materials scored well for 2019, earning a 95. Its score decreased by one point from 2017, illustrating a trend based on increases in the Bureau of Labor Statistics' producer price indices for intermediate goods and intermediate services, which rose to values of 104 and 114, respectively. The one-point score reduction from 2017 to 2019 also reflects a slight decrease in the price of the largest rare earth minerals exchange-traded fund (ETF), which fell $0.82 per share to an annualized price of $16.52 per share.

As defense contractors consume intermediate goods, intermediate services, and materials when fulfilling contracts, the cost of such items affects industry's productive capability. Furthermore, the changing costs of these production inputs can force producers to adapt production plans by either changing the per-unit cost structure of their final products, changing production volumes, or passing additional costs onto clients. The Bureau of Labor Statistics' Producer PPI records average prices experienced by end-producers of goods and services across a single sector. In this way, the PPI of services for intermediate demand captures average prices for services consumed by end-producers to generate final products such as trade, transportation, and information. However, the PPI of processed goods for intermediate demand shows average prices for durable and non-durable goods used in the making of other products. Nevertheless, many high-technology defense systems use rare earth minerals and metals for manufacturing purposes. For this reason, we consulted the Rare Earths/Strategic Metals Exchange Traded Fund (REMX) and its proxy measure of average price activity across all rare earth metals when calculating our rare earths indicator. While both PPI indicators were scored against the default value of 100, the rare earths indicator was scored against a baseline annualized REMX ETF price for 2014 of $25.

In recent years, price growth in materials used for durable manufacturing—a category that includes processed materials like textiles, lumber, metals, and cement—has driven a rising trend in prices for processed goods for intermediate demand.[xxvi] Meanwhile, prices for services for intermediate demand have risen as the result of price growth in transportation services. Another factor contributing to rising commodity prices has been interest rate growth. For example, the federal funds rate increased from 0.5% in Q1 2017 to 2.5% in Q1 2019.[xxvii] U.S. tariffs on foreign goods, particularly steel, have also helped to push the prices of commodities upward.[xxviii]

## INDUSTRIAL WORKFORCE SIZE




*Source: NDIA*

The size of the defense industrial workforce trended slightly upward for 2019, earning a score of 34 after having increased by two points over 2017. This score is based on an NDIA estimate of private employment directly related to defense contracts of approximately 1.1 million.[xxix]

Since the defense industrial base relies on a large labor pool to deliver goods and services for the Defense Department, such trends in defense workforce size provide insight into the evolving availability of workers for defense industrial base production. The size of the defense industrial workforce was baselined against the defense industry's 1985 employment peak value of 3.2 million workers.[xxx]

Since then and especially over the last decade, the defense industrial base has experienced a significant reduction of its employment ranks—a function of declining federal defense expenditures as a percentage of overall GDP, budget instability, and the scaling back of U.S. military commitments in Afghanistan, Iraq, and other Middle Eastern countries. In fact, defense industrial employment fell by 9.4% between 2010 and 2016.[xxxi]

## WORKFORCE COMPENSATION


*Source: NDIA*

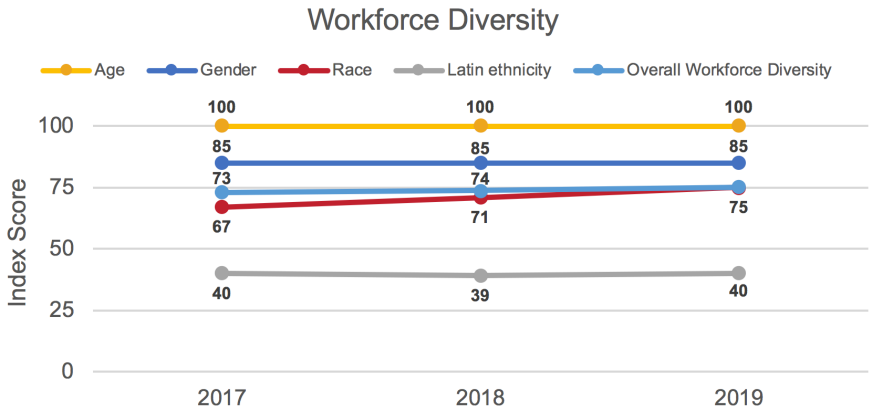
Workforce compensation scored an 80 for 2019, a score that is up five points from 2017 and based on an NDIA estimate of average annual per-worker pay in defense-related industries of approximately $80,243.

Workforce compensation strongly influences the defense industry's ability to recruit talented personnel. While skilled workers make essential contributions to the production of goods and services for defense contracts, trends in the average level of compensation provided to individual industry workers indicate the evolving valuation of their labor. In the case of rising wages—which is generally a very positive development for workers—it can indicate tight labor markets fueling wage escalation. Using wage data from the Bureau of Labor Statistics, NDIA estimated a weighted average of annual pay per worker in defense-related industries to demonstrate the trend in the valuation of talent within the defense industrial base. Average annual per-worker pay

was scored against a baseline value of $100,500, the updated level of annual per-worker compensation during the defense buildup peak of 1985.

Rising defense industry workforce compensation echoes a pattern of rising wages across the U.S. economy, which have risen 22.6% since 2014.[xxxii] This increase resulted from tightening labor markets amid an expanding economy. Consequently, though, the traditional wage premium experienced in manufacturing industries decreased by nearly 6% between 2010 and 2018.[xxxiii]

## WORKFORCE DIVERSITY



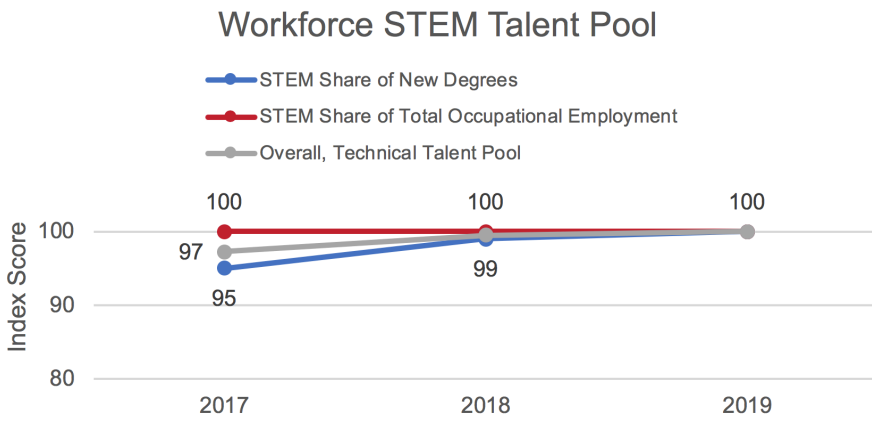

*Source: NDIA*

Workforce diversity scored a 75 for 2019, which marks a two-point increase over 2017. This score is based on NDIA's estimate of the value of Simpson's Diversity Index (SID) for employment in defense-related industries according to age, gender, race, and Latin ethnicity.

Industry's workforce derives its capabilities not only from its size and skills but through its ability to draw from different pools of talent. While diversity correlates to age, ethnicity, gender, and race, a diverse workforce enhances the array and depth of knowledge, skills, and abilities available in the workforce. To assess diversity within key supplier industries, an estimate of SID serves as a valid indicator of diversity among workers employed in important defense-related industries.[xxxiv] Used by biologists to summarize the biodiversity of ecosystems, SID shows the extent to which a particular group or classification dominates a population.[xxxv] Each dimension of diversity was scored against a SID value of 0.5—the threshold for qualifying as a diverse population.

Industry's rising workforce diversity reflects a growing institutional consciousness and, therefore, developing efforts to enhance workforce diversity within defense-related industries. A 2016 Ernst and Young survey found that 54% of human resource professionals at leading global aerospace and defense companies identified the "lack of diversity at different levels of the organization" as the top talent management challenge for the sector.[xxxvi] A 2017 Aviation Week survey of top U.S. aerospace and defense companies identified a surge in the percentage of minorities in the workforce, increasing from 15% to 21% between 2016 and 2017.[xxxvii]

## WORKFORCE STEM TALENT POOL




*Source: NDIA*

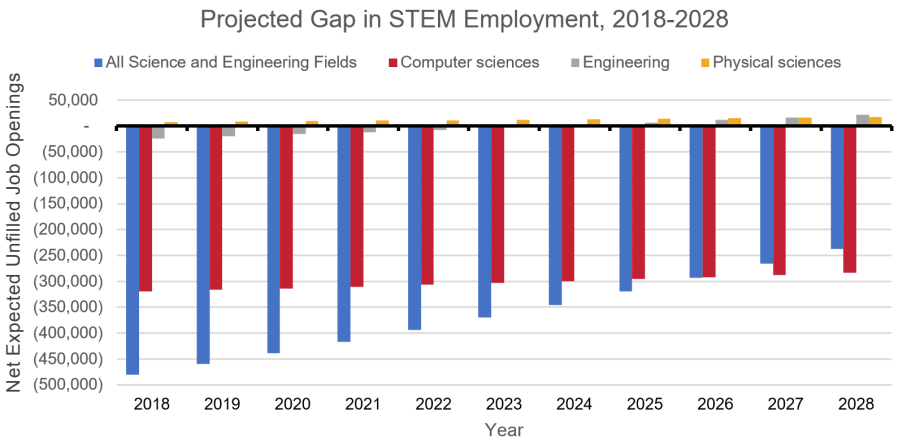
The size of industry's technical talent pool scored 100 for 2019—three points higher than in 2017. This score is a composite of the score for the STEM percentage of U.S. occupational employment and the average annual STEM share of total new degree awards. The 2019 score for the overall technical talent pool uses NDIA estimates of the average annual STEM share of total U.S. occupational employment of 12.4% and of the average annual STEM share of new degrees of 42.4%.

The availability of STEM workers affects the productive capabilities of the defense industrial base because they offer highly valuable though scarce technical skills that are essential for the design, development, and production of complex goods and services. Data from the Bureau of Labor Statistics on the share of STEM workers that comprise total U.S. occupational employment indicates the amount of STEM-trained talent active within the workforce. This percentage was scored against 11.2%, the peak value that the STEM share of employment reached in 2012. National Science Foundation data on the average annual share of total university degrees awarded in STEM fields demonstrates the flow of graduates with STEM degrees into the economy. This indicator was scored against a 2003 peak value of 41.9%.

The upward trend in the size of industry's technical talent pool reflects the influence of several factors. First, more undergraduate students choose STEM majors today than a decade ago.[xxxviii] STEM workers benefit from a wage premium when compared to workers in other industries or groups.[xxxix] Moreover, STEM training yields greater financial benefits even when individuals with STEM training do not enter STEM occupations. Even without special national policy initiatives, the number of bachelor's degree awarded in STEM fields increased by 114,000 each year between 2000 and 2012, setting the country up to achieve the Obama Administration's goal of producing one.[xl] However, such growth in the number of STEM graduates in the U.S. can be partially attributed to foreign students as they make up double the share of U.S. STEM graduates than they did.[xli] For example, between 2008 and 2014, the share of foreign STEM advanced degree students—those holding temporary student visas—grew by 35%.[xlii]

Nevertheless, a vigorous debate has arisen in recent years among industry and government leaders about a deficit of STEM skills in the U.S. workforce. Depending on the field, both shortages and surpluses exist within the STEM workforce.[xliii] Thus, STEM employment faces a paradox in which an expanding pool of STEM graduates fails to keep up with the growing demand for skilled labor while the overall STEM workforce is graying.[xliv] As Harvard economists David Deming and Kadeem Noray have argued, fundamental forces of technological change are at work. Fast-paced technological change makes older cohorts of STEM employees obsolete, changing STEM occupational skill requirements, forcing incumbent workers out of front-line STEM occupations, and increasing companies' STEM worker recruitment needs.[xlv]

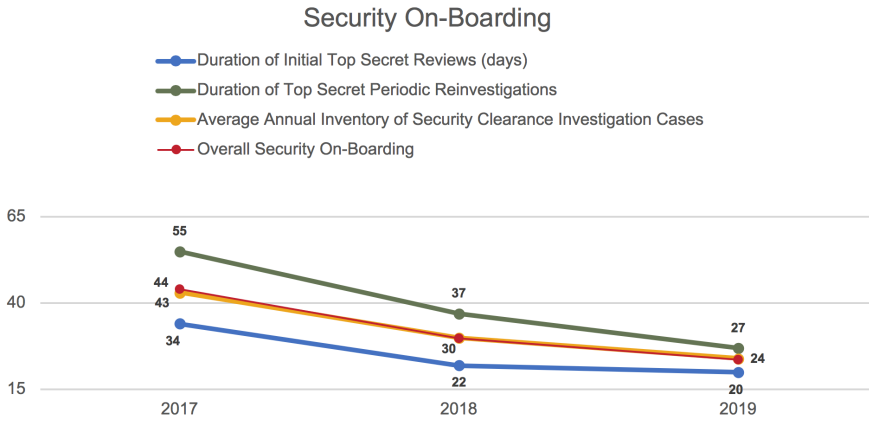
In the aerospace and defense sectors, concerns about the skills gap have focused on the availability of STEM workers for both manufacturing and engineering roles.[xlvi] In fact, a 2018 study of the skills gap by Deloitte and the Manufacturing Institute estimated that 2.4 million open manufacturing positions will go unfilled between 2018 and 2028 due to a lack of available skilled labor.[xlvii] Many defense leaders have issued calls to action to address this sort of STEM skills gap, citing growing shortages of engineers and technicians at a time of technological competition.[xlviii] Many leading defense firms have even invested in helping to grow the pipeline of STEM graduates entering defense engineering and manufacturing fields.[xlix]




*Source: BLS, NSF, NDIA Calculations*

NDIA's analysis of the STEM employment gap finds an overall deficit in the supply of new STEM graduates for expected STEM job openings. However, the deficit varies substantially by field. Each year, the Bureau of Labor Statistics produces a 10-year projection of employment and job openings by occupation. Its current analysis projects 8.8% growth in STEM employment between 2018 and 2028.[i] NDIA estimated the supply of new graduates trained in STEM fields through 2028 by applying the historical compound annual growth rate for annual STEM degree awards (3.66%) to the 2017 STEM degree award totals reported by field by the National Science Foundation.[ii] The "net supply" of new STEM graduates was estimated by subtracting the annual average job openings for STEM occupations from the expected number of new graduates in relevant fields. The resulting data illustrates a total current shortfall of STEM graduates in excess of 400,000 that is mostly driven by a large deficit of computer science graduates. However, the data also exhibits a small surplus of graduates with degrees in the physical sciences. Similarly, the net supply of graduates across all engineering fields reveals a relatively small deficit of 16,000. In this way, NDIA's analysis confirms other recent studies' finding of the STEM employment gap to be real but field specific.

## SECURITY ON-BOARDING




*Source: NDIA*

Federal security clearance processes earned an overall score of 24 for 2019, which is down 20 points from 2017. This score is a composite based on average values for the period of 2016 to 2018: average annual inventory of security clearance investigation cases (664,667 cases); duration of initial top secret clearance reviews (498 days); and duration of periodic top secret clearance reinvestigations (674 days).

On-boarding new personnel in the defense industry often requires navigation of the security clearance process. Access to security clearances affects the availability of skilled workers for the defense industrial base because national security requires some contract-based defense workers to acquire security clearances to be eligible to perform assigned duties. Achieving a permanent security clearance requires an extensive background investigation by law enforcement and security personnel. The capacity and efficiency of the security clearance investigation and issuance process may act as a control on the ability of

defense contractors to fill defense contracting jobs. The National Industrial Security Program Policy Advisory Council (NISPPAC) provides data on the annual inventory of pending cases, the duration of initial top secret clearance reviews, and the duration of periodic top secret clearance reinvestigations. These data points indicate the level of burden placed on the defense industrial base by the security clearance bureaucracy. The average annual inventory of security clearance investigation cases was scored against a baseline from FY 2010 (162,000); duration of initial top secret clearance reviews (100 days); and duration of periodic top secret clearance reinvestigations (180 days).

Industry's security on-boarding challenges reflect bureaucratic obstacles that have emerged over the past few years. In the aftermath of the 2015 cyber breach of the Office of Personnel Management (OPM), Congress established the National Background Investigations Bureau (NBIB) to manage security clearance investigations. However, organizational inefficiencies led NBIB to accumulate a backlog of approximately 725,000 pending investigations. As a result, NBIB reorganized its management of security clearances to cut the caseload nearly in half by the end of FY 2019.[lii] However, Congress mandated that NBIB relinquish its authority for managing security clearances to the Defense Department on October 1, 2019.[liii]

## CONCLUSION

Production inputs demonstrated increasingly poor conditions with an overall 2019 score of 68 after having decreased by two points from 2017. The deteriorating performance of the security clearance system led to a low 2019 score of 24 for security on-boarding, a key limiting factor in the defense industry's access to skilled labor. Meanwhile, the costs of goods, services, and materials scored a 95 for 2019 even though rising prices for intermediate services drove the score down one point from 2017. By contrast, other factors' scores gained points. Workforce diversity improved by two points, driven primarily by an eight-point improvement in its racial diversity. The skilled workforce pool scored a 100, rising by three points as a result of an expansion of STEM-trained graduates and workers drawn to the compensation premium associated with STEM jobs and educational backgrounds. Whether this downward trend for overall production inputs continues will depend on both emerging patterns in prices and the success of reforms to the security clearance investigation system.

# DEMAND CONDITIONS

## INTRODUCTION

DoD's demand for defense goods and services powers production and investment in the defense industrial base. As recent history has shown, changes in the volume and composition of DoD's purchasing of goods and services drives corresponding change in which firms participate in the defense industrial base, what they produce, and their role in supply chains. This section of the report presents analysis of major trends in DoD's contract demand and its impact on industry while offering scores for indicators of government demand for defense goods and services.

> ***Indicator scores are determined by the ratio of an indicator's average value to a baseline value. Baseline values reflect historical peak values or ideal standard values, which means that they are unique for each indicator. Ultimately, the availability of data in the public domain constrained the selection of baseline values. The overall section score averages variable scores that, in turn, consist of averages of indicator scores, which are capped at 100 to allow for a 0-to-100 scoring scale.***

Overall, the annual total amount of DoD contract obligations serves as the main indicator of demand. This indicator combines the total value of new DoD procurement contract awards, RDT&E (research, development, testing, and evaluation) contracts, and foreign military sales contracts. This analysis was provided by Govini, who calculated total contract obligation values based on its custom federal contracting dataset.

**Key takeaways:**

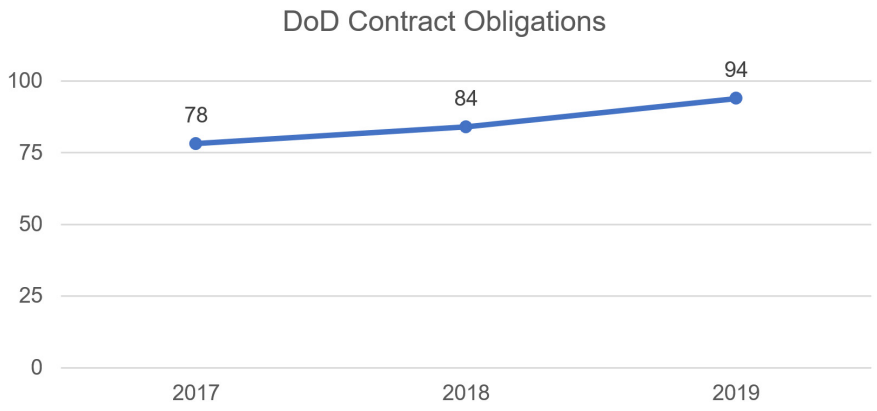
- Demand conditions scored a 94 for 2019
- Overall DoD contract obligation volume has surged with DoD budget growth
- While growth in total contract obligation value for construction (40%) led all service categories, growth in total contract obligation value for sustainment supplies and equipment (39%) led all product categories
- Total contract value of foreign military sales for major defense platforms, logistics management services, knowledge-based services, medical services, and equipment-based services grew by 100% or more between FY 2016 and FY 2018
- The lowest amount of growth in the total contract obligation value occurred in major platform acquisition (11%) and medical services (4%); for foreign military sales, the lowest amount of growth occurred in construction services (-77%) and electronic and communications equipment (-17%)

**DEMAND SCORES**

| Factor | Indicator | 2019 Score | Change, 2017 – 2019 |
|---|---|---|---|
| Demand for Defense Goods and Services | DoD contract obligations | 94 | ● +16 |
| ***Overall Demand for Defense Goods and Services*** | | ***94*** | ● ***+16*** |
| ***Overall Demand Score*** | | ***94*** | ● ***+16*** |

*Source: NDIA*

# DEFENSE DEPARTMENT CONTRACT OBLIGATIONS



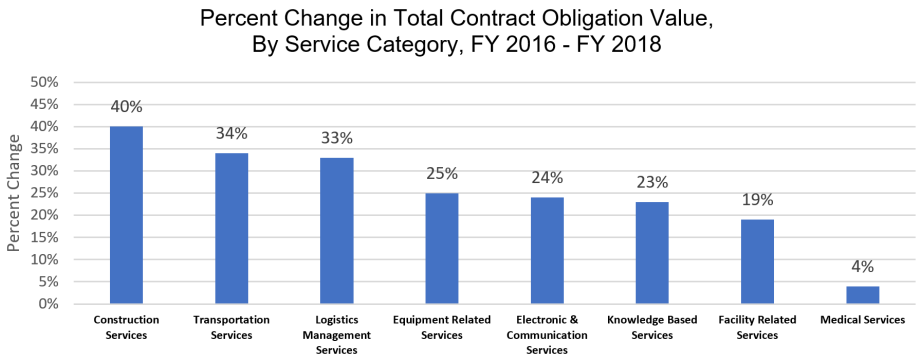

*Source: NDIA*

DoD's contract obligation volume scored a 94 for 2019, trending upward by 16 points over 2017. This score is based on the rise of DoD contract obligations to $368.7 billion in FY 2018—an increase of $61.9 billion over 2016.

As the nation's sole buyer of defense goods and services, and the largest such buyer in the world, the Defense Department and its annual total of contract obligations provide the best indication of the demand for defense goods and services. Contract awards drive production activity throughout industry as it relies on consistent demand from DoD to justify any investment in the productive capacity required to fulfill contracts and compete effectively for future awards. Due to a limited amount of data available from the Carter-Reagan buildup era, annual DoD contract obligations were scored against 2008's baseline value of $392.5 billion—the highest peak in contract obligation volume since the Cold War.

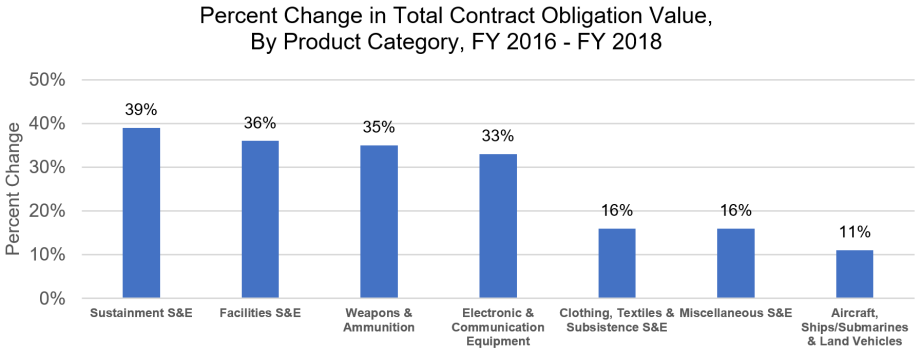
DoD's accelerating overall budget growth since FY 2016 has driven its increasing contract obligation volume. In fact, DoD's budget authority has increased over five consecutive fiscal years—FY 2016 to FY 2020—from $596 billion to $738 billion (current dollars, including overseas contingency operations funding).[liv] Similarly, DoD's contract obligations increased from $304 billion in FY 2016 to $402 billion in FY 2019. However, the growth in contract obligations has neither been constant nor always trending upward. While the annualized average increase in DoD contract obligations between FY 2000 and FY 2008 was +11.5%, contract obligations declined by an annualized average of 6.5% between FY 2008 and FY 2015.[lv] Since FY 2015, contract spending has increased by an annual average of 6%.[lvi]

Such budget growth for DoD is related to bipartisan consensus on the need to repair the military from the 2013 sequestration and to fully engage in great power competition. In its FY 2020 budget proposal, DoD explained the recent series of budget increases as a transition from shoring up near-term readiness and recovering from years of budget instability to making far-reaching strategic investments in innovation and modernization to secure long-term competitive advantages against adversaries.[lvii] Growing concern about the health of the nation's manufacturing and defense industrial base have also contributed to budget increases. By sounding the alarm about key defense supply chain vulnerabilities, the 2018 Executive Order 13806 report helped justify increased DoD contract obligation authority and procurement authority as a means of protecting critical defense supply chains.[lviii] The report also specifically identified budget spending caps imposed in 2013 as having harmed manufacturers by inducing mergers and acquisitions while reducing DoD's sourcing options.[lix] Growing consciousness among policymakers of a new strategic landscape, crystallized in the 2018 National Defense Strategy's declaration of an "era of great power competition," has also guided defense budgeting.[lx] According to analysis by Govini, President Trump's FY 2020 defense budget request showed clear evidence of rebalancing resources to enhance support for priority capability areas identified in the National Defense Strategy.[lxi]



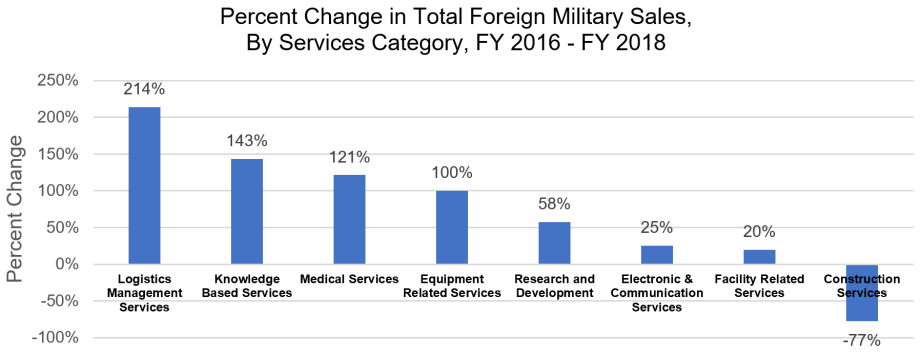

*Source: Govini*

This new period of rising contract obligation volume has created relative winners and losers among product and service categories. Among service contract categories, the largest increases occurred for construction (40%), transportation (34%), and logistics management services (33%), although combined these heavy industry categories account for less than 18% of all service contract obligation value awarded between FY 2016 and FY 2018. Knowledge-based services, which is the largest service contract category by constituting nearly 25% of all service contract obligation awards, received a proportional 23% increase in contract obligation value. At 4%, medical services attracted the lowest increase in total contract obligation value despite holding 10% of all service contract obligation value.



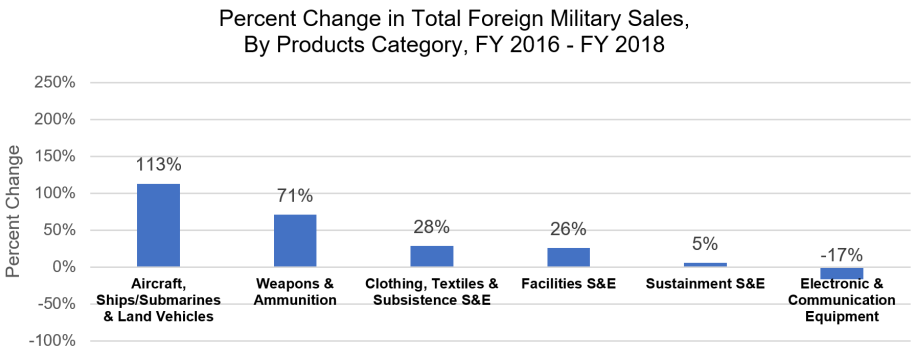

*Source: Govini*

Among product categories, sustainment (39%), facilities (36%), weapons and ammunition (35%), and electronic and communication equipment (33%) gained the most in total contract obligation value. Although major defense platforms (aircraft, ships, and land vehicles) account for 35% of product total contract obligation value awarded between FY 2016 and FY 2018, the category gained only 11% during that same period.




*Source: Govini*

Trends in foreign military sales (FMS) also reveal winners and losers. Several service categories gained heavily in FMS. For example, FMS involving logistics management services more than tripled in awarded contract value during the period between FY 2016 and FY 2018. Meanwhile, FMS involving knowledge-based services, medical services, and equipment-related services more than doubled in value. By contrast, construction services lost 77% of its FMS award value.




*Source: Govini*

Platforms and weapons systems led the growth in FMS among all product categories from FY 2016 to FY 2018: FMS of aircraft, ships, and land vehicles grew by 113% while FMS contracts for weapons and ammunition grew by 71%. Not surprisingly, these two categories accounted for 66% of all foreign military sales by FY 2018. On the opposite end of the spectrum, FMS of electronic and communication equipment declined by 17%, suggesting a declining international market for American defense-related electronics systems.

## CONCLUSION

DoD's demand for defense goods and services has trended sharply upward since 2017, rising by 16 points to a score of 94 for 2019. In general, demand for industrial output has improved because of DoD budget growth driven by bipartisan consensus on the need to reverse negative consequences from years of austere defense fiscal spending caps. Additional support for increased defense spending has come as a result of the National Defense Strategy's definition of the current strategic environment as one of "great power competition."[lxii] Among service procurement categories, construction services grew by 40% in new contract value while sustainment increased the most among supplies and equipment categories at 39%. Foreign military sales boomed among logistics management services (214%) and major hardware systems such as aircraft, land vehicles, and ships (113%).

# INNOVATION CONDITIONS

## INTRODUCTION

The United States' national defense strategy has long looked to industry and the national innovation system to maintain the nation's technological supremacy. Technology-intensive manufacturing services and industries form the backbone of DoD's technology supply chains. Understanding the trends in the innovation inputs and outputs from these industries illuminates the state of the defense industrial base's innovation capabilities.

> ***Indicator scores are determined by the ratio of an indicator's average value to a baseline value. Baseline values reflect historical peak values or ideal standard values, which means that they are unique for each indicator. Ultimately, the availability of data in the public domain constrained the selection of baseline values. The overall section score averages variable scores that, in turn, consist of averages of indicator scores, which are capped at 100 to allow for a 0-to-100 scoring scale.***

This section of the report presents scores for indicators of industrial innovation activity that describe key attributes such as the inputs, output, and international competitiveness of industrial innovation. Indicators of both innovation inputs and outputs are based on industrial R&D expenditures and annual patent applications obtained from National Science Foundation data. Indicators of innovation competitiveness employ patent data from the World Intellectual Property Office (WIPO) in addition to comparative international expenditures data from the Organization for Economic Cooperation and Development (OECD).

**Key takeaways:**

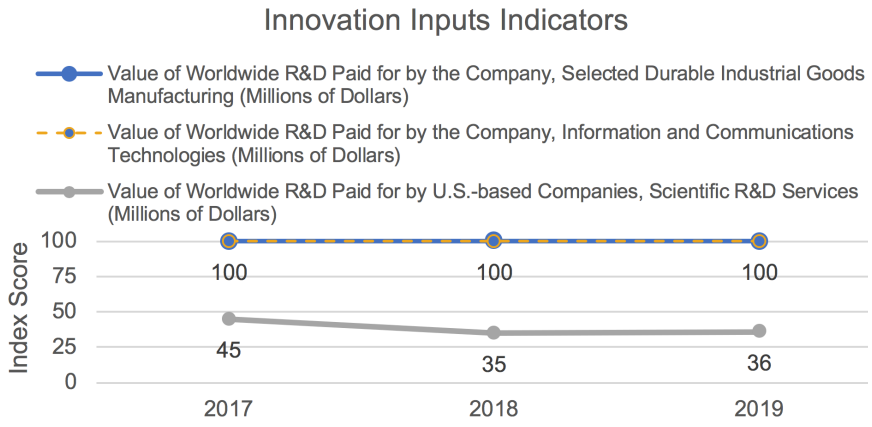
- Innovation conditions scored a 74 for 2019
- Declining innovation investment and productivity in scientific/basic R&D have driven innovation conditions downward
- Well-performing factors: none
- Poor-performing factors: innovation inputs, innovation outputs, and innovation competitiveness

**INNOVATION SCORES**

| Factor | Indicator | 2019 Score | Change, 2017 – 2019 |
|---|---|---|---|
| Innovation Inputs | Average annual value of worldwide R&D paid for by U.S.-based companies, selected durable industrial goods manufacturing industries | 100 | ● +0 |
| | Average annual value of worldwide R&D paid for by U.S.-based companies, information and communications technologies | 100 | ● +0 |
| | Average annual value of worldwide R&D paid for by U.S.-based companies, scientific R&D services | 36 | ● -9 |
| ***Overall Innovation Inputs*** | | ***79*** | ● ***-3*** |
| Innovation Outputs | Average annual patent applications, durable industrial goods manufacturing | 100 | ● +0 |
| | Average annual patent applications, information and communication technologies goods and services | 79 | ● +4 |
| | Average annual patent applications, scientific R&D services | 37 | ● -21 |
| ***Overall Innovation Outputs*** | | ***72*** | ● ***-21*** |
| Innovation Competitiveness | U.S. share of international patent applications | 69 | ● -8 |
| | U.S. share of global R&D investment | 74 | ● -2 |
| ***Overall Innovation Competitiveness*** | | ***72*** | ● ***-4*** |
| ***Overall Innovation Score*** | | ***74*** | ● ***-4*** |

*Source: NDIA*

# INNOVATION INPUTS



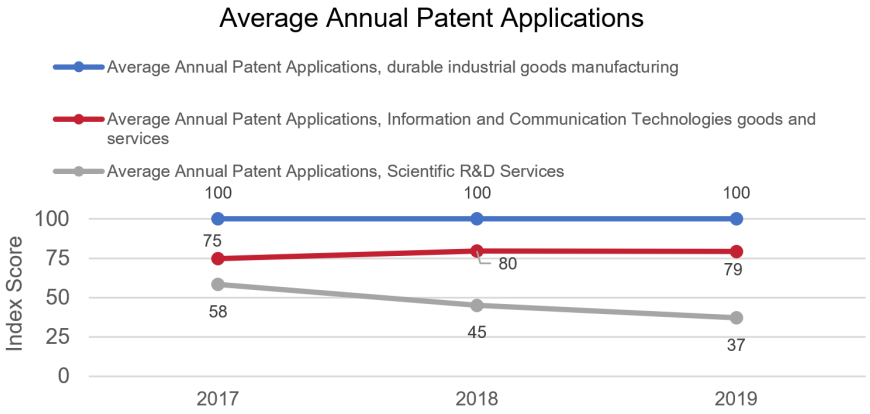

*Source: NDIA*

Innovation inputs scored a 79 for 2019, which illustrates a decline of three points from 2017. This score is based on a combination of three indicators related to worldwide research and development spending by U.S.-based companies in durable goods manufacturing, information and communications technology industries, and specialized R&D services. According to the National Science Foundation's most current data, American companies in these industries spent an average of $71.9 billion, $162.4 billion, and $4.7 billion, respectively, between 2014 and 2016.

Industrial investment in innovation plays an important role in advancing defense technology. Companies fund internal and external research and development projects to discover and develop profitable new products, services, and methods. Corporate R&D efforts can leverage unique talent, resources, and incentives to pioneer technical solutions with military applications. As a result, private industry often holds technical knowledge and skill advantages over government researchers, making their research activities more indicative of the leading-edge of science and engineering. Trends in worldwide corporate R&D spending indicate changes in the amount of effort focused on achieving broad, breakthrough technologies. Worldwide corporate R&D investment in durable goods manufacturing, information and communications technologies, and scientific R&D services was scored against a 2008 investment baseline—the most recent historical peak.

The trends for innovation inputs shown in this report suggest a divergence in the resourcing of traditional industrial sources of defense technology innovation. While durable goods manufacturing and information and communications technologies experience high levels of innovation investment, scientific R&D services experience dwindling investment. This split may be caused by the devaluing of investment in basic research in both the U.S. public and private sectors.[lxiii] The scientific R&D services industry includes the activities of organizations performing experimental scientific—rather than engineering-related—research. This grouping includes universities, independent research institutes and consortia, along with corporate and other private laboratories. A 2019 report by the Task Force on American Innovation declared that the U.S. "risks falling perilously behind in the basic scientific research that drives innovation" as the result of both declining federal support for basic scientific research and intensifying global competition in basic research.[lxiv] The Task Force also noted that U.S. basic research investment suffers from an imbalance that weighs disproportionately in favor of biotechnology and life sciences, which shortchanges mathematics, computer science, and the physical sciences. The continuing decline of corporate-funded basic research has left universities as the last bastion of innovation-oriented basic research and as hubs of increasingly complex innovation ecosystems.[lxv] However, a growing body of research suggests university-centered innovation ecosystems lack the productivity of earlier innovation systems in which industry played a larger role in funding and performing basic research.[lxvi]

## INNOVATION OUTPUTS



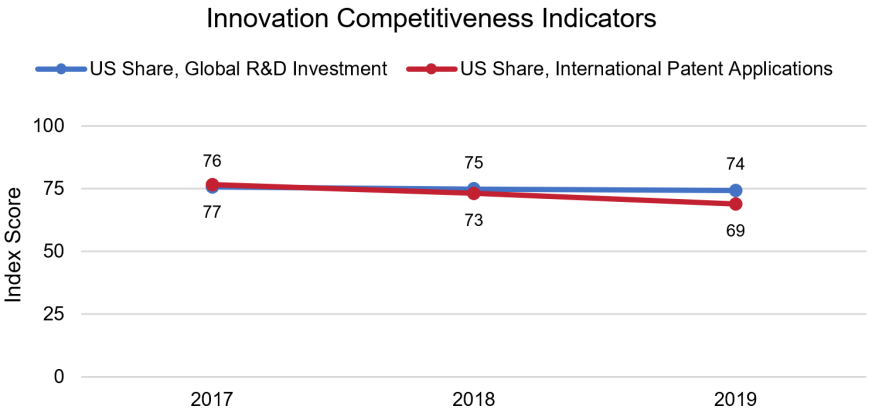

*Source: NDIA*

Innovation outputs earned a score of 72 for 2019—21 points less than in 2017. This score is based on a combination of three indicators related to annual patent application filings for inventions associated durable goods manufacturing, information and communications technologies, and scientific R&D services. For the most recent three years of data, average annual patent applications submitted between by Americans for durable industrial goods totaled 41,064; 51,309 for information and communications technologies; and 2,623 for scientific R&D services.

To assess industrial innovation output, NDIA understood output as how well the U.S. innovation system generates new inventions. Inventions are new technical solutions to problems and lie at the heart of innovation. Innovation processes generate new "market-ready" goods, services, and processes for usage. As patent applications provide one standard way of tallying innovation productivity, they serve as a useful measure of innovation productivity while helping to identify new technical inventions with potential commercial benefits. By contrast, patent issuances include only those innovations that qualify for a patent and, therefore, do not effectively represent all productive innovation output. Average annual patent application totals were scored against their respective 2008 value: 61,181 for durable goods manufacturing; 123,063 for information and communication technologies; and 13,095 for scientific R&D services.

Akin to the trends for innovation inputs, the trends for average patent applications show a divergence between applications submitted for inventions in durable goods manufacturing or information and communications technologies and applications submitted in the scientific R&D services category. Essentially, the decline in industry investment in scientific R&D services correlates with declining innovation output activity.

## INNOVATION COMPETITIVENESS




*Source: NDIA*

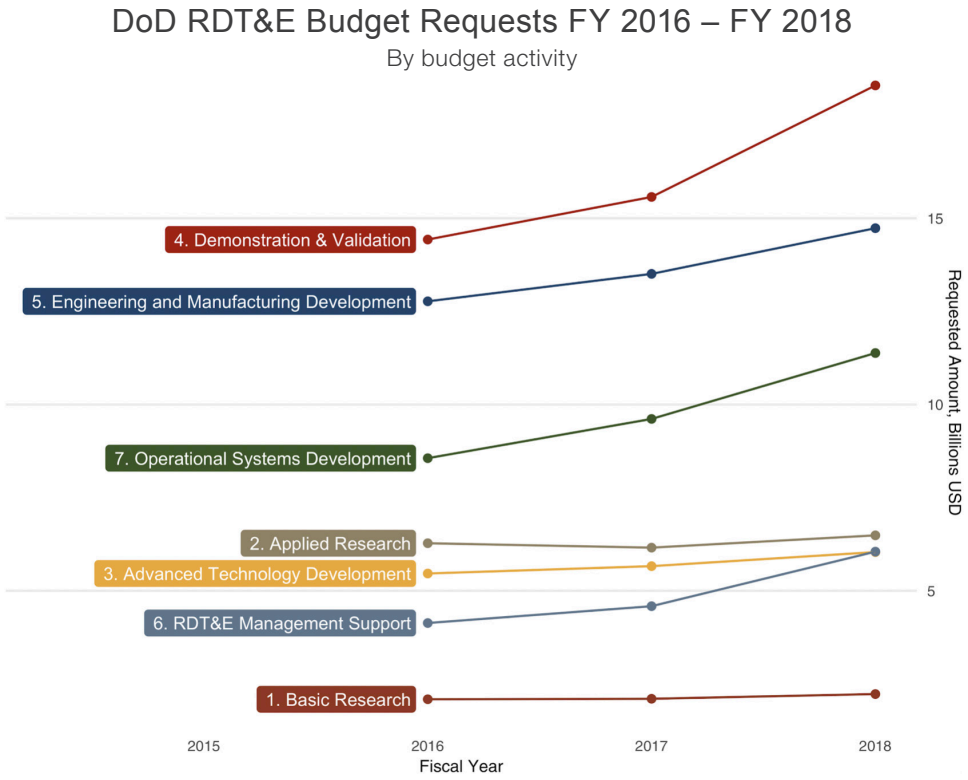
Innovation competitiveness scored a 72 for 2019, which is four points down from 2017 and based on the overall U.S. share of both global R&D investment at 28% and global patent applications at 16%.

Industrial innovation activity occurs within a global context. Assessing the competitiveness of the U.S. industrial innovation system requires comparison with international competitors. The international arena of innovation has changed radically over the past decade as China, nations in the European Union, and other dynamic economies challenge the U.S. in global innovation performance.[lxvii] The scale of U.S. innovation inputs and outputs with respect to that of competitor nations provides insight into the capability of U.S. industry to achieve a leading position in emerging technologies. For this report, the U.S. share of global patent applications was scored against a baseline value of 23% that was reached in 2007 and serves as the post-1980 peak value. Additionally, the U.S. share of global R&D investment was scored against a baseline peak value of 38.3% that was achieved in 2001.[lxviii]

The steady erosion of investment in the government-universities-industry "innovation triangle" pioneered during World War II has contributed most to America's recent innovation decline. Walter Isaacson of the Aspen Institute points out that U.S. investment in basic research at university and federal laboratories has declined for a generation while China has made radical investments in its own "innovation triangle."[lxix] In 2017, federal R&D spending as a share of the gross domestic product (GDP) fell to its lowest level since 1955.[lxx] Comparatively, China's public sector investment in R&D increased by 50% between 2011 and 2016.[lxxi] Unsurprisingly, Chinese entities now file nearly 50% of all patent applications submitted worldwide.[lxxii] Although the United States' position relative to its past peaks may be slipping, its innovation system remains highly competitive. In 2018, the World Economic Forum ranked the U.S. innovation system first among 140 countries, describing it as "the closest economy to the frontier."[lxxiii] Then, the World Intellectual Property Organization's Global Innovation Index 2019 rankings placed the U.S. as third out of 129 countries.

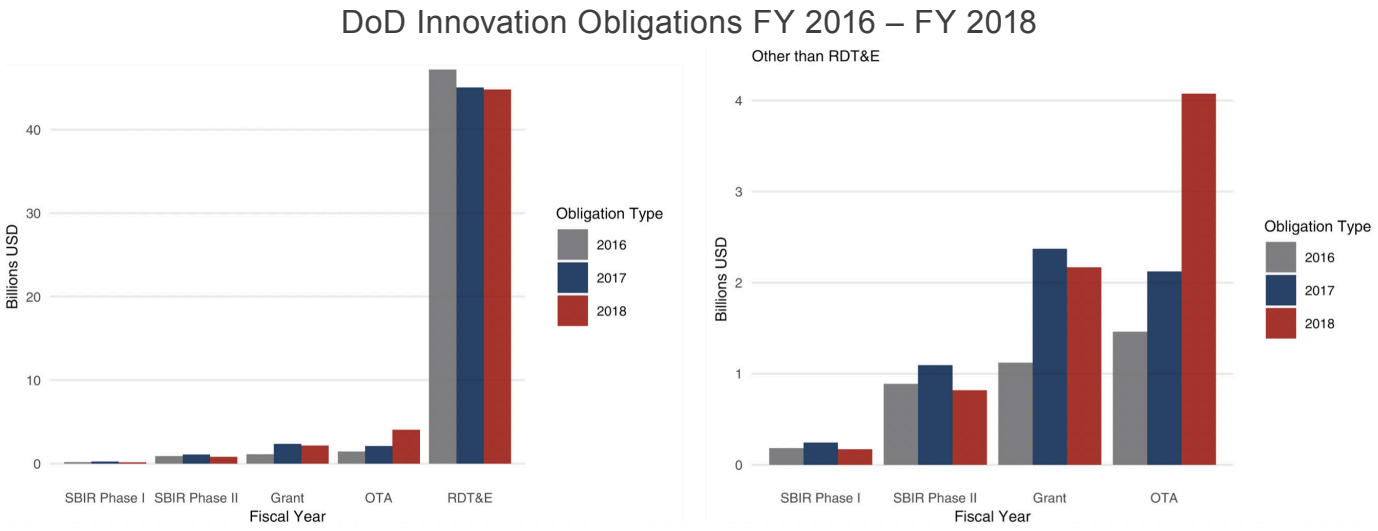
## TRENDS IN DEFENSE DEPARTMENT INNOVATION SPENDING

Defense Department innovation spending patterns provide another useful lens for understanding innovation trends. Trends in DoD innovation spending and defense contracting entrepreneurship are consistent with the other innovation trends previously presented. Since FY 2016, DoD's Research, Development, Test, and Evaluation (RDT&E) budget requests have shown a clear growth trend with that of FY 2020 being the department's largest in 70 years. Budget request growth is concentrated in later-phase RDT&E activities while earlier-stage activities—basic research in particular—remained largely static. In DoD's FY 2020 budget request, earlier-stage activities declined by approximately $1 billion. The department's RDT&E requests have targeted investment in developing usable capabilities in emerging technologies.



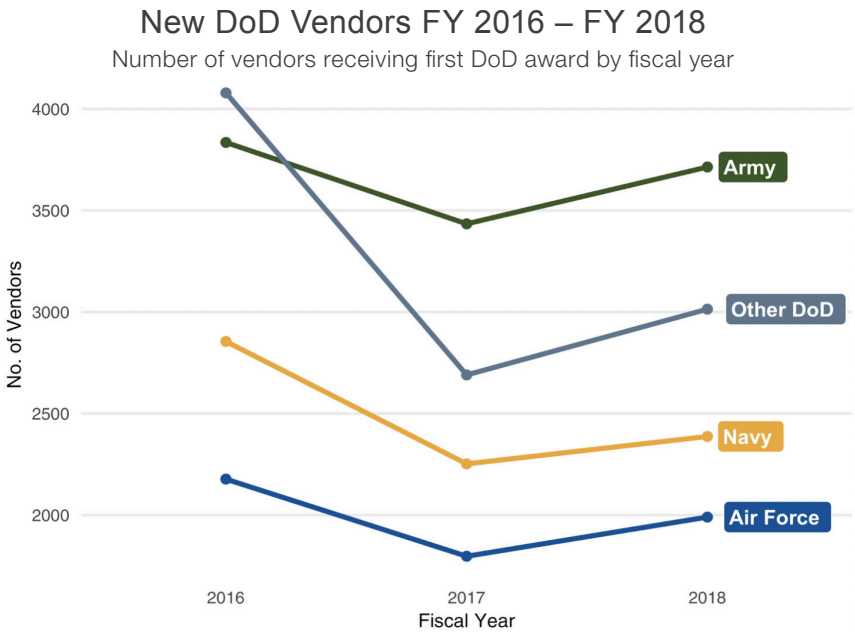

*Source: Govini*

DoD has shown increased interest in using alternative contracting authorities for its innovation investments. Although RDT&E contract obligations dominated DoD innovation spending between FY 2016 and FY 2018, obligations made through an Other Transaction Authority (OTA) sharply increased. OTA entails special procurement authority that enables DoD to conduct certain types of prototyping, applied research, and product development activities for non-contract and non-grant agreements. OTA obligations grew by 279% from FY 2016 to FY 2018. By comparison, Small Business Innovation Research (SBIR) awards and direct research grants declined or fluctuated over the same period.




*Source: Govini*

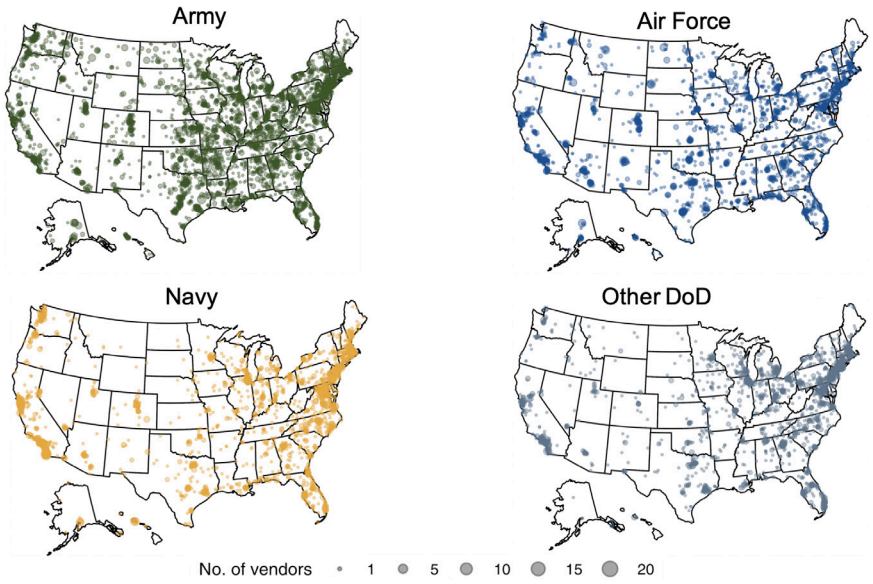
Despite rising DoD innovation expenditures, the trend in new defense contracting entrepreneurs is declining. The number of new entrants into the defense contracting market decreased between 2016 to 2018, going from 14,224 to 12,242—a drop of 14%. "Fourth estate" (other DoD) agencies witnessed a reduction in new vendor awards of 26%, from 4,181 in FY 2016 to 3,084 in FY 2018. Among the services, the Navy experienced the largest decrease in new vendors, falling by over 16%. The Air Force and the Army followed with decreases of 8% and 4%, respectively. This trend suggests that, despite the recent increase in DoD innovation funding and the growing use of faster, more flexible alternative acquisition pathways, the defense contracting market continues to lack attractiveness to non-traditional vendors.




*Source: Govini*

With that being said, thousands of new vendors are currently entering the larger DoD supply chain all over the country. New Army vendors are the most widely dispersed of the services with distinct concentrations across the Midwest, the Deep South, and California. The Northeast has originated the largest regional concentration of new Air Force vendors. The Navy has experienced new vendors emerge in high concentrations around its large coast bases and ports in Washington, California, Florida, and New England. New vendors to DoD "fourth estate" agencies are concentrated in major population centers.

Entrepreneurship Trends: The Geogaphy of New DoD Vendors, FY 2016 – FY 2018




*Source: Govini*

## CONCLUSION

Industrial innovation conditions are poor and trending downward. Overall conditions scored a 74 for 2019, which is four points fewer than in 2017. Corporate investment in industrial research and development in defense-related industries scored a 79—a decline of three points. Meanwhile, innovation output in the form of patent applications from defense-related industries scored a 72, which is 21 points lower than its 2017 score. Innovation competitiveness also fell by four points from 2017, attaining a score of 72 for 2019. Falling innovation investment and output coming from scientific R&D services industries, typically focused on basic research, is a key driver of decline in the innovation system.

# INDUSTRIAL SECURITY CONDITIONS

## INTRODUCTION

Good industrial performance requires secure business operations. Industry faces persistent threats of intellectual property (IP) theft, economic espionage, cybercrime, and the loss of data necessary for production integrity or operational security. Trends in the scale and severity of these threats indicate the future seriousness of industrial security challenges.

> ***Indicator scores are determined by the ratio of an indicator's average value to a baseline value. Baseline values reflect historical peak values or ideal standard values, which means that they are unique for each indicator. Ultimately, the availability of data in the public domain constrained the selection of baseline values. The overall section score averages variable scores that, in turn, consist of averages of indicator scores, which are capped at 100 to allow for a 0-to-100 scoring scale.***

This section of *Vital Signs 2020* presents scores for indicators of industrial security. Industrial security indicators describe factors such as threats to IP rights (IPR) and cybersecurity vulnerabilities. Indicators of threats to IP rights rely on data from the Federal Bureau of Investigation's (FBI) annual tabulations of intellectual property rights investigations. Indicators of cyber threats analyze data points and severity ratings of reported cyber vulnerabilities that are based on data provided by both the National Institute of Standards and Technology and the MITRE Corporation's Common Vulnerabilities and Exploits tracking project.

**Key takeaways:**

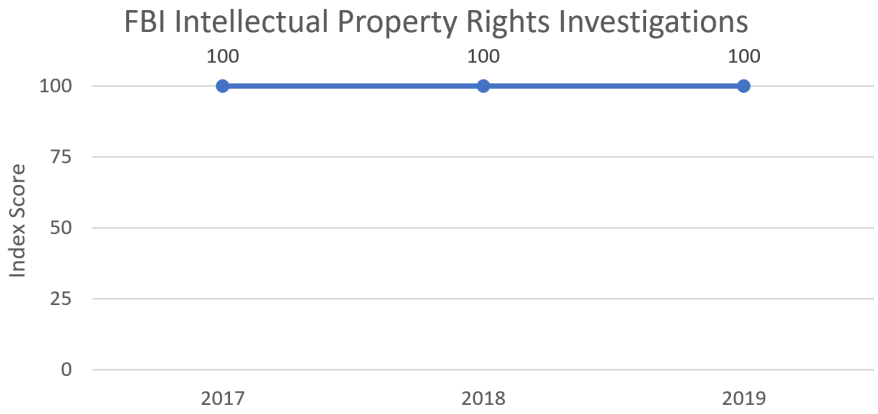
- Overall industrial security conditions scored a 63 for 2019
- Well-performing factors: threats to IP rights
- Poor-performing factors: threats to information security

**INDUSTRIAL SECURITY SCORES**

| Factor | Indicator | 2019 Score | Change, 2017 – 2019 |
|---|---|---|---|
| Threats to IP Rights | New FBI intellectual property rights violation investigations | 100 | ● +0 |
| ***Overall Threats to IP Rights*** | | ***100*** | ● ***+0*** |
| Threats to Information Security | Average annual newly reported common IT vulnerabilities | 33 | ● -27 |
| | Severity of newly reported common IT vulnerabilities | 17 | ● +1 |
| ***Overall Threats to Information Security*** | | ***27*** | ● ***-14*** |
| ***Overall Industrial Security Score*** | | ***63*** | ● ***-6*** |

*Source: NDIA*

## THREATS TO IP RIGHTS




*Source: NDIA*

FBI intellectual property rights investigations scored a 100 for 2019—the same as in 2017. This score is based on an annual average of 51 new FBI IPR investigations between 2016 and 2018 while the frequency of such investigations has continuously decreased since 2011.

Intellectual property rights form the foundation of profitability for companies in information-intensive, high-technology industries. Threats to intellectual property rights have proliferated, endangering the ability of companies to realize the full economic benefit of their investments to create intellectual goods and services. By one estimate, IPR-related crime steals $600 billion from the U.S. economy each year.[lxxiv] Companies' perception of IP risk shapes their willingness to invest in research, development, and commercialization activities. It also compels investment in costly information security protections.

**FBI INTELLECTUAL PROPERTY RIGHTS INVESTIGATIONS**

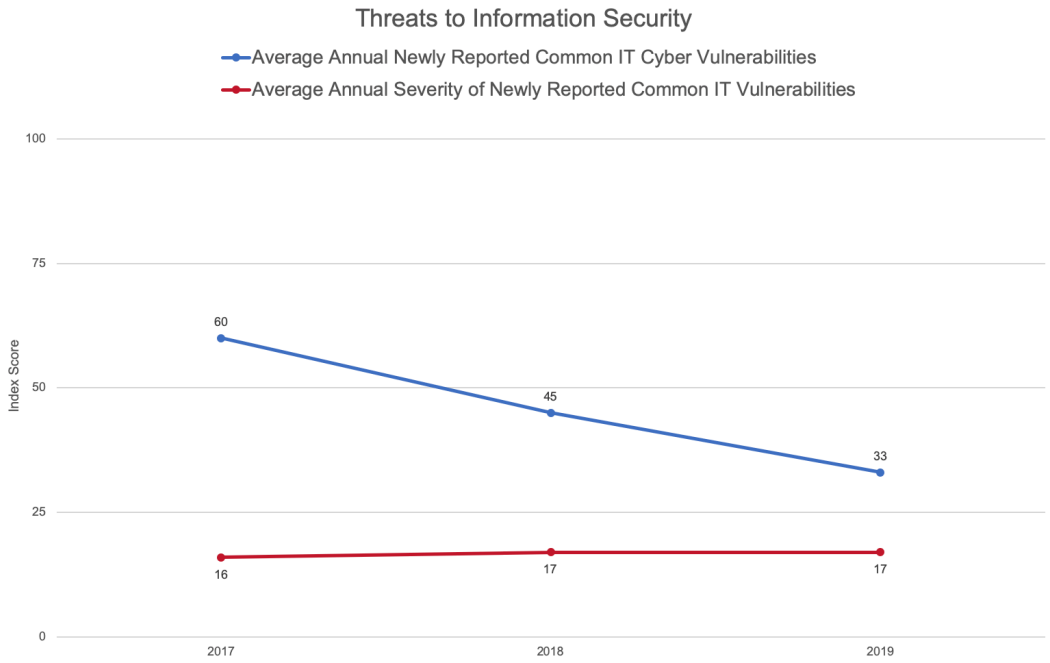
| | 3-year average period | | |
|---|---|---|---|
| | 2014 – 2016 | 2015 – 2017 | 2016 – 2018 |
| Average new FBI intellectual property rights investigations | 63 | 54 | 51 |

*Source: US Department of Justice; NDIA calculations*

FBI statistics on intellectual property rights investigations provide valuable insight into trends of threats to intellectual property. Every year since 2008, the FBI has publicly reported counts of its investigative activity into intellectual property rights crime. The FBI IPR investigation statistics include cases covering trade secrets theft, goods counterfeiting, and copyright or trademark infringement with a national security impact or a link to organized crime. The FBI IPR investigations indicator was scored against the 235 cases launched in 2011, the peak number of new cases since reporting began.

Multiple factors drive this trend. To begin, improved coordination with other federal law enforcement entities may have reduced the FBI's caseload. While the FBI shares intellectual property rights enforcement responsibilities with more than 20 other federal agencies, it collaborates on investigative activities through the National Intellectual Property Rights Coordination Center hosted by the Department of Homeland Security. The IPR Center de-conflicts—identifies and eliminates duplications of effort—thousands of investigations each year. This coordination may have led to fewer FBI IPR cases. The Commission on the Theft of American Intellectual Property, co-chaired by Admiral (Ret) Dennis Blair and former Intel CEO Craig Barrett, identified a decline in cyberattack volume from China since 2014 that coincides with increased efforts by U.S. and Chinese authorities to prevent and deter some Chinese cyber criminals.[lxxv] The commission also provided evidence that China, which is the largest source of IPR criminal activity, has become more serious about introducing legal reforms to strengthen IP protections domestically in order to support IP-intensive native industries.

# THREATS TO INFORMATION SECURITY

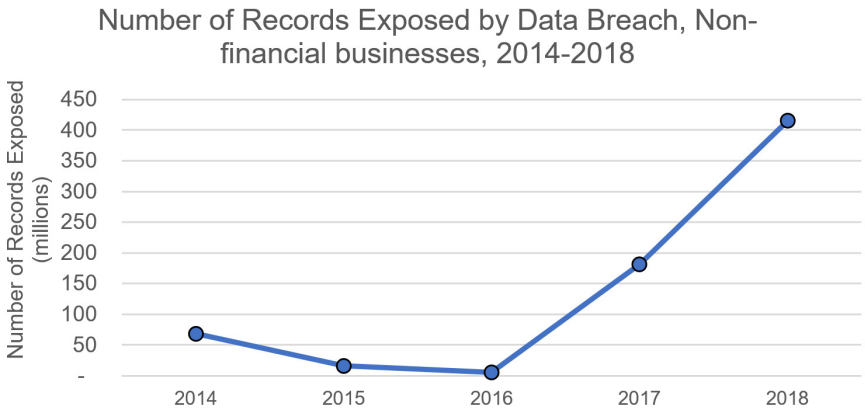



*Source: NDIA*

Threats to information security scored 14 fewer points in 2019 than in 2017, ending up with a final score of 27. This score incorporates the increased average annual number of newly reported cyber vulnerabilities, which rose from 6,957 between 2014 and 2016 to 12,535 for between 2016 and 2018. It also reflects the decreased average severity of newly reported vulnerabilities from 6.2 between 2014 and 2016 to 5.8 between 2016 and 2018.

Threats to information security constitute a major risk to industrial supply chains. Defense manufacturing and services rely on the production, manipulation, transaction, and distribution of information. Thus, vulnerabilities in the information systems that facilitate industrial information flow threaten production capabilities, service deliveries, and the integrity of intellectual property rights. The proliferation of information security vulnerabilities forces industrial supply chain managers to continuously adapt to a dynamic threat. Accordingly, information security threats constitute an enduring source of costs as companies invest in measures to prevent or recover from information system breaches and disasters. The MITRE Corporation maintains the Common Vulnerabilities and Exposures (CVE) List, a "dictionary of publicly disclosed cybersecurity vulnerabilities" that serves as the most authoritative list of known security holes in IT software and hardware products.[lxxvi] The National Institute of Standards and Technology (NIST) publishes a version of the CVE that includes severity scores for each vulnerability. The number of average annual documented IT cyber vulnerabilities was scored against a "peak low" value of 4,150 that occurred in 2011. The average severity of newly reported cyber vulnerabilities was scored against a theoretical standard of 1.

The trend for cyber vulnerabilities indicates a tremendous change for the worse in global cybersecurity conditions. New vulnerabilities increased by 127% year over year in 2017 before increasing by an additional 12% year over year in 2018. New vulnerabilities fell by approximately 25% in 2019, but they remained at twice the level of 2016. In both circumstances, vulnerabilities affecting business applications and internet and mobile software accounted for at least 45% of new CVE entries. Analysis by Skybox Security indicates that the popular commercial software products Google Android and Oracle's MySQL produced the newest vulnerabilities of any products for both years.[lxxvii] Researchers at NIST and Loyola University of Maryland found that two-thirds of the vulnerabilities posted to CVE related to simple and persistently unfixed software implementation errors.[lxxviii]




*Source: ID Theft Resource Center*

The surge in data breaches underscores the risk industry faces from proliferating cyber vulnerabilities. The ID Theft Center reports that data breaches affecting non-financial businesses more than doubled between 2014 and 2018, and that the number of records exposed increased by more than 600%.[lxxix] NDIA's 2019 survey of defense contractors revealed that 42.5% of respondents know their companies had suffered a cyberattack in the past while 30% were unsure.[lxxx] Nevertheless, the growing number of cyberattacks suggests that it is only a matter of time before new vulnerabilities become new attack vectors.

## CONCLUSION

Down six points from 2017, industrial security conditions received a score of 63 for 2019. The growing prevalence of cyber vulnerabilities in commercial information technology systems drove the score for threats to information security down to 27, a precipitous 14-point drop from 2017. This decline reflects larger trends in the erosion of industrial cybersecurity. Although industry's cyber threat environment has worsened, the threat to intellectual property rights continues to improve. Threats to IP rights violations scored a 100, remaining unchanged from 2017, because of a steadily declining number of new FBI IP rights investigations that came after years of enhanced law enforcement and deliberate diplomatic pressure.

# SUPPLY CHAIN CONDITIONS

## INTRODUCTION

Industry relies on well-functioning supplier networks to ensure it serves the needs of defense agencies. Consequently, the performance conditions of these networks affect industry's ability to deliver products and services with an acceptable cost, schedule, and quality. These conditions follow trends in factors such as frequency of contract terminations, financial performance, inventory management, schedule management, and cost management. These trends, thus, indicate how supply chain dynamics may be helping or hindering industry's performance.

> ***Indicator scores are determined by the ratio of an indicator's average value to a baseline value. Baseline values reflect historical peak values or ideal standard values, which means that they are unique for each indicator. Ultimately, the availability of data in the public domain constrained the selection of baseline values. The overall section score averages variable scores that, in turn, consist of averages of indicator scores, which are capped at 100 to allow for a 0-to-100 scoring scale.***

This section of the report presents scores for indicators of the performance of defense supply chains. These indicators describe key attributes such as patterns of contract failure, supply chain financial performance, inventory management, schedule management, and cost management. The indicator of contract failure rates was based on data on contract terminations for cause obtained from the Federal Awardee Performance and Integrity Information System. NDIA calculated industry's cash conversion cycle and inventory turnover ratio—indicators of supply chain financial and inventory management, respectively—by using financial data obtained through FTSE Russell's Mergent Online database. Indicators of schedule-based cost changes for MDAPs are based on cost change data from DoD's Selected Acquisition Reports on major platforms and weapons systems. Finally, the indicator for supply chain cost management was calculated based on counts of Nunn-McCurdy cost breaches reported by the DoD director of Cost Assessment and Program Evaluation.

**Key takeaways:**

- Supply chain conditions scored a 68 for 2019, which illustrates a decline of 15 points from 2017
- Industry supply chains today experience lengthening cash conversion cycles and a declining average rate of inventory turnover as they invest in new inventory to fulfill the rising demand for defense goods and services
- Schedule-based cost changes to MDAPs and Nunn-McCurdy cost breaches continue to fall below baseline values
- Well-performing factors: schedule management, cost management
- Poor-performing factors: contract failure, financial performance, and inventory management

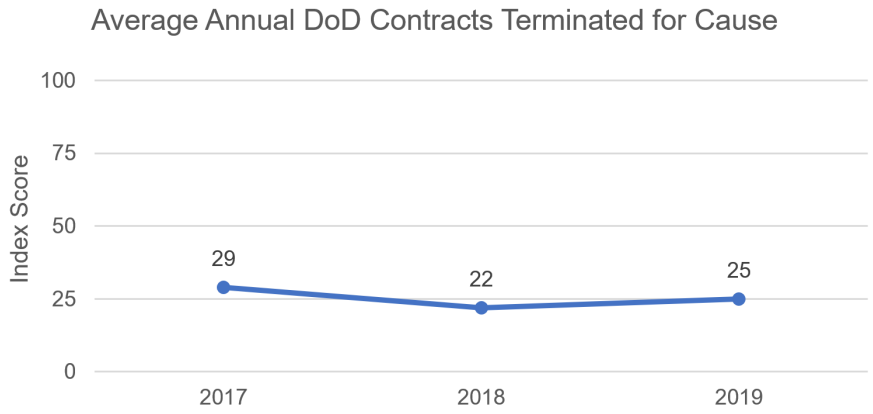
**SUPPLY CHAIN SCORES**

| Factor | Indicator | 2019 Score | Change, 2017 – 2019 |
|---|---|---|---|
| Contract Failure | Average annual DoD contracts terminated for cause | 25 | 🟡 -4 |
| ***Overall Contract Failure*** | | ***25*** | 🟡 ***-4*** |
| Supply Chain Financial Performance | Weighted average cash conversion cycle for selected defense contractors | 54 | 🔴 -31 |
| ***Overall Supply Chain Financial Performance*** | | ***54*** | 🔴 ***-31*** |
| Supply Chain Inventory Management | Weighted average inventory turnover ratio for selected defense contractors | 62 | 🔴 -37 |
| ***Overall Supply Chain Inventory Management*** | | ***62*** | 🔴 ***-37*** |
| Supply Chain Schedule Management | Schedule-based cost change in MDAPs | 100 | 🟡 +0 |
| ***Overall Supply Chain Schedule Management*** | | ***100*** | 🟡 ***+0*** |

| | | | |
|---|---|---|---|
| Supply Chain Cost Management | Average Nunn-McCurdy unit cost breaches | 100 | +0 |
| ***Overall Supply Chain Cost Management*** | | ***100*** | ***+0*** |
| ***Overall Supply Score*** | | ***68*** | ***-15*** |

*Source: NDIA*

## CONTRACT FAILURE




*Source: NDIA*

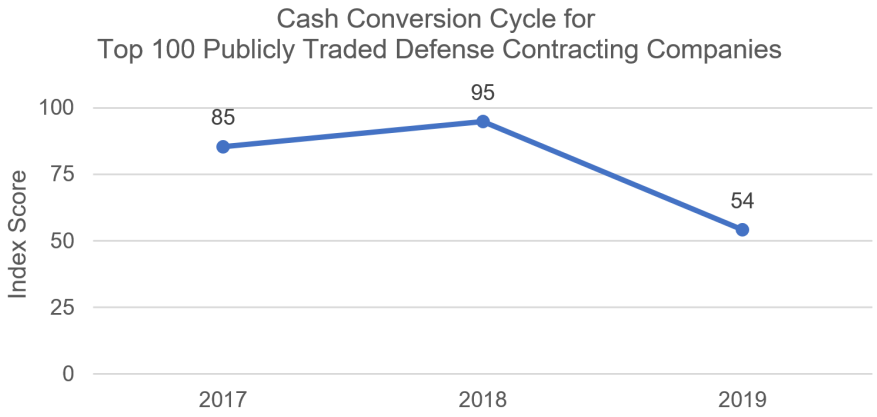
Industry's contract termination scored a 25 for 2019, a decrease of four points from 2017. This score is based on the two-point increase in the average number of contract terminations for cause up to 394 terminations.

Contract terminations serve as a useful barometer for systemic challenges with the DoD contract management system. Like all federal agencies, the Defense Department holds an inherent ability to terminate contract awards for reason of default by the contractor. Contracting officers can only exercise this contract provision after an extended and interactive process of official complaint and response. Trends in these contract terminations indicate a pattern of contract performance and contract award management, which could then illustrate an increasing or decreasing amount of contractor risk in the defense industrial base. Contract terminations were scored against a baseline of 135 for 2014, which is the first year for which a longitudinal data set for this statistic was available.

Terminations for cause often occur after a contracting officer assesses the ability of the contractor to perform on the contract. This assessment typically revolves around a judgment about the post-award behavior of the contractor in delivering on contract terms. Contractors have a strong incentive to avoid contract terminations because the record of such action are incorporated into their permanent contractor performance record and, thereby, risk their ability to win future contract awards. Although the government has an inherent right to terminate contracts for cause under the Federal Acquisition Regulation (FAR), it could still be liable for a contractor's costs incurred up to the time of termination.

The increased incidence of terminations for cause may relate to an expansion of DoD investigative and legal activity regarding contracting fraud. In a December 2018 report to Congress, the Office of the Under Secretary for Acquisition and Sustainment [OUSD(A&S)] disclosed the fact that the government prosecuted 1,059 cases of defense contracting fraud between FY 2013 and FY 2017.[lxxxi] It achieved convictions of 1,087 defendants, including 409 companies, and recovered $792.2 million in punitive and compensatory damages. During the same period of time, the government won civil judgments against 546 defendants, including 435 companies, and recovered $5.86 billion in civil damages. The 2018 report from OUSD(A&S) described a greater scale of anti-fraud legal activity than did DoD's 2011 report. The 2011 report, which covered a 10-year period from FY 2001 to FY 2010, revealed that the government had prosecuted 54 companies and had won civil judgments and settlements against "more than 300" companies."[lxxxii] It is not possible to discern whether the difference between the two periods is the result of increased contracting fraud or increased investigative activity.

## SUPPLY CHAIN FINANCIAL PERFORMANCE



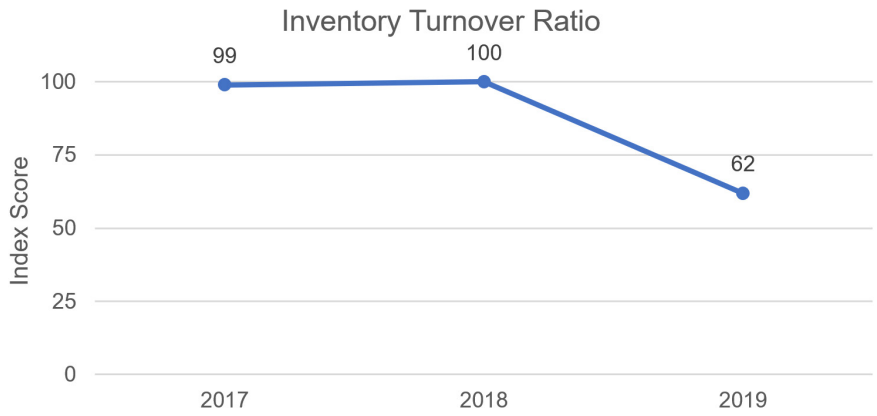

*Source: NDIA*

Industry's supply chain financial performance conversion cycle scored a 54 for 2019, marking a 31-point decrease over the index score for 2017. This score is based on the increase in the average length of cash conversion cycles by 20 days, up to 55 days.

Industry's cash conversion cycle illustrates how well its supply chains function by indicating the amount of time required for a company to regain a dollar invested in product inventory as cash receipts. The conversion of product investment into cash receipts involves the flow of goods, services, resources, and information through multiple supply chain processes, product stages, and partners. Trends in the length of the cash conversion cycle suggest a pattern of either improvement or decline in supply chain performance. In this way, cash conversion cycles also help with understanding supply chain liquidity. Companies rely on cash generated from sales to finance the production of additional goods for sales. While a shorter cash conversion cycle helps companies to fund operations without having to access capital markets, a longer cash conversion cycle indicates that companies face greater difficulty in relying on sales for the liquidity necessary to fund critical operations. NDIA estimated an aggregate cash conversion cycle using financial data for the top 100 publicly traded DoD contractors. Cash conversion estimates were scored against a standard value of 30 days, equivalent to the cash conversion cycle for "best-in-class" companies.[lxxxiii]

Various factors explain the lengthening cash conversion cycles. The recent growth of the defense budget has increased industry revenues from contract obligations, raising the average number of days of sales outstanding. Additionally, companies may be taking greater advantage of growing revenues than before to nurture their suppliers by reducing their days of payables outstanding. In turn, such companies can leverage suppliers to help build up inventories in anticipation of future sales. In the 2019 edition of their annual study of the working capital of the largest 1,000 largest U.S. public companies, the Hackett Group found that, on average, companies have built up inventories to inefficient levels, trapping lots of potential liquidity. A JP Morgan Chase and Co. study of corporate working capital trends discovered that aerospace and defense industry companies experienced the largest average increase in the length of cash conversion cycles between 2011 and 2018 due in part to a relatively high number of days of inventory outstanding.[lxxxiv]

## SUPPLY CHAIN INVENTORY MANAGEMENT



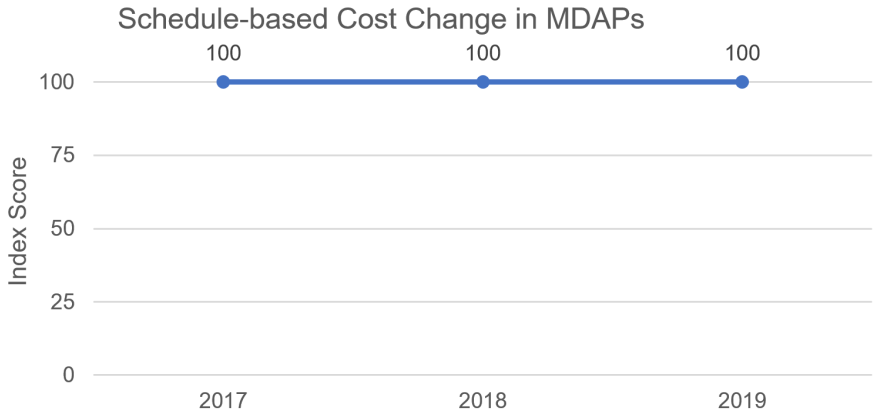
*Source: NDIA*

Industry's inventory turnover ratio scored a 62 for 2019—37 points below its score for 2017. This year's score is based on the decrease of the average inventory turnover ratio from 14 days to 9 days between 2016 and 2018.

The decreasing inventory turnover ratio indicates a growing inefficiency in inventory management. On average, inventory turnover ratio calculates the number of times that defense companies exhaust their inventory to fulfill sales. Higher ratios indicate better inventory management that often occurs in the form of lower storage costs and better coordination of sales with supply chain production. Companies seek to ensure they have enough inventory to facilitate quick sales but not such an excessive inventory that it becomes too costly to sustain existing inventory levels. The inventory turnover ratio was scored against a 5-year average inventory turnover ratio for the Standard & Poor's (S&P) 500 companies from Q3 2019 to Q4 2015.

Industry's growing investment in inventory is likely to have lowered turnover ratios. Historically, defense manufacturing firms maintain extra inventory because of the complexity of their supply chains and long production lead times.[lxxxv] As recent defense spending growth increases procurement and lifts industry revenues, industry investment in production will expand inventory valuations. In doing so, industry will help reduce both average production costs and acquisition lead times. While increased inventory can protect against potential sole-source chokepoints among lower-tier suppliers, industry risks a loss of both supply chain flexibility and working capital.[lxxxvi]

## SUPPLY CHAIN SCHEDULE MANAGEMENT



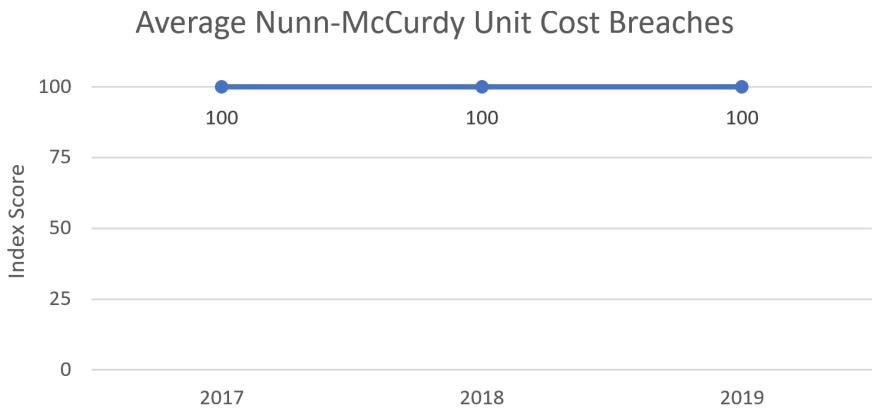

*Source: NDIA*

Schedule-based cost changes to major defense acquisition programs scored at the 100-point level for 2019, which was unchanged from 2017. This trend is based on the way in which schedule-based cost changes rose from an average of $27.1 billion between 2014 and 2016 to an average of $43.5 billion between 2016 and 2018—an increase of $16.4 billion.

Just as production times affect supply chain health, changes to production schedules induce changes in the cost of acquisition programs by either increasing or decreasing the need for resources. For MDAPs—the largest and often most complex acquisition programs—the cost impact of schedule changes can translate into billions of dollars. The Defense Department's quarterly Selected Acquisition Reports (SARs), which provide information on expected cost changes to MDAPs, offer important data for analyzing trends in schedule-based supply chain cost management. Using data taken from SARs ranging from FY 1981 to FY 2019, NDIA scored annual estimated schedule-based cost changes against an average annual percentage of schedule-based cost changes from FY 1981 to FY 1985. This baseline reflects a key historical standard as it corresponds to the last era of a major increase in defense hardware production.

Several major programs have contributed to schedule-based cost growth. First, schedule changes for the F-35 aircraft program constituted 48% of the combined total of schedule-based cost changes to date across all active programs (using then-year dollars). The F-35 has experienced many years of delays in both design and production schedules. In addition to the F-35, there are several other major programs that contribute greatly to schedule-based cost growth to date: the CH-47 Block II, the next-generation Chinook helicopter (7%); the AMRAAM air-to-air missile (7%); and the Guided Multiple Launch Rocket System (6%). One program, the Virginia-class nuclear-powered submarine (SSN 774,) reduced schedule-based cost changes by 18%.

## SUPPLY CHAIN COST MANAGEMENT




*Source: NDIA*

The number of significant or critical Nunn-McCurdy breaches earned a score of 100 for 2019, representing no change from its 2017 score. Increasing slightly from 1.3 between FY 2015 and FY 2017, MDAPs averaged 1.7 Nunn-McCurdy breaches from FY 2017 to FY 2019.

Like supply chain schedule management, supply chain cost management affects the health of the defense industrial base. Supply chain costs include multiple factors such as those related to changes in quantity, engineering, maintenance, milestone achievement schedules, and macroeconomics. For decades, Congress has focused on cost control and management for MDAPs. In 1983, Congress passed the Nunn-McCurdy Act, which established procedures for notifying Congress when an MDAP breaches a pre-determined cost growth threshold. Such congressional notification of Nunn-McCurdy breaches serves as a useful mechanism for cost management. Additionally, trends in Nunn-McCurdy breaches indicate evolving patterns in the defense supply chains efforts at controlling costs.

Nunn-McCurdy breaches reached a peak in both 2009 and 2010 with a total of 8 breaches. Analysis by the Congressional Research Service (CRS) found that, since FY 2007, most cost breaches have occurred during production phases of the MDAP acquisition process rather than during the engineering and manufacturing development phases.[lxxxvii]

## CONCLUSION

Industry faces deteriorating overall conditions with respect to supply chain management. Earning a score of 68 for 2019, supply chain conditions fell by 15 points since 2017. Accordingly, industry's average inventory turnover ratio fell by 37 points as growing defense demand drove inventory expansion. Supply chain financial performance declined by 31 points for 2019 as cash conversion cycles lengthened as the result of two specific factors: a growing body of contract awards to deliver on and growing inventories. Contract failure declined to a score of 25, indicating strain in the management and oversight of contract awards leading to a higher rate of termination. However, supply chain conditions for major defense acquisition programs remain favorable as scores for schedule-based cost changes and breaches of overall program cost limits continued at the 100 level.

# POLITICAL AND REGULATORY CONDITIONS

## INTRODUCTION

The political environment has profound effects on the productivity of the defense industry. Together, Congress and the Executive Branch shape defense production through legislation and regulation that control acquisition budgeting, product and service specifications, and contract management. Additionally, public opinion plays an integral role in guiding policymakers' decisions about these processes. Trends in these political factors help to indicate the direction of future resources and constraints on the defense industrial base.

This section presents scores for indicators of political and regulatory factors shaping defense production. These indicators describe key attributes such as public opinion, congressional budgeting, and rule-making trends. The public opinion indicators are based on long-standing publicly available survey data from The Gallup Organization. Congressional budgeting indicators are developed from historical data on the passage of NDAA legislation published by the CRS. The congressional interest indicator comes from custom text-analysis data provided by Govini. Finally, the regulatory indicator was constructed on the basis of NDIA's analysis of Federal Register records.

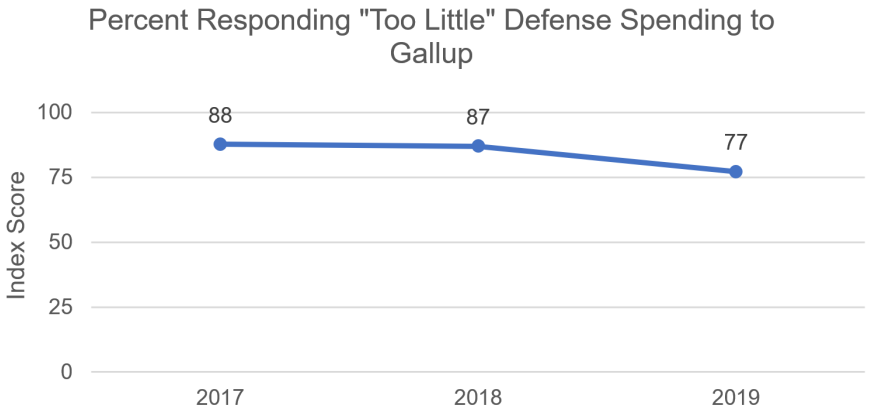
***Indicator scores are determined by the ratio of an indicator's average value to a baseline value. Baseline values reflect historical peak values or ideal standard values, which means that they are unique for each indicator. Ultimately, the availability of data in the public domain constrained the selection of baseline values. The overall section score averages variable scores that, in turn, consist of averages of indicator scores, which are capped at 100 to allow for a 0-to-100 scoring scale.***

**POLITICAL AND REGULATORY SCORES**

| Factors | Indicator | 2019 Score | Change, 2017 – 2019 |
|---|---|---|---|
| Public Opinion | Public opinion polling on defense spending (Gallup) | 77 | ● -11 |
| ***Overall Public Opinion*** | | ***77*** | ● ***-11*** |
| Congressional Budgeting Process | Average number of days to NDAA passage | 100 | ● +18 |
| | Congressional interest in MDAPs | 54 | ● -43 |
| ***Overall Congressional Budgeting Process*** | | ***77*** | ● ***-12*** |
| Regulatory Burden | Red tape ratio: rules decreasing acquisition restrictions per rule increasing | 82 | ● -18 |
| ***Overall Regulatory Burden*** | | ***82*** | ● ***-18*** |
| ***Overall Political and Regulatory Score*** | | ***79*** | ● ***-13*** |

*Source: NDIA*

## PUBLIC OPINION



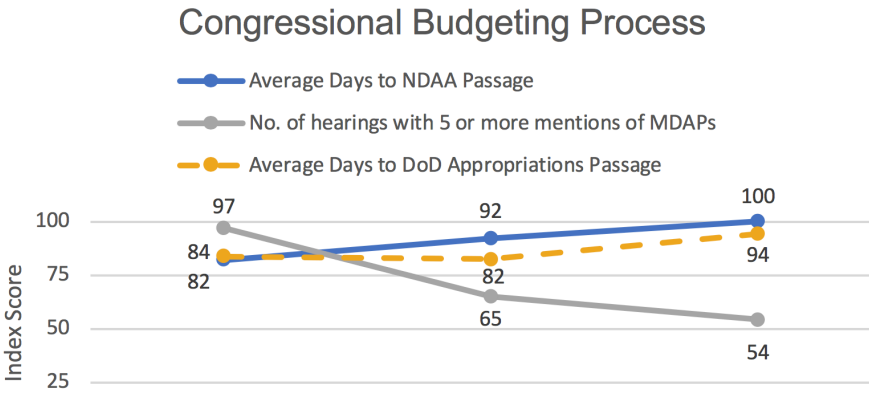

*Source: NDIA*

Public opinion received a score of 77 for 2019—11 points down from 2017. This score is based on the portion of respondents answering "too little" to the question of whether the federal government spends "too little," "about the right amount," or "too much" on national defense decreasing by 4 percentage points, from 36% to 32%, between 2017 and 2019.

Public opinion drives legislative and regulatory trends in defense acquisition policy as Congress and the Executive Branch consider public opinion when deciding on public policy. In general, public opinion about defense policy reflects broad attitudes about the state of national security and perceived trade-offs between preferred defense policies and other priorities. Since 1969, the Gallup Organization has conducted a random national poll of adults in which it asked, "There is much discussion as to the amount of money the government in Washington should spend for national defense and military purposes. How do you feel about this? Do you think we are spending too little, about the right amount, or too much?"[lxxxviii] As one of the longest continuous public polls on defense spending, this Gallup poll indicates the political climate shaping defense budgeting and acquisitions.

The decline in Americans' belief that government spends too little on defense partly results from the high-and-rising confidence that Americans have in the U.S. military. According to Gallup, the 45% percentage of Americans who believed the U.S. military was "not strong enough" in February 2017 decreased to 39% in February 2018.[lxxxix] Polling from the Pew Research Center confirms Gallup's results, finding in a March 2019 survey that 40% of U.S. adults favor an increase in defense spending while 23% favor a decrease in it.[xc] Furthermore, a February 2019 Eurasia Group Foundation survey uncovered the top reason cited for supporting a defense spending increase was linked to a belief that recent budget cuts had weakened the U.S. military.[xci] Recent defense spending increases may have reduced some of the public's anxiety about the need for more military investment. Nevertheless, while most Americans support continuing the country's tradition role in global security, they demonstrate a growing concern about the trade-offs involved.[xcii]

## CONGRESSIONAL BUDGETING PROCESS



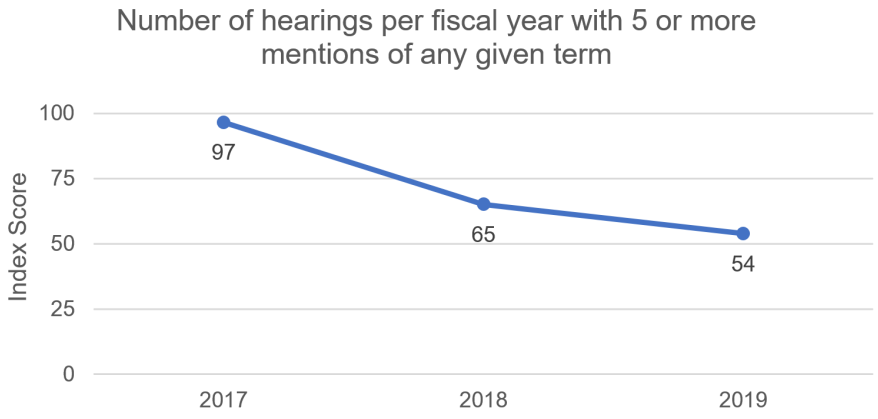

*Source: NDIA*

The congressional budgeting process for national defense programs scored a 77 for 2019, marking a decrease of 12 points from 2017. This score reflects a combination of two indicators with contrasting trend lines: the average number of days to NDAA passage and the number of hearing with five or more mentions of MDAPs. First, the average number of days required for passage of the annual National Defense Authorization Act decreased from 287 between FY 2015 and FY 2017 to 220 between FY 2017 and FY 2019. Over this same period, congressional interest in MDAPs heavily decreased; the number of congressional hearings with five or more mentions of MDAPs decreased from 86 in FY 2016 to 48 in FY 2018 (discussed in detail below).

The duration of the congressional budgeting process ultimately reveals the level of priority Congress awards to defense acquisition issues. Congress faces a statutory expectation to complete the defense budgeting process between the first week of February and October 1. When Congress breaches that schedule, the Executive Branch cannot advance, start, or sustain defense acquisition plans. Therefore, the amount of time Congress consumes in order to pass the annual National Defense Authorization Act indicates the performance of its legislative budgeting processes. To compare Congress's management of the current NDAA process with how it managed the NDAA process during the last era of great power competition, the average number of days required for NDAA passage was scored against the average number of days taken for NDAA passage for the period between FY 1978 and FY 1986 (226 days). Although not included in the index model, the average number of days required for DoD appropriations passage was also scored against an average for the period from FY 1978 to FY 1986 (294 days).

In recent years, the irregularity of congressional budgeting processes and the long durations required for NDAA passage have subjected the Defense Department to disruptive budget uncertainty. Frequently forced to operate under continuing resolutions, DoD has had to delay urgent contract awards and future acquisition planning.[xciii] Although ultimately averted, the threat of a continuing resolution in lieu of enactment of the FY 2020 defense appropriations led many to call the existing budgeting process outdated and due for major reform.[xciv] A 2019 report by the American Political Science Association's Subcommittee on the Appropriations Process identified several factors contributing to the breakdown of textbook "regular order," including increasing delays in the submission to Congress of the President's budget request, deterioration in completing budget resolutions by both houses of Congress, and the institutionalization of slow and late completion of separate appropriations bills.[xcv] The latter factor has led party leaders in Congress to turn more frequently to the use of often opaque omnibus bills to accelerate the defense budgeting process.

## CONGRESSIONAL INTEREST IN MAJOR DEFENSE ACQUISITION PROGRAMS



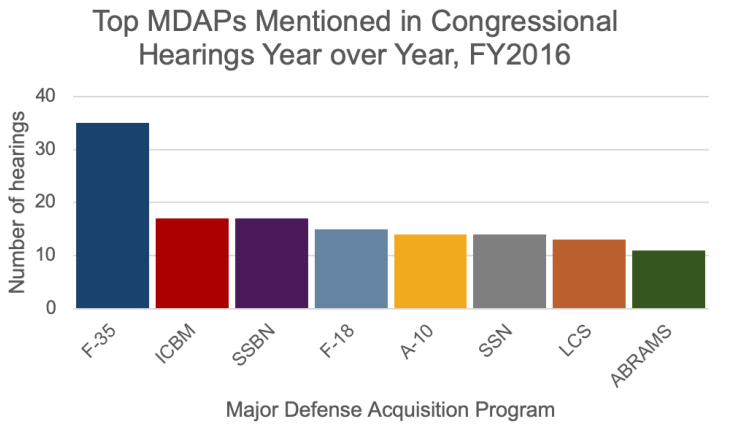

*Source: NDIA*

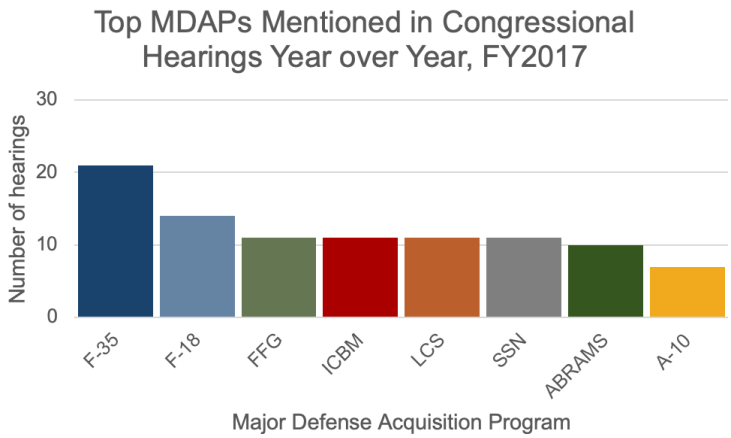
Congressional interest in MDAPs received a score of 54 for 2019, which is 43 points lower than its score in 2017. This score is based on the number of hearings with at least five mentions of any MDAP decreasing from 86 in FY 2016 to just 48 in FY 2018.

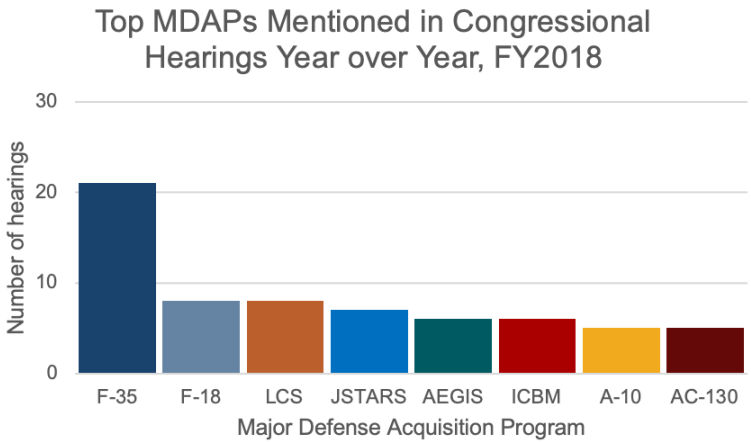
While Congress plays a central role in deciding, enabling, and supervising defense acquisition policy, congressional attention devoted to acquisition-related topics fuels policymaking activity. Therefore, the level of congressional interest in defense acquisitions indicates the amount of activity within the legislative and regulatory environment. Rising levels of interest in defense programs and systems suggests a correlation with increasing policy activity. For this report, Govini measured congressional interest as the number of mentions of MDAPs in congressional hearings, applying a significance threshold of five mentions. Annual congressional interest totals were scored against a baseline value of 89 from 2010, the earliest year for which data was producible.

## Top MDAPs Mentioned in Congressional Hearings Year over Year, FY 2016 – FY 2018

Number of hearings with 5 or more term mentions



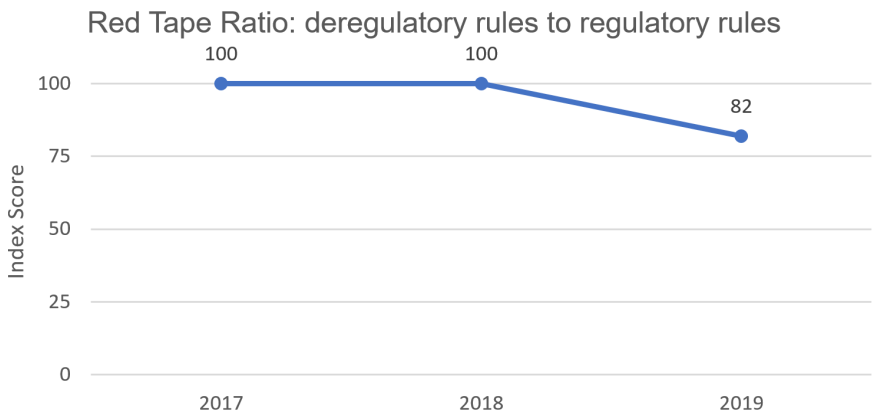




*Source: Govini*

Over the past several years, Congress has embraced a new campaign of acquisition reform that has involved the passage of hundreds of legislative provisions in the annual NDAA to improve the cost, schedule, and performance of the overall defense acquisition system. Meanwhile, congressional leadership has expressed caution about further reform legislative activity until DoD has had more opportunity to absorb past statutory acquisition reforms.[xcvi] The drafting of the FY 2020 NDAA reflected the new reticence toward legislating acquisition reforms.[xcvii] As a result, the last two years' declining congressional interest in MDAPs appears intentional rather than a matter of disregard.

## REGULATORY BURDEN




*Source: NDIA*

Regulatory conditions have also declined with the index score for regulatory trends, decreasing by 18 points from 100 to 82 as the result of a worsening red tape ratio of restrictive new regulations to de-restrictive rules.

The level of regulatory burden that industry faces in contracting with the Defense Department ultimately affects industry's productivity. DoD regularly issues new rules that modify the Defense Federal Acquisition Regulation Supplement (DFARS), defining the rights and obligations of the parties involved in defense contracting in accordance with the preferences of Congress, the President, and the Secretary of Defense. Often, such new rules add or subtract restrictions or requirements on actors in the contracting process. These rules add up to an overall regulatory burden that imposes costs on companies seeking to do business with the government. For this report, the level of regulatory burden was scored against a red tape ratio calculated for 2014, the earliest year available in this dataset.

Under the direction of Executive Orders 13771 and 13777, DoD has prioritized the exploration of ways to reduce the regulatory burden and, thereby, improve the performance of the defense acquisition system.[xcviii] This effort has involved various benefit-cost assessments of existing and proposed regulations in addition to the elimination of unnecessary ones, including those affecting defense acquisitions. The White House Office of Information and Regulatory Affairs reports that DoD implemented four deregulatory actions in both FY 2018 and FY 2019, achieving a cost savings of $101.2 million.[xcix] As a result, the Section 809 panel, which was commissioned to streamline existing DoD acquisition regulations, proposed many actions to reduce regulatory burden, including the repeal of outdated rules.[c]

## CONCLUSION

Political and regulatory conditions scored a 79, reflecting a sharp decline of 13 points since 2017. Public opinion towards defense spending fell by 11 points to a score of 77 driven by rising defense budgets. The rating of the state of congressional budgeting process fell by 12 points to an overall score of 77, the result of a broad loss of congressional interest in major defense acquisition programs. The regulatory burden scored an 82, down 18 points from 2017. The downward trend for regulatory conditions was driven by an increase in the number of restrictive contracting regulations issued by the Department of Defense.

# PRODUCTIVE CAPACITY AND SURGE READINESS

## INTRODUCTION

Recent measures of national economic productive capacity suggest the U.S. defense industrial base possesses a robust ability to meet some future scenarios involving a surge in demand for defense-related goods and services. However, certain industries that are critical to the manufacturing of military hardware, parts, and support systems struggle to meet national defense needs under varied surge demand scenarios. Moreover, evolving national economic conditions may curtail the currently favorable performance of national output relative to its potential. An evaluation of national productive efficiency, capital equipment usage in defense-related manufacturing, and industrial surge capacity results in a score of 77 for 2019. In other words, the health of defense productive capacity and surge readiness received an index score of 77 this year, which represents a slight improvement in productive capacity conditions over last year.

Productive capacity and surge readiness comprise important components of the health and readiness of the defense industrial base. Since productive capacity generally indicates the extent to which the national economy can expand to accommodate new demand for goods and services, its significance lies in its indication of the defense industrial base's ability to adapt to changes in defense supply chain requirements. Likewise, an assessment of the surge readiness of industries that provide critical defense supplies and equipment offers insight into the defense industrial base's ability to perform successfully under scenarios of heightened Defense Department procurement.

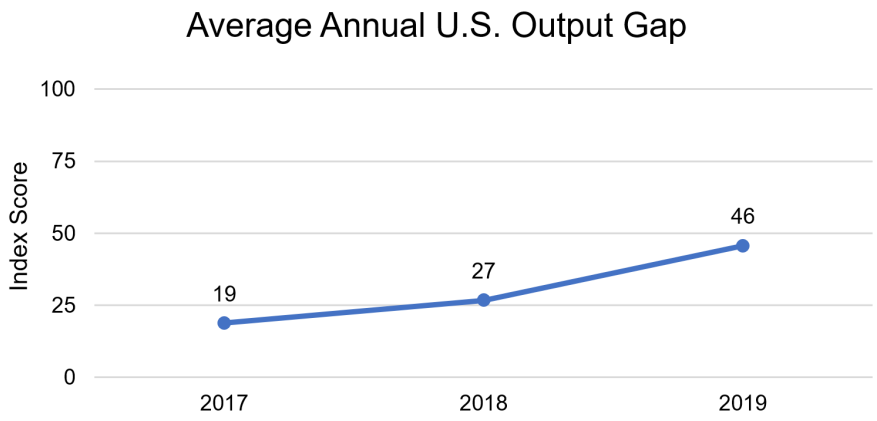
***Indicator scores are determined by the ratio of an indicator's average value to a baseline value. Baseline values reflect historical peak values or ideal standard values, which means that they are unique for each indicator. Ultimately, the availability of data in the public domain constrained the selection of baseline values. The overall section score averages variable scores that, in turn, consist of averages of indicator scores, which are capped at 100 to allow for a 0-to-100 scoring scale.***

**PRODUCTIVE CAPACITY AND SURGE READINESS SCORES**

| Factor | Indicator | 2019 Score | Change, 2017 – 2019 |
|---|---|---|---|
| Output Efficiency | U.S. output gap | 46 | +27 |
| ***Overall Output Efficiency*** | | ***46*** | ***+27*** |
| Intensity of Capital Usage | Durable goods manufacturing sector capacity utilization | 84 | -1 |
| ***Overall Intensity of Capital Usage*** | | ***84*** | ***-1*** |
| Surge Capacity | Estimated shortages in critical defense industries | 100 | +0 |
| ***Overall Surge Capacity*** | | ***100*** | ***+0*** |
| ***Overall Productive Capacity and Surge Readiness Score*** | | ***77*** | ***+9*** |

*Source: NDIA*

## MEASURING PRODUCTIVE EFFICIENCY: THE U.S. OUTPUT GAP




*Source: NDIA*

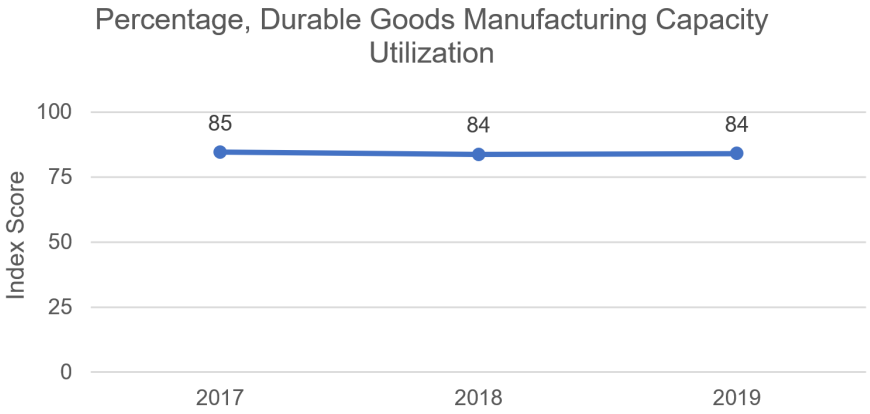
The U.S. output gap earned a score of 46 for 2019, which illustrates a 27-point increase over its 2017 score. This year's score is based on an output gap of -0.6% for the period of 2016 to 2018—a 142% increase between 2014 and 2016.[ci]

The macro-level productive efficiency of the U.S. economy shapes the productive capacity of the defense industrial base. Conceptually, the productive efficiency of the U.S. economy describes the degree to which actual economic output rises to the level of its potential. One statistical measure, the national output gap, serves as a useful indicator of the economy's productive efficiency by estimating the difference between an economy's actual output and its potential output. When this difference holds a positive value, the output gap indicates an economy overperforming its long-run potential, often nearing the end of an expansion. When this situation occurs, high aggregate demand for goods and services throughout the economy forces production facilities to operate unsustainably at peak efficiency levels in order to provide enough supply, leading to tight labor markets and possible price inflation. Under an output gap with a negative value, the economy's production capabilities experience inferior efficiency, indicating that some productive capacity is underutilized. Under ideal conditions, no output gap would exist with actual economic output matching potential output.

In broad terms, the output gap illustrates the way in which the economy would react to a surge in defense-related demand. For example, a surge of new demand when there is a positive output gap would likely result in production shortages, price inflation, and a lack of investment in new productive capacity. On the other hand, a surge of new demand when there is a negative output gap would likely activate dormant capacity; however, production could suffer from low productivity and other inefficiencies.

This trend of a growing positive output gap can be linked to multiple factors. To begin, the economic recovery from the great recession of 2008 to 2009 produced a tight labor market, leaving the economy in want of human resources to expand its productive capacity.[cii] According to the Congressional Budget Office, the 2017 tax reform legislation helped to increase the real GDP relative to potential GDP in the immediate years after its passage, pushing the economy towards a positive output gap.[ciii] Today, trade tensions between the United States and China may play a role as the imposition of tariffs on goods imported from China has incentivized some manufacturing to relocate back to the U.S., encouraging further utilization of productive capacity.[civ] In fact, the Congressional Budget Office finds that the output gap in the U.S. economy has been positive since the second quarter of 2018 and suggests it will continue to be positive until the second quarter of 2022.[cv]

# MEASURING THE USAGE OF U.S. MANUFACTURING CAPITAL ASSETS: CAPACITY UTILIZATION IN DURABLE GOODS MANUFACTURING



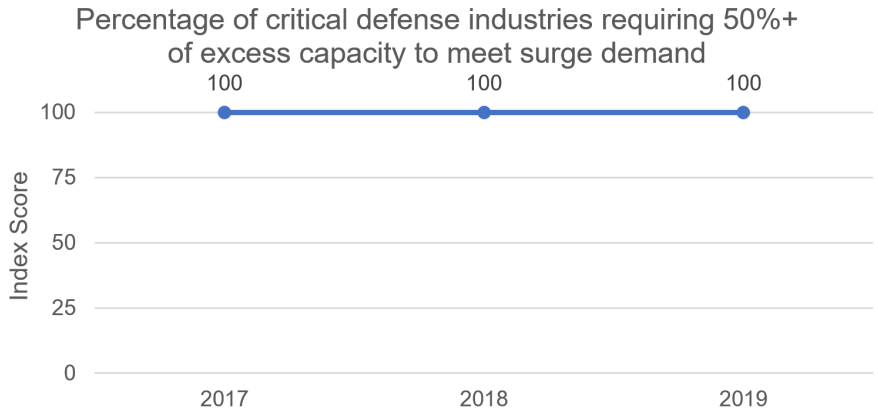

*Source: NDIA*

Capacity utilization in durable goods manufacturing industries earned a score of 84 for 2019, one point lower than in 2017. This score is based on a capacity utilization rate of 74.5% for the period between 2016 and 2018, which marks a decrease of 0.4% from the 74.9% utilization rate of 2014 to 2016.

The health of industry's productive capacity is inextricably linked to the extent to which manufacturing industries use their production capabilities. Physical capital assets include the facilities, machinery, and equipment used in the production of goods and services. For manufacturing industries, physical capital assets are a key limiting factor of productive capacity. Industrial capacity utilization rates serve as a useful indicator of the intensity of physical capital assets usage throughout such industries. Capacity utilization rates describe the share of industrial productive capacity in use, on average, during a given period.[cvi] Across the entire manufacturing sector, capacity utilization rates have exhibited cyclical behavior; however, they have consistently trended downward since the late 1960s.[cvii] With respect to understanding the slack in productive capacity in manufacturing industries required to produce critical defense systems, such capacity utilization rates in the durable goods manufacturing sector prove most useful. Upward-trending capacity utilization rates indicate an increasing dedication of productive capital assets to the production of supply to meet new market demand. Downward-trending capacity utilization rates suggest a decreased usage of productive capital assets by firms. For *Vital Signs 2020*, capacity utilization was scored against a 1973 baseline value of 88.6%.

Gains in several industrial groups within the durable goods manufacturing sector powered 3% growth in capacity utilization between Q4 of 2015 and Q4 of 2018. According to the Federal Reserve's 2019 annual industrial production index, such capacity utilization growth in machinery industries dominated all other industries with a 12.3% rise between 2015 and 2018.[cviii] During the same period, capacity utilization in primary metals manufacturing grew by 9.8%, in fabricated metal products by 4.5%, in semiconductors by 2.4%, in computer and electronic products by 0.9%, and in motor vehicles by 0.8%. By contrast, capacity utilization decreased by 9.0% for communications equipment manufacturing and by 2.5% for aerospace and miscellaneous transportation equipment manufacturing.

# MEASURING DEFENSE INDUSTRIAL SURGE CAPACITY: SHORTAGES IN CRITICAL DEFENSE INDUSTRIES




*Source: NDIA*

Industry's surge capacity earned a score of 100 for 2019, remaining unchanged from 2017. This score is based on an estimation of the share of critical defense industries that would require at least 50% of their unused industrial capacity to meet a demand shock that increased from 18% in FY 2017 to 27% in FY 2019.

Industrial surge capacity indicates the ability of an industry or sector to increase its output to meet a surge in final demand. In other words, industrial surge capacity provides a measure of ability of the national economy to supply U.S. armed forces under a heightened set of material needs, holding constant the current organization of the economy. As a proxy for industrial surge capacity, we estimated the percentage of "critical defense industries" requiring the activation of more than 50% of spare productive capacity. Industries requiring such large amounts of spare capacity to supply a surge in defense demand represent potential bottlenecks of critical materials, equipment, and systems. For this report, industrial surge capacity was scored against a 1980 baseline value of 55%.

## Breakdown of Industrial Surge Capacity Analysis

The basis of this industrial surge capacity assessment is economic input-output analysis. Input-output analysis uses a static model of the flows of goods and services between industries in an economy to enable an estimation of the impact of economic changes for a given industry on interconnected industries.[cix]

Following Miller (1978), a subset of manufacturing industries are highly important sources of combat capabilities:[cx]

| CRITICAL DEFENSE INDUSTRIES | |
|---|---|
| **Platforms** | Complete guided missiles (NAICS: 336414) |
| | Military armored vehicle, tank, and tank component manufacturing (NAICS: 336992) |
| | Aircraft manufacturing (NAICS: 336411) |
| | Ship building and repairing (NAICS: 336411) |
| **Parts and Support Systems** | Other aircraft parts and auxiliary equipment manufacturing (NAICS: 336413) |
| | Search, detection, and navigation instruments manufacturing (NAICS: 334511) |
| | Aircraft engine and engine parts manufacturing (NAICS: 336412) |
| | Broadcast and wireless communications equipment (NAICS: 334220) |
| | Propulsion units and parts for space vehicles and guided missiles (NAICS: 336415) |
| | Electronic computer manufacturing (NAICS: 334111) |
| **Munitions** | Ammunition, arms, ordnance, and accessories manufacturing (NAICS 332992, 332993, 332994) |

*Source: NDIA*

The variety of possible war mobilization scenarios makes it difficult to specify standard surge requirements for each critical industry. Therefore, to enable a viable analysis, NDIA assumed a single across-the-board demand surge requirement. The resulting analysis employs a surge scenario that echoes the surge in military demand experienced during the defense buildup of the late 1970s and early 1980s. Between FY 1977 and FY 1986, defense spending increased by 31%. To meet such demand surge, each of the critical industries must rely on output increases both from within the industry and from supplier industries. The linkages between industries are evident in the input-output table. Each relationship is characterized by a coefficient that indicates how much value is produced by a supplier industry to contribute to the production of $1 of value delivered to final demand.

To calculate the percent increase in supplier industry output required to adequately supply the demand surge, NDIA calculated a specific ratio:

$$\frac{100 \cdot (\text{Input/Output Coefficient}) \cdot (\text{Value of DoD Demand Surge from Supplier Industry})}{(\text{Total Output of Supplier Sector})}$$

Further, by comparing surge demand requirements with capacity utilization rates, we identified the critical industries that would experience extreme stress or shortages in meeting the requirements.

A key assumption of this analysis is that surge demand would have been met with the existing industrial organization and would not involve full economic mobilization for war production—a policy that would radically expand productive capacity. Another key assumption of input-output analysis is that interdependencies within industry remain constant over time. A focus on the 13 critical defense end-manufacturing industries does not imply that these are the only sectors on which DoD spends procurement dollars. Rather, these are the sectors that are most likely to be targeted as part of a surge requirement. This analysis focuses on vulnerabilities in lower-tier supplier manufacturing industries instead of service industries because the constant-interdependencies assumption of input-output analysis is less viable for adaptable service and commodity industries. Subsequently, this section of *Vital Signs 2020* excludes manufacturing industries involving products irrelevant or only incidental to the making of critical defense end-products. Further, industries supplying products available commercially are not included because surge demand can be easily accommodated due to the scale of the market. This analysis uses total requirements input-output tables produced by the U.S. Bureau of Economic Analysis in 2012.

## KEY RESULTS

Based on the top 20 supplier industries' total value of economic output, they must supply other industries in order to fulfill one dollar of DoD procurement demand. Industry heavily relies on intermediate primary metals and metal products to develop defense systems. Iron and steel mills produce the most value per dollar of final demand for defense-oriented industries. Metalworking industries that focus on nonferrous metals and copper also appear among the top 10 supplier industries related to critical defense demand. Furthermore, the same industries that are critical to the final production of defense platforms, parts, systems, and munitions serve as important suppliers for one another.

**REQUIRED SUPPLIER INDUSTRY OUTPUT PER DOD PROCUREMENT DOLLAR**

| Rank | NAICS Code | Industry Description | Required Sector Output (minus own sector) per DoD Purchase Dollar (cents) |
|---|---|---|---|
| 1 | 331110 | Iron and steel mills and ferroalloy manufacturing | 43.7 |
| 2 | 336412 | Aircraft engine and engine parts manufacturing | 25.9 |
| 3 | 336413 | Other aircraft parts and auxiliary equipment manufacturing | 22.3 |
| 4 | 334511 | Search, detection, and navigation instruments manufacturing | 16.4 |
| 5 | 336414 | Guided missile and space vehicle manufacturing | 16.2 |
| 6 | 334220 | Broadcast and wireless communications equipment | 15.0 |
| 7 | 331490 | Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying | 14.4 |
| 8 | 331420 | Copper rolling, drawing, extruding and alloying | 14.1 |

| | | | |
|---|---|---|---|
| 9 | 334413 | Semiconductor and related device manufacturing | 13.9 |
| 10 | 33291A | Valve and fittings other than plumbing | 11.0 |
| 11 | 332310 | Plate work and fabricated structural product manufacturing | 10.6 |
| 12 | 33211A | All other forging, stamping, and sintering | 10.6 |
| 13 | 33641A | Propulsion units and parts for space vehicles and guided missiles | 9.6 |
| 14 | 332710 | Machine shops | 9.2 |
| 15 | 331200 | Steel product manufacturing from purchased steel | 9.1 |
| 16 | 331410 | Nonferrous metal (except aluminum) smelting and refining | 9.0 |
| 17 | 332720 | Turned product and screw, nut, and bolt manufacturing | 8.7 |
| 18 | 325190 | Other basic organic chemical manufacturing | 8.3 |
| 19 | 325211 | Plastics material and resin manufacturing | 7.8 |
| 20 | 33441A | Other electronic component manufacturing | 7.8 |

*Source: NDIA*

## PERCENTAGE OF EXCESS CAPACITY REQUIRED TO SUPPLY SURGE DEMAND SCENARIOS

| | | 2017 | | 2018 | | 2019 | |
|---|---|---|---|---|---|---|---|
| NAICS Code | End Manufacturing Industry Description | 100% scenario | 31% scenario | 100% scenario | 31% scenario | 100% scenario | 31% scenario |
| 336411 | Aircraft manufacturing | 146 | 45 | 119 | 37 | 106 | 33 |
| 336611 | Ship building and repairing | 111 | 35 | 103 | 32 | 97 | 30 |
| 336413 | Other aircraft parts and auxiliary equipment manufacturing | 215 | 67 | 235 | 73 | 203 | 63 |
| 334511 | Search, detection, and navigation instruments manufacturing | 46 | 14 | 48 | 15 | 46 | 14 |
| 336414 | Guided missile and space vehicle manufacturing | 168 | 52 | 176 | 55 | 188 | 58 |
| 336412 | Aircraft engine and engine parts manufacturing | 113 | 35 | 134 | 41 | 111 | 34 |
| 33299A | Ammunition, arms, ordnance, and accessories manufacturing | 63 | 20 | 50 | 15 | 56 | 17 |
| 336992 | Military armored vehicle, tank, and tank component manufacturing | 137 | 43 | 168 | 52 | 173 | 54 |
| 334220 | Broadcast and wireless communications equipment | 16 | 5 | 17 | 5 | 18 | 6 |
| 33641A | Propulsion units and parts for space vehicles and guided missiles | 57 | 18 | 62 | 19 | 66 | 20 |
| 334111 | Electronic computer manufacturing | 19 | 0 | 19 | 6 | 19 | 6 |

*Source: NDIA*

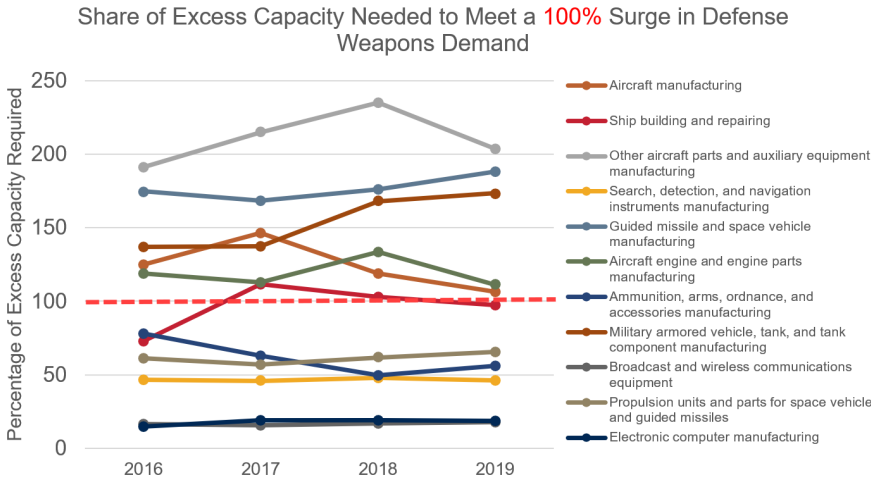
To understand the implications of these output increase requirements, NDIA tested them against reported measurements of the unused—or excess—productive capacity in their respective industries.

In zeroing in on the critical defense industries, NDIA tested them against two scenarios: one that assumed a 100% surge in demand for major defense systems and another that assumed a 31% surge in demand. Both scenarios represent different aspects of the Cold War-era defense industrial context, which remains the last period of great power competition. The 100% surge scenario would involve a doubling of defense spending, bringing overall defense spending to approximately 6% of GDP,

which is similar to defense spending levels last experienced during the 1980s. The 31% surge scenario echoes the percentage increase in defense spending experienced from approximately FY 1977 to FY 1986—during the Carter-Reagan buildup.

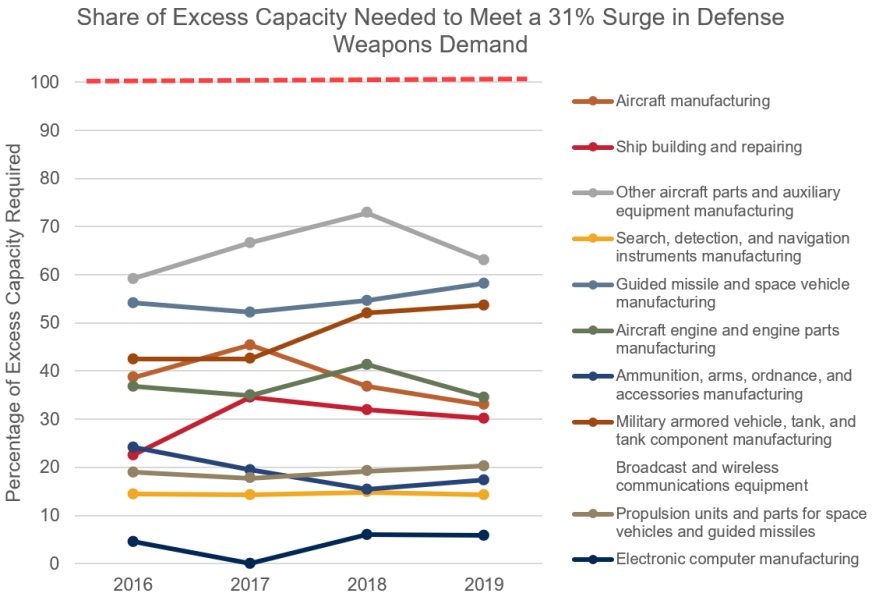
Industries requiring over 100% of the unused capacity to meet surge demand threaten production shortages. Even those requiring over 50% of unused capacity are likely to experience significant difficulty in meeting the surge demand because any use of unused capacity would require increasing the efficiency and productivity of production facilities and supply chains.

In the 100% surge scenario, capacity shortages occur for the manufacturing of aircraft, other aircraft parts, guided missiles, aircraft engines, and military armored vehicles. The capacity needs declined for the aircraft, aircraft engines, and other aircraft parts between 2017 and 2019. However, the capacity needs increased for military armored vehicles and guided missiles during the same time period. The shipbuilding industry declined by 14 percentage points from 111% to 97% between 2017 and 2019. By contrast, critical defense industries including search, detection, and navigation instruments, broadcast and wireless communications equipment, and electronic computer manufacturing required less than 50% of excess industrial capacity to meet a 100% surge in demand.




*Source: NDIA*

Under the 100% buildup scenario, no industry requires more than 100% of excess capacity to supply surge demand. However, for 2019, the "other aircraft parts," "guided missiles," and "military armored vehicles" industries require more than 50% of excess capacity to reach the surge demand. The resulting suggestion is that these industries would struggle to employ enough capacity to effectively supply surge demand; however, this situation would not constitute a technical impossibility. The "guided missiles" and "military armored vehicles" manufacturing industries display sharply rising trend lines for their excess capacity requirements between 2017 and 2019. By contrast, shipbuilding and aircraft manufacturing demonstrate declining trend lines for the same period. Meanwhile, ammunition, propulsion, broadcast and wireless communications, and electronic computers required 20% or less of their excess capacity to meet potential surge demand.




*Source: NDIA*

The turbulence in defense spending over the past decade has helped produce the oscillating pattern in productive capacity in critical defense industries. Defense budget cuts as a result of the 2013 budget sequestration going into effect led to lower levels of demand and, accordingly, a reduction of output in critical defense industries. Recent defense spending increases for FY 2018 and FY 2019 have spurred an increase in output and investment in more productive capacity. Meanwhile, an augmented global demand for military expenditures may also draw on U.S. capacity for fulfillment, reducing the capacity available to fulfill direct U.S. demand. In aircraft-related industries, rising commercial aircraft production has contributed to a rising need for capacity expansion. Pressures to reduce costs and improve productivity has driven an upward trend in mergers and acquisitions (M&A) activity, including mergers among prime contractors and upper-tier suppliers alongside acquisition by prime contractors of small- and mid-sized companies. Such consolidation could lead to reduction in excess capacity, rendering the defense industrial base less capable of meeting surge demand.

## CONCLUSION

The productive capacity and surge readiness of the defense industrial base are trending in a favorable direction. Consistently holding an adjusted index above 98 between 2017 to 2019, the U.S. defense industrial base appears to be doing well compared to its historical performance benchmarks. At the macroeconomic level, the manufacturing sectoral level, and even for specific critical industries, the defense industrial base appears capable of meeting a significant surge in demand. Nonetheless, the defense industrial base faces clear warning signs. As the output gap moves in a positive direction, the overall economy portrays signs of overheating, which would lead to inflation and higher production costs. Accordingly, higher costs for defense production reduce the defense sector's ability to meet surge demand. Higher capacity utilization rates—although indicating growing productiveness in the manufacturing sector in the short-run—may indicate that competing demand from consumer and commercial markets will crowd out potential expansion in defense-related production. Lastly, specific critical industries show indications of potential production shortages in a surge demand scenario. In a scenario echoing the Carter-Reagan buildup, several key industries, including military armored vehicles, aircraft parts, and guided missiles, would require output increases greater than 50% to meet surge demand.

# CONCLUSION

The health and readiness of the United States' defense industrial base pose numerous challenges to the national security establishment and the defense acquisitions community. *Vital Signs 2020* highlights the hurdles that exist as expectations of and demands on the defense industrial base rise under growing peer and near-peer challenges.

One area of increasing concern involves the risks that business operations face from cyberspace. Modern defense supply chains rely on sharing sensitive information across cyberspace to coordinate production. More cyber vulnerabilities within information systems mean more security breaches. Ultimately, industry will incur significant costs to protect itself from this threat. The National Defense Industrial Association's 2019 cybersecurity report found that industry—particularly businesses categorized within the lower tiers of defense suppliers—already struggles to absorb complex cybersecurity regulations and requirements.[cxi] Watch the Pentagon's Cybersecurity Maturity Model Certification and its forthcoming requirement that every contractor be certified before doing business with the Defense Department.

While such a requirement affects the operation of the defense industrial base, escalating costs and constraints on the availability of defense production inputs threaten the function of supply chains. Industry's productivity declines as the costs of goods, services, materials, and labor rise. When there is less cleared and skilled labor, industry cannot deliver contracted goods and services, resulting in greater costs to government and the taxpayer. When a sector depends on single producers or on supplies coming from global competitors or politically unstable regions, both cost and risk increase for that same supply chain.

The U.S. defense industrial base's overall health and readiness score of 77 out of 100 suggests a satisfactory ability to meet current requirements. However, such a middling score may not be good enough going forward. The fast-moving era of great power competition requires a more robust industry to deliver extraordinary capabilities and, thereby, maintain and extend advantages over competitors like China.

China resembles a rising power that is aggressively challenging an established power for international preeminence.[cxii] Already an economic peer of the United States, China is on a trajectory towards becoming uniquely capable of challenging U.S. military primacy. The most concrete example of this trajectory is evident in a generation's worth of investments in military modernization and defense industry expansion.[cxiii] Through the late 1990s, China's caliber of military technology lagged that of peers by a generation and typically exhibited poor manufacturing quality. Additionally, its lackluster domestic defense industry suffered from overcapacity, redundancy, inefficiency, and weak research and development investment. In 1997, China began market-based reforms of its defense sector. The Chinese Communist Party ordered the People's Liberation Army to privatize state-owned defense production companies and radically increased defense spending. These firms lowered their debt levels and sharply cut their industrial capacity, laying off millions of workers in the meantime. China's leading homegrown defense firms now also experience performance pressure from being listed on publicly traded stock exchanges. As a result, China has slashed its defense purchases from long-time suppliers in Russia to support its own defense industrial base.

Meanwhile, China's competitive rise has leveraged its dynamic private sector to rapidly develop advanced defense capabilities. Emphasizing acquisition strategy through "military-civil fusion," China has formed partnerships with leading domestic companies to facilitate dual-use technology development and the sharing of private capabilities with defense agencies.[cxiv] By correspondingly using international corporate partnerships as part of an extensive global industrial espionage campaign, China now boasts its own aircraft carrier. It has an active engineering program to produce its own fifth-generation fighter aircraft—a potential competitor to America's flagship fighter aircraft, the F-35 Lightning II.

Nevertheless, this study underscores points that confirm that the fundamentals of America's defense industry remain a sound foundation on which to build and invest. Industry's strong competitive dynamics—coupled with increasing defense budgets—indicate the onset of a more profitable and expansive defense industrial base. DoD's rising demand for products and services will find defense contracting's attractiveness to industry trending favorably over the timeframe of this report.

The U.S. defense industrial base's economics compare advantageously with those of the Chinese. China's defense industry suffers from a lack of competition as it is dominated by multisector conglomerates that draw only 10% to 25% of revenues from defense contracts.[cxv] Less than 1% of China's leading high-tech firms have been willing to participate in defense contracting because of a perception of poor profitability.

Moreover, as political scientist Michael Beckley explains, the United States has an industrial advantage over China's large but relatively inefficient economy.[cxvi] On one hand, Chinese companies have higher average production costs than U.S. firms and tend to rely more on capital and labor investment than on innovation and productivity growth. On the other hand, since U.S workers are the world's most productive, they out-produce Chinese workers by a ratio of seven to one. Additionally, U.S. workers receive twice as much education as Chinese workers while China suffers from an annual brain drain of about 6,000 scientists and engineers—3,500 of which relocate to the United States.[cxvii] At the same time, the United States greatly outperforms China with respect to the ease of doing business.[cxviii]

The U.S. defense industrial base is better than the rest, but its health and readiness present several areas in need of improvement—even during a time of cyclical expansion. Flattening budgets and growing international competition for defense-related sales will likely challenge that position going forward.

# APPENDIX I

## FULL INDICATOR LIST

| # | Factor | Indicator | 2017 | 2018 | 2019 | Change, 2017 – 2019 |
|---|---|---|---|---|---|---|
| ***Competition*** | | | | | | |
| 1 | Profitability | Weighted average core operating margin (return on sales) | 92 | 94 | 97 | 🟢 +5 |
| 2 | | Weighted average return on assets | 71 | 73 | 76 | 🟢 +5 |
| 3 | Cash Availability | Weighted average free cash flow | 96 | 100 | 100 | 🟡 +4 |
| 4 | Capital Investment | Weighted average capital expenditures | 100 | 97 | 99 | 🟡 -1 |
| 5 | Market Concentration | Level of market concentration (Herfindahl-Hirschman Index) | 100 | 100 | 100 | 🟡 +0 |
| 6 | Foreign Ownership | Market share of foreign-owned firms | 100 | 100 | 100 | 🟡 +0 |
| 7 | Contract Competition | Average number of competitive offers received per contract actions | 83 | 86 | 88 | 🟢 +5 |
| | | ***Overall score:*** | ***94*** | ***95*** | ***96*** | 🟡 ***+2*** |
| ***Production Inputs*** | | | | | | |
| 8 | Costs of Goods, Services, and Materials | Producer price index, services for intermediate demand | 92 | 90 | 88 | 🟡 -4 |
| 9 | | Producer price index, processed goods for intermediate demand | 96 | 98 | 96 | 🟡 +0 |
| 10 | | Average rare earths minerals (REMX) ETF prices | 100 | 100 | 100 | 🟡 +0 |
| 11 | Workforce Size | Estimated total defense-related direct employment | 32 | 33 | 34 | 🟡 +2 |
| 12 | Workforce Compensation | Estimated average annual per-worker pay, for defense-related employment | 75 | 77 | 80 | 🟢 +5 |
| 13 | Workforce Diversity | Gender diversity in employment in defense supplier industries | 85 | 85 | 85 | 🟡 +0 |
| 14 | | Racial diversity in employment in defense supplier industries | 67 | 71 | 75 | 🟢 +8 |
| 15 | | Latino ethnicity diversity in employment in defense supplier industries | 40 | 39 | 40 | 🟡 +0 |
| 16 | | Age ethnicity diversity in employment in defense supplier industries | 100 | 100 | 100 | 🟡 +0 |
| 17 | STEM Talent Pool | STEM percentage of total U.S. occupational employment | 100 | 100 | 100 | 🟡 +0 |
| 18 | | STEM degree awards as average share of total degree awards | 95 | 99 | 100 | 🟢 +5 |
| 19 | Security On-Boarding | Annual inventory of security clearance investigation cases | 43 | 30 | 24 | 🔴 -19 |
| 20 | | Duration of initial top secret clearance reviews (days) | 34 | 22 | 20 | 🔴 -14 |
| 21 | | Duration of periodic top secret clearance reinvestigations (days) | 55 | 37 | 27 | 🔴 -28 |
| | | ***Overall score:*** | 70 | 68 | 68 | 🟡 -2 |
| ***Demand*** | | | | | | |
| 22 | Demand for Defense Goods and Services | DoD contract obligations | 78 | 84 | 94 | 🟢 +16 |
| | | ***Overall score:*** | 78 | 84 | 94 | 🟢 +16 |

| | | | | | | |
|---|---|---|---|---|---|---|
| ***Innovation*** | | | | | | |
| 23 | Innovation Inputs | Average annual value of worldwide R&D paid for by U.S.-based companies, selected durable industrial goods manufacturing industries | 100 | 100 | 100 | ● +0 |
| 24 | | Average annual value of worldwide R&D paid for by U.S.-based companies, information and communications technologies | 100 | 100 | 100 | ● +0 |
| 25 | | Average annual value of worldwide R&D paid for by U.S.-based companies, scientific R&D services | 45 | 35 | 36 | ● -9 |
| 26 | Innovation Outputs | Average annual patent applications, durable industrial goods manufacturing | 100 | 100 | 100 | ● +0 |
| 27 | | Average annual patent applications, information and communication technologies goods and services | 75 | 80 | 79 | ● +5 |
| 28 | | Average annual patent applications, scientific R&D services | 58 | 45 | 37 | ● -21 |
| 29 | Innovation Competitiveness | U.S. share of international patent applications | 77 | 73 | 69 | ● -8 |
| 30 | | U.S. share of global R&D investment | 76 | 75 | 74 | ● -2 |
| | | ***Overall score:*** | ***78*** | ***76*** | ***74*** | ● ***-4*** |
| ***Industrial Security*** | | | | | | |
| 31 | Threat to IP Rights | New FBI intellectual property rights violation investigations | 100 | 100 | 100 | ● +0 |
| 32 | Threats to Information Security | Average annual newly reported common IT vulnerabilities | 60 | 45 | 33 | ● -27 |
| 33 | | Severity of newly reported common IT vulnerabilities | 16 | 17 | 17 | ● +1 |
| | | ***Overall score:*** | ***69*** | ***65*** | ***63*** | ● ***-6*** |
| ***Supply Chain*** | | | | | | |
| 34 | Contract Failure | Average annual DoD contracts terminated for cause | 29 | 22 | 25 | ● -4 |
| 35 | Supply Chain Financial Performance | Weighted average cash conversion cycle for selected defense contractors | 85 | 95 | 54 | ● -31 |
| 36 | Supply Chain Inventory Management | Weighted average inventory turnover ratio for selected defense contractors | 99 | 100 | 62 | ● -37 |
| 37 | Supply Chain Schedule Management | Schedule-based cost change in MDAPs | 100 | 100 | 100 | ● +0 |
| 38 | Supply Chain Cost Management | Average Nunn-McCurdy unit cost breaches | 100 | 100 | 100 | ● +0 |
| | | ***Overall score:*** | ***83*** | ***83*** | ***68*** | ● ***-15*** |
| ***Political and Regulatory*** | | | | | | |
| 39 | Public Opinion | Public opinion polling on defense spending (Gallup) | 88 | 87 | 77 | ● -11 |
| 40 | Congressional Budgeting Process | Average number of days to NDAA passage | 82 | 92 | 100 | ● +18 |
| 41 | | Congressional interest in MDAPs | 97 | 65 | 54 | ● -43 |
| 42 | Regulatory Burden | Red tape ratio: rules decreasing acquisition restrictions per rule increasing | 100 | 100 | 82 | ● -18 |
| | | ***Overall score:*** | ***92*** | ***89*** | ***79*** | ● ***-13*** |
| ***Productive Capacity and Surge Readiness*** | | | | | | |
| 43 | Output Efficiency | U.S. output gap | 19 | 27 | 46 | ● +27 |
| 44 | Intensity of Capital Usage | Durable goods manufacturing sector capacity utilization | 85 | 84 | 84 | ● -1 |
| 45 | Surge Capacity | Estimated shortages in critical defense industries | 100 | 100 | 100 | ● +0 |
| | | ***Overall score:*** | ***68*** | ***70*** | ***77*** | ● ***+9*** |

*Source: NDIA*

# APPENDIX II

## TOP 100 PUBLICLY TRADED DEFENSE CONTRACTORS

| Rank | Parent Vendor | FY 2015 – 2019 Total Contract Obligations |
|---|---|---|
| | ***Total*** | ***$1,534,383,656,972.66*** |
| 1 | Lockheed Martin Corp | $192,823,509,591.79 |
| 2 | Boeing Co/The | $105,494,165,432.88 |
| 3 | General Dynamics Corp | $71,101,123,145.28 |
| 4 | Raytheon Co | $65,177,059,659.67 |
| 5 | Northrop Grumman Corp | $56,359,072,001.55 |
| 6 | Huntington Ingalls Industries Inc | $27,715,663,958.76 |
| 7 | L3Harris Technologies Inc | $26,794,865,876.56 |
| 8 | United Technologies Corp | $25,999,604,374.81 |
| 9 | BAE Systems PLC | $25,778,426,665.75 |
| 10 | Humana Inc | $20,880,951,826.03 |
| 11 | Science Applications International Corp | $13,888,405,839.96 |
| 12 | Centene Corp | $13,878,707,437.30 |
| 13 | Leidos Holdings Inc | $13,325,332,534.83 |
| 14 | Booz Allen Hamilton Holding Corp | $12,923,346,487.04 |
| 15 | McKesson Corp | $11,962,152,783.13 |
| 16 | General Electric Co | $10,849,141,528.61 |
| 17 | AmerisourceBergen Corp | $9,820,565,848.61 |
| 18 | UnitedHealth Group Inc | $9,790,770,221.91 |
| 19 | CACI International Inc | $9,324,567,812.88 |
| 20 | Textron Inc | $8,819,079,423.77 |
| 21 | Oshkosh Corp | $8,311,639,431.34 |
| 22 | Fluor Corp | $7,115,499,802.10 |
| 23 | AECOM | $7,106,672,055.38 |
| 24 | KBR Inc | $6,482,727,280.72 |
| 25 | Honeywell International Inc | $6,331,471,964.37 |
| 26 | Perspecta Inc | $5,986,604,053.15 |
| 27 | Leonardo SpA | $5,385,465,178.08 |
| 28 | Vectrus Inc | $5,144,969,638.56 |
| 29 | Jacobs Engineering Group Inc | $4,838,010,187.50 |
| 30 | Rolls-Royce Holdings PLC | $3,946,438,583.47 |
| 31 | Royal Dutch Shell PLC | $3,675,055,018.82 |
| 32 | FedEx Corp | $3,565,899,325.85 |
| 33 | BP PLC | $3,422,956,087.86 |
| 34 | Cigna Corp | $3,282,090,065.62 |
| 35 | Parsons Corp | $2,999,102,267 |
| 36 | ManTech International Corp/VA | $2,849,913,894.81 |
| 37 | Cardinal Health Inc | $2,768,505,710.88 |
| 38 | Insight Enterprises Inc | $2,566,696,616.96 |
| 39 | Cubic Corp | $2,260,665,318.66 |
| 40 | Great Lakes Dredge & Dock Corp | $2,165,762,346.19 |
| 41 | Valero Energy Corp | $1,995,554,598.14 |
| 42 | CDW Corp/DE | $1,986,470,570.99 |
| 43 | Accenture PLC | $1,977,025,552.25 |
| 44 | AP Moller - Maersk A/S | $1,719,751,877.38 |
| 45 | Airbus SE | $1,599,923,785.17 |
| 46 | Exxon Mobil Corp | $1,555,147,042.81 |
| 47 | ViaSat Inc | $1,553,798,126.62 |
| 48 | International Business Machines Corp | $1,536,470,119.86 |
| 49 | Marathon Petroleum Corp | $1,527,625,599.37 |
| 50 | Microsoft Corp | $1,497,948,032.07 |
| 51 | Verizon Communications Inc | $1,496,954,309.91 |
| 52 | Serco Group PLC | $1,478,321,687.89 |
| 53 | Abu Dhabi National Oil Co | $1,428,207,566.60 |
| 54 | AAR Corp | $1,352,637,702.98 |
| 55 | CAE Inc | $1,351,839,819.49 |
| 56 | TransDigm Group Inc | $1,338,996,979.17 |
| 57 | McDermott International Inc | $1,327,851,550.07 |
| 58 | Sodexo SA | $1,302,136,095.37 |
| 59 | VSE Corp | $1,301,692,920.81 |
| 60 | Interpublic Group of Cos Inc/The | $1,287,068,026.51 |
| 61 | Navistar Defense LLC | $1,270,125,273.48 |
| 62 | WSP Global Inc | $1,241,803,153.64 |
| 63 | CenturyLink Inc | $1,175,297,941.65 |
| 64 | Kratos Defense & Security Solutions Inc | $1,172,093,663.65 |
| 65 | Par Pacific Holdings Inc | $1,153,359,885.57 |
| 66 | Phillips 66 | $1,129,616,156.52 |
| 67 | Johnson Controls International plc | $1,127,779,408.33 |
| 68 | Dell Inc | $1,111,737,014.73 |
| 69 | HP Inc | $1,064,707,082.70 |
| 70 | Cisco Systems Inc | $1,062,897,606.37 |
| 71 | Owens & Minor Inc | $1,029,683,177.59 |
| 72 | Elbit Systems Ltd | $1,025,934,729.58 |
| 73 | Magellan Health Inc | $1,018,615,675.04 |
| 74 | FLIR Systems Inc | $927,462,077.53 |
| 75 | Parker-Hannifin Corp | $909,627,967.41 |
| 76 | MetLife Inc | $901,571,416.47 |
| 77 | Caterpillar Inc | $889,189,854.18 |
| 78 | Meggitt PLC | $813,148,071.91 |
| 79 | Motor Oil Hellas Corinth Refineries SA | $809,720,435.20 |
| 80 | ASGN Inc | $805,492,659.47 |
| 81 | Siemens AG | $804,597,093.25 |
| 82 | Moog Inc | $789,148,001.77 |
| 83 | Teledyne Technologies Inc | $786,762,881.85 |
| 84 | Aerojet Rocketdyne Holdings Inc | $773,903,803.98 |
| 85 | Thales SA | $772,891,996.69 |
| 86 | JXTG Holdings Inc | $743,306,398.12 |
| 87 | BBA Aviation PLC | $734,808,465.03 |
| 88 | Sysco Corp | $712,781,421.48 |
| 89 | Berkshire Hathaway Inc | $701,802,641.22 |
| 90 | Southern Co/The | $689,902,118.64 |
| 91 | Cobham PLC | $674,403,933.51 |
| 92 | TOTAL SA | $671,106,918.04 |
| 93 | Safran SA | $654,557,043.20 |
| 94 | Cummins Inc | $646,437,582.04 |
| 95 | WPP PLC | $644,043,499.04 |
| 96 | Cosmo Energy Holdings Co Ltd | $629,960,537.24 |
| 97 | John Wood Group PLC | $629,812,596.87 |
| 98 | Ball Corp | $622,882,210 |
| 99 | Tutor Perini Corp | $604,542,046.71 |
| 100 | Kongsberg Gruppen ASA | $600,353,449.96 |

*Source: Bloomberg Government*

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