Organic Industrial Base Industry Study: Surge Limiting Factors Report

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"The Business Enterprise of the U.S. Department of Defense"

25-P-0141

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Executive summary

The organic industrial base is a critical part of our national security apparatus. Its mission is to maintain, repair, and overhaul the military equipment of our Armed Forces, and employs over 80,000 civilian employees across 17 government-owned, government-operated industrial facilities. The organic industrial base (OIB) must be postured to support peacetime requirements but also agile enough to respond to a mobilization, national defense contingency, and other emergency requirements. These requirements are the essence of readiness.

As the Department of Defense implements the National Defense Strategy and acquires new aircraft, ships, vehicles, and weapons systems, it cannot ignore the operations and support portion of the acquisition cycle and must plan strategically for the future. If the OIB cannot quickly repair weapons systems as they require maintenance, then we are doing a disservice to our Armed Forces and our nation. It is a national priority to sustain, resource, and ultimately expand the OIB's capabilities and capacity.

This report provides an overview of the OIB's role as the business enterprise of the Department of Defense (DoD), the OIB's ability to surge operations for future contingencies, and opportunities to expand capacity through technology, innovation, and strategic partnerships. The report is framed by an achievable concept using adopted business best practices to enhance OIB effectiveness and efficiency but is limited in assessing the OIB's ability to surge due to fundamental differences between DoD's measurement of capacity and industry standard output metrics.

This report builds off previous Eisenhower School reports offering fundamental direction of OIB strategy and execution covering business operations, infrastructure, finance, and human capital. A framework defining surge levels and capital investments required to achieve them is also provided. Aspirational recommendations include:

- Direct the Services to develop and follow business plans supported by long-term strategies focusing on: Value Creation, Value Propositions, Value Delivery, Value Capture and Value Communication.
- Direct the Services to adopt business case analysis methods to capture capital investment for new facilities and equipment as part of Net Present Value calculations.
- Follow a production-based model to drive OIB programming toward industry best practices rather than focus on direct labor hours as the principal production metric.
- Conduct a rigorous analysis at each government-owned maintenance, repair, and overhaul facility to determine both actual output and maximum output (measured in repaired military equipment and not direct labor hours) of each OIB production line.
- Direct the Services to describe how investment strategies for sustained technology insertion are part of infrastructure optimization plans.

Author Team Alphabetically (by last name)
LtCol David Arenas, USMC
COL Chris Bachman, USA
Ms. Julie Chisholm, DoD Civ
CDR William Coffeen, USN
LtCol Bryan Collins, USAF
Ms. Lee Conesa, DoD Civ
LTC Brian Davis, USA
COL Rafael Dellane de Amorim Pires, Brazilian Army
Mr. David Denning, DoD Civ
LtCol Michael Hansen, USAF
LtCol Andrew Jutte, USAF
LTC Cody Koerwitz, USA
Mr. Joey Larman, DoD Civ
LtCol Sean McClune, USAF
Mr. Kevin McKenna, DoD Civ
CDR Paul Parsoneault, USN
Col Scott Pendley, USAF
COL Azman Bin Rabani Royal Malaysian Navy
LTC Anthony Wilson, USA

Professors / Instructors
Col Grant Izzi, USAF, NDU Faculty
COL Yolanda Hines, USA, NDU Faculty
Dr. Steven Bloom, Civ NDU Faculty

Industry Study Field Studies and Outreach
Site visits to:
Letterkenny Army Depot
Defense Logistics Agency Aviation
Logistics Management Institute
U.S. Coast Guard Shipyard
Anniston Army Depot
U.S. House of Representatives Armed Services Committee, Readiness Subcommittee

Guest speakers from:
Lockheed Martin Corporation
General Dynamics Corporation

Virtual engagements with:
Oklahoma Air Logistics Center
Wichita State University
National Institute for Aviation Research
Fleet Readiness Center Southeast
Government Accountability Office
Office of Deputy Assistant Secretary of Defense, Materiel Readiness

Chapter 1 – Introduction

1.1 Background

> *"It is essential for the national defense that the Department of Defense maintain a core depot-level maintenance and repair capability that is Government-owned ... to ensure a ready and controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency situations, and other emergency requirements."*[1] *U.S. Code, Title 10, Section 2464*

To follow codified law, the Department of Defense (DoD) owns and operates industrial facilities to maintain, repair, and overhaul military equipment - these facilities are collectively referred to as the organic industrial base.[2] Industrial facilities in the organic industrial base (OIB) include depots, shipyards, fleet readiness centers, air logistics complexes, and production plants and will be referred to collectively as *depots* in this report. A robust list of terms is provided in Appendix A.

There are 17 government-owned, government and contractor operated fixed depots in the OIB where *depot level maintenance* – material and/or software maintenance or repair requiring the overhaul, upgrading, or rebuilding of parts, assemblies, or subassemblies and the testing and reclamation of equipment as necessary – is performed on a wide range of military assets (combat vehicles, aircraft, ships, engines and software).[3] Over 80,000 civilian personnel are employed across the 17 depots depicted in Figure 1.1.[4] A complete inventory of OIB facilities and locations is provided in Appendix B.

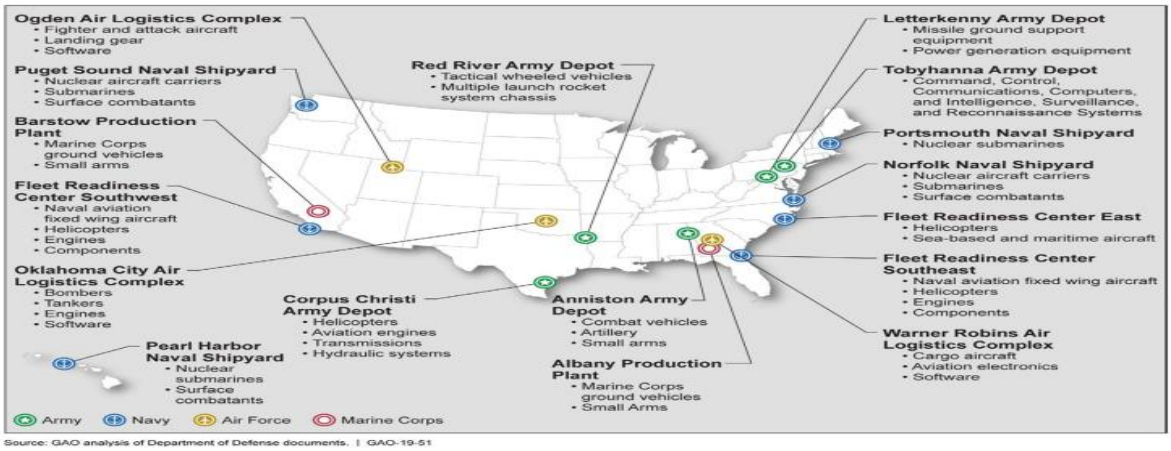


Figure 1.1 DoD Maintenance Depots & Locations

[1] Core Depot-Level Maintenance and Repair Capabilities, 10 U.S.C §2464 (2019), https://www.acq.osd.mil/log/mpp/.depot.html/10USC2464_Core_Logistics_Capabilities.pdf (accessed January 9, 2020).
[2] G. James Herrera, Defense Primer: Department of Defense Maintenance Depots, Washington, DC: U.S. Library of Congress, Congressional Research Service, March 19, 2020, page 1.
[3] Herrera, Defense Primer: Department of Defense Maintenance Depots, 1.
[4] Herrera, Defense Primer: Department of Defense Maintenance Depots, 2.

For Fiscal Year 2020, the Operation & Maintenance portion of the $718 billion defense budget request was $292.8 billion (~ 41%). Depot maintenance funding represented $32.5 billion making up 11% of the entire Operation & Maintenance budget authority, or 4.5% of the total DoD request.[5] Section 2466 of Title 10 mandates no-less than 50% of annual depot maintenance funding is to be used to resource the OIB to prevent "DoD from outsourcing a majority of its maintenance workload to ensure organic facilities, equipment and personnel receive a sufficient peacetime workload to remain qualified and available in times of emergency."[6] The other 50% of depot maintenance funding may be used to resource private depots in the Commercial Industrial Base complimenting the OIB in the overall United States Defense Industrial Base.[7]

1.2 Eisenhower School OIB Industry Study Body of Work

Research and analysis of OIB contributions to national security and military readiness by OIB Industry Study teams over the past two years developed a standard *OIB Definition*, *Key Readiness Enablers*, an *Iterative OIB Metrics Framework*, and an *OIB Improvement Plan*.

OIB Definition: Government-owned industrial capability comprised of the organizations and facilities performing research, development, production, or depot-level maintenance, repair, demilitarization, and disposal of weapon systems equipment, materials, munitions, hardware, and software. These include laboratories, research centers, arsenals, depots, shipyards, aircraft plants, and ammunition plants, whether operated by government personnel or contractors.

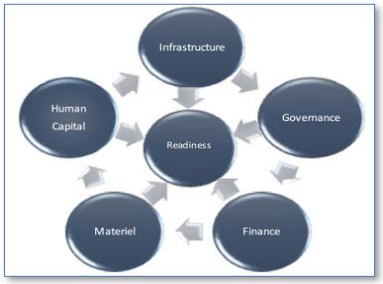


Figure 1.2 Key Readiness Enablers

Key Readiness Enablers: Relationships between Governance, Finance, Human Capital, Infrastructure, and Materiel impact the OIB's ability to maintain readiness, posture for surge, and preserve necessary linkages with the Commercial Industrial Base (CIB), enabling the Defense Industrial Base (DIB) writ large to meet national security goals.

Iterative OIB Metrics Framework: The Key Readiness Enabler construct became re-imagined in tactical, operational, and strategic levels. The interrelated contributions and associated metrics inform stakeholders, senior leaders, and supporting activities across the OIB ecosystem.

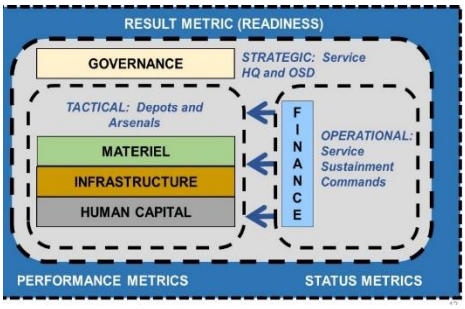


Figure 1.3 Iterative OIB Metrics Framework

[5] Office of the Under Secretary of Defense (Comptroller)/Chief Financial Officer, Operation and Maintenance Overview Fiscal Year 2020 Budget Estimates (Washington, DC: Department of Defense, March 2019), https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2020/fy2020_OM_Overview.pdf (accessed April 13, 2020).
[6] Herrera, Defense Primer: Department of Defense Maintenance Depots, 2.
[7] For a complete list of OIB Governance & Policies, see Appendix C.

OIB Improvement Plan: The Interagency Task Force report to Executive Order 13806, *"Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States"* identified the following negative impacts to the OIB:

- Workforce gaps in critical skills hiring
- Overuse and underfunded infrastructure
- Diminishing manufacturing sources, materiel shortages, and the degradation of supply chain integrity
- Levels of funding and the way funding has been made available and allocated.[8]

The OIB Improvement Plan leveraged Key Readiness Enablers, along with Metrics from the Iterative OIB Framework to provide near and long-term recommendations to address the negative impacts to the OIB identified in the report.

This year's OIB Industry Study team builds off the past body of work by focusing on limiting factors to surge by analyzing the negative impacts OIB business operations have on Key Readiness Enablers, the OIB's ability to surge, and levels of surge for future readiness contingencies, providing aspirational recommendations offering a fundamental redirection of OIB strategy and execution.

1.3 Capacity utilization – a tale of two meanings

"Bad terminology is the enemy of good thinking." -Warren Buffet

Terminology is important. "Often, participants in a discussion on defense matters will use the same words but mean different things, diminishing the value of the exchange."[9] Students of the OIB Industry Study appreciate the wisdom of this statement considering the term *capacity* in the context of Eisenhower School Industry Analysis curriculum (IA-18, *"Defense Readiness, Surge, and Mobilization at the Industry Level")* juxtaposed term usage by depots as per DoD 4151.18-H, *Depot Maintenance Capacity and Utilization Handbook*.

From a basic industry standpoint, *capacity* is a measure of maximum output using productive resources to produce goods in a given period; *capacity utilization* is how much available capacity is actually being used to produce goods.[10] Consider an automobile repair shop able to repair 1,000 cars a month assuming it has enough workers, parts, supplies, and equipment to process cars through the repair production activity. Therefore, its *capacity* is 1,000 cars. *Capacity utilization* is expressed as a percentage and is calculated by taking the actual level of output, divided by the maximum possible output, and multiplied by 100:

(Actual Output / Maximum Output) x 100 = Capacity Utilization

[8] ES6752, Organic Industrial Base Industry Studies Lesson 1, AY19 OIB IS Group Report – Seminar 15, accessed January 13, 2020 via Blackboard, 3.
[9] Tom D. Miller, "The Defense Sustainment Industrial Base – A Primer," Brooking Institution, June 2010, https://www.brookings.edu/research/the-defense-sustainment-industrial-base-a-primer/ (accessed April 13, 2020), 6.
[10] ES6206, Industry Analysis Lesson 18, accessed March 5, 2020, via Blackboard.

If the repair shop repairs 750 cars in one month, then its capacity utilization for the month is: 75%. [Read: (750 cars / 1000 cars) x 100 = 75%] In this example, the auto repair shop is operating below potential capacity and has spare capacity of 25%. Factors which might contribute to operating below capacity are: some cars require more maintenance than just a basic tune-up; or some cars are older and are awaiting on parts not on hand; or gas was expensive over the past six months and people drove their vehicles less so fewer customers bring their cars to be serviced; or auto lifts need maintenance; or some technicians called out sick, etc.

DoD 4151.18H uses a standard method for measuring depot capacity via direct labor hours, based on a standard 40-hour, 5-day work week and calls it the "Baseline Capacity Index."[11] The "Utilized Capacity Index" is the number of direct labor hours (DLH) required by a production line to support funded depot maintenance requirements and is equal to the total number of DLH required for a production line to execute funded workload requirements. Finally, the "Funded Operations Utilization Indicator" provides an indication of the degree of alignment between capacity required to support funded workload and the Baseline Capacity of a production line and is expressed as a percentage:

(Utilized Capacity Index / Baseline Capacity Index) x 100 = Funded Operations Utilization.[12]

Simply put, an industry standard definition of capacity and capacity utilization is based on potential and actual output (repaired cars to continue the analogy); while DoD 4151.18H relates capacity and capacity utilization to labor output in the form of labor hours. The DoD Handbook's method works for a DoD budget focused operation where the goal is for Funded Operations Utilization to always equal 100%. But this method tells us nothing about how many pieces of repaired military equipment (combat vehicles, aircraft, ships, engines, software, etc.) a production activity can potentially produce, nor does it give any sign of where a production activity is operating relative to potential output – which is a critical indicator to determining a production activity's ability (or inability) to increase capacity utilization in response to an emergency or contingency.

1.4 Defining *surge*

> *"I understand counting steel. I understand rail cars. I understand housing and lumber. I understand things that if you drop them on your foot, it will hurt." – Dennis Gartman*

Unlike the term *capacity* where an entire handbook is dedicated to a method of determining it, the term *surge* as it relates to the OIB is not defined in any governing publication or instruction. A cursory review of the governing instructions reveals the term twice:

> *U.S. Code, Title 10, Section 2464*: Assign such facilities sufficient workload to ensure cost efficiency and technical competence in the peacetime while preserving the ***surge*** capacity and reconstitution capabilities necessary to support

[11] U.S. Department of Defense, Depot Maintenance Capacity and Utilization Handbook, Handbook 4151.18H (Washington, DC: U.S. Department of Defense, March 10, 2007), 10.
[12] Department of Defense Handbook 4151.18H, 16.

> fully the strategic and contingency plans prepared by the Chair of the Joint Chiefs of Staff under section 153 of this title.[13]
>
> *DoD Manual 4151.23*: Maintenance programs will: Be structured to meet the required readiness and sustainability objectives (including mobilization and ***surge*** capabilities) of national defense strategic and contingency requirements.[14]

In discussions with depot managers about their ability to surge production, the response relates to the output of DLH in the form of "overtime and extra shifts," or words to that effect. If the measure of output (capacity) is labor hours, then overtime and extra shifts to increase output is logical. But labor hours don't hurt if you drop them on your foot quite like repaired military equipment does. Repaired military equipment measured as output is far more understandable and meaningful than labor hours. And the volume of repaired equipment beyond what is being produced using fixed inputs (increasing capacity utilization) is the true measure of surge ability. Therefore, surge as it relates to the OIB is defined as follows:

> ***surge***: The ability to increase organic industrial base programmed capacity utilization, using fixed capital, in response to operational requirements or unforeseen circumstances.

1.5 The need for efficiency and effectiveness in the OIB

"Efficiency is the foundation for survival.
Effectiveness is the foundation for success." – John C. Maxwell

Depots run under the construct of a Defense Working Capital Fund, allowing them to act like a commercial business with buyer-seller relationships. But depots are non-profit generating government operations, and depot managers concede the CIB is much more efficient due to the bottom-line driver: profit. Depot prioritization of effectiveness over efficiency (and profit) is understandable given the salient difference. Further, prioritizing effectiveness is codified into law.

> U.S. Code, Title 10, Section 2464: It is essential for the national defense that the Department of Defense maintain a core depot-level maintenance and repair capability that is Government-owned ... to ensure a ready and controlled source of technical competence and resources necessary to ensure ***effective*** and timely response to a mobilization, national defense contingency situations, and other emergency requirements.[15]

But how is effectiveness or a "timely response" measured? If peacetime operations of the OIB is current capacity utilization for each production line, do we know what capacity is? Do we know how long capacity might take to achieve *if* required? And if not, how do we know if

[13] Core Depot-Level Maintenance and Repair Capabilities, 10 U.S.C §2464 (2019).
[14] U.S. Department of Defense, DoD Organic Depot Maintenance Cost Comparability, Manual 4151.23 (Washington, DC: Department of Defense, June 24, 2016), 1.
[15] Core Depot-Level Maintenance and Repair Capabilities, 10 U.S.C §2464 (2019).

the OIB can meet the requirement by law? How do we know the OIB will be effective in its insulated role?

As mentioned earlier, Section 2466 mandates no-less than 50% of annual depot maintenance funding is to be used to resource the OIB. Using the Fiscal Year (FY) 2020 defense budget request figures already discussed, over $16.0 billion will go to the OIB. If the CIB uses over $16.0 billion towards inputs and is more efficient by virtue of profit generation, doesn't the OIB have a responsibility to be just as efficient and produce a cost-savings where it can? Doesn't the efficiency aspect of Section 2464 mandate this occurs?

> U.S. Code, Title 10, Section 2464: Assign such facilities sufficient workload to ensure cost ***efficiency*** and technical competence in the peacetime while preserving the surge capacity and reconstitution capabilities necessary to support fully the strategic and contingency plans prepared by the Chair of the Joint Chiefs of Staff.[16]

Based on the concept of profit maximization, rational firms in the CIB will not take part in the market if the marginal cost (MC) to repair a piece of military equipment does not equal marginal revenue (MR). In these cases, the OIB can exercise its innate effectiveness, able to produce unimpeded by a lack profit where the CIB will not. Other instances where the OIB's effectiveness can be leveraged is for emergent, unplanned, and time critical requirements where the CIB may not be able to elicit a "timely response" or does not have available capacity. But up to this point, the OIB can and should seek efficiency in day-to-day operations, staying aligned with the third line of effort of the National Defense Strategy: "reforming the Department's business practices for greater performance and affordability."[17] Figure 1.4 below offers a graphic construct and recent examples of this idea.[18]

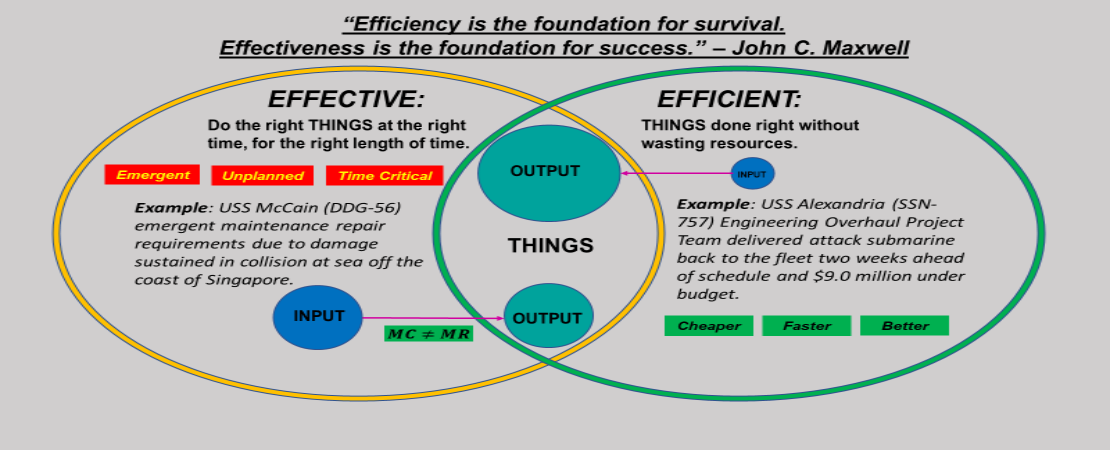


Figure 1.4 The Effective AND Efficient OIB

[16] Core Depot-Level Maintenance and Repair Capabilities, 10 U.S.C §2464 (2019).
[17] James N. Mattis, 2018 National Defense Strategy of the United States of America (Washington, DC: U.S. Department of Defense, 2018), https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf (accessed April 17, 2020), 5.
[18] "Measure Effectiveness First To Earn A Seat At The Strategy Table," https://visionedgemarketing.com/measure-effectiveness-first-earn-your-strategy-table-seat/ (accessed April 15, 2020).

Chapter 2 – Business Operations

2.1 Introduction

The OIB is the business enterprise of DoD and generates strategic readiness by performing industrial activities maintaining, repairing, and overhauling military equipment in exchange for revenue. With revenues of $20 billion in 2019, as a private entity the OIB would rank #154 in the Fortune 500.[19] Representing a business, DoD should evaluate and hold the OIB accountable in the same manner investors hold private enterprises accountable. Investors evaluate firms by examining if value is being created at an acceptable level of risk. DoD can evaluate value creation of the OIB by benchmarking performance and output against private industry. In a free market, DoD would bid all maintenance, repair, and overhaul (MRO) requirements between the OIB and CIB and choose the option providing the most value. The OIB incurs opportunity cost in resources (money, labor, equipment, etc.) anytime depot maintenance is cheaper to outsource to the CIB.

But law (specifically Section 2466) doesn't allow the OIB to consistently outsource to avoid opportunity costs. Further, and as discussed in the last chapter, if marginal cost to perform repair work does not equal marginal revenue for the CIB, required work simply will not be done. Improving OIB efficiency could reduce opportunity costs via adoption of industry best practices with an enhanced business mentality. A business plan built on accepted business models, utilizing competition to force efficiency, developing a holistic capital investment strategy, and production-based programming are all industry best practices the OIB should leverage to optimize resources to effectively generate strategic readiness and create value.

2.2 Financial Standards of the OIB

The OIB is funded through a combination of revolving Working Capital Funds (WCF), direct appropriations, reimbursement for work performed, and direct sales.

> Working capital funds allow depots to function in a business-like capacity generating sufficient revenue to cover the full cost of operations on a break-even basis over time - that is, neither make a gain nor incur a loss.[20]

Two financial indicators drive OIB operations and pricing strategies reported annually: Net Operating Results and Accrued Operating Results. Net Operating Results (NOR) is the business equivalent of net profit or net earnings from the income statement. NOR shows operating revenue, expenses, direct appropriations received, and capital surcharges if applied and is the profit/loss generated by annual activities within the OIB. Accrued Operating Results (AOR) is a cumulative summary of operations of the WCF over the years of fund use and is equivalent to retained earnings from the balance sheet. Retained earnings provide private

[19] 2020 Fortune 500, https://fortune.com/fortune500/2019/search/ (accessed May 9, 2020).
[20] U.S. Government Accountability Office, Depot Maintenance: DoD Should Adopt A Metric That Provides Quality Information On Funded Unfinished Work (Washington, DC: U.S. Government Accountability Office, July 2019), https://www.gao.gov/reports/GAO-19-452/ (accessed April 11, 2020).

businesses flexibility to reinvest into the company, keep cash reserves, or pay dividends to investors. Since the WCF is guided by law to break-even over time, accumulated profits are used to subsidize reduced composite rates for work performed in the future. When AOR runs negative, the Services are required to increase rates to generate positive NOR and bring AOR back to a zero-balance.

Results of the financial performance of the military departments are reported in the annual justification materials supporting the President's budget request. Data is presented as actuals for the prior fiscal year, expected performance of the current year, and projections supporting the President's budget request for the future fiscal year. All three WCFs reported negative NORs for FYs 2019 and 2020. The U.S. Army was the only department running a positive AOR over the five-year review of operations as displayed in Figure 2.1.

U.S. Air force					
Financial Performance ($ Millions)	**FY2017**	**FY2018**	**FY2019**	**FY2020** *Projection*	**FY2021** *(PB Request)*
Total Revenue	12,637.0	11,927.8	11,857.9	12,496.6	13,672.3
Total Expenses (with Work in Progress)	12,404.0	12,350.9	12,943.8	12,616.3	12,895.2
Other Adjustments Affecting NOR and Other Changes	29.2	30.2	31.3	27.2	27.2
Net Operating Results	**262.2**	**(402.0)**	**(1,056.6)**	**(91.7)**	**804.4**
Non Recoverable Adjustments Impacting AOR	3.9	0.0	0.0	0.0	0.0
Accumulated Operating Results	**746.0**	**344.0**	**(712.6)**	**(804.4)**	**0.0**
U.S. Army					
Total Revenue	4,654.1	4,483.0	4,729.5	4,936.6	4,842.6
Total Expenses (with Work in Progress)	4,809.6	4,710.0	4,940.7	5,132.0	4,997.0
Net Operating Results	**230.2**	**(161.5)**	**(71.4)**	**(48.9)**	**(83.9)**
Deferred Accumulated Operating Result	0.0	0.0	0.0	0.0	(263.8)
Accumulated Operating Results	**629.5**	**468.0**	**396.6**	**347.7**	**0.0**
Department of the Navy - Fleet Readiness Centers (Air)					
Total Revenue	2,207.7	2,527.1	2,648.0	2,588.8	2,977.4
Total Expenses (with Work in Progress)	2,233.4	2,468.7	2,668.6	2,625.5	2,710.3
Capital Surchrge	(11.9)	(0.5)	(0.1)	0.0	0.0
Net Operating Results	**(37.7)**	**57.9**	**(20.8)**	**(11.1)**	**267.1**
Accumulated Operating Results	**(290.6)**	**(235.2)**	**(256.0)**	**(267.1)**	**0.0**
Department of the Navy - Marine Corps Depots (Ground)					
Total Revenue	382.2	360.1	395.3	416.6	407.2
Total Expenses (with Work in Progress)	365.2	354.3	426.5	422.5	382.0
Capital Surcharge	0.0	0.0	(5.4)	(3.7)	0.0
Net Operating Results	**17.0**	**5.8**	**(36.6)**	**(9.6)**	**25.2**
Accumulated Operating Results	**17.8**	**23.6**	**(13.0)**	**(25.2)**	**0.0**

Source: FY2018, 2019, 2020, 2021 Working Capital Fund Justification Materials for the President's Budget Request. https://comptroller.defense.gov/Budget-Materials/

Figure 2.1 Financial Performance of Industrial Operations

Total expenses reflect direct labor, materials, operational costs, and overhead. AOR is managed at the enterprise level by each respective department. Mandated to operate with AOR at $0, each department establishes a composite labor hour rate used for budget planning and execution. Actual work-center rates vary by location and/or equipment repaired and often show more efficiency than reported in the composite rate. But the composite rate is the official rate reported and used to balance AOR. Since the Planning Programming, Budgeting, and Execution process is a multi-year effort to produce a budget request seven months before the beginning of the fiscal year, correct actual execution data is not shown for two budget cycles in budget justification books. The time-lag presents challenges to enterprise planners to account for unexpected performance swings. As a result, all service branches are required to keep a cash balance between an approved floor and ceiling level in a revolving fund to account for immediate outlays to cover emergent requirements. The cash levels are necessary to mitigate risk of default and Antideficiency Act violation(s) due to the time-lag of reimbursable work. In business terms, the revolving account shows a subsidy to offset deficiencies in operations.

2.3 Financial performances of the three military departments

Department of the Air Force: NOR of -$1,056.6 million in FY2019 and expecting a loss in FY2020. The loss in FY2019 was $600.0 million more than expected during FY2020 budget development. To account for negative AOR, FY2021 prices will increase 9.7% and flying-hour rates will increase 14.9%.[21] The negative AOR coincides with a reduction in cash level of their revolving fund. Simply put, the U.S. Air Force is providing added funding resources to stabilize OIB operations.

Department of the Army: Losses in NOR reported in four of the last five years while keeping a positive AOR balance.[22] The reported NOR includes appropriated funding to subsidize excess arsenal infrastructure and mobilization capacity. Appropriated funding has varied year-to-year between $140.0 and $180.0 million. To account for positive AOR, the U.S. Army stabilized its composite rate to draw down the positive AOR returning a dividend through stable composite rates. The last rate change reported was a decrease from $157.3 to $155.3 in FY2019. The U.S. Army received permission to defer the return of AOR over subsequent fiscal years.

Department of the Navy: Industrial operations supported by WCFs are divided into Fleet Readiness Centers supporting U.S. Navy and U.S. Marine Corps aviation, and depot's supporting U.S. Marine Corps ground equipment. [Note: Ship maintenance, repair, and overhaul is funded through direct appropriations and excluded from the WCF analysis.] The Fleet Readiness Center (FRC) reported negative NOR in three of the last four years and is projecting positive NOR in FY2021.[23] Positive NOR projection in earlier budget materials never materialized in execution. To balance AOR, the department is increasing composite rates 18.8%. Meanwhile, depot operations primarily operated by the U.S. Marine Corps conveyed a loss of $9.6 million in FY2019 and is expected to lose money in FY2020.[24] With AOR at -$25.2 million, the department is increasing composite rates by 15% in FY2021.

2.4 Value Creation and Industry Analysis of the Defense Ground MRO Market

The business world is guided by a single mantra providing purpose and intent - ***is the firm creating value at an acceptable level of risk?*** The creation of value drives the development of business plans and goals. For production and manufacturing corporations, every component of the business is evaluated to understand the level of value created by raw materials, labor inputs, production lines, and overhead costs. Time, capacity, and utilization all have monetary measures. Unfinished goods and downtime represent carrying costs. Manufacturing firms ruthlessly drive planning of material delivery, production processes, and distribution to decrease

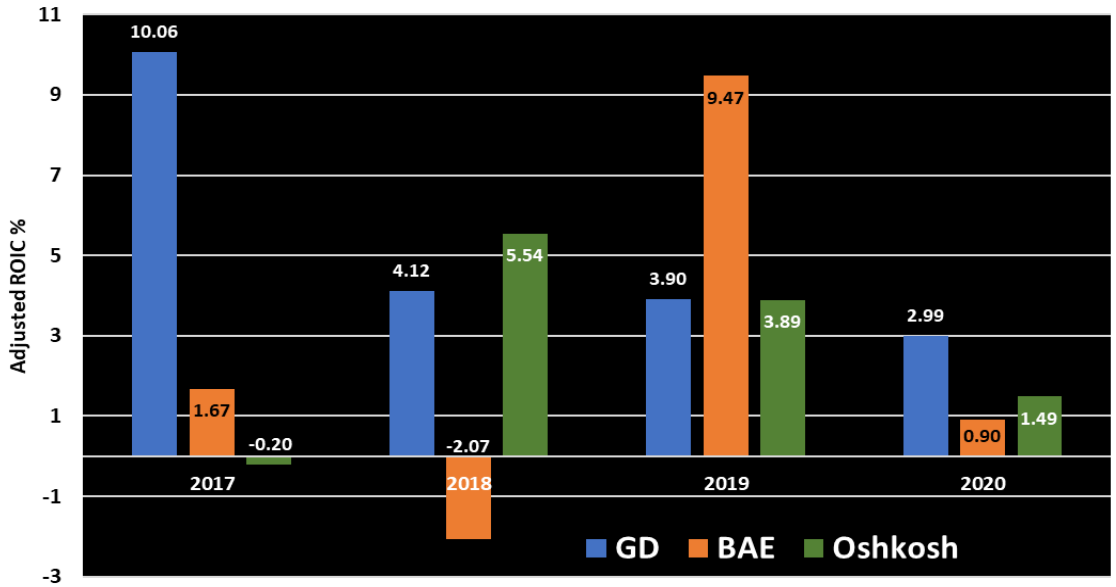
[21] U.S. Air Force, *United States Air Force Working Capital Fund, Fiscal Year (FY) 2021 Budget Estimates* (Washington, DC: U.S. Air Force, 2020), 21.
[22] U.S. Army, *Army Working Capital Fund Fiscal Year 2021 Budget Estimates* (Washington, DC: U.S. Army, 2020), 57.
[23] U.S. Navy, *Department of The Navy Fiscal Year (FY) 2021 Budget Estimates, Navy Working Capital Fund* (Washington, DC: U.S. Navy, 2020).
[24] Ibid., 56.

downtime. A commercial aircraft parked awaiting work is a negative revenue stream. The OIB does not view downtime as lost revenue, only as lost availability. The performance and success of the business sector gives the OIB with a model to optimize value creation.

Investors developed metrics to evaluate performance of corporations. Of the metrics available, return on invested capital is the best indicator of company performance and value generation. Return on invested capital (ROIC) represents the added value investors receive above original investment. ROIC is further measured by comparing the weighted average cost of capital to create an adjusted ROIC. Businesses use the selling of bonds, equity, and loans to acquire capital for internal investment. And ROIC above the cost of capital is the representation of value creation at the corporate level.

Business managers use net present value calculations to determine if a project or business segment is generating value. Net present value (NPV) is determined by discounting all future returns to current dollars and subtracting project costs. Positive NPV above the expected rate of return in other investments is value creation at the project level.

For illustration purposes, consider the ground combat maintenance, repair, and overhaul (MRO) industry leaders: General Dynamics, BAE Systems, and Oshkosh Defense. Besides serving as defense contractors, these firms take part in DoD's Public-Private Partnership program. They work jointly within OIB facilities to conduct MRO and give a blueprint for effectiveness. The operational and supply chain disruptions challenging the OIB are shared with these industry leaders. Despite shared MRO challenges, these firms consistently generate profits. Figure 2.2 gives details representing the value generation above cost of capital. The firms within the industry share commonalities in business practices and operations applicable to the OIB, providing a benchmark for the OIB to evaluate itself.



Source: Bloomberg Terminal

Figure 2.2 Adjusted ROIC of Ground MRO Primes

2.5 Recommendations

Applying Business Practices

1. ***The Services should develop and follow business plans supported by long-term strategies.*** A business plan is a representation of a firm's underlying core logic and strategic choices for creating and capturing value.[25] The Services rely on long-term strategies to guide their OIB activities. In private industry, firms develop strategies to supplement and enhance their business plan. The closest semblance to a business plan is approved Defense WCF budgets for each service.[26] An example framework the Services could adopt to build their respective plans is found in *360° Business Model Innovation*:

    - **Value creation** - Value creation derives from core competencies, key resources, governance, complementary assets, and value networks. Firms create value by combining core competencies with key resources.
    - **The value proposition** - The value proposition specifies what is offered (the product or service) and at what price. It must be sustainable for the firm and suitable to the market.
    - **Value delivery** - Describes how the value created is delivered.
    - **Value capture** - Includes profit allocation across the value chain. Profit allocation has become more important as firms seldom produce value on their own but rather increasingly rely on co-innovation and other mechanisms to extend their reach and gain access to complementary assets and competencies.
    - **Value communication** - How companies communicate with customers and partners about their products and the value they create. [27]

    The creation of a business plan is necessary to start the transformation of the OIB into a business entity. A business plan gives the OIB a road map to guide business development, seeking efficiencies and improving effectiveness.

2. ***Compete Depot Source of Repair between depots and across services throughout the end-item lifecycle.*** The introduction of competition is necessary to drive innovation, efficiency, and effectiveness. Section 2466 (a.k.a. the "50/50 rule") was implemented to ensure the U.S. maintained a viable and active OIB. But the 50/50 rule, along with the Depot Source of Repair (DSOR) designation, inhibits innovation derived from competition by guaranteeing market share. Newly acquired major end-items receive a DSOR designation naming a depot to perform lifecycle sustainment; and most end-items lock into a depot for their lifecycle. The lack of competition does not imply the Services are not working to generate efficiencies within the OIB. The Services adopted and

[25] Scott H. Shafer, Jeff Smith, and Jane C. Linder, "The Power of Business Models", Business Horizons 48, no.3 (February 2005), 199-207.
[26] Calibre, **"**Defense Working Capital Fund (DWCF) Basics for Organic Industrial Base (OIB) Leaders", briefing slides.
[27] Thierry Rayna and Ludmila Striukova, "360° Business Model Innovation: Toward an Integrated View of Business Model Innovation." Research Technology Management 59, no.3 (2016), 21–28.

implemented best practices to include Lean, Value Engineering, and the Art of the Possible to drive efficiencies and improve effectiveness. But efficiencies will only be pursued on a process driven basis without competition applying market-loss pressure.

Effectiveness is generated through the synchronization of efficient operations within the business by focusing on throughput. According to Michael Porter:

> Operational effectiveness means performing similar activities better than rivals perform them. Operational effectiveness includes but is not limited to efficiency. It refers to any number of practices that allow a company to better utilize its inputs.[28]

Depots are not under the same pressure manufacturing firms are to innovate and drive operational efficiency because no rival competition exists. A senior leader within the OIB said, "Innovation will always be situational until non-innovation is punished quickly, and innovation is seen as the only method of survival and the rewards are over the top. Casual rewards will get casual innovation."[29] The threat of losing market share to another depot would infuse business-like competition generating efficiency and improving effectiveness.

3. ***The Services should adopt business case analysis methods where capital investment for new facilities and equipment would be included as part of NPV calculation.*** The OIB is inhibited through poor synchronization of programming, funding, and prioritization due to a program or appropriation-centric budgeting process. This process encourages short-term decision making at the cost of long-term returns. Businesses build capital investment planning into business case analysis and NPV determination. Capital expenditures for buildings and equipment are factored into decision making. The holistic assessment gives a clear picture of the requirements necessary to pursue opportunities and view projects as investments.

4. ***Follow a production-based model to drive programming to move the OIB towards industry best practices and improve effectiveness.*** As discussed in Chapter 1, the OIB is anchored to DLHs as a production and programming metric. DoD 4151.18H uses DLHs for measuring depot capacity.[30] Composite rates for depot work are based on labor hour execution. The primary measure of performance for a depot is the percentage of DLHs executed. As said by a senior OIB leader, "direct labor hours are the #1 metric the industrial operation sites look at as this drives everything else - number of personnel, associated expenses, how much overhead is affordable, etc. - All other metrics are supplementary."[31]

   Labor based modeling is inefficient and not in line with industry best practices.

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[28] Michael E. Porter, *On Competition* (Boston, MA: Harvard Business Review Press, 2008), Ch 2.
[29] Communication with OIB Senior Leader, April 9, 2020.
[30] Department of Defense Handbook 4151.18H, 10.
[31] Communication with OIB Senior Leader, April 12, 2020.

> In deciding how best to measure productivity, managers should focus not on dollars per hour but on labor dollars per product. That is, on labor content, not labor cost.[32]

The lack of focus on output metrics is magnified at the enterprise level. Funding decisions are made based on the composite cost per hour and AOR. The program-centric model of budgeting hides the true requirements within each service and precludes senior leaders from making comprehensive decisions on maintenance funding and capital investment plans. Professional Staff Members of a congressional committee expressed frustration with the Services and maintenance funding requirements during the FY2021 President's budget roll-out. When pressed for details on how much of the MRO requirements are funded within their respective budgets, Service officials were unable to give specifics. The U.S. Army stated roughly 62% of the requirement is funded in FY2021.[33]

If a service does not know what their depot maintenance requirements are, then any amount of output, be it DLH or actual repaired military equipment is irrelevant. From the U.S. Army perspective where 62% of depot maintenance is funded in FY2021 based off DLH and composite rates, if 100% of the funding is executed in FY2021, then their OIB operations seem to be effective since DLH is the output metric. But this is meaningless since it says nothing about how many pieces of military equipment were repaired. Also, 62% of a requirement based off DLH and composite rates says nothing about how much U.S. Army equipment is not being repaired in FY2021.

Several external factors influencing the amount of funding for maintenance beyond a percentage of the requirement exist. Senior leader priorities, global military operations, and political influences are a few examples influencing the Planning Programming, Budgeting, and Execution (PPBE) process.

2.6 Conclusion

Through its ability to generate strategic readiness and support mobilization, the OIB is a readiness insurance policy for DoD. The OIB is effective at providing the core capability and infrastructure to meet emergent, unplanned, and time critical requirements. Measuring the effectiveness of the OIB to provide day-to-day support is challenging due to the budgeting process and focus on DLH. Four business practices were identified to improve effectiveness within the OIB: implementing a business plan; introducing competition within the Services and depots; incentivizing capital investment; and adopting a production-based model. The OIB should adopt new business practices to improve business operations and optimize its resources to generate strategic readiness.

[32] Bruce Chew, "No Nonsense Guide to Measuring Productivity", Harvard Business Review (January 1988), https://hbr.org/1988/01/no-nonsense-guide-to-measuring-productivity (accessed April 7, 2020).
[33] Communication with Congressional staff member, Spring 2020.

Chapter 3 – Infrastructure & Finance

3.1 Introduction

As discussed in Chapter 1, last year's *OIB Improvement Plan* identified OIB infrastructure overuse and lack of adequate funding as a negative impact to readiness generation. Little changed in the past year, and the outlook for more infrastructure funding is bleak. Congressional Budget Office projections for DoD infrastructure expenditures across the 2020 Future Years Defense Program show a 25% decrease in funding; beyond the 2020 Future Years Defense Program (FYDP), DoD infrastructure expenditures are only forecast to increase 1% per year from 2025.[34] These projections don't bode well for OIB infrastructure improvements needed today. Uneven capital investments caused by non-standard business practices impact the OIB's ability to self-fund future infrastructure projects; therefore, policy changes associated with the collection and expenditure of capital investment funding must be made so the OIB can modernize facilities and equipment organically.

3.2 Infrastructure

As part of the 2007 National Defense Authorization Act, Congress mandated DoD invest in the capital budgets of the depots not less than 6% of the average total combined workload funded for the preceding three fiscal years of maintenance.[35] In the FY2012 National Defense Authorization Act (NDAA), Section 2476 was amended to specifically cite, "maintenance, repair and overhaul," as the source for the 6% calculation, and made clear, "funds spent for sustainment of existing facilities, infrastructure or equipment," should not be included.[36] By adding prejudicial language, Congress made clear to DoD to invest in the future to ensure the OIB has capability and capacity to sustain military equipment.

> Without significant future investment, the organic base will remain challenged by outdated equipment, tooling, and machinery. The erosion of organic infrastructure continues to impact turnaround time and repair costs of newly fielded weapon systems, reducing inventory, decreasing operational readiness, and impacting future deployment schedules.[37]

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[34] F. Matthew Woodward and David Arthur, Congressional Budget Office *Long-Term Implications of the 2020 Future Years Defense Program* (Washington, DC: U.S. Congress Congressional Budget Office, August 2019), https://www.cbo.gov/system/files/2019-08/55500-CBO-2020-FYDP_0.pdf (accessed May 1, 2020), 19.

[35] John Warner National Defense Authorization Act for Fiscal Year 2007, Pub. L. No.109-364, § 332 (2006), codified at 10 U.S.C. § 2476. https://www.congress.gov/109/plaws/publ364/PLAW-109publ364.pdf (accessed May 9, 2020).

[36] National Defense Authorization Act for Fiscal Year 2012, Pub. L. No. 112-81, (2011), 10 U.S.C. § 2476. https://www.congress.gov/112/plaws/publ81/PLAW-112publ81.pdf (accessed May 9, 2020).

[37] U.S. President, Executive Order, "Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States." Executive Order 13806 of July 21, 2017, https://www.whitehouse.gov/presidential-actions/presidential-executive-order-assessing-strengthening-manufacturing-defense-industrial-base-supply-chain-resiliency-united-states/ (Accessed April 10, 2020), 51.

Since the 6% rule was established in 2007, the Services (except for the U.S. Army in 2011 and 2013) met or exceeded the 6% requirement as Figure 3.1 below illustrates.[38] Since language in Section 2476 requires reporting at the department-level, the Department of the Navy (DoN) was able to show compliance. But the chart fails to illustrate FRCs only received a 6% capital investment in 2008 and 2012, while the U.S. Marine Corps Depots never reached the 6% goal.[39]

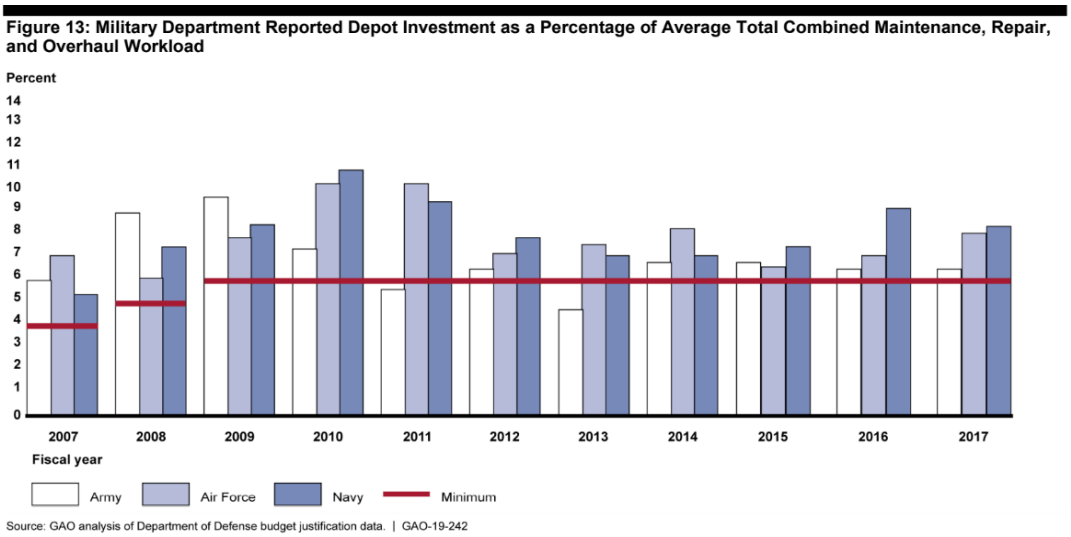

Figure 3.1 Depot Investments

The Government Accountability Office report of April 2019 on depot infrastructure says, "condition of facilities at a majority of the Department of Defense's depots is poor and the age of equipment is generally past its useful life, but the Services don't consistently track the effect that these conditions have on depot performance." As Figure 3.2 details, only three depots are

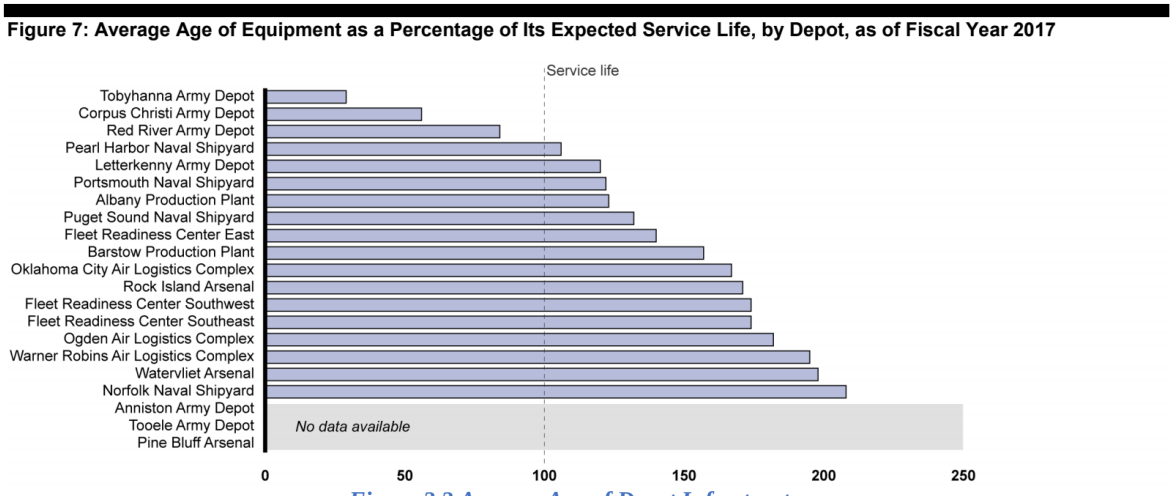

Figure 3.2 Average Age of Depot Infrastructure

[38] U.S. Government Accountability Office, Military Depots: Actions Needed to Improve Poor Conditions of Facilities and Equipment That Affect Maintenance Timeliness and Efficiency (Washington, DC: U.S. Government Accountability Office, April 2019), https://www.gao.gov/products/GAO-19-242 (May 9, 2020), 37.
[39] Ibid., 37-38.

operating with equipment within their expected service life, and more than half of the depots received a facility condition rating of poor.[40]

Unfortunately, this data from the Government Accountability Office (GAO) is not surprising, as the majority of OIB facilities were built in the first half of the twentieth century. Moreover, several of the OIB's oldest facilities, like Rock Island Arsenal and the Portsmouth Shipyard, were built in the 18th and 19th centuries, but are expected to provide surge and mobilization requirements for a 21st century military.[41] To be fair, the infrastructure across the OIB has been modernized, but the most liberal DoD estimates put the design-life of a typical building at 50 years, assuming proper maintenance.[42] Years of boom-or-bust funding have led to a patchwork of old and modern facilities, sub-optimal workflows, and more than $6.5 billion in infrastructure modernization backlogs.[43]

Given the deteriorated state of OIB infrastructure, 6% capital investment may not be enough. Considering Congressional Budget Office projections for DoD infrastructure expenditures across the FYDP and beyond, understanding the funding sources and how best to invest them moving forward is imperative.

3.3 Financing

As discussed in the last chapter, Defense WCFs are revolving funds financing OIB facilities, excluding four public navy shipyards, for reimbursable MRO services.[44] Operational military units (buyers) pay for MRO services from the OIB (sellers) with appropriated funds. Each of the Services is responsible for managing their respective WCF and setting depot labor rates. Rates are established two-years in advance, to align with the PPBE budget cycle, and based on planned workload costs (i.e. labor, material, overhead, and capital depreciation). When a difference develops between actual and anticipated workload in the year of execution, depots experience a net profit or net loss.[45] The OIB incorporates the net profit or loss into future rates with the goal of breaking-

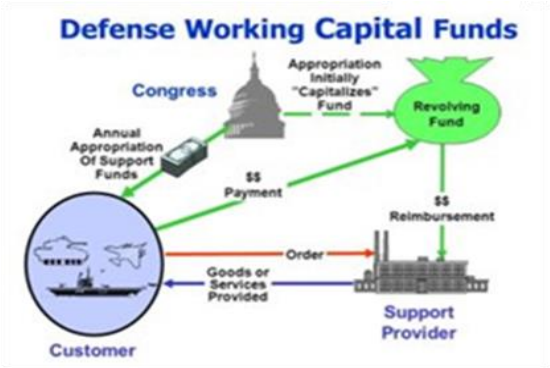

Figure 3.3 Financing the OIB

[40] U.S. Government Accountability Office, Military Depots: Actions Needed to Improve Poor Conditions of Facilities and Equipment That Affect Maintenance Timeliness and Efficiency, 16.
[41] Samuel Stebbins, "America's Oldest Military Bases," https://247wallst.com/special-report/2019/03/18/americas-oldest-military-bases/2/ (accessed February 27, 2020).
[42] The Concrete Society, "Concrete @ your Fingertips," http://www.concrete.org.uk/fingertips-nuggets.asp?cmd=display&id=750 (accessed March 1, 2020).
[43] U.S. Government Accountability Office, Military Depots: Actions Needed to Improve Poor Conditions of Facilities and Equipment That Affect Maintenance Timeliness and Efficiency, 28.
[44] "Navy Working Capital Fund: Department of the Navy Fiscal Year (FY) 2020 Budget Estimates." 2019. https://www.secnav.navy.mil/fmc/fmb/Documents/21pres/NWCF_Book.pdf (accessed May 9, 2020).
[45] U.S. Congressional Budget Office, Comparing Working-Capital Funding and Mission Funding for Naval Shipyards (Washington, DC: U.S. Congress Congressional Budget Office, April 12, 2007), https://www.cbo.gov/publication/18555 (accessed May 9, 2020), 8-10.

even over time – a stark difference from private industry's goal of maximizing profit and shareholder value.

This model presents several challenges, the first being the Services' inability to correctly predict workload two years in advance. Because labor rates are established on full-cost recovery, setting stable labor rates yearly, never mind 24 months in advance is nearly impossible. For example, look at labor rate fluctuations for the DoN at FRCs from FY19 to FY21 in Figure 3.4 below.[46] Even if consistent, steady workload is projected, future emergent, unplanned, or time critical requirements able to significantly impact NOR are impossible to forecast. Further, when requirements decrease (i.e. at the end of a conflict) operational costs at the depots stay elevated even as incoming workload decreases, causing future rates to rise and hurting the OIB's ability to stay competitive with the CIB.[47] Finally, depots are not given enough incentive to optimize resources and maximize profit making it difficult for the Services to source 6% recapitalization from Defense WCFs.

Customer Rate Change *(Percent Change)*	**FY 2019**	**FY 2020**	**FY 2021**
Supply - Navy	-0.34%	2.06%	4.02%
Supply - Marine Corps	-9.46%	-8.10%	1.82%
Depot Maintenance - Aircraft	7.37%	-1.05%	18.76%
Depot Maintenance - Marine Corps	8.07%	-2.17%	14.95%

Figure 3.4 Department of the Navy Labor Rate Fluctuations

For FY2019-2021, U.S. Air Force 6% capital investment requirement was $397.4 million, $404.1 million, and $417.3 million. During this timeframe, U.S. Air Force depots generated more than $6.7 billion in revenue annually but were unable to source more than a 3.6% capital investment from WCF accounts. The remaining capital investment came from various appropriations, complying with Section 2476 and even exceeding the 6% mandate (9.8%, 8.0%, and 9.1% respectively).[48] During those same fiscal years, the DoN averaged more than $8.0 billion in revenue annually, exceeding the minimum investment with 12.6%, 11.7%, and 9.4%. Similarly, the DoN sourced only 2.3%, 1.2% and 1.5% from WCF accounts – the rest coming from various appropriations.[49] U.S. Army revenues are considerably smaller than the other two services, averaging just over $3.6 billion annually across FY2019-2021. Even though the U.S. Army also met the minimum 6% investment, 1.6%, 1.4%, and 1.4% was sourced through their WCF accounts.[50]

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[46] U.S. Navy, Navy Working Capital Fund: Department of the Navy Fiscal Year (FY) 2021 Budget Estimates (Washington, DC: U.S. Navy, 2020), https://www.secnav.navy.mil/fmc/fmb/Documents/21pres/NWCF_Book.pdf (accessed May 9, 2020).

[47] Kimberly Hanson, "The Army's OIB: a National Security Insurance Policy", army.mil. https://www.army.mil/article/158816/the_armys_oib_a_national_security_insurance_policy (accessed April 17, 2020).

[48] U.S. Air Force, Air Force Working Capital Fund: Department of the Air Force Fiscal Year (FY) 2021 Budget Estimates (Washington, DC: U.S. Air Force, 2020), https://www.saffm.hq.af.mil/Portals/84/documents/FY21/WCF_/FY21%20Air%20Force%20Working%20Capital%20Fund_1.pdf?ver=2020-02-10-091425-393 (accessed May 9, 2020), 26.

[49] U.S. Navy, Navy Working Capital Fund: Department of the Navy Fiscal Year (FY) 2021 Budget Estimates.

[50] U.S. Army, Army Working Capital Fund: Department of the Army Fiscal Year (FY) 2021 Budget Estimates (Washington, DC: U.S. Army, 2020), https://www.asafm.army.mil/Portals/72/Documents/BudgetMaterial/2021/Base%20Budget/awcf/AWCF_FY_2021_PB_Army_Working_Capital_Fund.pdf (accessed May 9, 2020), 73.

The DoD Financial Management Regulation allows the Services to take credit for Procurement, Military Construction, and Operations & Maintenance appropriation investments at the depots and offer exclusions on how the 6% investment can be used. Some examples of non-approved outlays include major weapon systems procurement, mobilization projects, environmental projects, and minor construction exceeding a $6.0 million threshold. The size of the list implies the Services are extremely limited on where they can invest. But upon closer examination, most of these exclusions result in non-depreciable projects. This is significant because ***non-depreciable projects must be recovered through the depot sales rate***, ultimately increasing MRO costs, and passing them to the customer. Conversely, money expended on a ***depreciable project does not affect the depot sales rate*** due to the depot's ability to take a cost credit over the depreciation life. Recognizing the positive impact depreciation has on sales rates, the OIB should focus on expending funds in such a manner as to not impact their sales rate and jeopardize competitiveness.

3.4 Recommendations

1. ***Increase minor construction threshold germane to OIB depots***. The minor construction cap is $6.0 million per Section 2805. Facilities constructed in direct support of peacetime depot operations are 100% depreciable; therefore, depot rates will be unaffected. Increasing the minor construction cap at depots would allow the Services to prioritize their own depot infrastructure projects to better help service specific infrastructure requirements to improve depot performance. These projects should only be funded from depot-generated revenue via WCFs vice other appropriations.

2. ***Mandate Program Managers fund depot equipment to support lifecycle sustainment of new and updated systems.*** Program Managers (PM) are accountable for lifecycle management, but PMs "have no requirement to include the depots in the sustainment planning process."[51] The Services will continue to source the 6% capital investment from multiple sources other than WCFs. Language should be added to the DODI 5000.01 and/or 5000.02 directing PMs to engage with depot leadership early in the sustainment process to make sure depots:

    - Are considered for new sustainment
    - Have existing infrastructure to support future work
    - Can plan for added investments.

3. ***Treat the OIB like an insurance policy and have the Services pay an annual insurance premium into a low risk, interest bearing security account to be used for stabilizing depot rates and improving infrastructure.*** As the nation's insurance policy, the OIB needs to be responsive and reliable. Private industry insurance companies charge customers annual insurance premiums to mitigate the financial burden or risk associated

[51] U.S. Government Accountability Office, Depot Maintenance: Improved Strategic Planning Needed to Ensure That Army and Marine Corps Depots Can Meet Future Maintenance Requirements (Washington, DC: U.S. Government Accountability Office, September 2009), https://www.gao.gov/products/GAO-09-865 (accessed May 9, 2020), 16.

with unforeseen events. To make the OIB more efficient, the OIB could benefit from a funding construct like insurance companies. It should be pointed out Congress gives DoD direct appropriations to keep essential industrial surge and expansion capabilities at facilities during peacetime in the form of War Reserve Material, Unutilized and Underutilized Plant Capacity, and Industrial Mobilization Costs.[52]

The idea of paying an annual premium for excess capacity and capability is not a novel concept. In FY2019-2021 the U.S. Army requested $59.0 million, $57.5 million, and $32.6 million for Industrial Mobilization Costs (IMC) associated with maintaining facilities to meet surge capacity needed for mobilization or war. Industrial base equipment left idle for more than 80% in any one month but used at least once during the year is sustained by IMC funding. U.S. Army OIB workload declined steadily over the past ten years resulting in some equipment being used at these lower rates. The U.S. Army requires IMC funding to sustain this equipment, enabling the OIB to rapidly surge in support of future mobilization.[53]

The customers (DoD components) should pay an annual surge protection premium to the OIB working capital fund manager. The WCF manager would invest the payments into a safe, interest bearing security (e.g. accumulation account), like the Social Security trust fund. The fund would initially be used to stabilize labor rates, making the OIB more competitive with private industry and give greater clarity on projected budget maintenance levels. When the OIB makes a net operating profit during the year of execution, the Defense WCF accumulation manager deposits the profit into the investment account. When the OIB suffers a net operating loss during the year of execution, the Defense WCF accumulation manager will offset the loss by withdrawing funds from the investment account. With an incentive to maximize profit, the OIB will place greater emphasis on cost, quality, and schedule and engage consumers for more exact workload projections, increasing efficiency.

As the accumulation account grows from steady streams of annual cash flow and compounding annual interest, it could finance the OIB capital investment program, to improve and modernize facility infrastructure and equipment, as well as workforce development programs. With a productive workforce and more advanced equipment, the OIB can drive down capital depreciation and labor costs, keeping labor rates suppressed, spurring new innovative ideas, and increasing profitability. After the accumulation account builds enough capital, more labor (government overtime and contractor support) and more material procurement to meet emergent, unplanned, or time critical requirements can be financed. This would reduce the need for emergency supplemental funding from Congress in year of execution, lowering future budget deficits and create greater resource efficiency.

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[52] U.S. Department of Defense, DoD Financial Management Regulation, Volume 2B, Chapter 9 (Washington, DC: U.S. Department of Defense, 2004), https://comptroller.defense.gov/Portals/45/documents/fmr/archive/02barch/02b_09_062004.pdf (accessed May 9, 2020), 9-11.

[53] U.S. Army, Army Working Capital Fund: Department of the Army Fiscal Year (FY) 2021 Budget Estimates, 61.

3.5 Conclusion

Executive Order 13806 says, "Overuse and underfunding in infrastructure … directly impacts[sic] DoD's ability to repair equipment and materiel quickly … for future deployments." A decade before Executive Order 13806, Congress recognized the eroding condition of the OIB infrastructure and wrote law to enable corrective action. But those funds aren't executed efficiently. By better targeting investments and placing greater emphasis on maximizing profit, the OIB will mitigate risks, drive efficiencies, and remain our 21st century insurance policy.

Chapter 4 – Surge Framework

4.1 Introduction

Simply mandating the OIB have *"surge capacity"* as per Section 2464 is empty without a measurable requirement. Congress cannot effectively appropriate funds to resource the OIB to sustain surge requirements without knowing the surge capacity needed compared to current capacity utilization. DoD must have a framework – a tool to make informed decisions about the OIB's posture to meet emergent, unplanned, and time critical requirements - where levels of surge are defined. This framework may need to be classified. Otherwise, surge will remain a generalized topic without quantifiable meaning and will be difficult to resource accurately.

Relative to Chapter 1, and in the context of surge, two essential questions the OIB and DoD must answer are:

1. What is the capacity (in terms of repaired military equipment) of each production line in the OIB?
2. And what are the levels of surge the OIB must be able to support for emergent, unplanned, and time critical requirements?

Modeling, simulation, and analysis are needed to rigorously answer the first question. Information and data from correctly understanding capacity will inform the second. This chapter presents a framework defining surge levels and the capital investments required to achieve them. This idea should not be taken as sacrosanct; rather, the proposed framework is an example to show the importance of creating surge levels. The final framework requires a robust analysis of each service and their requirements to support the National Defense Strategy (NDS).

4.2 Background and Challenges

Understanding the level of surge the OIB can sustain is directly tied to its capacity. Before defining a framework to determine surge levels, a review from Chapter 1 of how the OIB measures capacity is required.

Defining how DoD should measure the capacity of the OIB is DoD 4151.18-H, *Depot Maintenance Capacity and Utilization Measurement Handbook*.[54] DoD 4151.18-H offers the following equation to measure capacity:[55]

((work positions) x (availability factor) x (annual productive hours)) + (Depot Field Team DLH)
(0.95) (1,615)

Step-by-step instructions for conducting the calculation are spelled out and the output of the equation is direct labor hours (DLH). As thoroughly discussed in Chapter 2, DLH "are the #1 metric the industrial operation sites look at as this drives everything else." But how useful is

[54] Department of Defense Handbook 4151.18H, 10.
[55] Ibid., 10.

DLH as a metric for productivity? Consider the Services' executed workloads in Figure 4.1 below.[56]

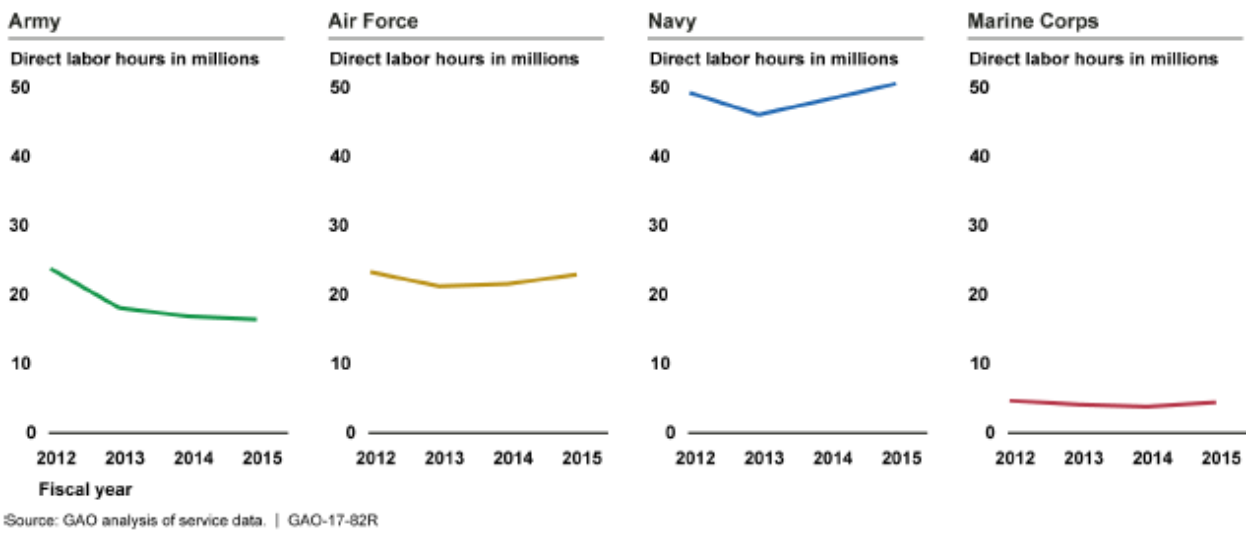

Figure 4.1 Workload Executed at Depots in Direct Labor Hours

Workload executed, expressed in DLH says nothing about how many pieces of repaired military equipment the Services produced as output; nor does it give any sign of where the Services' MRO activities operated relative to potential output – which is a critical indicator to determining a production activity's ability (or inability) to increase capacity utilization in response to an emergency or contingency. Simply put, DLH may be an effective method for DoD to convey yearly budgetary requirements, but DLH are not an effective measure of capacity. Using a historical perspective, World War II producers did not use labor hours to calculate production capacity. Instead, the "Arsenal of Democracy" was measured by the volume of planes, tanks, ships, guns, etc. produced - not the labor hours it took to produce them.

Section 2464 mandates the OIB have surge capacity, but how can DoD determine if the OIB can meet this requirement? This is a two-part problem. First, the OIB must determine capacity to know how much more support it can give above current output. Second, it requires the DoD to quantify the surge requirement the OIB must support.

Quantify surge capacity: The U.S. Air Force Plan 70 is the best unclassified example to quantify surge capacity linking an assessed baseline and surge capacities to "relevant War Plans."[57] Plan 70 also directs the creation of surge plans taking into consideration "plant capacity, manpower, repair parts, carcasses, and other production factors."[58] Anecdotal evidence from this year's OIB Industry Study team indicates some MRO facilities don't have quantified and documented surge plans, and in most cases, responses were rough estimates of what might

[56] U.S. Government Accountability Office, Depot Maintenance: Executed Workload and Maintenance Operations at DOD Depots, (Washington D.C.: U.S. Government Accountability Office, February 3, 2017), 4.
[57] U.S. Air Force, Plan 70: Materiel Surge, (Wright-Patterson AFB, OH: U.S. Air Force Headquarters Air Force Materiel Command, December 22, 2014), 8.
[58] Ibid., 10.

be possible.[59] The common response from both government and private MRO providers was, "How much more do you need?" or words to that effect.

Quantify surge requirements: Throughout the OIB Industry Study's engagements, both government and private MRO leadership understood surge colloquially to mean "more" - but how much more was never defined. A similar occurrence happened during World War II to Bill Knudsen, one of the key architects of the national industrial mobilization effort. When Bill Knudsen asked generals what they needed to prepare for war, they were unable to quantify it in a manner industry could produce.[60] Extending the Bill Knudsen example, DoD leadership must be able to quantify surge requirement levels so the OIB can assess its posture to meet them.

4.3 Recommendations

1. ***Determine capacity and capacity utilization rates within the OIB.*** A rigorous analysis at each of the 17 government-owned MRO facilities must be conducted to determine both actual output and maximum output, measured in repaired military equipment and ***not*** direct labor hours, of each production line within OIB.

2. ***Conduct a multifactor production study at each MRO facility***. As Arthur Herman points out in *Freedom's Forge*, "machine tools are the heart of the industrial process."[61] MRO facilities must account for the capacity of machine tools and other fixed capital and material production factors to correctly determine capacity of production lines. Specifically, the facilities should leverage computer aided modeling and simulation used in capacity requirements planning software.[62] These tools allow modeling of complex systems and their interactions and join resources such as machines, manpower, and material use factors, wait times, and mean arrival and service rates (queuing theory).[63] Utilizing powerful modeling and simulation tools built for answering manufacturing capacity problems can also inform many of the efficiency initiatives already in place as described in Chapter 2.

3. ***Extend a policy like U.S. Air Force Plan 70 to all Services.*** A single policy directing how to measure facility capacities (in terms of repaired military equipment and not direct labor hours) and mandating surge plans taking into consideration "plant capacity, manpower, repair parts, carcasses, and other production factors" is needed to ensure compliance with Section 2464.

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[59] The OIB industry study was unable to complete its MRO facility visits, due to the Coronavirus, which included Navy, Marine, and Air Force facilities. More specifically, it is not clear how detailed the Air Force facilities surge plans are or how much they have completed the guidance in Plan 70.

[60] Arthur Herman, *Freedom's Forge: How American Business Produced Victory in World War II* (New York: Random House Trade Paperbacks, 2012), 78.

[61] Herman, 146.

[62] R. Dan Reid and Nada R Sanders, *Operations Management: An Integrated Approach, Third Edition* (New Jersey: John Wiley & Sons, 2007), 528-530.

[63] Frederick S. Hillier and Gerald J. Lieberman, *Introduction to Operations Research, Seventh Edition* (New York: McGraw-Hill, 2001), 838-840.

4. ***Surge levels need to be defined.*** Without defined surge levels, determining OIB supportability is impossible. Further, without defined surge levels, funding a surge risks being resource uninformed. To define surge levels, DoD should establish a baseline for each service. From the baseline, increasing levels of surge can be set. If increasing surge levels are coupled with data from modeling and simulating the capacity of each OIB facility, then DoD can identify capacity gaps. Once the OIB identifies respective capacity gaps, resources needed and costs to mitigate or resolve the gaps can be determined. Figure 4.2 below gives an illustrative example pairing surge levels with associated costs.

Figure 4.2 Service Surge Level vs. OIB Capacity Costs

Critical to this framework is establishing a baseline. The NDS should guide DoD in determining the baseline. Each service would use NDS pacing threats as the foundation for respective baselines. For example, the U.S. Army would determine the Operational Plan requiring the most demand to successfully execute. The resources needed to maintain the U.S. Army's readiness during peacetime to successfully execute the scenario in the Operational Plan (OPLAN) would serve as the baseline force and baseline cost. Using OPLANs for framework baselines will help better align DoD with Congress since OPLANs are also used by the Professional Staff to determine military readiness.[64] DoD can then expand from the baseline for increasing levels of surge, while Congress can better gauge resourcing decisions to meet the requirement(s).

Figure 4.2 shows equal increments of increased surge from the baseline. But the increments don't need to be equal: X1 could represent 25% more than the baseline, and X2 could be a 100% increase vice 50%. Also, the framework does not have to be limited to four levels. Further, defining the criteria for each level of surge is important. A recommended method to define the levels could be as follows:

[64] The OIB industry study sat down with professional staff members of the Armed Services Committee. During this meeting, they stated they use OPLANs when setting a foundation for surging.

- X1: Global Engagement Force + Peer OPLAN Ready Force
- X2: Limited Regional Adversary Operation + Peer OPLAN Ready Force
- X3: Major Regional Adversary Operation + Peer OPLAN Deter Force
- X4: Peer OPLAN Execution + Regional Adversaries Deter Force
- MOB: Mobilization.

The first level of surge (X1) is the baseline plus a service's current global engagement not specifically tied to generating readiness for the OPLAN ready force. This is an important first level because it highlights the costs associated with maintaining the OPLAN ready force in addition to current global engagements. The nation's global engagements often use readiness needed for the OPLAN force. This ultimately increases the costs to maintain the OPLAN ready force. In addition to X1, the nuance between X2 and X3 is important to highlight. The OPLAN force is significantly different. Due to X3 being a major regional operation, it may be infeasible to maintain an OPLAN force ready to successfully execute the OPLAN. As a result, rather than an OPLAN ready force, it is only an OPLAN deter force. This is a situation where more granularity may be needed, thus requiring more defined surge levels. Lastly, DoD should conduct analysis to determine where the potential line between surge and mobilization occurs. This is not a definitive or quantified value, but a range of criteria indicating mobilization is necessary. While the x-axis is challenging to define, the y-axis is exceedingly more complex and difficult.

To determine the y-axis, DoD should apply two multi-layer analytical approaches. Through modeling and simulation, the OIB must quantify current capacity and capacity gaps and then determine what is needed to successfully support each surge level. The second layer requires another set of models and simulations. DoD must use combat simulations to run operational scenarios associated with each surge level. This is necessary because these operational scenarios provide unit and weapon system attrition quantities over time. These combat simulations generate MRO requirements for weapon system sustainment the OIB will need to meet for each surge level. Knowing current capacity, needed capacity, capacity gaps, and the resources necessary to mitigate gaps, allows DoD to produce cost estimates for the y-axis associated with surge levels on the x-axis. Having data and analysis to generate service specific surge level requirements would give strategic decision-making information to DoD and Congress.

4.4 Conclusion

If DoD wants to understand the OIB's readiness to surge, it must take an aggressive approach to determining capacity and capacity utilization of the OIB. Also, DoD must leverage a framework like the one offered here to establish surge levels. With this information, DoD will be able to determine if baseline requirements as well as the costs associated with resourcing a surge can be met. The speed of future conflict will not allow the time needed to ready the nation to mobilize as it did during World War II. As a result, the nation must know OIB capacity and the resources, capital investment, and time necessary to support specified levels of surge. Failing to do so could mean the difference between winning and losing a war against a peer adversary.

Chapter 5 – Human Capital

5.1 Introduction

The 2017 National Security Strategy states "A healthy defense industrial base is a critical element of U.S. power" and on July 21, 2017 President Trump signed Executive Order 13806 *"Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States."* The report completed over a year later in September 2018 by an Interagency Task Force and identified five macro forces driving risk and ten risk areas threatening the DIB. One of the macro forces was "Diminishing U.S. STEM [Science Technology Engineering and Math] and Trade Skills" and one of the risk areas was "Gaps of U.S.-based Human Capital." OIB human capital is negatively affected by both the macro force and the risk area identified in the report when recruiting the next generation OIB workforce – a workforce requiring a wide range of skills from basic trades to STEM, managed by senior leaders with strong business acumen. A revised marketing approach will help make sure OIB hiring managers attract high quality candidates willing to make federal manufacturing jobs within the OIB long term careers, and opportunities exist to expand current human capital talent programs to infuse the OIB with commercial industry expertise to improve business operations.

5.2 Background

Diminishing U.S. STEM and Trade Skills: The assessment of Executive Order 13806 cited increasing globalization of the supply chain and a diminishing manufacturing sector combining to create human capital gaps and erosions of American capabilities in these two areas. STEM occupations have experienced significant job growth while manufacturing occupations have lost jobs. Even though the U.S. graduates the largest number of doctorate recipients of any individual country, 37% were earned by temporary visa holders. Also, the number of manufacturing workers is aging out at the rate of baby boomers across the OIB with a decreasing number of workers in the 35-44 age range filling the void.[65]

Gaps of U.S.-based Human Capital: U.S.-based human capital gaps arise when industry or the government is unable to hire or keep U.S. workers with the skills needed to support the OIB. The OIB competes with commercial industry for STEM talent and the education pipeline isn't producing enough supply to meet labor demand. On the other end of the skills spectrum, the OIB is also unable to hire and keep trade skill workers which could have significant impacts on production of critical defense-related products.[66]

Three interactive forces – demographics, globalization, and technology – all impact the OIB simultaneously making for a challenging labor force requirement problem. Globalization of supply chains reduced trade skill jobs in the manufacturing sector; the few jobs left are occupied by elderly workers who should be passing their skills onto a younger workforce; but the younger workforce isn't there as they've hedged technology and moved to higher skilled positions in demand (STEM), or the workforce without the higher skills isn't interested in risking losing a job

[65] Executive Order 13806, 43.
[66] Executive Order 13806, 50.

in the shrinking manufacturing sector and likely look to growing sectors (i.e. the health-care sector to take care of all the elderly). Opportunities exists in the OIB for a wide range of job skills and applications for those willing to seize them. Since the OIB competes with the commercial sector for human capital, recruitment initiatives are essential. OIB hiring managers need to maximize new approaches to marketing job openings and take advantage of all available tools and opportunities.

Finally, if business best practices are required to improve efficiency and effectiveness of the OIB, then personnel in OIB management positions should have the acumen required to run "the business enterprise of DoD." Recruiting from outside of DoD will always be difficult as government compensation will likely lag industry. But this does not mean DoD cannot standardize training to both uniform and civilian managers to run OIB facilities like commercial businesses.

5.3 Challenges

Challenges exist in inspiring and incentivizing youth to pursue engineering and science-related careers. In general, the U.S. loses potential talent at every level of education. In 2014-2015, just over 25% of college graduates earned a degree or certificate in a STEM field.[67]

Multiple U.S. government-level efforts exist to increase availability, education, and interest in STEM careers. In fact, the existing national STEM effort is so broad it is difficult to manage and oversee effectively. In 2019 alone, 125 different STEM education programs received federal investments and funding totaling more than $3.2 billion.[68] DoD is the largest employer of scientists and engineers in the U.S. and sponsors or supports many programs and initiatives to meet DoD and overall U.S. STEM labor demand. DoD also supports many scholarships, internships, and fellowships, as well as programs such as College Qualified Leaders, Gains in the Education of Math and Science program, high school apprentice programs, Engineering Apprenticeship Program, and many more.

In addition to supporting nation-wide STEM development efforts, DoD uses programs to bring commercial industry business leadership talent into the OIB. One of these programs is the Defense-Industry Talent Exchange Program. Launched in 2019, this acquisition-focused program targeted high-performing, mid-career civilians with demonstrated leadership potential for a six-month exchange program to gain a better understanding of business operations and innovative best practices.[69] Another program is public-private talent exchanges. The Services can take part in public-private talent exchange (PPTE) assignments of at least three months but

[67] Vital Signs, Education Commission of the States, https://vitalsigns.ecs.org/state/united-states/print (accessed May 9, 2020), 2.
[68] Ibid., p. 22.
[69] U.S. Department of Defense, "DoD Launches Talent Exchange Pilot Program to Strengthen the Acquisition Workforce," DoD Press Release, January 9, 2019, https://www.defense.gov/Newsroom/Releases/Release/Article/1727476/dod-launches-talent-exchange-pilot-program-to-strengthen-the-acquisition-workfo/ (accessed April 12, 2020).

no longer than two years with extensions possible up to four years. PPTE is open to GS-12 and above employees and Federal Wage System journeyman and above.[70]

A third program involves Highly Qualified Experts. Highly Qualified Experts (HQE) are intended to "bring enlightened thinking and innovation to advance the DoD national security mission" and are a temporary infusion of talent, and give non-permanent support for short-term endeavors.[71] HQEs can be appointed for up to five years with a one-year extension possible and may be terminated at any time. They are individuals with expertise or recognized knowledge, skills, and experience in fields like engineering, business, transformation, and logistics.

In addition to expanding commercial business skills and perspectives via these talent exchange programs, DoD can increase internal development of business acumen for senior leaders. Five executive core competencies are required for entry into the Senior Executive Service. These executive core competencies (ECQ) "were designed to assess experience and potential, not technical expertise."[72] ECQ 4 is specifically "business acumen" and requires the ability to manage financial, human capital, and technology resources strategically. But the Office of Personnel Management's "Guide to SES Qualifications" gives no specific references to particular or universal academic business courses or qualifications required to have "business acumen."

5.4 Recommendations

1. ***Increase younger talent recruitment.*** DoD and the Services must increase efforts to recruit and keep younger talent for the OIB with a focus on STEM skilled personnel. Avenues to pursue these efforts are:

    - Career Fairs. Train a cadre of younger employees in engagement and recruiting techniques to attend specifically targeted recruitment fairs.
    - Relationships with Academia. The OIB needs to keep building its outreach programs with local universities and alumni associations. Utilizing alumni networks to advertise and promote the OIB vacancies can greatly increase the applicant pool. Also, expand the network of universities and trade schools OIB hiring managers are in contact with regularly.
    - Social media recruiting**.** Social media is used extensively by younger generations. This demographic expects companies will post job announcements easily accessed via mobile platforms to simplify and expedite the hiring process. According to a Glassdoor survey, "nine in ten of job seekers report they used a mobile device during

[70] Vicki A. Brown, "DoD PPTE Program Questions and Answers", DoD Defense Civilian Personnel Advisory Services, August 28, 2018, https://www.dcpas.osd.mil/Content/documents/OD/PPTEQuestions_Answers23Aug2018.pdf (accessed April 23, 2020), 2.
[71] U.S. Department of Defense, *DoD Civilian Personnel Management System: Employment of Highly Qualified Experts (HQEs), Incorporating Change 1*, DoD Instruction 1400.25, Volume 922 (Washington, DC: U.S. Department of Defense, January 18, 2017), 2.
[72] U.S. Office of Personnel Management, Guide to Senior Executive Service Qualifications" (Washington, DC: U.S. Office of Personnel Management, September, 2012), https://www.opm.gov/policy-data-oversight/senior-executive-service/reference-materials/guidetosesquals_2012.pdf (accessed May 9, 2020), 1.

their job search."[73] Also, according to the research firm Aberdeen Group, "73% of 18 to 34-year-olds got their last job through a social network."[74] Federal hiring managers must maximize all tools to include social media recruiting and virtual interviews to fully leverage future hiring opportunities.

- Include OIB recruitment within existing military recruiting stations. Roughly 25% of all applicants 17-24 years of age are eligible to serve in the military due to various health conditions, educational shortfalls, or criminal records.[75] An opportunity exists to recruit at least some of the remaining 75% of applicants for potential careers in the OIB. Recruiters and recruiting stations should be trained and incentivized to recruit candidates for the OIB if these same candidates are not eligible for traditional military service.

2. Expand commercial industry business talent and acumen within the OIB.

- Expand the Defense-Industry Talent Exchange Program from the focus on GS-12/13 level positions to include OIB senior leadership positions in acquisition and logistics career fields, with a focus on STEM and business acumen opportunities.
- Create a pilot program utilizing PPTE or HQE personnel with commercial manufacturing industry business acumen and place these experts in senior OIB business operations leadership positions. These HQE personnel would leverage commercial business best practices to increase OIB efficiencies and responsiveness, particularly from a strategic level perspective.
- Establish standardized commercial equivalent business training requirements for senior-level military and civilian acquisition, logistics, and material readiness personnel, especially those tracking for positions leading major segments of the OIB such as a repair depot or air logistics complexes.

5.5 Conclusion

The OIB is a vital part of the U.S. manufacturing industry. The ability of the OIB, to sustain military equipment when required hinges on an ability to recruit, train, and keep a dynamic workforce. A specific focus area is the growing need for younger talent with leading-edge trade and STEM skills. This limited pool of STEM personnel is in high demand in the commercial and government sectors. If hiring managers across the OIB are going to successfully recruit the future workforce, they will need to emphasize recruiting techniques able to connect to younger candidates. An emphasis on social media recruiting and building relationships with universities, colleges, and trade schools is essential.

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[73] Glassdoor Team, "9 in 10 Job Seekers Search for Jobs Via Mobile, Glass Door State of Mobile Job Search Survey," Glassdoor.com, May 13, 2014, https://www.glassdoor.com/blog/9-10-job-seekers-search-jobs-mobile-glassdoor-state-mobile-job-search-survey/ (accessed May 9, 2020).

[74] Alexi Venneri, "Social Recruiting is Growing – Are you Prepared?", Forbes.com, Jan 18, 2018, https://www.forbes.com/sites/gradsoflife/2018/01/18/social-recruiting-is-growing-are-you-prepared/#78f793729cae (accessed May 9, 2020).

[75] Blaise Misztal and Jack Ramettal, "Supplying the Manpower That America's National Security Strategy Demands," Heritage Foundation, October 4, 2018, https://www.heritage.org/military-strength-topical-essays/2019-essays/supplying-the-manpower-americas-national-security, (accessed May 9, 2020), 14.

Another human capital imperative is a need to increase the number of OIB leaders with adequate business acumen skills necessary to run the OIB as the business enterprise of DoD. Programs exist within the DoD to leverage this type of talent, but these programs should be expanded to maximize potential efficiencies gained from external experts with a commercial industry perspective toward business operations.

Chapter 6 – Technology & Innovation

6.1 Introduction

Sustained and predictable investment in technology and innovation in the OIB is necessary to meet the NDS goals. The NDS calls for a "more lethal, resilient, and rapidly innovating Joint Force" and an "unmatched twenty-first century National Security Innovation Base effectively supporting Department operations and sustains security and solvency."[76] The OIB answers this call by providing depot-level MRO capabilities and technical expertise to ensure weapon system readiness and availability. But DoD faces challenges in maintaining these capabilities due to aging equipment, an increased shortage of skilled artisans, rising depot maintenance costs, and growing budget constraints. The private industry faces similar challenges along with market competition. In private industry, successful companies create an environment to foster and embrace technology innovations to overcome these challenges and become market leaders. The OIB must apply lessons from the private industry and develop and adopt innovative technologies to overcome the challenges facing the OIB and be positioned to support surge and readiness requirements in the 21st century.

Technology can increase industrial capability, capacity, and effectiveness and mitigate a lack of workers and rising operating costs. Yet, the OIB often lags private industry in technology development and adoption and traditionally only applies incremental innovations. The cycle time from technology gap identification to resolution and implementation in a depot can vary from 2 to 10 years or more.[77] Also, entrepreneurial individuals and organizations within the OIB have successfully leveraged technology and innovation; however, the results are usually localized small-scale improvements. Also, policies in the OIB don't align with industry best practices to foster and adopt innovative technology. The DoD must change policies to encourage sustained and predictable technology investments in the OIB to develop and adopt innovative technology at speed and scale.

6.2 Background

The private industry is rapidly developing and adopting advanced technology in 3D and additive manufacturing, robotics, automation, and artificial intelligence to stay competitive. Commercial factories and warehouses use an estimated 1.9 million robots to mitigate an aging and declining workforce and increased competition. Japan leads the world in industrial robots use with over 306,000 robots, compared to 237,000 in North America, 182,000 in China, and 175,000 in South Korea and Germany each.[78] Also, in a survey of aviation MRO industry executives, more than half of respondents reported a planned migration or major upgrade in their

[76] Mattis, National Defense Strategy, 10.
[77] U.S. Air Force Sustainment Center, Logistics & Sustainment Enterprise 2040, AF Instruction, (Wright-Patterson, OH: U.S. Air Force Sustainment Center, April 2016), https://www.afsc.af.mil/Portals/24/documents/LSE%202040%20v2.0%20-%2015%20April%202016%20-%20FINAL[1].pdf?ver=2017-01-25-110933-350 (accessed May 9, 2020), 6.
[78] Darrell M. West, "How technology is changing manufacturing," Brookings Institute, June 2016, https://www.brookings.edu/blog/techtank/2016/06/02/how-technology-is-changing-manufacturing/ (accessed March 7, 2020).

systems for engineering (68%), supply chain (55%), and engine maintenance, technical support, and planning (50%) to mitigate a shrinking and less skilled workforce.[79] Moreover, the additive manufacturing (AM) industry grew to $5.2 billion in 2015 at a 25.9% compound annual growth rate. The manufacturing, production, and MRO industries are quickly adopting these and other advanced technologies out of necessity to stay competitive. Like industry, the DoD is working to develop and adopt advanced innovative technology.

DoD has several programs and organizations aimed at developing advanced technologies. Two programs most germane to the OIB are the Defense-wide Manufacturing Science and Technology program and Commercial Technologies for Maintenance Activities program. The Defense-wide Manufacturing Science and Technology (DMS&T) program funds the DoD Manufacturing Technologies Program. The DoD Manufacturing Technologies Program (ManTech) concentrates on manufacturing technology capabilities and needs beyond the ability of a single service to address such as broad technology initiatives in advanced electronics, optics, materials, composites, emerging manufacturing processes, and energetics manufacturing. Additionally, DMS&T funds nine DoD Manufacturing Innovation Institutes. These institutes are public-private partnerships addressing commercial and defense manufacturing needs. For FY 2020 DoD ManTech and Manufacturing Innovation Institutes budgets were $30.2 million and $167.2 million, respectively.[80] Also, each service has a ManTech program as well as research labs conducting research and development of various materiel science and manufacturing technologies. The Commercial Technologies for Maintenance Activities program is a partnership between the Office of Deputy Assistant Secretary of Defense, Materiel Readiness (ODASD MR), and the National Center for Manufacturing Sciences to execute joint efforts to develop maintenance and sustainment technologies. Commercial Technologies for Maintenance Activities (CTMA) gives a streamlined contracting vehicle to show potential dual-use commercial MRO technology to address depot needs. CTMA is the only DoD-wide program singularly focused on maintenance and sustainment technologies. Project funding comes from a combination of private industry and government. CTMA has received $75 million in funding from the Office of the Secretary of Defense (OSD) and Congressional funds since 1998 and $243 million from the Services since 2008.[81]

[79] Brian Prentice, Derek Costanza, and John Smiley, "MRO SURVEY 2017," Oliver Wyman, 2017, https://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2017/apr/MRO_Survey_2017.pdf (accessed March 7, 2020), 2.
[80] U.S. Department of Defense, *DoD FY 2021 Budget Estimates, Defense-Wide Justification Book Vol. 3 of 5 Research, Development, Test & Evaluation, Defense-Wide* (Washington, DC: Office of the Secretary of Defense, February 2020), 217.
[81] Greg Kilchenstein, Debbie Lilu, "CTMA Overview (Partnering with Industry)," *SAE International.* https://www.sae.org/events/dod/attend/program/presentations/Lilu.pdf, (accessed March 7, 2020), 2.

Ingredients for Disruptive Innovation

Companies can often fail despite discovering a disruptive innovative technology. Research found management approaches to spur and capitalize on innovation include new measures of product value, an ambidextrous organizational structure, and senior management leadership. When firms identify a new technology but apply metrics of value from existing product architectures the new technology is often rejected.[82] This is because the existing metrics of value are not able to account for the new attributes of value the innovation provides. The value of a disruptive innovation must be measured in a new framework. For example, initial MP3 players were valued for memory capacity vs. size instead of minutes of music per tape like the cassettes they replaced. Leaders must use a future reference frame to measure an innovative technology's value when considering investments. Also, new organizational structures are often needed to support innovative technology because firms develop capabilities and organize resources tailored to a product's distinctive value network.[83] Ambidextrous organization structures are often helpful to market and capitalize on disruptive technology products

An ambidextrous organization allows companies to keep an existing business making incremental innovations while simultaneously growing an emerging business around a disruptive innovation (see *Figure 6.1*).[84] A separate organization is better able to discover, develop, and market the disruptive product or service because it can structurally align with the new value metrics of a disruptively innovative product. Firms create independent project teams with independent processes, structures, and culture which stay integrated into the existing company hierarchy. These new business organizations must be empowered to achieve quick wins with early adopters of the innovative product while being able to rely on parent company resources. Senior management must also give clear strategic intent, a shared vision of the future, team cohesion, and reward success to achieve an effective ambidextrous organization.[85] Famously, Fujifilm was able to transform its business by implementing an ambidextrous organization while Kodak went bankrupt.[86] Also, a Harvard Business Review study examined 35 innovation initiatives across multiple companies and fund ambidextrous organizations had a 90 percent success rate in achieving their goals.[87] DoD could increase the likelihood of adopting and benefiting from disruptive innovations by applying these organizational and management approaches used by the commercial industry.

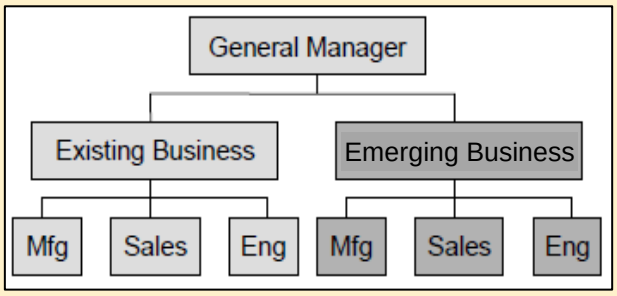

Figure 6.1: Ambidextrous organization structure

[82] Clayton M Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Boston: Harvard Business Review Press, 2013), 34.
[83] Ibid, xix.
[84] Charles A O'Reilly III and Michael L. Tushman, "The Ambidextrous Organization." Harvard Business Review 82, no. 4 (April 2004): 74.
[85] Seyed Amir Siada, and Sara Mirzataghi Chaharmahali. "Achieving Organizational Ambidexterity." Academy of Management Journal 43 (2010): 837-853.
[86] Tomoatsu Shibata Yasunori Baba, Mitsuru Kodama, and Jun Suzuki, "Managing Ambidextrous Organizations for Corporate Transformation: A Case Study of Fujifilm: Managing Ambidextrous Organizations for Corporate Transformation," *R&D Management*, May 7, 2018, https://doi.org/10.1111/radm.12326 (accessed May 9, 2020), 1.
[87] O'Reilly, "The Ambidextrous Organization," 74.

The individual services manage capital investments in OIB sustainment technologies by delegating responsibilities to logistics and sustainment commands. Funding for technology development and implementation in the OIB can come from many sources. Maintenance funding, working capital funds, or direct investment from weapon system or Research Development Test and Evaluation programs are the primary sources. DoD Operations & Maintenance contracted obligations for research and development (R&D) on average are approximately three to four percent of total obligations.[88] Working capital funds available for capital investments are limited to the surcharge amount included in the rates charged to depot customers. A variety of government programs focused on technology development and demonstration make up the other funding sources. In 2013, there were no fewer than 20 technology transition programs in OSD.[89] These programs include the Small Business Innovation Research program, Rapid Innovation Funds, ManTech programs, Strategic Environmental Research and Development Program, Environmental Security Technology Certification Program, and the Joint Capability Technology Demonstration (JCTD) program. These programs give full or partial funding for technology development and capability demonstration with partial funding matched by the Services. Another program must fund the production and fielding of the technology after the demonstration program ends.

The individual services and/or individual depots select the technologies to invest in and transition to the OIB. They often inform technology investments by using DoD's Product Support Business Case Analysis Guidebook or service-specific guidance. Depots may use financial performance factors such as NPV, payback period, return on investment, internal rate of return, life cycle cost, time value of money considerations and Operations & Sustainment cost along with risk and sensitivity analysis of input factors.[90] Typical input factors are direct labor and material rates. Qualitative factors such as the potential for more lines of revenue may be considered as well. Information sharing about technology developments and investments across the OIB is conducted through a variety of formal and ad hoc working groups. The Joint Technology Exchange Group is the primary working group focused on new technology development and application in the OIB. The Joint Technology Exchange Group was chartered to better leverage technology improvements in DoD maintenance through collaboration amongst the Services, Joint Staff, OSD, academia, and industry collaboration.

The Services are moving forward with efforts to leverage innovative technologies for sustainment. For example, there are over 81 locations across the depots, maintenance facilities, and field locations using AM to produce parts, decrease maintenance time, and mitigate parts

[88] Jesse Ellman, Samantha Cohen, Andrew Hunter, Kaitlyn Johnson, "Defense Acquisition Trends, 2016" Center for Strategic and International Studies, March 28, 2017, https://www.csis.org/analysis/defense-acquisition-trends-2016J (accessed February 24, 2020), 54.
[89] U. S. Government Accountability Office, *Defense Technology Development: Technology Transition Programs Support Military Users, but Opportunities Exist to Improve Measurement of Outcomes,* GAO-13-286 (Washington DC: U.S. Government Accountability Office, March 2013), 5.
[90] U.S. Department of Defense, *DoD Product Support Business Case Analysis (BCA) Guidebook,* (Washington, DC: US Department of Defense, 2014), https://www.dau.edu/tools/t/Product-Support-Business-Case-Analysis-(BCA)-Guidebook (accessed May 9, 2020).

obsolescence.[91] In July 2018, the U.S. Air Force stood up the Rapid Sustainment Office to increase mission readiness by rapidly identifying, applying, and scaling technology across the U.S. Air Force. In 2019 the U.S. Air Force Rapid Sustainment Office reported an investment of $38.9 million which resulted in saving or avoiding $69.8 million.[92] The U.S. Navy stood up a Naval Enterprise Sustainment Technology Team and is using $30.0 million of the Navy's Small Business Innovation Research program to address sustainment gaps and quickly field technology solutions to support maintenance operations.[93] Tinker Air Force Base has created a Reverse Engineering and Critical Tooling Lab to give AM solutions to decrease depot maintenance costs, rapidly prototype, perform dimensional verification, and provide low volume tooling.[94]

Overall, DoD's OIB relies on a patchwork of programs, funding sources, and investment approaches to develop and transition technology to support MRO and depot capabilities. This approach resulted in disparate, incremental, and inefficient technology development and adoption efforts across the OIB. Also, individual depot efforts have not translated into increased technology insertion at a level needed to boost productivity and maintain readiness or prevent sustainment cost growth. From FY07-17, the U.S. Army, U.S. Navy, U.S. Air Force, and U.S. Marine Corps invested a combined $13.0 billion in the OIB depots.[95] Yet, a 2018 GAO report noted "the erosion of organic infrastructure continues to impact turnaround time and repair costs of both legacy and newly fielded weapon systems, reducing inventory, decreasing operational readiness, and impacting future deployment schedules."[96] This ineffective patchwork approach to innovative technology development and insertion in the OIB is a result of many challenges.

6.3 Challenges

The efforts of the OIB to develop and adopt innovative technologies to increase productivity and capabilities are challenged by aging infrastructure, misaligned incentives, an insufficient business case analysis process, funding policies, and organizational structure. OIB technologies (i.e. the sum of techniques, skills, methods, and processes used to execute MRO) reside in the equipment, facilities, and technical acumen of the workforce. As discussed in Chapter 3, many depot facilities are in poor condition and much equipment is past expected service life.[97] In many cases depots are using old, outdated, and inefficient technology to

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[91] U.S. Department of Defense Inspector General, *Audit of the DoD's Use of Additive Manufacturing for Sustainment Parts*, Report No. DODIG-2020-003, (Washington, DC: U.S. Department of Defense, October 2019), 6.
[92] U.S. Air Force Rapid Sustainment Office, *Rapid Sustainment Office Annual Report, 2019* (Washington, DC: U.S. Air Force, 2019), https://www.afrso.com/RSO-2019-Annual-Report.pdf (accessed January 4, 2020), 8.
[93] Marine Corps Logistics Command, "NESTT aligns sustainment improvements across the Navy and Marine Corps," Logcom.marines.mil, February 4, 2020, https://www.logcom.marines.mil/Archived-News/News-Article-Display/Article/2074333/nestt-aligns-sustainment-improvements-across-the-navy-and-marine-corps/ (accessed March 14, 2020).
[94] Jacob McGuire, "Knowing how to REACT," Tinker.af.mil, September 2019, https://www.tinker.af.mil/News/Article-Display/Article/1972530/knowing-how-to-react/ (accessed April 4, 2020).
[95] U. S. Government Accountability Office, *Military Depots: Actions Needed to Improve Poor Conditions of Facilities and Equipment That Affect Maintenance Timeliness and Efficiency*, 1.
[96] Office of the Under Secretary of Defense for Acquisition and Sustainment, Fiscal Year 2018 Industrial Capabilities Annual Report to Congress, (Washington, DC: U.S. Department of Defense, May 2019), 82.
[97] U. S. Government Accountability Office, *Military Depots: Actions Needed to Improve Poor Conditions of Facilities and Equipment That Affect Maintenance Timeliness and Efficiency*, 14-15.

perform MRO. The age of depot facilities and equipment can limit the technology used or implemented due to infrastructure limits such as power or utility supplies and configuration. GAO noted the U.S. Navy's 2018 *Shipyard Infrastructure Optimization Plan* does not have a method to plan for advanced technology insertion during optimization and consolidation of its facilities.[98] This means technology insertion in the OIB will continue to be prevented by old infrastructure and poor future planning. Requiring the Services include details for technology insertion in future depot infrastructure planning could increase the ability to adopt technology more quickly and at a lower cost in the future.

In addition to infrastructure, policies don't promote investments in innovative technology insertion in the OIB. First, depot leaders and PMs are not incentivized to invest in innovative technologies for sustainment. Depot commanders must keep annual labor rates low to stay competitive with private industry and other depots. This creates an incentive to limit surcharge amounts and in-turn working capital available for investments in new technology. Additionally, weapon system PMs are evaluated based on optimizing program cost and schedule to meet system performance requirements. Section 2464 requires program maintenance plans to make sure core depot-level maintenance and repair capabilities are established by 4 years after the declaration of initial operational capability. But funding the development of sustainment technologies not tied to a weapon system requirement is beyond the scope of the PM's responsibilities.[99] The result is neither depot commanders nor program managers are incentivized to make strategic investments in sustainment technology. Policies incentivizing depot commanders and PMs to invest in advanced sustainment technologies could improve depot surge capabilities and weapon system availability.

Second, the business case analysis used by depot commanders to prove capital investments are insufficient to value advanced technology or the OIB's competitive advantage. DoD's Product Support Business Case Analysis (BCA) Guidebook says "all criteria should be numerical and may include both *quantitative* and *qualitative* criteria," but also notes certain "criteria may require *numerical transformation* of a *qualitative* variable" and "rationalization for numerical transformation of subjective (qualitative) factors must be fully described."[100] Typical financial performance measures used to inform the BCA for technology investments take start-up costs, labor, materials, utilities, waste, etc. into account. Yet, no common method is used across the OIB to numerically transform surge related qualitative variables (i.e. depot flexibility to unplanned work or return on employee knowledge) into a quantitative value. Methods such as knowledge value-added and Capability Measures have been proposed as methods to quantify intangible aspects of advanced technologies into cost savings based on a return on knowledge. Knowledge value-added (KVA) is used to monetize learning time, the number of times executed, automation, training time, and knowledge content. Capability Measures (CM) is used to quantify an innovation index, conversion capability, and ability to meet future needs.[101] A Return on Knowledge (ROK) can then be determined using KVA use rates. In one study a ROK based

[98] U. S. Government Accountability Office, *Naval Shipyards: Key Actions Remain to Improve Infrastructure to Better Support Navy Operations*, (Washington, DC: U.S. Government Accountability Office, November 2019), 26.
[99] Miller, "The Defense Sustainment Industrial Base – A Primer," 18.
[100] U.S. Department of Defense, *DoD Product Support Business Case Analysis (BCA) Guidebook*.
[101] Johnathan Mun, "Risk-Based ROI, Capital Budgeting, and Portfolio Optimization in the Department of Defense," *Defense Acquisition Research Journal* 27 (January 1, 2020), https://doi.org/10.22594/dau.19-829.27.01 (accessed May 9, 2020), 60–107.

model showed the U.S. Navy could achieve a 614% ROK and a $1.5 billion savings by implementing AM combined with collaborative product life cycle management software by communicating ideas, increase collaboration, and improve process efficiency.[102,103] Failure to establish new metrics to quantify the true value of advanced sustainment technologies results in missed opportunities to invest in game-changing capabilities in the OIB. Establishing BCA best practices to *numerical transform* the qualitative value of innovative technologies, such as AM and information technology, could better inform OIB sustainment technology investment decisions.

Third, DoD funding policies create an added challenge to technology adoption in the OIB due to a lack of funds, budget authority limits, and difficulty tracking R&D spending on sustainment. Overall defense Research Development Test and Evaluation spending on sustainment is approximately 3% despite 55-70% of the weapon system LCC occur during operations and support of the system.[104,105] Also, the OIB must leverage funding from multiple programs across different budget authorities. Federal law limits the time and purpose for which appropriated funds can be used. These limits are implemented by various budget authorities in the DoD.[106] A technology transition 'valley of death' occurs when a lack of funding across any one of the multiple budget authorities necessary to develop and insert a sustainment technology in the OIB exists. A limited amount of funding spread across multiple programs with multiple-use and timing restrictions make achieving OIB technology insertion difficult and limits the ability to reduce weapon system costs. Also, budget artifacts providing a summary of total funding for depot maintenance funding or specific investments in technology applied to depot MRO capabilities do not exists. Depot maintenance can be financed by the U.S. Transportation Command and the Military Sealift Command using Defense Working Capital Fund authority, but these depot maintenance costs are not identified separately in budget exhibits given to Congress.[107] Also, OSD does not regularly check or report depot improvements, including technology insertion, to DoD decision-makers, or Congress.[108] Therefore, proving to Congress the need for existing funding or more funding to support OIB technology investments is difficult

[102] Product Lifecycle Management (PLM) Software is an information management system that can integrate data, processes, business systems and, ultimately, people in an extended enterprise. It allows this information to be managed throughout a product lifecycle from ideation, design and manufacture through service and disposal. https://www.plm.automation.siemens.com/global/en/our-story/glossary/product-lifecycle-management-plm-software/12506

[103] Michael E. Kenney, Cost Reduction through the Use of Additive Manufacturing (3D Printing) and Collaborative Product Life Cycle Management Technologies to Enhance the Navy's Maintenance Programs (Monterey, CA: Naval Post Graduate School, September 2013), 56.

[104] Composites Technical Interchange Meeting (TIM), Greg Kilchenstein, ODASD for Maintenance Policy and Programs, 22 August 2017, https://slideplayer.com/slide/12060008/ (accessed April 15, 2020).

[105] Gary Jones, Edward White, Erin T. Ryan, Jonathan D. Ritschel, "Investigation into the Ratio of Operating and Support Costs to Life-Cycle Costs for DoD Weapon Systems," *Defense Acquisition Research Journal* 21 (January 1, 2014), 441–62.

[106] National Research Council, "Examination of the U.S. Air Force's Aircraft Sustainment Needs in the Future and Its Strategy to Meet Those Needs", (Washington, DC: The National Academies Press, 2011), 165.

[107] Nicholas J. Avdellas, Joseph L.Berry, Michael D. Disano, David M. Oaks, and Earl R. Wingrove, "Future Capabilities of DoD Maintenance Depots" (Washington, DC: LMI, February 2011), https://www.acq.osd.mil/log/mpp/.plans.html/1_LG901M2_REPORT_FINAL_02-14-11.pdf (May 9, 2020), 4-16.

[108] U. S. Government Accountability Office, *Military Depots: Actions Needed to Improve Poor Conditions of Facilities and Equipment That Affect Maintenance Timeliness and Efficiency*, 25.

for the Services or OSD. A lack of clear accounting of investment in OIB improvements and technology investments inhibits strong advocacy and compelling arguments for sustainment technology funding. A change in budgeting and funding of OIB sustainment technology investments could give better insight, improve spending efficiency, and help gain advocacy for sustainment technology efforts. A DoD enterprise-level sustainment technologies program element would allow a sustained, accountable, and predictable investment in technology in the OIB. Also, such a program element (PE) could provide a source of funding to help transition technology to sustainment and reduce weapon system LCC at the enterprise level. Finally, a sustainment technology PE managed at the OSD level could be used for a 'JCTD' like full scale prototyping and demonstration program. This would incentivize depot commanders, PMs, and the Services to pool funding and share cost on technology development and achieve innovation at speed and scale.

Finally, organizational structures inhibit OIB technology adoption. As part of the FY17 NDAA, the office of the Under Secretary of Defense (OUSD) (AT&L) was re-organized into the Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) and Office of the Under Secretary of Defense for Acquisition & Sustainment (OUSD(A&S)). Congress intended to have these new organizations more clearly focused on delivering "game-changing" technology and management of the defense acquisition system, respectively. OSD programs demonstrating and transitioning technology now reside under OUSD(R&E). For example, the DMS&T and JCTD programs are supposed to serve as a technology catalyst between the OUSD(R&E) and OUSD(A&S). But, by being placed under OUSD(R&E) it is unlikely these programs will focus on advanced technologies for the OIB as sustainment, logistics, and MRO technologies have no clear home in the USD(R&E) structure. Two reports noted the USD(R&E) managed Manufacturing Innovation Institutes need to make more effort to make sure projects are relevant to the DoD and more engagement with the OIB would be beneficial.[109,110] Programs with technologies applicable to the OIB but managed by OUSD(R&E) will likely become less responsive to funding technology transition for sustainment. Mr. Kevin M. Fahey, Assistant Secretary of Defense for Acquisition, commented on sustainment technology when asked how the research and engineering enterprise could support the missions of the OIB by saying:

> Advocacy and implementation of a comprehensive sustainment technology program would act as a nexus for applying and incentivizing technology solutions across the enterprise that would have high payoff for improving readiness and reducing cost. In some instances, the organic base should be used to prototype and build new capabilities working with our labs.[111]

[109] National Academies of Sciences, Engineering, and Medicine, "Strategic Long-Term Participation by DoD in Its Manufacturing USA Institutes," (Washington, DC: The National Academies Press, 2009), 4-5.
[110] U. S. Government Accountability Office, Advanced Manufacturing: Innovation Institutes Have Demonstrated Initial Accomplishments, but Challenges Remain in Measuring Performance and Ensuring Sustainability, (Washington, DC: U.S. Government Accountability Office, March 2013), 46.
[111] U.S. Congress, Senate, Armed Service Committee, "Advance Policy Questions for Nominee for Assistant Secretary of Defense for Acquisition Responses of Mr. Kevin M. Fahey", February 8, 2018, https://www.armed-services.senate.gov/imo/media/doc/Fahey%20APQ%20Responses_02-08-18.pdf (accessed May 9, 2020), 40.

The OIB can offer an environment with flexibility to experiment and prototype new capabilities due to the lack of contractual or intellectual property rights between DoD organizations. Steps should be taken to overcome OSD organizational challenges and increase OIB use for prototyping new capabilities. Manufacturing Innovation Institutes and OUSD(R&E) programs should target more projects with the organic depots. OUSD(A&S) could work with OUSD(R&E) to establish goals for DOD-sponsored manufacturing institutes and projects to support technology transition to the OIB. Goals could be set for the prototyping of OIB surge capabilities or efforts to increase readiness. Also, OUSD(A&S) could coordinate with OUSD(R&E) to establish an annual minimum number of OUSD(R&E) prototype programs or portion of the prototyping budget to directly support OIB capabilities. Alternatively, funding could be re-allocating from OUSD(R&E) prototype programs to OUSD(A&S) or OSD to better support the sustainment mission through prototyping. The Strategic Capabilities Office, which reports to the Deputy Secretary of Defense, could serve to execute prototype funding for sustainment like an emerging business unit of an ambidextrous organization. The Strategic Capabilities Office's already existing Quick Win Projects aims to development, demonstration, and transition capabilities to improve U.S. security posture. Funding to this PE could support projects specifically targeting sustainment technology prototypes with high payoff strategic level surge and readiness capabilities. This would allow exploration of new concepts outside of the constraints of existing value networks both in USD(R&E) and the service level depots or logistics and sustainment commands.

6.4 Recommendations

1. ***Address the limits of infrastructure on sustainment technology insertion in the OIB.*** The Secretary of Defense should direct the Service Secretaries to provide an addendum to their response to the FY2019 NDAA provision for optimal placement and consolidation of facilities and major equipment describing the Service's investment strategy for sustained technology insertion as part of infrastructure optimization.

2. ***Better inform business case analysis and future strategic investment decisions for sustainment technology development and adoption.***

    - The Office of the Assistant Secretary of Defense for Acquisition (OUSD(A&S)) should direct the President of the Defense Acquisition University to develop product support business case assessment methods, techniques, and training for how to best quantify qualitative variables for advanced sustainment and logistics technologies.
    - Additionally, the Secretary of Defense should direct the Service Secretaries to report all investments in sustainment technologies in the organic depots and resulting impacts on the OIB's ability to support surge and readiness annually.

3. ***Overcome DoD organizational challenges and increase efforts to support the transition of technology to the OIB and use the OIB for prototyping new capabilities.***

    - The Office of the Under Secretary of Defense for Acquisition & Sustainment (OUSD(A&S)) should ask the Office of the Under Secretary of Defense for Research

and Engineering (OUSD(R&E)) to provide information on programs being planned or executed supporting sustainment technology development and transition.

- The Secretary of Defense should direct the Director of DoD's Manufacturing USA institutes and the Office of Deputy Assistant Secretary of Defense, Materiel Readiness (ODASD MR) to establishing criteria to check and evaluate the level at which DOD-sponsored institutes are transferring advanced manufacturing technologies to the OIB.

4. ***Improve the DoD budget, fund, and monitor investments in sustainment technology at an enterprise level.*** The DoD should establish an advanced sustainment technology PE for the specific purpose of funding advanced prototyping and demonstration of technologies.

5. ***Promote joint service development of sustainment technologies and speed innovation at scale to support surge and readiness.*** The DoD should establish a sustainment technology prototype program funded by an advanced sustainment technology program element and executed by the Strategic Capabilities Office to fund full-scale demonstrations of advanced technology for insertion in the OIB.

6.5 Conclusion

Industry has been able to overcome the same challenges faced by the OIB by creating environments fostering and leveraging innovative technology. The OIB must do the same. The OIB must create an environment where innovative sustainment technologies are spurred at speed and scale. Policy changes can create incentives, more thoughtful investments, and better aligned resources and lines of effort to transition technologies to the OIB. New organization approaches and bold leadership are needed to leverage disruptive technologies and unleash new sustainment concepts. The recommendations above can help the OIB find ways to innovate at speed and scale to meet NDS goals and support national defense in the 21st century.

Chapter 7 – Global Alliances and Partnerships

7.1 Introduction

As mentioned throughout this report, the OIB is the business enterprise of DoD. Providing strategic readiness for an entire global DoD effort, the OIB is a global business. But the OIB is a global business without a comprehensive global depot maintenance strategy and the OIB is constrained in its ability to leverage allies to buffer its own capacity limits. The NDS warns the U.S. must modernize for resilient and agile logistics or risk failure in sustaining lethal Joint Forces globally and in key regions. Further, it says investments in this area must prioritize partner and allied support to underpin DoD's global reach. The OIB maintains unique competencies in depot maintenance but is focused on continental U.S. MRO operations while product support outside the U.S. is the responsibility of the Program Offices. The OIB has not developed the structure or culture needed to guide Combatant Commands to identify and build depot maintenance requirements or mentored the Services on evaluating foreign market capabilities and creating global MRO strategies.

The NDS makes clear the U.S. network of alliances and partnerships remains a backbone of global security. Along with force posture and modernization, alliance and partnership architecture will provide the capabilities and agility needed to prevail in conflict and preserve peace through strength.[112]

In support of the NDS, the Undersecretary for Acquisition and Sustainment (A&S) is working on new guidance for international arms cooperation with nations in Europe and the Indo-Pacific region. A&S plans to work with "Combatant Commanders (COCOMS) to shape their country engagement papers to include International Armaments Cooperation goals as part of Security Cooperation Goals Theater Campaign Plans, as well as to advance cooperative activities with emerging partners."[113] Further, the A&S Deputy Assistant Secretary of Defense for Industrial Policy is working to create opportunities with close allies to make sure technological and intellectual capabilities of domestic *and* foreign companies support the NDS. Recent efforts include getting a new bi-lateral agreement with Norway and working with allies in the National Technology and Industrial Base – Canada, the United Kingdom, and Australia – to explore activities able to enhance industrial base partnerships and defense activities among the four nations.[114]

Focused and prioritized DoD efforts to strengthen U.S. alliances and partnerships to leverage allies and deter threats exist. Every organization should understand how they can and should contribute to this goal. For the OIB, increased cooperation and support from allies for

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[112] Mattis, National Defense Strategy, 1.
[113] Justin Doubleday, "DoD Developing New Guidance for International Arms Cooperation," Inside Defense, May 16, 2019, https://insidedefense.com/daily-news/dod-developing-new-guidance-international-arms-cooperation (accessed May 9, 2020).
[114] "2018 Annual Report to Congress: Industrial Capabilities," Department of Defense, May 13, 2019, https://www.businessdefense.gov/Portals/51/Documents/Resources/2018%20AIC%20RTC%2005-23-2019%20-%20Public%20Release.pdf?ver=2019-06-07-111121-457 (accessed May 9, 2020), 8.

depot maintenance is critical because it will help mitigate limits within the U.S. OIB enterprise while adding agility to depot maintenance in support of global joint operations.

7.2 Background

The U.S. has many depot level maintenance facilities positioned in forward locations outside U.S. borders and these types of depot capabilities include U.S. government and contractor operations with efforts to stand up U.S. government facilities using host nation labor. But existing guidance and execution lacks a coherent global strategy. As a result, the U.S. risks failure to establish the right capabilities and capacities in the right places abroad to dampen the impact of limits on U.S. based facilities when emergent, unplanned, and time critical requirements occur.

Guidance found in depot maintenance statutes are key considerations of any weapon system product support strategy and drive funding, logistics capabilities, and labor hours into the U.S. government-owned and operated depot facilities.[115] Since World War II the nation has recognized a need to have an OIB to ensure the ability to surge and mobilize. Through these statutes and others, DoD ensures the OIB today keeps an incredible set of industrial capabilities.[116] But when overseas depot maintenance functions or requirements are contemplated, they are done so outside the OIB and without the competencies and expertise specifically created within the OIB. Abroad, COCOMs and the Services develop their requirements and the Program Offices contract for the maintenance. Typically, COCOM requirements are assigned to one service and there may be no cross-service coordination.[117] This may suffice in the case of service unique weapon systems, but in the case of component repairs and other depot maintenance and industrial functions the capabilities can cut across multiple systems. COCOMs and service Program Offices are not staffed with the maintenance expertise, nor keep the broader situational awareness of the depot enterprise to best capture depot level requirements and determine most effective courses of action. Integrating the expertise of the OIB into overseas depot strategy development will become more important as more U.S. weapon systems are shared with allies.

A comprehensive global depot maintenance strategy is increasingly important to support increased cooperation with partners and allies on weapon system development and operation. DoD will soon announce new projects for the recently launched Allied Prototyping Initiative aiming to "boost international cooperation in military research and development by expanding prototyping opportunities on a shared basis between the U.S. and its closest allies."[118] Undersecretary of Defense for A&S, Ms. Ellen Lord, made clear the "culture is shifting to integrate early planning for exportability into our requirements and acquisition systems, ensuring

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[115] Bill Kobren, "CORE and the 50-50 Rule – A Study in Contrasts," Defense Acquisition University, September 4, 2018, https://www.dau.edu/training/career-development/logistics/blog/Core-and-the-50-50-Rule-–-A-Study-in-Contrasts (accessed March 10, 2020).

[116] For a complete list of OIB Governance & Policies, see Appendix C.

[117] Interview with Ms Lois Huizar, AFSC/LG Chief, Maintenance and Supply Requirements, January 31, 2020.

[118] Jon Harper, "Just In: Pentagon to Kick off New Prototyping Projects with Allies," National Defense, March 10, 2020, https://www.nationaldefensemagazine.org/articles/2020/3/10/pentagon-to-kick-off-new-prototyping-projects-with-allies (accessed May 9, 2020).

DoD programs plan for technology sharing and foreign sales from the outset … only through applying common technology to our platforms and weapon systems can we be interoperable."[119] The U.S. is assured to continue to build on the 33% increase in Foreign Military Sales seen from 2017 to 2018.[120] From a sustainment perspective, there should also be a strategy to leverage U.S. allies for depot maintenance to support increased common defense systems use.

7.3 Challenges

COCOMs and the Services have communicated the problems retrograding unserviceable components and weapon systems from areas like the Indo-Pacific region to U.S. based contractors or military facilities for repair due to time constraints and inefficiency. Such inefficiencies will compound during times of surge. Planning effectively for high-end conflict in terms of MRO requirements dictates a need to optimize access to forward MRO sources with the expectation both (or multiple) nations benefit from regional synergies.[121] With on-going efforts to establish forward depot capabilities in Australia and the United Kingdom, a few primary challenges have been identified in the process.

The first challenge is understanding terms and conditions of International Agreements and Export Controls able to enable or constrain Program Office efforts to establish an in-country depot facility or contract.[122] Types of agreements include:

- *Security of Supply Agreements*. Allows reciprocal industrial priority systems to encourage partner nations to acquire defense goods from each other. The U.S. has agreements with eight countries.
- *Cooperative International Agreements*. Used to establish information exchanges and assignments, cooperative acquisitions, or cooperative or reciprocal logistics support.
- *Reciprocal Defense Procurement Agreements*. Framework for on-going communication between or among DoD and respective counterparts on market access and procurement matters enabling effective defense cooperation. The U.S. has agreements with 27 countries.
- *Reciprocal Government Quality Assurance Agreement*. Promotes common quality assurance standards and protocols whereby each government supports purchases of defense equipment from its industry by the other government. [123]

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[119] Ibid.
[120] U.S. Department of Defense, *Annual Report to Congress Fiscal Year 2018: Industrial Capabilities* (Washington, DC: U.S. Department of Defense, May 13 2019), https://www.businessdefense.gov/Portals/51/Documents/Resources/2018%20AIC%20RTC%2005-23-2019%20-%20Public%20Release.pdf?ver=2019-06-07-111121-457 (accessed May 9, 2020), 26.
[121] U.S. Department of Defense, *Logistics Working Group Bilateral Planning Team, Australia – United States, Terms of Reference*, (Washington, DC: U.S. Department of Defense, June 24, 2019), 1.
[122] Interview with Ms Lois Huizar, AFSC/LG Chief, Maintenance and Supply Requirements, and draft Australia – US Ministerial Defense Acquisition Committee Logistics Working Group Bilateral Planning Team Maintenance, Repair, Overhaul Sub-Working Group Information Paper, January 31, 2020.
[123] Executive Order 13806, 121-123.

Another challenge is understanding potential markets and determining where to operate and how. Like any company evaluating a global market, the U.S. government must complete market research to understand the concerns, costs, risks, and benefits. Considerations for setting up a forward depot facility are significant and include identifying the components or systems required, demand for industry to realize a return on investment, vulnerabilities in the supply chain, identifying sources of repair, and source approval process. Then potential service options must be evaluated. These include contract arrangements, leveraging existing Cooperative Agreements, working with U.S. Original Equipment Manufacturers to set up subcontract arrangements, or even forward deploy a permanent or temporary organic capability in the region or country.[124]

Australian-based Commercial MRO
An In-Progress Model for Developing Global Depot Strategy

A bilateral US-Australian MRO Planning Team convened in June 2019, led by ODASD Product Support and the Australian DoD Liaison Officer with the task of increasing depot level repair options and resilience for US components in the SW Pacific by leveraging Australian commercial sector capacity and capability. Stakeholders pulled into the discussions on the DoD side included representatives from A&S International Cooperation, NAVAIR program offices, NAVSUP Weapon Systems Support, and Navy International Program Office. With the appropriate stakeholders participating, the team determined they would evaluate U.S. manufactured aircraft which Australia operates (H-60, P-8A, F/A-18A-G), and identify depot-level repairable components as candidates to explore four courses of action: 1) Traditional Source Qualification & Manufacturing Approval – Contract for Repair Process, 2) Leverage International Military Contracts for Commercial Components (Cooperative Agreement), 3) U.S. OEM Contract Vehicle via PBL (OEM to Australian Subcontractor), 4) Forward Deployed Capability Investment Support / Enhanced I-Level Capability (U.S. Navy depot artisans deployed for repair). For each COA, NAVAIR and NAVSUP Weapon System Support developed a process map and qualitative cost benefit analysis.

To date, the U.S. Navy has reviewed degrader lists for subject aircraft and have identified possible candidate areas where additional support is required. Additionally, the U.S. Navy is developing master qualification checklists to provide the Australian Department of Defence for review and discussion with Australian industry before formally commencing the source approval process. Next steps include site surveys of identified potential Australian Defense Suppliers as well as progress physical test cases under different COA's to identify potential barriers, understand costs, comparisons to U.S. counterpart repair, and capacity issues. From this, identify key areas within Australia when depot-level capabilities could be of benefit, reducing the burden on the CONUS repair pipeline. Finally, assess other Foreign Military Sales countries in the region who could benefit from having their assets repaired in the region.

Finally, when a depot capability is established a challenge with coordinated use across the joint force exists. Depot requirements from a COCOM may originate to support a service-centric weapon system, but the facility may have general industrial capabilities able to support other weapon systems. For example, the Support Center Pacific located on Kadena Air Base in

[124] Interview with Ms Lois Huizar, AFSC/LG Chief, Maintenance and Supply Requirements, and draft Australia – US Ministerial Defense Acquisition Committee Logistics Working Group Bilateral Planning Team Maintenance, Repair, Overhaul Sub-Working Group Information Paper, January 31, 2020.

Okinawa, Japan, aligns under the Ogden Air Logistics Center and has been in place since 1985. It has a forward deployed capability and capacity but is underutilized requiring roadshow briefs to educate potential customers of their capabilities.[125]

7.4 Recommendations

1. ***OSD Materiel Readiness should examine partner and allied sustainment-support agreements and build on key aspects to better integrate the strong and far reaching OIB capabilities into these arrangements.*** Such frameworks should improve global visibility and application of the often-unique competencies of the OIB to meet COCOM requirements. OSD Materiel Readiness should work with other OSD agencies tasked with primary action on international agreements, shown in green in Figure 7.1:

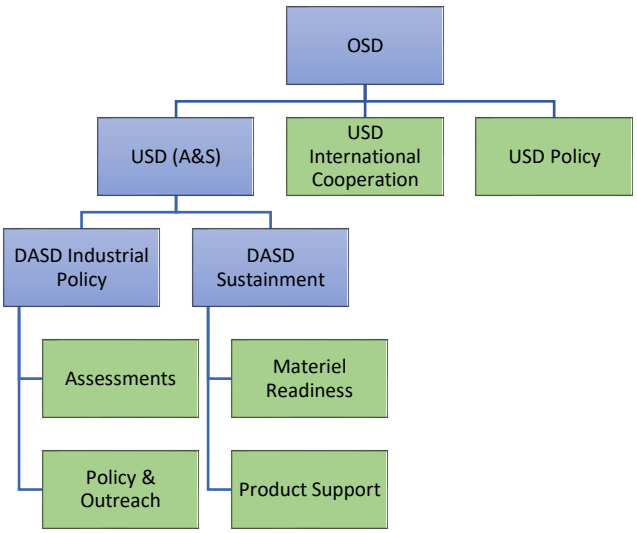

Figure 7.1 OSD Depot Maintenance Framework into International Agreements

2. ***The OIB should coordinate with the Services and COCOMs to determine how to best develop a global depot maintenance strategy linking the OIB enterprise from CONUS to OCONUS facilities.*** Such a strategy would need a more active role by the OIB in matching COCOM requirements to constraints in the OIB as well as evaluating the industrial capabilities and courses of action in a country or region. Not only would this better support the NDS and the OIB's ability to surge by adding the right capacity and capabilities in the right places, it also enables the business benefits of a global strategy realized by global commercial companies:

    - *Cost Benefits of Scale and Replication*. Use U.S. OIB knowledge to replicate at a fraction of the costs in new national markets.
    - *Serving Global Customers*. In addition to serving the globally dispersed DoD force structure, global customers will continue to grow as DoD continues to

[125] Ogden Air Logistics Complex, "Supply Chain Brief on Support Center Pacific," October 8, 2019.

increase arms cooperation with partner nations and shared common systems use increases.

- *National resources*. Arbitrage Benefits: a global depot maintenance strategy will enable access to other national resources, such as scarce industrial labor skills, facilities, and manufacturing technologies.
- *Learning benefits*. Transferring and integrating industrial knowledge and using the exposure to different national environments to create new knowledge.
- *Competing strategically*. A global depot maintenance strategy allows the U.S. to draw on partner nation resources and leverage a competitive advantage over potential rivals (i.e. China).[126]

3. ***The U.S. will not mobilize without the help of our closest partners. OSD should work with Congress to reevaluate depot-maintenance statutes and merge allied capabilities in a manner like existing Public-Private Partnerships with the DIB.*** Strategically developing surge and mobilization capacity with allies acts as an insurance policy in case of compromises to U.S. OIB enterprise capacity.

7.5 Conclusion

The OIB, and its relationship with the DIB, are critically important to ensuring the U.S. can surge and mobilize industrial capacity when national security requires. But the time is now to radically open the OIB aperture to better integrate expertise designing ally and partner nation support. This requires OIB participation in reviewing and changing international agreements to enable the supporting global structure. It also requires OIB cooperate more closely with COCOMs to better identify depot requirements and with the Services to build a global execution strategy. None of this is likely to occur until Title 10 requires DoD to consider ally depot capabilities critical to supporting U.S. mobilization. Depot maintenance is the business of the OIB, and the U.S. must better leverage the OIB capabilities to facilitate an efficient and agile global capability.

[126] Robert M. Grant, Contemporary Strategy Analysis, 9th Edition, (United Kingdom: Wiley, 2013), 325-326.

Chapter 8 – Conclusions & Recommendations

The OIB Industry Study team set out to determine limiting factors to surging the OIB. Despite not having a definition for surge, the task seemed straightforward – simply analyze the ability of Key Readiness Enablers to increase output, determine where shortfalls exist and violá. The task even seemed easy considering the volume of reports and studies discussing human capital deficits throughout the DIB, aging infrastructure woes of the OIB, and no expectation DoD budgets will increase.

Through the course of the Eisenhower School curriculum, with a focus on business operations and industry analysis, the task still seems straightforward provided generally accepted business practices and industry standards are adopted by DoD and the OIB. To facilitate, we offer the following immediate recommendations:

- The Services should develop and follow business plans supported by long-term strategies focusing on: Value Creation, Value Propositions, Value Delivery, Value Capture and Value Communication. ***See Chapter 2, Page 12.***
- The Services should adopt business case analysis methods to capture capital investment for new facilities and equipment as part of their Net Present Value calculations. ***See Chapter 2, Page 13.***
- Consider following a production-based model to drive OIB programming toward industry best practices, rather than focus on direct labor hours as the principal production metric. ***See Chapter 2, Pages 13-14.***
- A rigorous analysis at each of the 17 government-owned MRO facilities must be conducted to determine both actual output and maximum output, measured in repaired military equipment and not DLH, of each production line within OIB. ***See Chapter 4, Page 24.***
- OSD should direct the Services to describe how their investment strategy for sustained technology insertion is part of their infrastructure optimization plan. ***See Chapter 6, Page 41.***

These recommendations represent five of 20 provided in the report. This does not discredit the merit of the other recommendations found below. Instead, these recommendations are ones able to implement now, offering a fundamental redirection of OIB strategy and execution more aligned with characteristics befitting "the business enterprise of the Department of Defense."

Additional Recommendations

- To drive innovation, efficiency and effectiveness, new weapon systems should compete the depot source of repair between depots, and across services, throughout the lifecycle management process. ***See Chapter 2, Pages 12-13.***
- Facilities constructed in direct support of peacetime depot operations are fully depreciable, thus OSD should work with Congress to increase the minor military construction threshold – specifically for the OIB – to help hold labor rates in check. ***See Chapter 3, Page 19.***
- OSD should add language to DODI 5000.01 and/or 5000.02 mandating Program Managers engage with depot leadership early in the sustainment process and, once selected, fund new equipment for weapon systems. ***See Chapter 3, Page 19.***
- To increase OIB efficiency, and reduce the need for emergency supplementals, consider establishing an interest-bearing security account to stabilize depot rates and improve infrastructure. ***See Chapter 3, Pages 19-20.***
- OIB facilities should leverage computer aided modeling and simulation to perform a multifactor production study, to correctly determine the capabilities of their fixed capital assets and, ultimately, production line capacity. ***See Chapter 4, Page 24.***
- OSD should direct each service to develop a policy like the Air Force Plan 70, so consistent guidance directing how facility capacities are measured to ensure compliance with U.S. Code, Title 10, § 2464 exists. ***See Chapter 4, Pages 24-25.***
- To define surge levels, OSD should establish a baseline rate for each service from which increasing levels of surge can be coupled with modeling and simulation data to identify capability and capacity gaps. ***See Chapter 4, Page 25.***
- Through a combination of career fairs, academic partnerships, social media and existing military recruiting stations, the DoD and OIB should collaborate to increase the pool of young talent, with a focus on STEM-skilled personnel. ***See Chapter 5, Pages 30-31.***
- To expand commercial industry talent, the OIB should undertake a series of steps including: expanding the Defense-Industry Talent Exchange Program; standardized commercial business training requirements for senior civilian and military personnel; and a pilot program for recruiting HQE personnel into leadership positions to leverage commercial best practices. ***See Chapter 5, Page 31.***
- To better inform future strategic investment decisions OSD should direct DAU to develop product support business case assessment methods, techniques, and training for how to best quantify qualitative variables for advanced sustainment and logistics technologies. ***See Chapter 6, Page 41.***
- OSD should provide technology development, and transition, roadmaps to overcome organizational challenges slowing the evolution of technology within the OIB. ***See Chapter 6, Page 41-42.***
- OSD should work with Congress to establish an advanced sustainment technology Program Element to better plan, program, budget and execute technology investments to achieve greater technology transition and promote joint development of sustainment technologies. ***See Chapter 6, Page 42.***

- OSD should examine partner and allied sustainment-support agreements and build on key aspects to better integrate the strong and far reaching OIB capabilities into these arrangements. ***See Chapter 7, Page 47.***
- To better support the NDS, OIB should coordinate with the Services and COCOMs to determine how to best develop a global depot maintenance strategy linking the OIB enterprise from CONUS to OCONUS facilities. ***See Chapter 7, Pages 47-68.***
- The U.S. will not mobilize without the help of our closest partners, thus OSD should work with Congress to reevaluate Title 10 depot-maintenance statutes, and merge allied capabilities in a manner like existing Public-Private Partnerships with the Defense Industrial Base. ***See Chapter 7, Page 48.***

Appendix A

Glossary of Terms

6% Investment: statutory law requiring depots to gather no less than six percent of the average total dollar value of the combined maintenance, repair, and overhaul (MRO) workload performed over the preceding three fiscal years. This money is intended to fund capital investments for the organic industrial base to include facilities, equipment, and infrastructure.

Agile: the ability to anticipate demand and when necessary quickly respond to sustain operational tempo. This includes the flexibility to support rapid deployment, maneuver, aggregation, disaggregation, and redeployment of forces; the ability to attain and process accurate critical information in the near-real-time to inform decision-making; and the ability to build integrated plans that simplify command relationships, responsibilities, and common-user support.

Capacity: potential output.

Capacity Utilization: expressed as a percentage and is calculated by taking the actual level of output, divided by potential output.

Capability: the ability to complete a task or execute a course of action under specified conditions and level of performance. Capability is how well customer expectations are met.

Carryover: funded depot level work not completed by the end of a given fiscal year.

Commercial Industrial Base (CIB): the part of the larger DIB, consisting of the commercially-owned organizations, facilities or installations with capabilities to perform research, development, production, and depot-level maintenance/repair and upgrades/modifications on necessary military weapon systems, equipment, materials, munitions, hardware, and software to meet the requirements of national security.

Core: the depot maintenance capability (including personnel, equipment, and facilities) maintained by the Department of Defense at Government-owned, Government-operated facilities as the ready and controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency situations, and other emergency requirements. Depot maintenance for the designated weapon systems and other military equipment is the primary workload assigned to DoD depots to support core depot maintenance capabilities.

Cost per Day of Availability (C/DA) Metric: used to measure efficiency sustainment efforts that affect the availability of a defined population of weapon systems.

Defense Industrial Base (DIB): the worldwide industrial complex comprised of the OIB and CIB that enables research and development as well as design, production, delivery, and maintenance of military weapons systems/software systems, subsystems, and components or parts, as well as purchased services to meet U.S. military requirements.

Defense Industrial Capability: the skills and knowledge, processes, facilities and equipment needed to design, develop, manufacture, repair and support DoD products. Defense industrial capabilities include private and public industrial activities.

Defense Sustainment Industrial Base: the package of support functions required to maintain the readiness and operational capability of weapon systems, subsystems, software and support systems.

Defense Working Capital Fund (DWCF): used by OIB to charge for goods and services provided to a variety of customers, including the Army, the Navy, the Air Force, other DoD and non-DoD agencies, and foreign countries. Under the working capital fund concept, the DWCF charges these customers for the anticipated full cost of these goods and services.

Demilitarization: the act of destroying the military offensive or defensive capability inherent in certain types of equipment or materiel. The term includes mutilation, scrapping, melting, burning, or alteration designed to prevent the further use of this equipment and materiel for its originally intended military or lethal purpose. It applies equally to materiel in unserviceable or serviceable condition that has been screened through an Inventory Control Point (ICP) and declared excess or foreign excess.

Depot Capacity: the amount of workload, expressed in actual direct labor hours, that a facility can accommodate with all work positions manned on a single-shift, 5-day, 40-hour week basis while producing the product mix that the facility is designed to accommodate.

Depot Maintenance: That maintenance performed on materiel requiring major overhaul or a complete rebuild of parts, assemblies, subassemblies, and end-items, including the manufacture of parts, modifications, testing and reclamation as required. Depot maintenance serves to support lower categories of maintenance by providing technical assistance and performing that maintenance beyond their responsibility. Depot maintenance provides stocks of serviceable equipment by using more extensive facilities for repair than are available in lower level maintenance activities.

Disposal: the act of getting rid of excess, surplus, scrap, or salvage property under proper authority. Disposal may be accomplished by, but not limited to, transfer, donation, sale, declaration, abandonment, or destruction.

Distribution: the movement of goods from supplier or manufacturer to point of sale. Distribution management is an overarching term that refers to numerous activities and processes such as packaging, inventory, warehousing, supply chain and logistics.

Effectiveness: the degree to which someone or something is successful in achieving a desired result. “Do the right THINGS at the right time, for the right length of time.”

Efficiency: the degree to which a desired result is achieved without wasting time and resources. “THINGS done right without wasting resources.”

Fixed Capital: property, plant, and equipment.

Flow Days: the number of days an item is in the depot maintenance process.

GOCO: government-owned, contractor operated.

GOGO: government-owned, government operated.

Highly Qualified Expert (HQE): individuals possessing expertise or recognized knowledge, skills, and experience in an occupational field. They are intended to bring enlightened thinking and innovation to advance the DoD national security mission. They are a temporary infusion of talent and provide non-permanent support for short-term endeavors.

Lexicon: a standard set of terms and definitions.

Maintenance: all action taken to retain materiel in a serviceable condition or to restore it to serviceability. It includes inspection, testing, servicing, classification as to serviceability, repair, rebuilding and reclamation.

Maintenance and Availability Data Warehouse (MADW): a database that provides availability, cost, inventory, and transactional data on every weapons system and readiness reportable piece of equipment within the DoD.

Materiel: equipment, apparatus, and supplies used by an organization or institution.

Materiel Availability (Am) Metric: used to measure both effectiveness and efficiency of sustainment efforts to affect the availability of a given weapon system being utilized within the system's planned lifecycle.

Military Readiness: a condition of the Armed Forces and their personnel, weapon systems, technology and equipment to perform during military operations.

Net Operating Result (NOR): the net difference between expenses and funds received in a given fiscal year.

Operational Availability (Ao) Metric: used to measure the effectiveness of sustainment efforts to affect the availability of a weapon system's active inventory.

Organic Industrial Base (OIB): the government-owned industrial capability comprised of the organizations and facilities that perform research, development, production, or depot-level maintenance, repair, demilitarization, and disposal of weapon systems, equipment, materials, munitions, hardware, and software. These include laboratories, research centers, arsenals, depots, shipyards, aircraft plants, and ammunition plants, whether operated by government personnel or contractors.

Outcome-Focused Metrics: used to assess the degree to which expected outcomes have been achieved.

Performance to Promise (P2P): a commitment to meet a customer-required delivery date.

Reliability Contribution: measures the work performed by a depot for reliability and quality.

Resilient: the ability to withstand and quickly recover from kinetic or non-kinetic attacks against forces and asset; includes force protection measures, hardening critical infrastructure from attack, and deception efforts to complicate adversary decisions and targeting; and provide necessary support to maintain sufficient combat power to achieve campaign objectives, even in the face of continued and adaptive near-peer adversary actions.

Service: one of the military Services: Army, Navy, Marine Corps, Coast Guard, and Air Force.

STEM: science, technology, engineering, and math.

Supply: the procurement, distribution, maintenance while in storage, and salvage of supplies, including the determination of kind and quantity of supplies. The Producer Phase extends from determination of procurement schedules to acceptance of finished supplies by the military services. The Consumer Phase extends from receipt of finished supplies by the military services through issue for use or consumption.

Supply Chain: the linked activities associated with providing materiel to an end user starting from a raw material stage to a finished product.

Surge: the ability to increase organic industrial base programmed capacity utilization, using fixed capital, in response to operational requirements or unforeseen circumstances.

Sustainment: the supportability of fielded systems and their subsequent lifecycle product support – from initial procurement to supply chain management (including maintenance) to reutilization and disposal.

Weapon System: a combination of one or more weapons including all services, materials, equipment, and means of delivery and deployment required for self-sufficiency.

Appendix B

Organic Industrial Base Inventory

Site	State	Service	Type	Financing Model	Primary Mission	Primary Capability
Anniston Army Depot	AL	Army	GOGO	WCF	Maintenance	Ground Vehicles & Equipment
Anniston Munitions Center	Al	Army	GOGO	WCF	Storage & Distribution	Missiles and Munitions
Blue Grass Army Depot	KY	Army	GOGO	WCF	Storage & Distribution	Missiles and Munitions
Crane Army Ammunition Activity	IN	Army	GOGO	WCF	Storage & Distribution	Missiles and Munitions
Corpus Christi Army Depot	TX	Army	GOGO	WCF	Maintenance	Aviation
Hawthorne Army Depot	NV	Army	GOCO	Contract	Storage & Distribution	Missiles and Munitions
Holston Army Ammunition Plant	TN	Army	GOCO	Contract	Manufacturing & Production	Missiles and Munitions
Iowa Army Ammunition Plant	IA	Army	GOCO	Contract	Manufacturing & Production	Missiles and Munitions
Joint Systems Manufacturing Center	OH	Army	GOCO	Contract	Manufacturing & Production	Ground Vehicles & Equipment
Letterkenny Army Depot	PA	Army	GOGO	WCF	Maintenance	Air Defense
Letterkenny Munitions Center	PA	Army	GOGO	WCF	Storage & Distribution	Missiles and Munitions
Lake City Army Ammunition Plant	MO	Army	GOCO	Contract	Manufacturing & Production	Missiles and Munitions
McAlester Army Ammunition Plant	OK	Army	GOGO	WCF	Storage & Distribution	Missiles and Munitions
Milan Army Ammunition Plant	TN	Army	GOCO	Contract	Manufacturing & Production	Missiles and Munitions
Pine Bluff Arsenal	AR	Army	GOGO	WCF	Manufacturing & Production	Missiles and Munitions
Rock Island Arsenal Joint Manufacturing & Technology Center	IL	Army	GOGO	WCF	Manufacturing & Production	Ground Vehicles & Equipment
Radford Army Ammunition Plant	VA	Army	GOCO	Contract	Manufacturing & Production	Missiles and Munitions

Site	State	Service	Type	Financing Model	Primary Mission	Primary Capability
Red River Army Depot	TX	Army	GOGO	WCF	Maintenance	Ground Vehicles & Equipment
Scranton Army Ammunition Plant	PA	Army	GOCO	Contract	Manufacturing & Production	Missiles and Munitions
Sierra Army Depot	CA	Army	GOGO	WCF	Storage & Distribution Operations	Ground Vehicles & Equipment
Tobyhanna Army Depot	PA	Army	GOGO	WCF	Maintenance	C4ISR
Tooele Army Depot	UT	Army	GOGO	WCF	Storage & Distribution	Missiles and Munitions
Watervliet Arsenal	NY	Army	GOGO	WCF	Manufacturing & Production	Armaments
Aviation and Missile Research and Development Center	AL	Army	GOGO	Reimbursable	Design, Development & Engineering	Aviation & Missiles
Armaments Research, Development and Engineering Center	NJ	Army	GOGO	Reimbursable	Design, Development & Engineering	Armaments
Army Research Laboratory	MD	Army	GOGO	Direct Appropriation	Research	*Unknown
Edgewood Chemical and Biological Center	MD	Army	GOGO	Direct Appropriation	Design, Development & Engineering	Chemical and Biological Defense
Natick Soldier Research, Development and Engineering Center	MA	Army	GOGO	Direct Appropriation	Design, Development & Engineering	Individual Equipment
Tank Automotive Research, Development and Engineering Center	MI	Army	GOGO	Direct Appropriation	Design, Development & Engineering	Ground Vehicles & Equipment
Aircraft Plant 4 Dallas	TX	Air Force	GOCO	Contract	Manufacturing & Production	Aviation
Aircraft Plant 6 Marietta	GA	Air Force	GOCO	Contract	Manufacturing & Production	Aviation
Aircraft Plant 42 Palmdale	CA	Air Force	GOCO	Contract	Manufacturing & Production	Aviation
Air Force Research Laboratory	OH	Air Force	GOGO	Direct Appropriation	Research	Aviation

Site	State	Service	Type	Financing Model	Primary Mission	Primary Capability
Air Force Test Center	CA	Air Force	GOGO	Direct Appropriation	Test & Evaluation	Aviation
Arnold Engineering and Development Center	TN	Air Force	GOGO	Direct Appropriation	Test & Evaluation	Aviation
412th Test Wing	CA	Air Force	GOGO	Direct Appropriation	Test & Evaluation	Aviation
96th Test Wing	FL	Air Force	GOGO	Direct Appropriation	Test & Evaluation	Aviation
Oklahoma City Air Logistics Complex	OK	Air Force	GOGO	WCF	Maintenance	Aviation
Ogden Air Logistics Complex	UT	Air Force	GOGO	WCF	Maintenance	Aviation
Warner-Robins Air Logistics Complex	GA	Air Force	GOGO	WCF	Maintenance	Aviation
Marine Depot Maint Command Production Plant Albany	GA	Marine Corps	GOGO	WCF	Maintenance	Ground Vehicles & Equipment
Marine Depot Maint Command Production Plant Barstow	CA	Marine Corps	GOGO	WCF	Maintenance	Ground Vehicles & Equipment
Fleet Readiness Center - East	NC	Navy	GOGO	WCF	Maintenance	Aviation
Fleet Readiness Center - Southeast	FL	Navy	GOGO	WCF	Maintenance	Aviation
Fleet Readiness Center - Southwest	CA	Navy	GOGO	WCF	Maintenance	Aviation
Norfolk Naval Shipyard	VA	Navy	GOGO	Direct Appropriation	Maintenance	Ships
Pearl Harbor Naval Shipyard	HI	Navy	GOGO	Direct Appropriation	Maintenance	Ships
Portsmouth Naval Shipyard	ME	Navy	GOGO	Direct Appropriation	Maintenance	Ships
Puget Sound Naval Shipyard	WA	Navy	GOGO	Direct Appropriation	Maintenance	Ships
Coast Guard Yard	MD	Coast Guard	GOGO	WCF	Maintenance	Ships
Surface Combat Systems Center	VA	Navy	GOGO	Direct Appropriation	Test & Evaluation	Ships

Site	State	Service	Type	Financing Model	Primary Mission	Primary Capability
Naval Surface Warfare Center Carderock	MD	Navy	GOGO	Direct Appropriation	Design, Development & Engineering	Ships
Naval Surface Warfare Center Corona	CA	Navy	GOGO	Direct Appropriation	Test & Evaluation	Independent performance Assessment
Naval Surface Warfare Center Crane	IN	Navy	GOGO	Direct Appropriation	Design, Development & Engineering	Sensors and Electronic Warfare
Naval Surface Warfare Center Dahlgren	VA	Navy	GOGO	Direct Appropriation	Design, Development & Engineering	Surface Warfare
Naval Surface Warfare Center Indian Head EOD Technology	VA	Navy	GOGO	Direct Appropriation	Design, Development & Engineering	Missiles and Munitions
Naval Surface Warfare Center Panama City	FL	Navy	GOGO	Direct Appropriation	Design, Development & Engineering	Mine Warfare
Naval Surface Warfare Center Philadelphia	PA	Navy	GOGO	Direct Appropriation	Design, Development & Engineering	Logistics
Naval Surface Warfare Center Port Hueneme	CA	Navy	GOGO	Direct Appropriation	Test & Evaluation	Surface Warfare
Naval Underwater Warfare Center Keyport	WA	Navy	GOGO	Direct Appropriation	Test & Evaluation	Submarines
Naval Underwater Warfare Center Newport	RI	Navy	GOGO	Direct Appropriation	Design, Development & Engineering	Submarines
Naval Air Warfare Center Patuxent River	MD	Navy	GOGO	Direct Appropriation	Design, Development & Engineering	Aviation
Naval Air Warfare Center Lakehurst	NJ	Navy	GOGO	Direct Appropriation	Design, Development & Engineering	Aviation
Naval Air Warfare Center Orlando	FL	Navy	GOGO	Direct Appropriation	Design, Development & Engineering	Aviation
Naval Air Warfare Center China Lake	CA	Navy	GOGO	Direct Appropriation	Design, Development & Engineering	Aviation
Naval Air Warfare Center Point Mugu	CA	Navy	GOGO	Direct Appropriation	Design, Development & Engineering	Aviation
Office of Naval Research	VA	Navy	GOGO	Direct Appropriation	Research	Navy & Marine Crops
Demilitarization and Disposal	**While demilitarization and disposal facilities are considered part of the OIB, inventory of these facilities was beyond the scope of this study.**					

Appendix C

Organic Industrial Base Governance & Policies

DEPOT MAINTENANCE STATUTES

- 10 USC 2460 Definition of Depot Maintenance; the term "depot-level maintenance and repair" means material maintenance or repair requiring the overhaul, upgrading, or rebuilding of parts, assemblies, or subassemblies, and the testing and reclamation of equipment as necessary, regardless of the source of funds for the maintenance or repair or the location at which the maintenance or repair is performed
- 10 USC 2464 Core Logistics Capabilities; Core Logistics Capabilities is essential for the national defense that the Department of Defense maintain a core logistics capability that is Government-owned and Government operated to ensure a ready and controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency situations, and other emergency requirements.
- 10 USC 2466 Limitation on the Performance of Depot-Level Maintenance of Materiel; Not more than 50 percent of the funds made available in a fiscal year to a military department or a Defense Agency for depot-level maintenance and repair workload may be used to contract for the performance by non-Federal Government personnel of such workload for the military department or the Defense Agency.
- 10 USC 2476 Minimum Capital Investment for Certain Depots; Each fiscal year, the Secretary of a military department shall invest in the capital budgets of the covered depots of that military department a total amount equal to not less than six percent of the average total combined maintenance, repair, and overhaul workload funded at all the depots of that military department for the preceding three fiscal years.
- 10 USC 2474 Designation of Centers of Industrial and Technical Excellence; The Secretary concerned, or the Secretary of Defense in the case of a Defense Agency, shall designate each depot-level activity or military arsenal facility of the military departments and the Defense Agencies as a Center of Industrial and Technical Excellence in the recognized core competencies of the designee
- 10 USC 2366a MDAPs-Certification Required before Milestone A Approval
- 10 USC 2366b MDAPs-Certification Required before Milestone B Approval

POLICY & ISSUANCES

Listed are the OSD instructions following the statues above:

- DoDD 4151.18, Maintenance of Military Materiel — March 31, 2004
- DoD 4151.18-H, Depot Maintenance Capacity and Utilization Measurement — March 10, 2007
- DoDI 1348.30, Secretary of Defense Maintenance Awards Program — April 8, 2019
- DoDI 4151.19, Serialized Item Management (SIM) for Life-Cycle Management of Materiel — November 1, 2017

- DoDI 4151.20, Depot Maintenance Core Capabilities Determination Process — May 4, 2018
- DoDI 4151.21, Public-Private Partnerships for Product Support — Change 4, July 31, 2019
- DoDI 4151.22, Condition Based Maintenance Plus (CBM+) for Materiel Maintenance — Change 2, August 31, 2018
- DoDI 4151.24, Depot Source of Repair (DSOR) Determination Process — Change 2, May 28, 2019
- DoD Financial Management Regulation 7000.14-R, Volume 6A, Chapter 14 — Depot Maintenance Reporting
- DoD Financial Management Regulation, Summary of Major Changes to DoD 7000.14-R, Volume 6B, Chapter 12
- DoDM 4151.22-M, Reliability Centered Maintenance (RCM) - June 30, 2011
- DoDM 4151.23, DoD Organic Depot Maintenance Cost Comparability - June 24, 2016
- Public-Private Partnerships Guidebook — October 7, 201

Appendix D

Performance Metrics: To quantitatively understand if the OIB is properly positioned to meet readiness needs and future surge requirements, DoD needs to understand conditions. This requires an assessment based on objective and reliable data, not speculation. Such an assessment needs to exactly account for functional areas impacting the health of the individual depots and the OIB overall. DoD needs to assess the OIB using outcome-focused metrics in a more robust manner to adequately measure today's effectiveness and efficiency levels to ensure readiness for tomorrow's surge requirements. Potential functional area metrics are offered in the below table.

Potential Functional Area Metrics		
Functional Area	**Type of Metric**	**Measurement**
Business Operations	Performance	Calculate Return on Invested Capital by depot (ROIC). ROIC is a standard business metric to evaluate firm or business division performance.
Business Operations	Performance	Net Present Value (NPV). NPV measures the current value of future cash flows against original investment.
Business Operations	Performance	Work not performed due to supply/labor unavailability. These metric measures downtime incurred due to external factors. Downtime = inefficiency.
Business Operations	Capital Productivity	Capital Productivity measures the ratio of output goods and services to the input of physical capital (not labor). Provides a metric on effectiveness and efficiency.
Business Operations	Planned Execution	Execution of planned Maintenance, Repair, & Overhaul (MRO) against the original plan as presented in the President's budget request.
Business Operations	Requirements Validation	Measurement of executed MRO against total requirement.
Business Operations	Capacity Utilization	Depot utilization by square feet of available space; necessary to evaluate underutilized infrastructure.
Financial Resourcing	Working Capital Fund	Actual production at a given depot using actual annual labor rates for a given year in comparison to the projected production for the same depot

		using projected annual labor rates for the same year.
Human Capital	Vacancy Rate of Personnel	The percentage of a given depot's required number of personnel to meet established baseline production requirements that are vacant during a given period.
Human Capital	Time to Hire	The average number of days it takes a given depot to fill a vacant position once the position is announced.
Human Capital	Fully Staffed Workforce	Actual production at a given depot over a period with its current workforce in comparison to the same depot's actual production over the same amount of time with a fully staffed workforce.
Human Capital	Technical Competency of Workforce	Actual production at a given depot over a period with its current workforce in comparison to the same depot's actual production over the same amount of time with a workforce that meets all required technical competencies.
Infrastructure	Capital Investment	The percentage of established capital investment goals for a period that are met by actual capital investments during the same period.
Infrastructure	Facilities	Actual production at a given depot over a period with current facilities in comparison to the same depot's actual production over the same amount of time when the same facilities were considered optimal. An initial historical analysis is necessary to determine a given depot's level of production when its facilities were considered optimal and other variables were like current conditions.
Infrastructure	Equipment	Actual production at a given depot over a period with current equipment in comparison to the same depot's actual production over the same amount of time when the same equipment was considered optimal. An initial historical analysis is necessary to determine a given depot's level of production when its equipment was

		considered optimal and other variables were like current conditions.
Maintenance Performance	Performance to Promise	The percentage of a given depot's deliveries of a completed product over a period that are on schedule in accordance with customer commitments.
Maintenance Performance	Direct Labor Hour Usage	Actual direct labor hour usage in comparison to projected direct labor usage over a period.
Maintenance Performance	Reliability Contribution	The percentage of a given depot's work that is quality control certified and customer accepted without rework over a period.
Maintenance Performance	Flow Days	Actual flow days in comparison to projected flow days over a period.
Maintenance Performance	Net Operating Result	Actual Net Operating Result in comparison to projected Net Operating Result.
Maintenance Performance	Capacity Utilization	The percentage of the total output capacity a given depot utilized over a period.
Maintenance Performance	Carryover	Actual carryover in comparison to projected carryover.
Strategic Partnering	Capacity	Measure, by location, the capacity limits of overseas depots e.g. military material items production capacity.
Strategic Partnering	Capability	Count, by location, the capabilites of overseas depots e.g. critical equipment, tooling, artisan skill sets, and etc.