

MAY 17, 2019

NSWC Crane Innovation Analysis:
**Contributing to
Regional Innovation
Ecosystems**

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1. Executive Summary

The Naval Surface Warfare Center, Crane Division, (NSWC Crane) is successfully responding to the needs of the Department of Defense (DoD) *and* serves as a catalyst for regional industrial development. Its ability to achieve this dual national and regional mission is an example for other defense laboratories in the wider Defense Laboratory Enterprise.

The Indiana Uplands, also referred to as Southwest Central Indiana, is a rural region just southwest of Indianapolis. It is home to Indiana University, the Hoosier National Forest, and the third largest naval installation in the world. That naval installation hosts the Naval Surface Warfare Center, Crane Division, (NSWC Crane) which is dedicated to providing engineering and technical support to the United States Navy in key mission areas, including electronic warfare, expeditionary warfare, and strategic missions.

The Massachusetts Institute of Technology (MIT) Innovation Initiative research team was asked to “conduct research that identifies and documents key success factors, lessons learned, best practices and recommendations for further enabling innovation that can be shared across the DoD Laboratory Enterprise”¹. As such, the aim of the analysis on NSWC Crane is to provide insights and recommendations for how laboratories in the Defense Laboratory Enterprise can meet their dual purpose: to serve the national defense interest through innovation and, simultaneously, to play a role in supporting their regional innovation economies.

The MIT iEcosystem Model² separates out Innovation Capacity (I-Cap) and Entrepreneurial Capacity (E-Cap) as the twin engines of growth of innovation ecosystems. Using this approach, the MIT Innovation Initiative team has identified key lessons and recommendations based on NSWC Crane’s contribution to its region’s I-Cap and E-Cap. Our analysis concludes that NSWC Crane is quite strong in I-Cap but has room to improve in E-Cap. We believe that the latter is likely common among other defense laboratories. Therefore, many of the recommendations to NSWC Crane can likely be applied to wider defense laboratories. Furthermore, many of the recommendations to the wider defense laboratories are based on understanding NSWC Crane’s best practices. The recommendations are categorized based on the five critical inputs into I-Cap and E-Cap: (1) human capital, (2) funding, (3) infrastructure, (4) demand, and (5) culture and incentives. After each recommendation, we specify to whom the recommendation is “Directed to”. The first organization listed is the organization responsible for implementing the recommendation. Subsequent organizations mentioned may wish to also consider or facilitate implementation of the recommendation.

a) Recommendations

i) Human Capital

Recommendation 1. Prioritize Workforce Development

We recommend wider defense laboratories, similar to the practice of NSWC Crane, prioritize workforce participation in leadership and innovation coursework to build in an organizational culture that internalizes and champions the leadership and innovation practices taught. Prioritization can be achieved through (1) highlighting workforce development as part of the organizational ethos³, (2) teaching high quality workforce development programs using a train-the-trainer propagation method, and (3) tracking, by sub-organization, the number of trained participants with the expectation that all employees will be trained.

Directed to wider defense laboratories

Recommendation 2. Collaborate with Regional Entrepreneurship Communities

We recommend NSWC Crane collaborate with regional entrepreneurship communities to build a supportive network of regional startups who have the interest, risk tolerance and skills required to mature defense technologies. Collaboration can be achieved through (1) presenting on Broad Agency Announcements (BAAs), technology transfer and licensing opportunities, (2) hosting business school exchange programs, internships and prototype competitions, and (3) mentoring entrepreneurs through various ‘pathways to small business innovation research (SBIR)’ contracts such as the National Science Foundation’s (NSF) Innovation Corps (I-Corps) program.

Directed to NSWC Crane and wider defense laboratories

ii) Funding

Recommendation 3. Engage with Risk Capital

We recommend NSWC Crane connect to the risk capital community (including banks, angels and others) to address stymied technology transfer due to very low amounts of financing for high-risk, high-reward technologies. Engagement can be achieved through informative public discussions regarding the complexities of both the defense and risk capital communities⁴, risk capital participation in startup prototype competitions⁵ and networking between entrepreneurs and risk capital. Providers of risk capital include but are not limited to venture capital firms⁶, SBA loans, private loans, In-Q-Tel, and the newly formed National Security Innovation Capital fund⁷.

Directed to NSWC Crane and wider defense laboratories

iii) Infrastructure

Recommendation 4. Make World-class Equipment Available to Startups

We recommend NSWC Crane make available its unique technical equipment for startups and others. This will improve NSWC Crane’s contribution to the ecosystem and encourage the startup community to participate in the National Security Innovation Base. (See also Recommendation 2.) Army Research Laboratory’s Open Campus may be a model to scrutinize and, potentially, replicate.

Directed to NSWC Crane and wider defense laboratories

Recommendation 5. Prioritize Technology Transfer through Special Programming

We recommend NSWC Crane prioritize technology transfer to encourage collaboration with regional non-traditional contractors. FedTech™ is a private company that offers an emerging practice of teaming startup applicants with training, market discovery and appropriate laboratory licensing opportunities based on the applicant’s background. This organization may be one to collaborate with or it may serve as a model to scrutinize and, potentially, replicate.

Directed to NSWC Crane and wider defense laboratories

iv) Demand

Recommendation 6. Reduce Time from Pitch to Contract for Small Businesses

We recommend NSWC Crane create a fast track that enables small businesses and startups to go from pitch to contract within 2 weeks. This will improve NSWC Crane’s engagement with startups and small business, thus expanding the regional innovation base. An emerging practice comes from leaders at AFWERX who directly coordinated with the SBIR and STTR Program Office to create a two-week pro-

cess to get small businesses on contract. Similarly, consortiums (including a few of which NSWC Crane is already a member) allow for expedited contracting.

Directed to NSWC Crane and wider defense laboratories

v) Culture and Incentives

Recommendation 7. Establish a Director of Engagement

We recommend wider defense laboratories, similar to the practice of NSWC Crane, serve as a full-time partner for other regional stakeholders to aid in developing regional- and state-level support. One method to effectively prioritize regional partnership begins with establishing a laboratory-level Director of Engagement. This senior leader should report directly to the Commander and is committed to working with all regional stakeholders in a way that synthesizes strategic regional goals.

Directed to wider defense laboratories

Recommendation 8. Incentivize Regional Engagement at the Individual Level

We recommend NSWC Crane incentivize employee community engagement that is focused on entrepreneurial activities. This addresses the need for greater connection across the community that, according to both the census and interviews, does not seem to arise automatically. This can be achieved by providing incentives for employees to attend events at the WestGate Technology Park or to participate in entrepreneurial community events in Bloomington and beyond. Other options might include tours or limited open house days to help familiarize local residents with the base's work.

Directed to NSWC Crane and wider defense laboratories

Recommendation 9. Offer Entrepreneurial Sabbaticals

We recommend offering competitive entrepreneurial sabbaticals to scientists and engineers within the workforce each year. This will empower the ~8% of the NSWC Crane workforce that is interested in entrepreneurship⁸, encourage a sense of respect toward startup communities, and develop companies that will benefit the region. The sabbaticals should include an offer to return to laboratory employment after a couple years so that the entrepreneur may effectively transition his or her technology if desired. We recommend ensuring a competitive process by selecting based on the most promising technologies. We see this as an emerging practice at the Army Research Laboratory, where the host organization offers seed funding and return rights after three years.

Directed to the Navy



2. Introduction and Background

The purpose of this case study on NSWC Crane is to:

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Conduct research that identifies and documents key success factors, lessons learned, best practices and recommendations for further enabling innovation that can be shared across the DoD Laboratory Enterprise.⁹

”

As such, our analysis of NSWC Crane provides a template for analysis of other Naval and wider defense laboratories and explores the various ways in which these laboratories can meet their dual purpose: to serve the national defense interest through innovation and, simultaneously, to play a role in their regional innovation economy. While a single case study cannot provide a clear rendering of best practice (given a lack of explicit comparison), it can provide insights into the various successful modes of engagement with other actors in the innovation ecosystem that will provide elements of a comprehensive playbook for other laboratories – a topic of considerable importance to the Federal Laboratories Consortium (who commissioned this study).

Our analysis comes against the backdrop of the Summary of the 2018 National Defense Strategy whose objectives include at least two objectives of particular relevance to the Defense Laboratory Enterprise:

Establishing an unmatched twenty-first century National Security Innovation Base that effectively supports Department operations and sustains security and solvency; and

Continuously delivering performance with affordability and speed as we change Departmental mind- set, culture, and management systems.¹⁰

NSWC Crane and its sister defense laboratories must be responsive to the needs of the National Security Innovation Base, meeting the technological needs of the warfighter in the short- and long-term. However, it must also serve as a catalyst for industry (particularly in the regional economies in which these laboratories are based), and do so in a way that provides more than simply technical know-how but also talent, infrastructure and a window into technical needs. Today’s Defense Laboratory Enterprise must meet these dual national and regional needs rapidly – a particular challenge given the legacy acquisitions system in place today, built on half a century of defending the federal acquisition system against fraud.

3. Context and Urgency

The Summary of the 2018 National Defense Strategy states that the US’s “competitive military advantage has been eroding”.¹¹ The use of the term “eroding” in this context emphasizes the technological advancement of the United States in comparison to that of its adversaries. In particular, China has emerged as a “strategic competitor”¹² with its Made in China 2025 strategy dedicated to growing critical industries within its own borders and reducing its reliance on foreign technology.¹³ China’s strategic investment in nascent US technology companies (in the realm of \$45.6 billion in 2016¹⁴) specifically aligns with those critical technical mission areas that have dual use in both the commercial and military sectors.¹⁵ While policy-makers grapple with whether and how to restrict Chinese technology espionage without stifling US technology startups, organizations within the United States DoD can enhance guidelines and business processes to ensure the teams creating the technologies critical to winning future wars can perform optimally and make the best use of the wealth of innovation assets throughout the entire DoD system.

Beyond national security, great innovation has historically begun within the walls of the national and defense laboratory enterprises. Technology ranging from the moon landing to life-saving vaccines all originated from federally-funded projects. However, policy and strategy makers have grown concerned that “[t]he current bureaucratic approach, centered on exacting thoroughness and minimizing risk above all else, is proving to be increasingly unresponsive.”¹⁶ In the 1950s the federal acquisitions process was designed with a certain level of rigidity to combat fraud, waste, and abuse, and it has only become more rigid in the intervening years. Given the current threat of losing predominance in the United States defense community’s speed of technological innovation, the rigidity of the acquisition framework is counterproductive.

The defense community is facing a loss of technological superiority due (at least in part) to the defense community’s impaired speed in capability acquisition. Additionally, government has had a critical role in funding, sponsoring, and conducting the science and engineering research that has resulted in many modern-day innovations, changing the lives of billions across the globe. As part of the Defense Laboratory Enterprise, NSWC Crane is heir to both the history of bureaucratic rigidity and the creation of groundbreaking innovation. NSWC Crane must find ways to mitigate the former and emphasize the latter to fulfil its mission of rapidly delivering complex technical solutions for warfighter use.

a) The Regional Context

The Indiana Uplands, also referred to as Southwest Central Indiana, is a rural region just southwest of Indianapolis, and is home to Indiana University, the Hoosier National Forest, and the third largest naval installation in the world. That naval installation hosts the Naval Surface Warfare Center, Crane Division, (referred to as NSWC Crane for the remainder of this document) which is a tenant organization dedicated to providing engineering and technical support to the United States Navy in key mission areas, including electronic warfare, expeditionary warfare, and strategic missions.¹⁷

NSWC Crane is situated in Indiana’s Economic Growth Region 8. Within the region’s boundaries, Bloomington, Indiana is its most populated city, with 85,071 residents.¹⁸ The largest employer in the region is Indiana University at 7,701 employees¹⁹, followed by combined tenant organizations on the naval installation at approximately 5,000 employees²⁰. In addition to the university and naval installation, the region hosts a number of small- and medium-sized defense and medical instrument manufacturing companies²¹, economic development organizations and public-private partnerships committed to NSWC Crane’s success. For example, Radius Indiana²² and the Indiana Innovation Institute²³ specifically cite supporting NSWC Crane as a part of their core missions.

b) Short History of Regional Strategic Planning

After the 2005 Base Realignment and Closure process, in which some NSWC Crane activities were under consideration for relocation, we observe that state and regional officials made deliberate efforts to improve economic development, and, presumably, prevent the threat of closing the installation in the future. For example, the state established the Indiana Office of Defense Development in 2013 via Executive Order.²⁴ The 2013 Lilly Endowment Annual Report highlights the region’s forwarding-looking approach with its section entitled “Unique Region Makes New Plans,”²⁵ where it discusses some of the grant funding going to a few of the region’s non-profit organizations. In 2014, Battelle published [the] ‘Strategic Plan for Economic and Community Prosperity in Southwest Central Indiana,’ funded by the Lilly Foundation.²⁶ In 2016, the Lilly Foundation announced \$42 million for the region.²⁷ These funds established the Regional Opportunities Initiative, Radius Indiana and the Indiana Innovation Institute, the latter two with offices at WestGate, one of two master-planned technology parks just outside the naval installation perimeter.

c) History of NSWC Crane

Founded in 1941 in Martin County, Indiana, NSWC Crane was originally the Burns City Ammunition Depot. From its founding, it provided significant benefits to the United States Navy with highlights including the incorporation of more advanced weapons technologies in the 1970s and the development of its three focus areas – expeditionary warfare, strategic missions, and electronic warfare – in the 2000s. In more recent times it is seen as contributing to the regional economy of the Indiana Uplands, providing 3,500 direct jobs, over 1,600 contracted jobs and offering on-the-job engineering training.

This case study reflects that regional impact and identifies the areas in which leadership has made clear choices in ways of working e.g. in programmatic activities that can be leveraged across other laboratories in the Defense Laboratory Enterprise to support regional innovation ecosystems in other US locations.

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4. MIT Approach & Methodology

The following subsections discuss the Innovation Ecosystem (iEcosystem) model we applied to NSWC Crane and its role in the regional ecosystem. This model is a valuable lens through which to assess and produce strategies that will move NSWC Crane forward in its role as an emerging hub for national and regional impact.

The MIT iEcosystem model is a useful in assessing NSWC Crane for several reasons. First, with its emphasis on regionally bounded innovation ecosystems, it addresses the scope of the study, which specifically highlights the role of NSWC Crane in the regional (rather than state or national) innovation economy. Next, it outlines critical inputs into Innovation Capacity (I-Cap) and Entrepreneurship Capacity (E-Cap), which guide the identification of concrete areas of strengths and weaknesses for NSWC Crane (and the region). The rigor that goes into disaggregating E-Cap, specifically, has the potential to illuminate a path toward meeting the DoD’s nascent interest in collaborating with (and even potentially generating) highly-technical startup companies. Defense laboratories are typically not known for their collaboration with entrepreneurs and venture capital. This iEcosystem approach also emphasizes the need for collaboration between NSWC Crane and these players and again provides a template against which to measure the strengths and weaknesses of such collaboration. We believe this is important so that the DoD gains the advantage of access to inclusive human capital, as small firms, including startups, contribute about half of GDP annually.²⁸

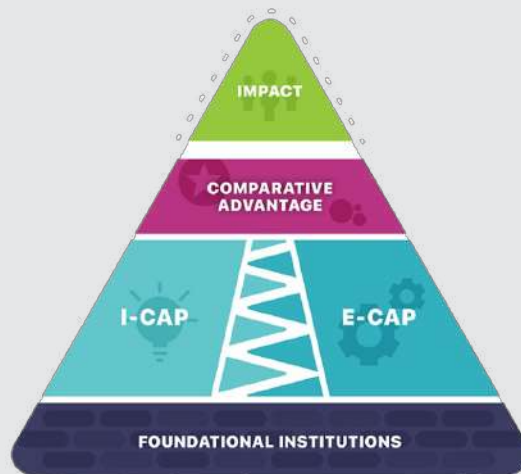
Before delving into the results of the analysis, the following subsections will precisely define and explain the components of the MIT iEcosystem model both in a theoretical sense, and in how we have applied them for this study.

a) MIT iEcosystem Framework

The MIT iEcosystem model emphasizes a comprehensive understanding of the ‘system’ that underpins innovation-driven entrepreneurship in regional innovation ecosystems. For simplicity, the ‘system’ is decomposed into four elements (see Figure below). Taken together, these elements provide a useful decomposition of an iEcosystem that allows for an evaluation of the strengths and weaknesses of any particular ecosystem (alone, over time or in comparison to others).

Figure 4-A:

The ‘system’ for innovation-driven entrepreneurship



Working from the base of the system up, we explore each of these elements in turn:

Foundational institutions are those institutions, rules, practices, and norms that are often taken for granted, yet ensure that investments in a wide variety of capacities and assets can be effectively pro-

tected and leveraged to the benefit of the economy. At the core, they include rule of law (and, conversely, lack of corruption), protection of property rights (especially for intellectual property), financial institutions, freedom for new ideas (including scientific openness), and general ease of doing business.

Next, the two ‘capacities’ provide the twin engines of the ‘system’, resting on the foundational institutions and combining distinctive ‘inputs’ to ultimately drive impact, often in the form of ‘innovation-driven enterprises’ (IDEs), rather than standard ‘small/medium-sized enterprises’ (SMEs). A key contribution from MIT’s work on innovation, entrepreneurship, and ecosystems is to separate out these two capacities:

- **Innovation Capacity (I-Cap)** is, in our definition, the capacity of a place – a city, a region or a nation – to develop ‘new-to-the-world’ ideas and to take them from ‘inception to impact’ (whether this be to economic, social and/or environmental impact). In other words, I-Cap covers not only the development of basic science and research but also the translation of their ‘solutions’ across the entire technology readiness continuum into useful products, technologies and/or services that truly solve problems.
- **Entrepreneurship Capacity (E-Cap)** emphasizes a subset of the more general entrepreneurial capability and conditions for forming enterprises: the latter supports all types of entrepreneurship (leading mostly to SMEs rather than IDEs). The aspects of E-Cap most of interest to iEcosystems are those supporting this ‘innovation-driven’ side of E-Cap, tailored to support the growth of IDEs in a specific place – such as a city, region or nation.

Building on foundational institutions, it is the combination of, and linkages between, innovation and entrepreneurship capacities within a city, region or nation that drives impact. However, innovation- and entrepreneurial-capacity are not always general assets developed in a regional context: they are more likely to be specialized around areas of expertise or around particular sectors, which we view as a broader form of comparative advantage.

Comparative Advantage of any region's economy is based on specific areas of strength that differentiate it from others around it (at a country, continent or global level). For example Greater Boston has differential advantage in the life sciences, while New York might have advantages in Financial Services. For iEcosystems, such comparative advantage is shaped by underlying strengths in both innovation and entrepreneurship capacities but is also distinctive. A region’s comparative advantage will often find expression in geographical clusters or industrial sectors – as agglomeration and specialization remain factors even in this latest phase of the industrial revolution – whether they be clusters in the life sciences, IT services, or education.

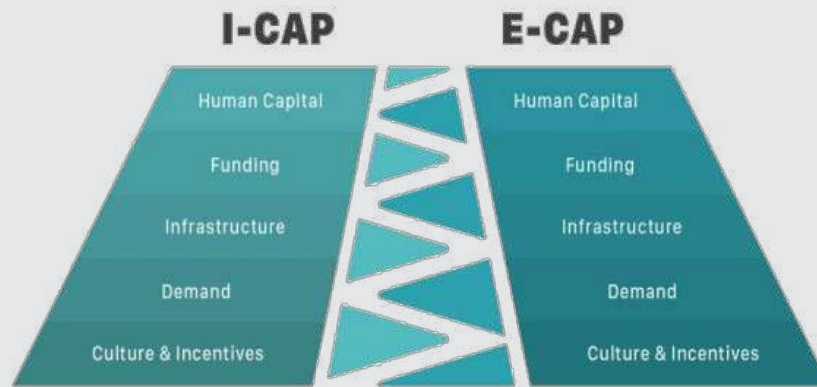
Impact comes from the combination of innovation and entrepreneurial capacities, when combined with core comparative advantage. The key ‘impact’ metrics are, in part, a matter of choice and prioritization on the part of the decision-makers and iEcosystem stakeholders. It should be recognized that even the most profound interventions in the system will only drive measurable changes in impact over the longer run.

b) Measuring Innovation and Entrepreneurship Capacities

Since the purpose of this research is specifically to examine the contributions of NSWC Crane to the regional ecosystem, I-Cap and E-Cap are the most relevant aspects of the framework for our purposes. Together, I-Cap and E-Cap capture the sense that a system is capable of two particular activities: innovation and entrepreneurship respectively. As a starting point, we usefully think of a ‘capacity’ as a sort of ‘production function’ - i.e. a way of relating a series of well-defined inputs to the outputs, in this case of entrepreneurial or innovative capacity outputs.

The framework considers five critical inputs into the I-Cap and E-Cap production functions, based on MIT research about the drivers of ‘innovation-driven entrepreneurship’ in a variety of locations, some within the United States and others from regions worldwide, including Singapore, Tokyo, Finland, Scotland, London, and Israel.

Figure 4-B:
MIT I-Cap/E-Cap
framework



This simplified framework allows us to determine NSW Crane’s strengths and greatest points of weakness and thus identify the points of leverage. These five components are:

- **Human Capital (people):** the appropriate human talent (from within a region, or attracted into a region) with relevant education, training and experience for either innovation or entrepreneurship, or both.
- **Funding:** a variety of types of public and private capital that support innovation and entrepreneurship both at their origins and also throughout the journey from idea to impact, or startup to scale-up.
- **Infrastructure:** the physical infrastructure that is necessary to support innovation and entrepreneurship at their different stages, including physical space as well as equipment required for discovery, production, and supply chains, and other aspects.
- **Demand:** the level and nature of specialized demand for the outputs of innovation and entrepreneurial capacities supplied by different organizations in the system.
- **Culture & incentives:** the nature of role models and individuals who are celebrated, the social norms (‘culture’) that shape acceptable career choices and the incentives that shape individual and team behaviors.

For each of the different inputs into I-Cap and E-Cap, we select measures which capture the strength of these specific elements while avoiding overlap.

c) Considerations Specific to NSW Crane

NSW Crane differs from the typical case to which this framework is applied in several ways, so adjustments of the framework were made to accommodate. We can take for granted that the foundational institutions in this case are sufficient to support an innovation ecosystem. NSW Crane and its region are on US soil, so the rule of law, protection of property rights, and similar characteristics of the region are sufficient to provide a stable foundational institution for the innovation ecosystem.

Next, recall that the purpose behind applying this framework is to understand NSW Crane’s contribution to the regional ecosystem, rather than the ecosystem as a whole. In this spirit we have adapted our approach to assess capacities, and then structure recommendations in a way that strengthens NSW Crane’s contributions to the I-Cap and E-Cap of the region, and the network among the stakeholders to allow these resources to flow in ways that ultimately drives NSW Crane’s impact.

Many of the metrics in the iEcosystem model that provide useful information are derived either from national/state level data which is too coarse to be useful or from survey questions. To ensure comparability and similarity to other uses of this model wherever possible, we have compiled the applicable questions from those surveys into a single questionnaire. With the cooperation of NSWC Crane leadership, that questionnaire was sent out to all NSWC Crane employees. This document provides at least one metric in each of the five categories of input that comprise I-Cap and E-Cap.

The results of the questionnaire are supplemented where appropriate by data solely on NSWC Crane. Some of that data, such as employment numbers and educational attainment of employees, was provided by NSWC Crane directly or through their archives of operational reports. Other data was gathered from government surveys on the Southern Indiana nonmetropolitan area which contains NSWC Crane. While this data is too broad to perfectly represent NSWC Crane, it is a sparsely populated region and NSWC Crane is a significant part of it. For instance, NSWC Crane employees represent nearly 40% of engineers in the local non-metropolitan statistical area²⁹, and this does not count their contractors or other local partners. The simple fact that NSWC Crane is such a significant employer in this area means that government data can provide useful metrics of NSWC Crane's impact on the region.

d) Methodology

Our methodology consisted of A) open research, B) direct data and document requests from NSWC Crane leadership dating back to 2005, C) semi-structured interviews with NSWC Crane's higher headquarters (both Navy and Office of the Secretary of Defense), D) semi-structured interviews with individuals of peer and non-peer organizations working on technical problem sets, and E) both in-person and telephonic interviews with employees, contractors, and regional partners.

First, we researched a variety of publications including academic and periodic publications. To target this research, we applied institutional knowledge of the DoD, organization, business and technology development. We conducted research into archives of Congressional hearings, referenced National Defense Authorization Acts (NDAAs), and the current academic literature on innovation research.

Next, we conducted a series of data and document calls. NSWC Crane outreach personnel provided archives of Annual Reports, NISE Reports, human resources statistics and strategy documents from 2005 to present.

Then, we conducted a series of interviews. We performed semi-structured interviews with NSWC Crane employees and contracted personnel throughout our investigative process, optimally narrowing our questions to specific topics of interest. We conducted semi-structured interviews with ecosystem partners and others within the naval ecosystem to learn about external perceptions of the organization, typical metrics assessed in highly technical, mission-driven organizations, and innovative approaches that leverage current acquisition policy to quickly address mission needs.

Finally, we assembled an online census for NSWC Crane employees. Of the 3,471 NSWC Crane employees, we received 429 responses for the ten-minute form, achieving results above a 95% confidence interval.³⁰

Throughout the primary data collection period, we analyzed the information we had and identified gaps to fill. We continued with a second iteration of data collection, followed by a subsequent analysis of information. Throughout these periods, we assembled a research paper outline, drafts, and final papers, sought and incorporated feedback from key opinion leaders and subject matter experts, and met with faculty advisors and post-doctoral fellows to refine our interpretations.

5. Analysis of NSWC Crane in its iEcosystem Context

We assess the five inputs of human capital, funding, infrastructure, demand and culture & incentives to derive the two key outputs, I-Cap and E-Cap. Assessing these five inputs for each capacity gives leadership valuable information on the right interventions and forms the basis for our recommendations. In the case of NSWC Crane, we also assess each of these inputs to identify best practices in the context of a defense laboratory for other laboratories across the DoD.

a) Innovation Capacity and Entrepreneurial Capacity for the Region

i) Human Capital

(1) I-Cap

Our I-Cap Assessment of Human Capital reveals that NSWC Crane has made deliberate strides to improve technical expertise among their staff. Since 2005 NSWC Crane has tripled the percentage of PhDs in the workforce. This is in contrast to the state of Indiana which has remained constant and the nation which has less than doubled. More generally, NSWC Crane has increased the share of its workforce with a Bachelor's Degree or higher. However, in that same time period the percentage of engineers compared to the total NSWC Crane employee population decreased by 9% while administrative and clerical employees increased by 6%. Despite the frequently cited challenges of hiring new employees in a rural area, 65% of respondents to our survey indicated that scientists and engineers were available for hire as needed.

Figure 5-A.

PhDs per capita among NSWC Crane employees

Crane employees

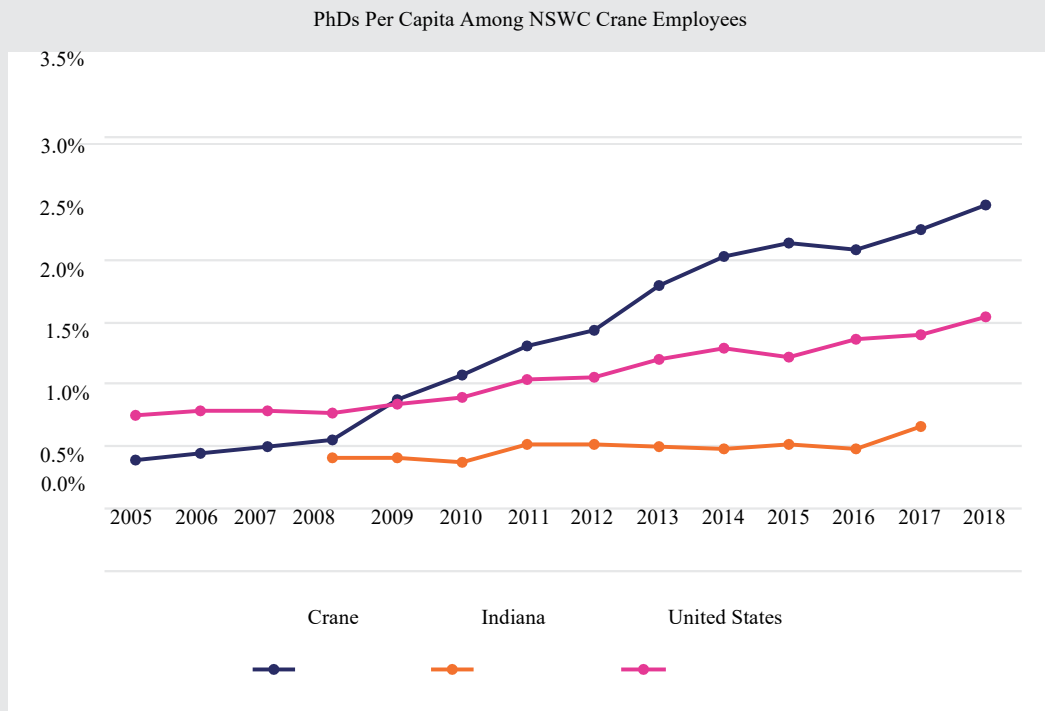
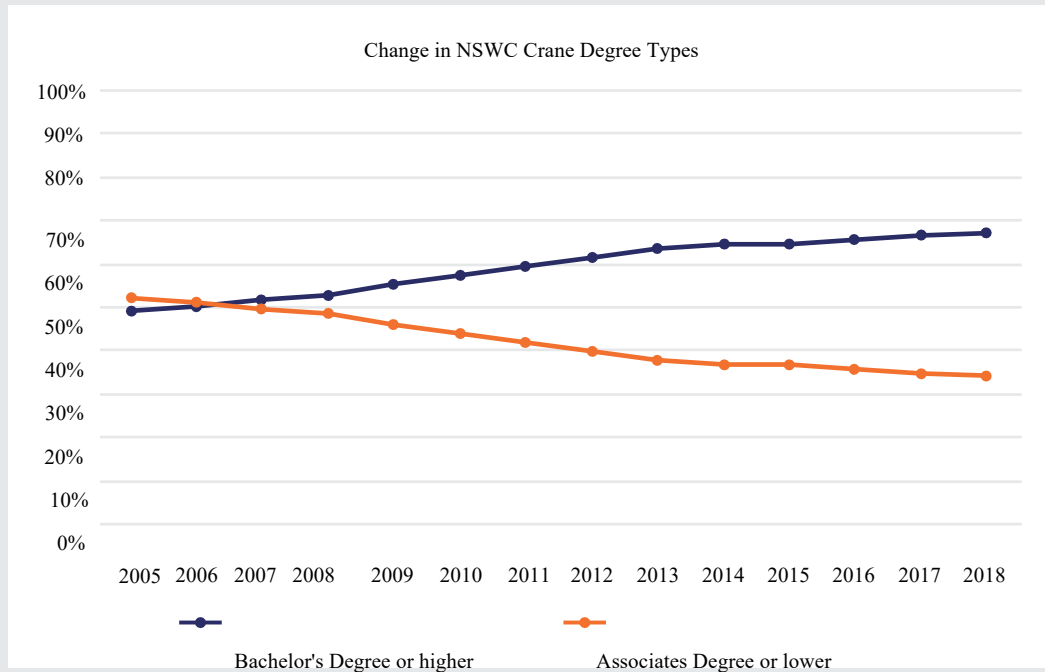


Figure 5-B:
Change in
NSWC Crane
degree types



NSWC Crane employees also benefit from robust workforce development outside of degree-producing programs. Crane Division University, the education center at the facility, develops and administers coursework in leadership, team dynamics, and innovation. The NSWC Crane leadership team implements successful policy to encourage its workforce to participate. For example, NSWC Crane includes in its annual strategic goals certain amounts of participation for its leadership courses. Commenting on a course completed, one employee said, “That was a truly enriching course which I honestly believe has changed my perspective for the better, likely for the rest of my career.”

(2) E-Cap

In terms of Entrepreneurship-Capacity, we find that the region hosts one of the top twenty-five business schools in the nation in the Kelley School of Business at Indiana University Bloomington.³¹ Of those well-trained graduates, fully half find jobs in the mid-west upon graduation.³² While the quality of entrepreneurs is similar or superior to comparable regions that include large swaths of rural area, the value of the connection between NSWC Crane and these entrepreneurs remains weak. Historically, the DoD has had little to do with technical startups. In 1953, the federal contracting environment created the small business set-aside.³³ This act defines a small business as having average annual receipts less than \$38.5 million.³⁴ Connecting with entrepreneurs enables companies a fraction of the size of larger federally-defined small businesses, and relatedly creates connections with the individuals who create and lead companies with high rates of dissolution in those first few vulnerable years.

Increasingly, the DoD has expressed interest in enabling technical startup participation in the National Security Innovation Base. This is indicated in DoD’s establishment of the Defense Innovation Unit (DIU) with its flagship office in the heart of the richest innovation ecosystem in the world, the San Francisco Bay Area’s Silicon Valley. While DIU contracts often attract larger companies, the DoD’s subsequent establishment of programs such as MD5, AFWERX and the funding of commercial companies like Fed- Tech, has helped entrepreneurs connect with marketable and dual-use federal IP enriches the landscape. For NSWC Crane, if

deepened this connection may prove valuable in enabling startups to take higher risk IP and mature to desirable and useful levels without tying up limited internal human capital.

While the broader DoD context supports engagement with entrepreneurs, when we assessed NSWC Crane employee E-Cap, we determined that E-Cap human capital is low. Only 40% of survey respondents said they were sure of their ability to successfully start a business, compared to 55% of US citizens overall. Many cited a lack of knowledge as the reason for their uncertainty around the skills necessary to start a business. Considered together, it becomes clear that, despite an educated workforce with nearly 30% having degrees in business or related fields, NSWC Crane employees have a notable lack of confidence in their ability to start businesses which likely leads them to be less effective in supporting early-stage businesses in the community.

While E-Cap human capital is currently low, NSWC Crane partnered with the Purdue Research Foundation and the WestGate Authority to produce Purdue@WestGate. This organization includes, among others, “Firestarter” a 6-week program to develop entrepreneurial ideas run by Purdue Foundry. This has the potential to strengthen E-Cap in coming years, and thus contributes to a medium-to-long term plan for the region.

ii) Funding

(1) I-Cap

The Office of Naval Research has a policy that requires NSWC Crane and its fellow laboratories within NAVSEA to function on a working capital model, where program offices may enlist NSWC Crane’s assistance by funding specific work on major defense acquisition programs. The key distinction is that within the working capital model, NSWC Crane must compete with other government laboratories as well as industry to perform engineering services.

NSWC Crane, like its sister organizations within the Office of Naval Research, may conduct internal research and development projects under 219 funding. This funding, specifically under the NISE program, allows naval research organizations to take a small percentage of revenue, somewhere between two and three percent, and apply that funding to workforce development and technical projects that don’t immediately impact existing naval equipment. These projects allow engineers to develop and compete for funding their own advances that may have a more radical or transformative impact in naval engineering. These projects are not currently and specifically sought by a naval program manager, as they may be considered not fully mature and a higher risk of technical infeasibility. This is in contrast with the more traditional incremental innovation that occurs by the NSWC Crane staff on major defense acquisition programs.

Outside of federal monies, the Lily Foundation granted \$42,000,000 in 2015³⁵ to improve economic development opportunities in the Indiana Uplands. Specifically, the grant money helped establish an Applied Research Institute to the amount of \$16,225,000.³⁶ This institute, dubbed the Indiana Innovation Institute, or IN3, bridges government, academia, and industry on the technical areas on which the ecosystem has particular expertise: microelectronics, hypersonics, and electro-optics.³⁷

(2) E-Cap

In terms of Entrepreneurship-Capacity for the region, the availability of risk capital comes predominantly in the form of credit and traditional bank loans. The SBA reported \$506,714,229 in approved loans for Indiana small businesses in 2018.³⁸ Indiana’s 8th Congressional District, home of Crane, had 122 small businesses with approved loans worth \$29,125,457 in the same year. However, these numbers don’t distinguish technology companies nor which region they operate. Approximately 76% of venture capital funding is isolated to three communities: Silicon Valley, Boston-Cambridge, and New York City³⁹; therefore, we assess Indiana understanding that it’s generally competing for the remaining 24%. According to the 2018 PWC Report on venture investment, Indiana as a whole had 46 venture capital deals for a total of \$220.1 million. This is approximately 0.2% of total US VC funding.⁴⁰

“We need venture capital,” stated Kirk White, Indiana University’s Assistant Vice President for Strategic Partnerships, in reference to the region as a whole. “Indiana University has a small VC ecosystem in Bloomington, but around Crane it’s still pretty sparse yet there’s the potential for it.”

When NSWC Crane employees were asked about how hard it would be to get VC funding, over 60% reported that they didn’t know how easy or hard it would be. Similarly, over 50% of survey respondents stated they don’t know how easy or hard it would be to get a bank loan.

iii) Infrastructure

(1) I-Cap

NSWC Crane faces several challenges with I-Cap Infrastructure, both internally and with regard to the local community. Within the base, 50% of survey respondents said that new technology was slow to be adopted, and many specifically cited challenges with the acquisition process as an area that limited their work. This applied even to the use of well-established technologies. One respondent had hoped to use a specific Python programming language package - one that was first released in 2012 - and was told by others who had attempted the process that it was impossible to get approval. Traditional infrastructure areas vary widely in quality. Internet connectivity, at 80-200 Mbps is sufficient, but a common refrain in interviews and from NSWC Crane IT staff was that cellular coverage on the installation does not meet peak demand.

External to the base, NSWC Crane could serve as a source of innovation-enabling infrastructure for the region using their extensive catalogue of specialized research equipment. However, those granted access to the equipment tend to be national companies, and it is rarely made available in service to regional innovation players. As an example of this, the nearby Battery Innovation Center would benefit from occasional access to electron microscopes, but have found that progress in that direction doesn’t exist⁴¹. Two of our more critical interviewees independently used the term “Cranified” to refer to a reputation of over-promising and under-delivering. NSWC Crane would benefit from putting significant effort into both improving their own infrastructure, and in improving access to it for regional research projects.

Similarly, external access to NSWC Crane’s intellectual property is another area where progress has been made, but small improvements could produce significant benefits. NSWC Crane does put patents available for license online. However, they use sites that are not particularly well known. Additionally, there is no obvious link between NSWC Crane’s website and the websites where they list their patents. Work has clearly been done in creating the list in the first place and finding a place to host it. A small effort to make that list more findable could be very beneficial to NSWC Crane’s ability to leverage its IP infrastructure for the benefit of the region.

(2) E-Cap

NSWC Crane’s E-Cap infrastructure is developing, but has room to grow. During the 2005 BRAC process two of the cited flaws of NSWC Crane were (1) the lack of an interstate highway for easy access and (2) the lack of a local technology park to foster innovative business. The state and regional stakeholders have since addressed both of these concerns.

Since 2005, Interstate 69 (I-69) has been expanded from Evansville past Crane and Bloomington to Martinsville with plans to reach Indianapolis. Cell service has improved in and around NSWC Crane, particularly in areas close to the interstate, though as mentioned above it is still not sufficient to meet all of NSWC Crane’s needs. The interstate allows for easier collaboration and visits from partners in Bloomington and Evansville. Once extended to Indianapolis, this interstate may spur strong innovation and entrepreneurial growth.

While the expansion of I-69 has been an unalloyed good, the technology park at WestGate has faced challenges in generating sufficient growth. Spaces meant for conferences, training, or presentations are instead rented for community events such as weddings. That said, WestGate has contributed to the development of modern startup infrastructure. Beginning in the 2009, National Institute for STEM Education (NISE) initiatives have emerged at WestGate to encourage use of office and makers spaces. After initial struggles, the Purdue Research Foundation was brought in to manage WestGate, and it has generated momentum in creating an ideal space for companies. Other organizations, most notably Radius Indiana, were founded largely to support economic development around NSWC Crane and have a presence at WestGate. Through regional organizations and the generous support of the state by way of the Indiana Office of Defense Development, the prerequisite elements are being established for NSWC Crane to then grow the infrastructure for entrepreneurial activity.

iv) Demand

(1) I-Cap

Due to the Working Capital model, we have a clear demand signal for NSWC Crane technical work. Below we showcase volume of the business base completed by NSWC Crane employees, as well as the volume of contracting dollars that NSWC Crane issues from that business base to facilitate their work through additional technical staff, low rate manufacturing off-installation, or other similar tasks. Based on these numbers, demand for NSWC Crane technical work is substantial, particularly in volume of dollars for research and development in a rural region.

Table 5-A: Vendor contracting (in \$millions)

	Vendor Contracting (in \$millions)⁴²
FY18	\$1,392
FY17	\$1,165
FY16	\$777
FY15	\$884
FY14	\$917
FY13	\$719

Additionally, the region hosts Indiana University, a large, public research university with a research budget approaching, if not surpassing, \$1 billion.⁴³ According to the survey, 67% of NSWC Crane employees state there is high or somewhat high degrees of collaboration with universities. This is also demonstrated in the volume of CRADAs, EPAs, WPPs, and other contract vehicles. Since FY 2010, the volume of information exchange agreements has grown more than twofold. When asked about collaboration with industry, 58% of survey respondents indicated a high or somewhat high degree of collaboration, and 59% of respondents indicated a high or somewhat high degree of collaboration with Other Research Institutions.

The only caveat to this positive indicator is the time it takes to establish any of the contract types discussed here. Interviews revealed a mixed impression of NSWC Crane’s time to contract. Some, particularly the larger universities such as Indiana University, praised the relative speed of NSWC Crane at setting up additional contracts once the overall partnership was established, especially in the last five years. Others, mostly smaller universities and private companies, lamented the lengthy wait times inherent in the process. This problem is not unique to NSWC Crane, and they have certainly made strides, but there is definitely room for improvement.

Table 5-B: Volume of agreements by contract vehicle

	CRADA	PLA	PIA	EPA	WPP	Total	Disclosed	Filed	Issued
FY18	123	20	17	70	30	260	33	44	34
FY17	58	21	19	69	23	190	33	52	51
FY16	41	23	18	63	35	180	26	71	34
FY15	25	23	19	60	30	157	35	86	18
FY14	12	18	17	49	33	129	68	68	25
FY13	21	15	12	49	33	130	37	38	36
FY12	27	12	9	45	43	136	19	20	37
FY11	20	7	5	42	54	128	28	36	24
FY10	18	7	4	35	56	120	26	39	8

(2) E-Cap

With regard to E-Cap Demand, NSWC Crane and the other two major regional players are the best sources of regional demand. Since 2010, NSWC Crane has offered roughly 20% in its small business set-aside portfolio (by contract value obligated) with 2018 numbers valued at \$314,252,276.

Table 5-C: Total contract awards, small business awards and small business set-aside ratios⁴⁴

	Total Contract Awards (in \$millions)	Small Business Awards (in \$millions)	Small Business Set-aside Dollars in terms of total contracting dollars (as percentage of total contract obligations)
FY18	1,392.0	314.2	22.5
FY17	1,165.6	239.5	20.5
FY16	777.0	170.1	21.9
FY15	884.8	176.3	19.9
FY14	917.3	190.5	20.7
FY13	719.6	176.8	24.5

The DoD has awarded 313 projects (261 SBIR and 52 STTR)⁴⁵ to Indiana since 2005 to total \$117 million. In 2009, the DoD awarded 35 projects, but there have been fewer than 20 projects awarded funds each year since 2014 in the state of Indiana, ranking it 23rd in states funded via SBIRs and STTRs. Unfortunately, these data points aren't specific to NSWC Crane-funded opportunities.

v) Culture & Incentives**(1) I-Cap**

NSWC Crane has a strong internal culture of innovation. As a research institution, NSWC Crane has a very high percentage, almost 70%, of employees with STEM degrees. Moreover, NSWC Crane employees place a very high value on the mission guiding their work. Over 60% said that the mission of

NSWC Crane is very clear in everyday work. In interviews, former employees spoke highly of NSWC Crane’s focus on innovating for the warfighter. It is unquestionably successful as a research institution, and the entire region views its capabilities in that sphere with pride.

The culture around NSWC Crane is more mixed in opinion with regards to its role in the region’s wider innovation culture. Regional development organizations and universities comprise a very pro-NSWC Crane culture, one that seeks to enable the base at seemingly any cost, perhaps for fear that a future Base Realignment and Closure (BRAC) process might remove it entirely. The view of NSWC Crane as a positive place to work or conduct research is not uniformly held by the people living in local communities, partially due to a lack of familiarity with the base. One NSWC Crane staff member who had grown up in the region recalled having no awareness of NSWC Crane’s work, despite noting their presence at career fairs.⁴⁶ Another longtime resident of the region fondly remembered that the base held an open-gate event on Armed Forces Day, providing a welcoming way for the community to see NSWC Crane as less of a figurative black box.⁴⁷ Considering the significant number of employees with local personal ties, it might be fruitful to examine methods to align the NSWC Crane pro-innovation culture with the perspective of the local residents.

Though opinions were mixed on NSWC Crane as a whole, NSWC Crane’s Office of Engagement was universally well regarded, even when those interviewees also spoke negatively of the base in general. The most negative respondent took the time to note that the Office of Engagement was making all the right moves in correcting what that person saw as NSWC Crane’s deficiencies. We understand this office to be unique to NSWC Crane, in scale at the very least. Other laboratories, particularly those that would like to replicate NSWC Crane’s extensive support from government and local organizations could form Offices of Engagement of their own. However, merely forming the office would not be sufficient. NSWC Crane invests significant resources in and attention to the office, and the community responds to that level of emphasis. As one example, the Office of Engagement made first contact with a number of interviewees external to NSWC Crane to request that they participate in this research. The vast majority of people contacted in this way were willing to undergo hour-long interviews with very little prior notice. This is emblematic of the buy-in NSWC Crane receives from the community. If other defense laboratories want that level of support from their communities, a significant step toward getting it would be developing an Office of Engagement similar to that of NSWC Crane.

(2) E-Cap

NSWC Crane does not have a strong entrepreneurial culture. As can be seen from the table below, employees at NSWC Crane have around half the entrepreneurial intent of the US population at large. More fundamentally, NSWC Crane employees are dramatically less likely to view entrepreneurship as a desirable career choice than the US population in general. Both interviews and survey comments portray employees who are content with their stable government jobs and uninterested in the uncertainty entrepreneurship represents.

Table 5-D: Survey results from questions related to entrepreneurship of NSWC Crane employees

	United States ⁴⁸	Crane
Entrepreneurship as a desirable career choice	75%	16.88%
Entrepreneurial intention	15%	8.33%
Fear of failure rate	33%	33.65%

Local entrepreneurs and accelerators/training programs such as the Purdue Research Foundation at WestGate noted that, aside from NSWC Crane leadership, employees are unlikely to attend local meetups or discussions of technology-based business opportunities such as the WestGate First Tuesday events. NSWC Crane staff have demonstrated an unwillingness to serve in an advisory capacity to local startups. While it is understandable that NSWC Crane is not meant to be a factory of startup technology, it is our opinion that greater connection between NSWC Crane staff and the broader entrepreneurial community at WestGate, in Evansville, and in Bloomington may benefit the entire region.



6. Findings and Recommendations

The MIT Innovation Initiative research team has identified recommendations based on NSWC Crane's contribution to its region's Innovation and Entrepreneurship Capacities as specified in the MIT iEcosystem Model.⁴⁹ These capacities are based on five inputs, of which the recommendations are categorized: (1) human capital, (2) funding, (3) infrastructure, (4) demand, and (5) culture and incentives. After "Directed to", the first organization listed is the organization responsible for implementing the recommendation. Subsequent organizations mentioned may wish to also consider or facilitate implementation of the recommendation.

a) Human Capital

Investments in I-Cap human capital have elevated the status of NSWC Crane and its host communities. With education levels that are considerably above national levels for rural regions, NSWC Crane's influence has a lifting effect for the region. In comparison, E-Cap human capital lags behind, though it may be advanced by concerted effort among the region's present and future stakeholders, particularly anchor stakeholders such as Indiana University, industry and government entities.

A recurring theme supported by survey and interview data was the high level of workforce satisfaction. Many employees remain at NSWC Crane for the majority of their careers, leaving occasionally to gain experience or education before returning. Additionally, NSWC Crane offers classes on a diverse range of topics through what is referred to as "Crane Division University." A unique feature of this program is that it is taught by current NSWC Crane employees, many of whom first took the classes themselves, and then adopted a train-the-trainer style program.

Handling Crane Division University internally is a key success factor for creating a sense of ownership for the program and ensuring accurate educational and cultural messaging. The program also gives employees the opportunity to teach and apply leadership principles. While many defense laboratories have similar workforce development programs, these subtleties go a long way in improving employee morale. Crane Division University specifically could be leveraged by detailing NSWC Crane employees who currently run the program to other laboratories to implement the program and by so doing build I-cap human capital in other locations. This would have the added benefit of strengthening connections among the different laboratories.

Defense laboratories appear wary of re-prioritizing efforts to increase engagement with startups in their communities. In NSWC Crane's region there is a top-25 Masters of Business Administration (MBA) program at Indiana University, and additional entrepreneurial demand is created via NSWC Crane's own Small Business Innovation Research (SBIR) program. However, the incentives for engaging with startups, or entrepreneurs interested in creating startups, are inconsistent. Fortunately, organizations like Defense Innovation Unit (DIU), National Security Innovation Network (NSIN), and AFWERX Technology Accelerator effectively build these relationships in major innovation hubs. It is possible that they can provide a guide to improving NSWC Crane's performance in this area, particularly via NSIN. Crane Division University may also wish to partner with Indiana University's Kelley School of Business to provide entrepreneurship courses to staff and students.

Adding relevant technical startups capable of solving complex problems to an existing inter-organizational team benefits not only the startup, but also the defense laboratory and, ultimately, the warfighter as well. These entities can tackle problems with new ideas and mature technology predominantly using private funding, all with the understanding that, once matured, the U.S. DoD will be a buyer. This may also expand human capital in other ways as entrepreneurs' careers progress, boosting economic gains for the region and applying the technology to commercial applications. The DoD tackles some of

the most complex problems, and the more diverse the cross-disciplinary minds working to solve them, the better chance they will be solved.

Recommendation 1. Prioritize Workforce Development

We recommend wider defense laboratories, similar to the practice of NSWC Crane, prioritize workforce participation in leadership and innovation coursework to result in an organizational culture that internalizes the leadership and innovation practices taught. Prioritization can be achieved through (1) highlighting workforce development as part of the organizational ethos⁵⁰, (2) internally teaching high quality work- force development programs using a train-the-trainer propagation method, and (3) tracking by sub-organization the number of trained participants with the expectation that all employees will be trained.

Directed to wider defense laboratories

Recommendation 2. Collaborate with Regional Entrepreneurship Communities

We recommend NSWC Crane collaborate with regional entrepreneurship communities to result in a supportive network of regional startups who have the interest, risk tolerance and skills required to mature defense technologies. Collaboration can be achieved through (1) presenting on broad agency announcement content, technology transfer and licensing opportunities, (2) hosting business school exchange programs, internships and prototype competitions, and (3) mentoring entrepreneurs through various ‘pathways to small business innovation research (SBIR)’ contracts such as the National Science Foundation’s (NSF) Innovation Corps (I-Corps) program.

Directed to NSWC Crane and wider defense laboratories

b) Funding

The working capital model performs best when applied to maintenance and engineering support services of high technology readiness level (TRL) technologies for major defense acquisitions programs. As a result, NAVSEA organizations such as NSWC Crane are better candidates for an effective use of working capital than, for example, the Naval Research Laboratory. By attributing between two and three percent of laboratory revenue to independent research and development (IRAD) projects, the Navy’s funding model incentivizes large work volume in a competitive environment while offering a small amount of funding to higher risk but related technical projects. This funding composition works well in supporting NSWC Crane’s funding I-Cap.

Challenges arise outside the gates of NSWC Crane. Opportunities for technology transfer may be stymied by very low amounts of financing for high-risk, high-reward endeavors, such as business ventures formed to mature and deploy advanced technologies into the marketplace. NSWC Crane’s technology portfolio, including, but not limited to, patents, must be presented with greater transparency for commercial and defense purposes. This will encourage entrepreneurs and risk capital to leverage such technologies, resulting in opportunities for NSWC Crane’s work to be deployed more widely. Additionally, attention and support will still be needed to improve the E-Cap of NSWC Crane’s host region, since budding local entrepreneurs and their funders lack the resources of the DoD funding ecosystem and are consequently more susceptible to remaining at the economic status quo.

Recommendation 3. Engage with Risk Capital

We recommend NSWC Crane engage with the risk capital community to address stymied technology transfer due to very low amounts of financing for high-risk, high-reward technologies. It may be worth- while starting with angel investing networks, some family offices or large endowments as a starting point. Engagement can be achieved through informative public discussions regarding the complexities of both the defense and risk capital communities⁵¹, risk capital participation in startup prototype competitions⁵² and networking between entrepreneurs and risk capital. Providers of risk capital in-

clude but are not limited to venture capital firms⁵³, SBA loans, private loans, In-Q-Tel, and the National Security Innovation Capital fund⁵⁴.

Directed to NSWC Crane and wider defense laboratories

c) Infrastructure

NSWC Crane unquestionably represents a significant concentration of capabilities and equipment. Similar to the previous recommendation, NSWC Crane could make more of an effort to engage with the community in the technical realm. NSWC Crane has made its innovation infrastructure available to national corporations in the past, and is connected to local universities by an ample volume of Cooperative Research and Development Agreements (CRADAs) and Education Partnership Agreements (EPAs). However, these capabilities have not been used to benefit local technology companies. Additionally, startups in the region are advised not to bother reaching out to NSWC Crane for equipment time or technical advice because the process takes too long for a young company and is unlikely to be successful in the long run.

Furthermore, the Defense Laboratory Enterprise has tremendous amounts of intellectual property (IP), some of which is available for licensing. While Broad Agency Announcements and multiple listing websites do exist, it is important to provide clarity on where regional industry and startup partners can search and license patents. Without clarity on licensing opportunities, companies and the DoD are hindering opportunities to leverage private funds and market forces in maturing inventions through the often costly final, high-utility stages of the technology readiness levels (TRLs).

Recommendation 4. Make World-class Equipment Available to Startups

We recommend NSWC Crane make available its unique technical equipment for startups and others. This will improve NSWC Crane's contribution to the ecosystem and encourage the startup community to participate in the National Security Innovation Base. (See also Recommendation 1.2.) Army Research Laboratory's Open Campus may be a model to scrutinize and, potentially, replicate.

Directed to NSWC Crane and wider defense laboratories

Recommendation 5. Prioritize Technology Transfer through Special Programming

We recommend NSWC Crane prioritize technology transfer to encourage collaboration with regional non-traditional contractors. FedTech™ is a private company that offers an emerging practice of teaming startup applicants with training, market discovery and appropriate laboratory licensing opportunities based on the applicant's background. This organization may be one to collaborate with or it may serve as a model to scrutinize and, potentially, replicate.

Directed to NSWC Crane and wider defense laboratories

d) Demand

Demand is one of NSWC Crane's strongest points. The base demonstrates its success in this metric through positive performance under the working capital model, the high level of demand for regional innovation, success at meeting that demand, and the number and variety of university partners brought in for their innovative capabilities. Demand for E-Cap is also significant and the state as a whole is doing reasonably well in this sector.

One caveat is that several industry and university partners referenced the speed of getting on contract as a hindrance to a more steadfast partnership. In general, the pace of paperwork is a Navy-wide problem, and one that a great many people are attempting to solve.

Recommendation 6. Reduce Time from Pitch to Contract for Small Businesses

We recommend NSWC Crane create a fast track that enables small businesses and startups to go from pitch to contract within 2 weeks. This will improve NSWC Crane’s engagement with startups and small business, thus expanding the regional innovation base. An emerging practice comes from leaders at AFWERX who directly coordinated with the SBIR and STTR Program Office to create a two-week process to get small businesses on contract. Similarly, consortiums (including a few of which NSWC Crane is already a member) allow for expedited contracting.

Directed to NSWC Crane and wider defense laboratories

e) Culture and Incentives

With regards to culture and incentives, NSWC Crane’s strength is also its weakness. The organization has a very strong culture around innovation and serving the warfighter. The people who self-select into this culture by choosing to work at NSWC Crane also tend to be less interested in entrepreneurship. If NSWC Crane wishes to increase their E-Cap, they should encourage greater participation by all parts of their workforce, particularly those already interested in entrepreneurship, and attempt to make that participation as easy as possible.

In the regional culture, NSWC Crane has a mixed reputation. Regional organizations and larger universities view it as an essential part of the region and are willing to put in the work to avoid the threat of base closure. Smaller universities and members of local communities are either ignorant of NSWC Crane’s operations or feel disregarded by the base. However, the Office of Engagement specifically is uniformly well respected for the work that office does and has laid the groundwork for building regional connection.

NSWC Crane unquestionably represents a significant concentration of capabilities and equipment. However, its ties to the region beyond simple economic and contractual mechanisms could be improved. Much as it has worked to shed the reputation of “the Pentagon’s best-kept secret”⁵⁵ among the region, it can and should also work to change that reputation among the local communities, both by exposing more of NSWC Crane’s work to the community, and by encouraging employees to be more active locally.

Recommendation 7. Establish a Director of Engagement

We recommend wider defense laboratories, similar to the practice of NSWC Crane, serve as a full-time partner for other regional stakeholders to aid in developing regional- and state-level support similar to NSWC Crane. One method to effectively prioritize regional partnership begins with establishing a Director of Engagement. This senior leader should report directly to the Commander and is committed to working with all regional stakeholders in a way that synthesizes strategic regional goals.

Directed to wider defense laboratories

Recommendation 8. Incentivize Regional Engagement at the Individual Level

We recommend NSWC Crane incentivize employee community engagement to elucidate base activities and address the need for greater connection in a community that, according to both the census and interviews, does not appear to arise automatically. This can be achieved through providing incentives for employees to attend events at the WestGate Technology Park or participate in events at entrepreneurial communities in Bloomington and beyond. Other options might include tours or limited open house days to help familiarize local residents with the base’s work.

Directed to NSWC Crane and wider defense laboratories

Recommendation 9. Offer Entrepreneurial Sabbaticals

We recommend offering competitive entrepreneurial sabbaticals to scientists and engineers within the workforce each year. This will empower the ~8% of the NSWC Crane workforce that is interested in entrepreneurship, encourage a sense of respect toward startup communities, and develop companies that will benefit the region. The sabbaticals should include an offer to return to laboratory employment after a couple years so that the entrepreneur may effectively transition his or her technology if desired. We recommend ensuring a competitive process by selecting based on the most promising technologies. We see this as an emerging practice at the Army Research Laboratory, where the host organization offers seed funding and return rights after three years.

Directed to the Navy



7. Conclusion

NSWC Crane provides tremendous benefit to the DoD, the Navy and its region. In the context of the MIT iEcosystem Model, our analysis concludes that NSWC Crane is quite strong in I-Cap and has room to improve in E-Cap. Many of the recommendations to the wider defense laboratories are based on NSWC Crane's best practices, while many of the recommendations to NSWC Crane can likely be applied to wider defense laboratories if they are not already implementing those practices.

The MIT iEcosystem Model, through a defense lens, puts more onus on collaborating with entrepreneurs and risk capital than the defense community has historically. These two stakeholders are likely new stakeholders for many of the defense laboratories across the nation. But we see these stakeholders as holding key roles: maturing high-risk, high-reward technologies using private money, showcasing defense problems to a new population, bringing new ideas to a system traditionally fraught with bureaucracy and commercializing breakthrough technology that originates within the defense sector.

We also see an emerging appetite from the defense community in engaging with startups and risk capital. We were able to apply many emerging practices from across the DoD that will have lessons learned and assessments of these new programs and policies in the near future (if not already). These practices, when impactful, must be shared across the DoD. Collaboration for the new National Security Innovation Base must be across not only traditional defense engineering minds, but also those with new ideas from other industries.

As such, our analysis of NSWC Crane is meant to provide a template for analysis of wider defense laboratories and ultimately explore the various ways in which these laboratories can meet their dual purpose: to serve the national defense interest through innovation and, simultaneously, to play a role in their regional innovation economies. While a single case study cannot provide a clear rendering of best practice, it can provide insights into the various modes of engagement with other actors in the innovation ecosystem.

8. Endnotes

¹ “Federal Laboratory Consortium for Technology Transfer Request for Quote: NSWC Crane Innovation Eco-system Case Study.” Federal Laboratory Consortium for Technology Transfer. March 22, 2018.

² Murray, Budden. “A systematic MIT approach for assessing ‘innovation-driven entrepreneurship’ in ecosystems (iEcosystems).” MIT Lab for Innovation Science and Policy. September 2017.

³ NSWC Crane has three guiding principles, the first of which is “(1) Ethos: Creating a culture of innovation that values leadership and employee engagement.”

⁴ Among other complexities, funders must understand that the broader defense economy favors technology startups with markets in both the defense and commercial spaces.

⁵ See Recommendation 2. Collaborate with Regional Entrepreneurship Communities.

⁶ “About Elevate.” <https://www.elevateventures.com/about/>. Elevate Ventures. Accessed May 15, 2019.

⁷ Doubleday, Justin. “Pentagon seeks \$75M for dual-use tech venture capital program.” March 19, 2019. <https://insidedefense.com/daily-news/pentagon-seeks-75m-dual-use-tech-venture-capital-program>. Accessed May 15, 2019.

⁸ This number is based on our survey results.

⁹ “Request for Quote / NSWC Crane Innovation Ecosystem Case Study.” Federal Laboratory Consortium for Technology Transfer. March 22, 2018.

¹⁰ “Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military’s Competitive Advantage.” <https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>

¹¹ “Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military’s Competitive Advantage.” <https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>

¹² “Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military’s Competitive Advantage.” <https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>

¹³ Kennedy, Scott. “Critical Questions: Made in China 2025.” Center for Strategic and International Studies (CSIS). June 1, 2015. <https://www.csis.org/analysis/made-china-2025>

¹⁴ Brown, Michael and Pavneet Singh. “China’s Technology Transfer Strategy: How Chinese Investments in Emerging Technology Enable a Strategic Competitor to Access the Crown Jewels of US Innovation.” January 2018, page 4. [https://admin.govexec.com/media/diux_chinatechnologytransferstudy_jan_2018_\(1\).pdf](https://admin.govexec.com/media/diux_chinatechnologytransferstudy_jan_2018_(1).pdf)

¹⁵ Brown, Michael and Pavneet Singh. “China’s Technology Transfer Strategy: How Chinese Investments in Emerging Technology Enable a Strategic Competitor to Access the Crown Jewels of US Innovation.” January 2018. [https://admin.govexec.com/media/diux_chinatechnologytransferstudy_jan_2018_\(1\).pdf](https://admin.govexec.com/media/diux_chinatechnologytransferstudy_jan_2018_(1).pdf)

¹⁶ “Summary of the 2018 National Defense Strategy of the United States of America: Sharpening the American Military’s Competitive Advantage.” <https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>

- ¹⁷ “Who We Are.” Warfare Centers NSWC Crane Division. Accessed on April 29, 2019. <https://www.navsea.navy.mil/Home/Warfare-Centers/NSWC-Crane/Who-We-Are/>
- ¹⁸ “Monroe County.” Indiana IN-Depth Profile. Accessed April 29, 2019. https://www.stats.indiana.edu/profiles/profiles.asp?scope_choice=a&county_changer=18105
- ¹⁹ “Business Lookup Tool: Establishment Detail Indiana University.” Hoosiers by the Numbers. Accessed on April 29, 2019 <http://www.hoosierdata.in.gov/buslookup/page3.aspx?infousaid=584168017>
- ²⁰ “Business Lookup Tool: Establishment Detail US Naval Warfare Support Ctr.” Hoosiers by the Numbers. Accessed on April 29, 2019 <http://www.hoosierdata.in.gov/buslookup/page3.aspx?infousaid=468284799>
- ²¹ “Economic Regional 8 Analysis” Hoosiers by the Numbers. Accessed on April 29, 2019 <http://www.hoosierdata.in.gov/region8.asp>
- ²² “What we do.” Radius Indiana. Accessed on April 29, 2019. <http://www.radiusindiana.com/about-us/what-we-do/>
- ²³ “Who we are.” Indiana Innovation Institute. Accessed on April 29, 2019. <http://in3indiana.com/who-we-are/about-us/>
- ²⁴ “Welcome.” Indiana Office of Defense Development. Accessed on April 29, 2019. <https://www.in.gov/iodd/>
- ²⁵ “Lilly Endowment Annual Report 2013.” Lilly Endowment Inc., 2014. <http://lillyendowment.org/wp-content/uploads/2017/04/annualreport2013.pdf>
- ²⁶ “Strategic Plan for Economic and Community Development in Southwest Central Indiana.” https://swcindianadotorg.files.wordpress.com/2018/12/Battelle_strategic_plan_for_economic_and_community_development_in_swc_indiana_11-25-14_1.pdf
- ²⁷ “Who We Are”. Regional Opportunity Initiatives. Accessed on April 29, 2019. <https://regionalopportunityinc.org/who-we-are/>
- ²⁸ In 2008, small firms contributed 46% of US GDP according to Kathryn Kobe’s “Small Business GDP Update 2002 - 2010,” as part of the Small Business Research Summary in January 2012. https://www.sba.gov/sites/default/files/rs390_1.pdf
- ²⁹ “May 2018 Metropolitan and Nonmetropolitan Area Occupational Employment and Wage Estimates: Southern Indiana nonmetropolitan area.” Occupational Employment Statistics. Bureau of Labor Statistics. United States Department of Labor. https://www.bls.gov/oes/current/oes_1800003.htm
- ³⁰ When computing statistics of observed data, a 95% confidence level is most commonly used. See Zar, Jerrold H. *Biostatistical Analysis* (4th ed.). Upper Saddle River, N.J.: Prentice Hall. pp. 43–45. ISBN 978-0130815422. OCLC 39498633.
- ³¹ “Indiana University (Kelley).” Best Grad Schools Rankings. US News and World Report, 2020. <https://www.usnews.com/best-graduate-schools/top-business-schools/indiana-university-bloomington-01080>
- ³² “MBA Class of 2018 Student Profile.” Kelley School of Business. Indiana University. <https://kelley.iu.edu/recruiters-companies/graduate/employment-statistics/mba-full-time/index.cshtml>
- ³³ “SBA Act of 1953.” US Small Business Administration. <https://www.sba.gov/about-sba/organization>
- ³⁴ NAICS 541330 https://www.sba.gov/sites/default/files/Size_Standards_Table.pdf
- ³⁵ “Regional Opportunities Initiative.” Community Foundation Bloomington Monroe County. <https://www.cfbmc.org/southwest-central-indiana-regional-opportunity-initiatives-inc/>

- ³⁶ “Indiana Innovation Institute (IN3) Established to Solve Real World Problems for DoD and Industry.” About Us, Indiana Innovation Institute, in3indiana.com/who-we-are/about-us/. <http://in3indiana.com/who-we-are/about-us/>
- ³⁷ Notably another \$25,870,000 from this grant went to the Regional Opportunities Initiative, INC for the purpose of workforce development and education.
- ³⁸ Based on analysis by the authors of SBA 7(a) & 504 Loan Data Reports available at <https://www.sba.gov/about-sba/sba-performance/open-government/foia/frequently-requested-records/sba-7a-504-loan-data-reports>
- ³⁹ Based on analysis by the authors of value of venture capital investment in the United States in 2017 based on data from Statista provided by National Venture Capital Association and PitchBook. <https://www.statista.com/statistics/424167/venture-capital-investments-usa-by-state/>
- ⁴⁰ “Regional aggregate of venture investment.” PwC Moneytree Report: Insights on Venture Capital Investment. 2018. <https://www.pwc.com/us/en/industries/technology/moneytree.html>
- ⁴¹ Per Interview
- ⁴² Based on analysis of the authors of “Obligated All Actions” data provided by NSWC Crane
- ⁴³ Reschke, Michael. “IU brings in record amount of money for research, philanthropy”. IU Bloomington Newsroom August 12, 2016. <http://archive.news.indiana.edu/releases/iub/iu-in-the-news/2016-08-12-funding.shtml>
- ⁴⁴ Based on analysis of the authors of “New Large Contract Awards” and “Obligated All Actions” data provided by NSWC Crane.
- ⁴⁵ Award Information. “SBIR STTR: America’s Seed Fund”. 2019. <https://www.sbir.gov/reports/state-summary>
- ⁴⁶ Per Interview
- ⁴⁷ Per Interview
- ⁴⁸ Julian E. Lange, Abdul Ali, Candida G. Brush, Andrew C. Corbett, Donna J. Kelley, Phillip H. Kim, and Mahdi Majbouri. “2017 United States Report: Global Entrepreneurship Monitor. National Entrepreneurial Assessment for the United States of America.” Babson. Babson College. Babson Park, Massachusetts. 2018. http://www.babson.edu/media/babson/site-assets/content-assets/academics/centers-and-institutes/the-arthur-m-blank-center-for-entrepreneurship/global-research/GEM_USA_2017.pdf
- ⁴⁹ Murray, Budden. “A systematic MIT approach for assessing ‘innovation-driven entrepreneurship’ in ecosystems (iEcosystems).” MIT Lab for Innovation Science and Policy. September 2017.
- ⁵⁰ NSWC Crane has three guiding principles, the first of which is “(1) Ethos: Creating a culture of innovation that values leadership and employee engagement.”
- ⁵¹ Among other complexities, funders must understand that the broader defense economy favors technology startups with markets in both the defense and commercial spaces.
- ⁵² See 1.2. Recommendation 2. Collaborate with Regional Entrepreneurship Communities.
- ⁵³ “About Elevate.” <https://www.elevateventures.com/about/>. Elevate Ventures. Accessed May 15, 2019.
- ⁵⁴ Doubleday, Justin. “Pentagon seeks \$75M for dual-use tech venture capital program.” March 19, 2019. <https://insidedefense.com/daily-news/pentagon-seeks-75m-dual-use-tech-venture-capital-program>. Accessed May 15, 2019.
- ⁵⁵ Donnelly, Joe. “Crane is Pentagon’s best-kept secret.” IndyStar. June 21, 2016.

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B. Defense Innovation Mini Case Studies

AFWERX is a subunit of the Air Force Research Lab (AFRL) that works within the SBIR framework to offer contracts under “Other Transaction Authority”. AFWERX is located within technology hubs like Silicon Valley, Las Vegas, Boston and DC and reaches out to emerging companies of interest that wouldn’t typically think to work with the DoD.

Army Research Lab (ARL) offers Entrepreneurial Sabbaticals with 3-year return rights and \$200,000. This not only attracts more talent, including those interested in entrepreneurship, but allows technical experts inside the organization to mature and de-risk higher-risk technologies that may not be on ARL’s priority list in its original form with minimal funding.

Defense Digital Service (DDS). Created in 2016, DDS is a sub-unit of the United States Digital Service which repaired healthcare.gov in its time of need. Being a relatively young organization, DDS has applied OTA and SBIR contracting mechanisms to work within the Federal Acquisition System to deliver digital services in an effective manner. DDS also created TechFARHub, a website and downloadable playbook to help other federal organizations efficiently execute digital contracts.

Department of Defense Ordnance Technology Consortium (DOTC). DOTC is partnership between the National Armaments Consortium and the DoD to quickly put on contract those industry partners within the consortium that offer a specialized technical need to DoD laboratories. Registering as a consortium member, much of the contractual rigamarole is complete before a specific need is identified, easing and accelerating the contracting process.

FEDTECH. FEDTECH is a private company contracted through the National Security Technology Accelerator to run 2-month entrepreneurship courses for those interested in starting a company that applies licensed IP from federal laboratories. Startup teams are encouraged to work rigorously to identify targeted markets both in the defense and commercial spaces.

MassChallenge. A competition-style accelerator, MassChallenge offers programs in Boston, Rhode Island, Texas, Israel, Switzerland, and Mexico. MassChallenge collaborates with external partners with specific topics of interest. For example, MassChallenge in Boston is partnering with various DoD, DHS, police and safety organizations to determine a theme helpful to collaborators. Startup teams present their technologies in a well-attended event and, even if not a finalist winning prize money, may be approached by VCs or other funding agents with specific technology interests.

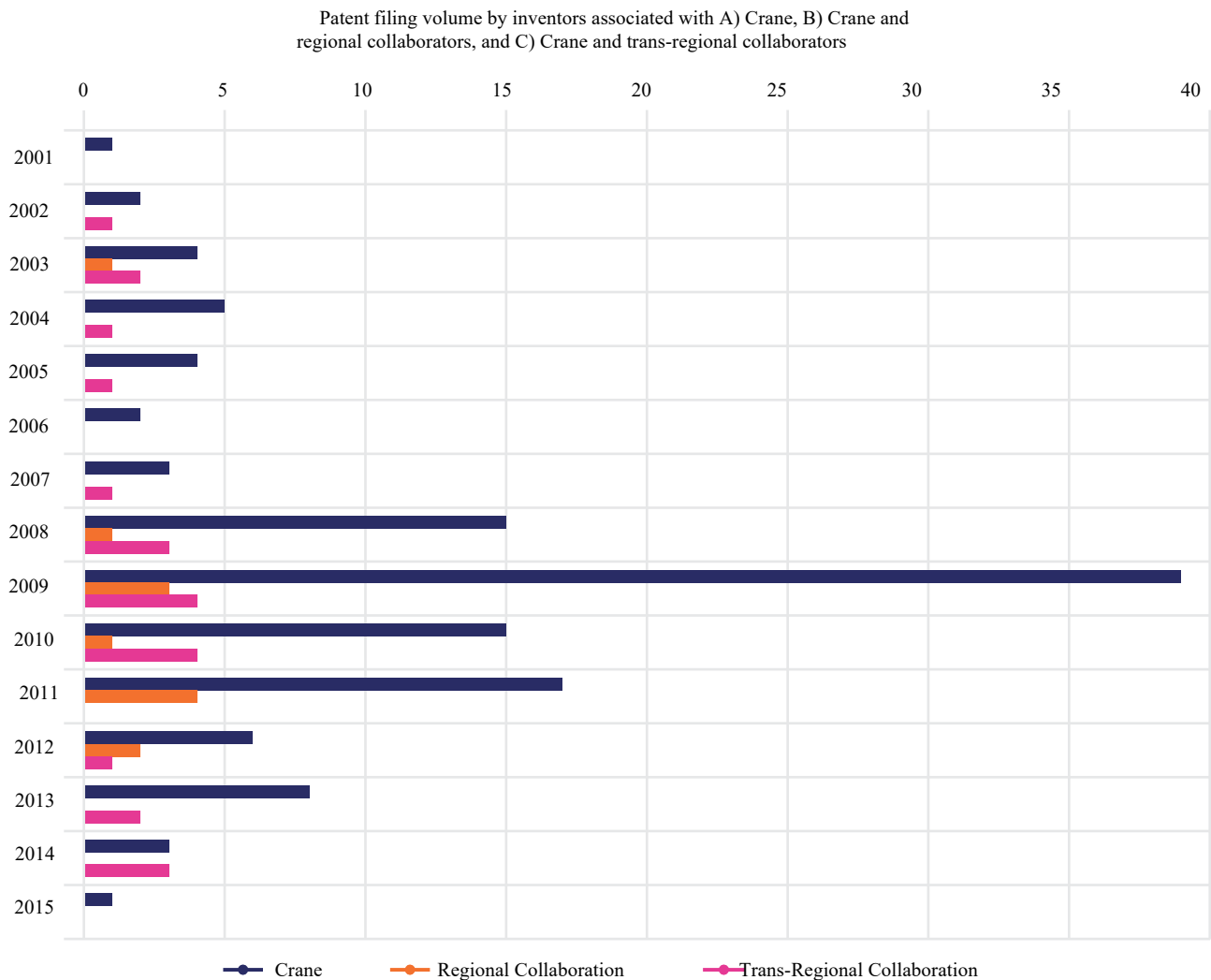
SOFWERX. SOFWERX is a private subsidiary of the DooLittle Institute. It hosts competitions to companies to present technical solutions based on a special theme. Special Operations Forces (SOF) work with SOFWERX to determine a specific theme and problem frame in a way that encourages ingenuity. All sizes of companies are welcome to participate. Prize monies are typically about \$10,000 to winning teams with the potential for subsequent follow-on work.

C. Patent Data

We received complete patent information for one of three of NSWC Crane’s strategic mission areas. Based on assessing the geographic affiliation of the listed patent inventors, we were able to group the patents into those that were invented by a) NSWC Crane only, b) through regional collaboration, and c) through trans-regional collaboration with individuals not affiliated with the Indiana region. Our analysis determined that most patents were filed solely by NSWC Crane between 2008–2011. This is based on analysis performed by the authors with assistance by Dr. Mercedes Delgado, Senior Lecturer at MIT Sloan School of Management and Research Director and Research Scientist of the MIT Innovation Initiative Lab for Innovation Science and Policy.

Figure A-C:

Patent filing volume by inventors associated with A) Crane, B) Crane and regional collaborators, and C) Crane and trans-regional collaborators.



D. List of Abbreviations

Entities

AFRL	Air Force Research Laboratory
ARL	Army Research Laboratory
DARPA	Defense Advanced Research Projects Agency
DDS	Defense Digital Service
DHS	Department of Homeland Security
DoD	United States Department of Defense
DOTC	Department of Defense Ordnance Technology Consortium
IN3	Indiana Innovation Institute
IODD	Indiana Office of Defense Development
IU	Indiana University
MIT	Massachusetts Institute of Technology
MITi	MIT Innovation Initiative
NASA	National Aeronautics and Space Administration
NAVSEA	Naval Sea Systems Command
NDIA	National Defense Industrial Association
NSF	National Science Foundation
NSWC	Naval Surface Warfare Center
NISE	National Institute for STEM Education
SBA	Small Business Administration

Acts and Programs

AFWERX	US Air Force AFWERX Technology Accelerator
DIUx	US DoD Defense Innovation Unit
I-Corps	Innovation Corps
MD5	US DoD MD5 National Security Technology Accelerator
NDAA	National Defense Authorization Act
SBIR	Small Business Innovation Research
STTR	Small Business Technology Transfer

Contracting Vehicles

CRADA	Cooperative Research and Development Agreement
EPA	Education Partnership Agreement
PIA	Partnership intermediary agreement
PLA	Patent license agreement
OTA	Other Transaction Authority
WPP	Work for Private Parties

Terminology

BRAC	Base Realignment and Closure
E-Cap	Entrepreneurship Capacity
FY	Fiscal year
HQ	Headquarters
I-69	Interstate 69
I-Cap	Innovation Capacity
ICBM	Intercontinental ballistic missile
IDE	Innovation-Driven Enterprise
iEcosystem	MIT Innovation Ecosystem
IP	Intellectual property
MBA	Master of Business Administration
Mbps	Megabits per second
MEM	Microelectromechanical systems
NAICS	North American Industry Classification System
PhD	Doctorate of Philosophy
SME	Small/Medium-Sized Enterprise
SOF	Special Operations Forces
STEM	Science, technology, engineering, and mathematics
VC	Venture capital

E. Interview Protocols

Crane Employee Interview Protocol

Topic	Questions
Intro	<ul style="list-style-type: none"> • What makes Crane great? • What makes Crane different? • What is your role in Crane? • Why do you work at Crane? • How long have you been here? • How did things change in 2005 (near shut down) and in last 5-10 years?
Innovation	<ul style="list-style-type: none"> • Walk us through the research process at Crane for a successful project <ul style="list-style-type: none"> ◦ Pick a specific project and answer with that in mind • When starting a new project does your team have a strong idea of what the end point would be? • Where is your team's endpoint compared with the endpoint of the entire research process? • How are you connected to local economy? Payment of staff? Direct investment? Collaboration with industry? Startups? • Are there unstructured connections with non-Crane people? Maker spaces, county fairs, etc.?
Leadership/ Organization/ Culture	<ul style="list-style-type: none"> • Do you collaborate regularly with colleagues outside Crane? • What are the growth opportunities for Crane employees? • How does being a working capital funded research lab affect your operations? • What is your acquisitions strategy? How do you find sources of new projects? • What are the organizational bottlenecks and how do you deal with them? • Walk us through the contracting process. Why do you do it this way and is this different from other similar locations? • (If interviewee is recently from industry) How is Crane different from a corporate lab? • What is the onboarding process for a new Crane employee? How do people come to fit with the organization? How long before they contribute?

Topic	Questions
Metrics	<ul style="list-style-type: none"> • Do you have specific metrics you use to compare yourselves to other labs? • What other internal metrics do you use? What metrics do you use for individual or team performance evaluations? • What is the common delta of TRL level from bringing tech in to passing it off? • How many and what type of partnerships do you have with industry? • What feedback mechanisms are there, how often are they used, and how detailed are they? Both to and from supervisors? • Are there any metrics you use to specifically track engagement with the community?
Challenges	<ul style="list-style-type: none"> • Looking back, what are some challenges Crane has faced during your time here? • Can you think of a project that was stumbling and then had a significant turnaround? What was the process for that? How did leadership react internally to the project failure? • What would you change about your interactions with the local community? • As a rural facility, have you had challenges developing industry connections either locally or at a distance? How have you overcome those challenges?
Open-ended	<ul style="list-style-type: none"> • Are there things we didn't ask that you think we should? Are there people we should talk to? • How is Crane different? For each question, come back to what makes Crane different. Specific project or methods that is unique to Crane? • How do you see yourself interacting with the innovation ecosystem? Does it exist internally, externally, or both? • How do individuals stay up to date on their field of science? Is there any back-to-school or other educational programs? • Do people leave and come back? • What type of organization do you envision being? If you were leader of Crane what would you change? • Is Crane research primarily top down or bottom up?
Others (If need more)	<ul style="list-style-type: none"> • What has changed at Crane during your time here? • Where do you see Crane in 3-5 years? In 20? • What is the biggest issue currently being debated in Crane (water-cooler talk)? • What would be one of the most challenging developments for Crane now? What field would it be in, military, technical, political, etc.? • Would you feel comfortable speaking to senior staff about serious concerns? • What are some of the best practices developed at Crane (if needed to prompt discussion)?

External Interview Protocol

Topic	Questions
Intro	<ul style="list-style-type: none"> • What is your organization, role, how long worked there, why joined? • How has your organization changed over the past 15 years? • Who are your major competitors or comparable agencies?
Essential	<ul style="list-style-type: none"> • Walk us through you/your organization’s relationship with Crane <ul style="list-style-type: none"> • Past, present, future • Describe how you view the role of Crane as a fellow member of the innovation ecosystem • What type of partnerships appear to work well with Crane? Work not so well?
Innovation	<ul style="list-style-type: none"> • What do you view as innovative about Crane? <ul style="list-style-type: none"> • What does innovation mean to you? Examples? • What technologies (“innovations”?) have you seen spin-out of Crane? <ul style="list-style-type: none"> • Who, what, why, how, result? • How is your interaction with Crane different than your interactions with a corporate lab? • Have your staff members engaged with Crane members in a non-work setting? If so, how and where? Maker spaces, mixers, etc? • How do does your organization find talent (technical, etc.)? With whom might you compete for talent? • Are you or anyone you know interested in using Crane facilities (instruments, etc.) for R&D? How would you look into it to find what services are available?
Metrics	<ul style="list-style-type: none"> • What metrics do you use to track engagement of the community? How effective do you feel these are? What is not being captured by these metrics that you feel is important? • What is the rate of ingress/egress of people into/out of Uplands region (SWC Indiana)?
Challenges	<ul style="list-style-type: none"> • What is one of the big economic issues being discussed in the Indiana Uplands? <ul style="list-style-type: none"> • What are the most challenging developments for the region? • As an organization outside of a major metro (except Indianapolis), have you had challenges developing industry connections either locally or at a distance? How have you overcome those challenges? • How is your organization funded? (e.g. Lily Endowment, sales, etc.?) • Have you, or anyone you know, had any interaction with risk capital (VC)? What was the interaction like? • Has the regional infrastructure been sufficient to meet your needs? (Internet access [fast.com], cell phone service, roads)

Topic	Questions
Open-ended	<ul style="list-style-type: none"> • What advice might you suggest to Crane, business community, politicians, or others to help advance the economic uplift in the region? • How is Crane different? For each question, come back to what makes Crane different. Specific project or methods that is unique to Crane? • Are there things we didn't ask that you think we should? Are there people we should talk to?
Others (If need more)	<ul style="list-style-type: none"> • What has changed in the region during your time here? • How do you see the Uplands region changing over the next several years?

F. Survey

This survey consists of 26 questions and should take an average user about 10 minutes to complete.

This survey was written by researchers from the MIT Mission Innovation Lab (MIL) conducting an assessment of the innovation ecosystem centered around NSWC Crane. The purpose of this survey is to gain insight into NSWC Crane's key success factors, lessons learned, best practices, and recommendations for further enabling innovation that can be shared across the DoD Research Enterprise. Your responses will provide an on-the-ground look at the functions and opinions of NSWC Crane employees to supplement a series of interviews with specific NSWC Crane personnel. If you would like to be considered as an interview candidate, you may leave your name and email at the end of the survey. If you do not choose to include your name, then your responses to this survey will be entirely anonymous.

Please contact Dylan Cohen (dhcohen@mit.edu) with any questions or concerns.

1. How do you assess the quality of the scientific research being conducted at NSW Crane?

Very high quality	High quality	Somewhat high quality	Neither high nor low quality	Somewhat low quality	Low quality	Very low quality
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. What information are you given at the start of a new project? (e.g. general instructions, specific requirements, detailed blueprints, a prototype, etc.)

3. To what extent do people at NSW Crane collaborate and share ideas with the following:

	High collaboration	Somewhat high collaboration	Neither high nor low collaboration	Somewhat low collaboration	Low collaboration
Universities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other research Institutions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Companies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. In your region, to what extent are scientists and engineers available for hire?

Very frequently available / Always available	Frequently available	Somewhat frequently available	Neither frequently nor infrequently available	Somewhat infrequently available	Infrequently available	Very infrequently available / Not available
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5. In your experience, how much initial training do new hires require before they can meaningfully contribute to a project?

Ready immediately	24 months of training	48+ months of training	
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>

6. Within NSW Crane, to what extent are the latest technologies and processes available for your research?

Available immediately	Available quickly	Available within a reasonable time frame	Available slowly	Never Available
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Comment or Clarification

7. Please answer the following questions on your entrepreneurial intent.

	Yes	Maybe	No
Are you, alone or with others, expecting to start a new business, including any type of self-employment, within the next three years?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
In your region, do most people consider starting a new business to be a desirable career choice?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
In the next six months, will there be good opportunities for starting a business in the area where you live?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Would fear of failure prevent you from starting a business?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
If you were to start a business in the next three years, would you know how to secure the necessary contacts for supplies and shipping?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Do you have the knowledge, skill, and experience required to start a business?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. If you answered "maybe" to any of the previous questions, please list some of the factors which might affect your answer.

9. If you were to start a business in the next three years, who may be your primary buyer(s)?

- Government, defense
- Government, non-defense
- Private, Industry
- Private, Individual

10. If you were to start a business in the next three years, on what basis would your buyers make purchasing decisions?

- Low Price
- High Performance
- Other (please specify)

11. In your region, how easy is it for businesses to obtain a bank loan?

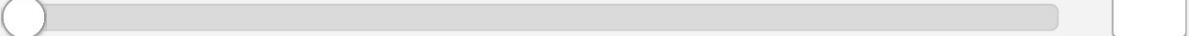
- | | |
|--|--|
| <input type="radio"/> Very easy | <input type="radio"/> Somewhat difficult |
| <input type="radio"/> Easy | <input type="radio"/> Difficult |
| <input type="radio"/> Somewhat easy | <input type="radio"/> Very difficult |
| <input type="radio"/> Neither easy nor difficult | <input type="radio"/> I don't know |

12. In your region, how easy is it for start-up entrepreneurs with innovative but risky projects to obtain equity funding?

- | | |
|--|--|
| <input type="radio"/> Very easy | <input type="radio"/> Somewhat difficult |
| <input type="radio"/> Easy | <input type="radio"/> Difficult |
| <input type="radio"/> Somewhat easy | <input type="radio"/> Very difficult |
| <input type="radio"/> Neither easy nor difficult | <input type="radio"/> I don't know |

13. How likely are you to recommend NSWC Crane as a good place to work?

0 – Not at all likely 10 – Extremely likely



14. What reason would you give for your score in the previous question?

15. How familiar are you with the mission, vision, and values of NSWC Crane?

- Extremely familiar
- Very familiar
- Somewhat familiar
- Not so familiar
- Not at all familiar

16. How clear is the link between your work and the organization's objectives?

- Extremely clear
- Very clear
- Somewhat clear
- Not so clear
- Not at all clear

17. To what degree are NSWC Crane's mission, vision, and values clear in everyday work and procedures?

- Extremely clear
- Very clear
- Somewhat clear
- Not so clear
- Not at all clear

18. What is your primary missions area within NSWC Crane?

- Strategic Missions
- Electronic Warfare
- Expeditionary Warfare
- Business Operations
- Other (please specify)

19. Aside from your primary mission area, in which of the NSWC Crane mission areas have you worked?

- Strategic missions
- Electronic warfare
- Expeditionary warfare
- Business operations
- Other (please specify)

20. What is your highest level of completed education?

- Some high school
- High school degree or certificate of equivalency
- Associate's degree
- Bachelor's degree
- Master's degree
- Doctorate degree

21. What is the field of study of your highest level of completed education? (if applicable)

22. How long have you been employed at NSWC Crane?

- 0 - 5 years
- 6 - 10 years
- 11 - 15 years
- 16 - 20 years
- 21 - 25 years
- 26 - 30 years
- 31 - 35 years
- 36 - 40 years
- Over 40 years

23. Which of the following best describes your work?

- I am primarily directed in my work by a supervisor.
- I am primarily self-directed in my work.
- I am primarily a supervisor of other's work.

24. Which of the following best describes your work?

- My work is primarily technical tasks.
- My work is a mix of technical and non-technical tasks.
- My work is primarily non-technical tasks.

25. Are there any additional comments on NSWC Crane or the regional innovation ecosystem that you would like to share with us?

26. If you would like to be considered for a follow up interview, please leave your name and email below. (This is **OPTIONAL**. If you choose to leave identifying information your survey will no longer be anonymous, but your answers will **NOT** be shared with any other NSWC Crane employees.)

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