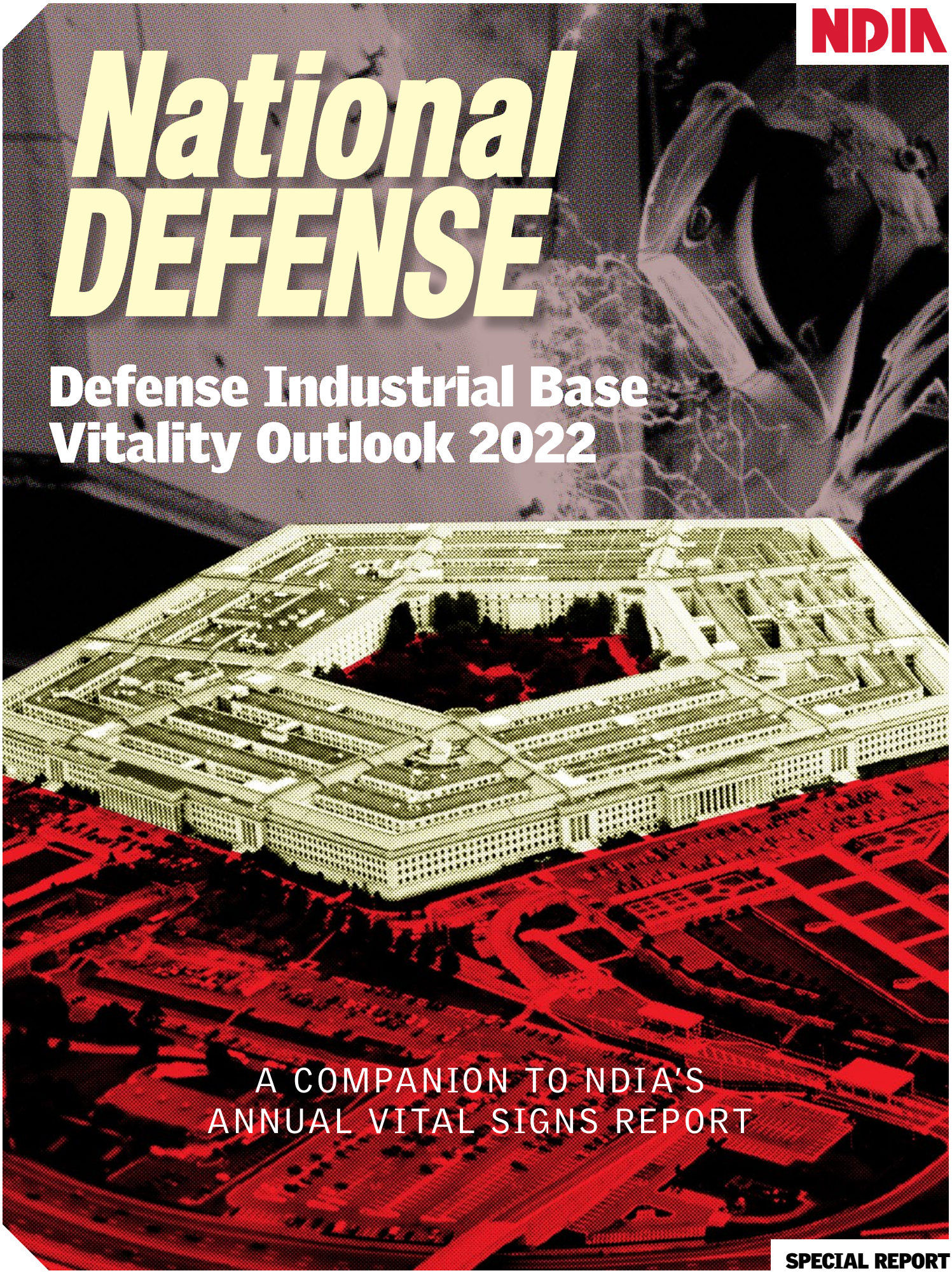


NDIA

National DEFENSE

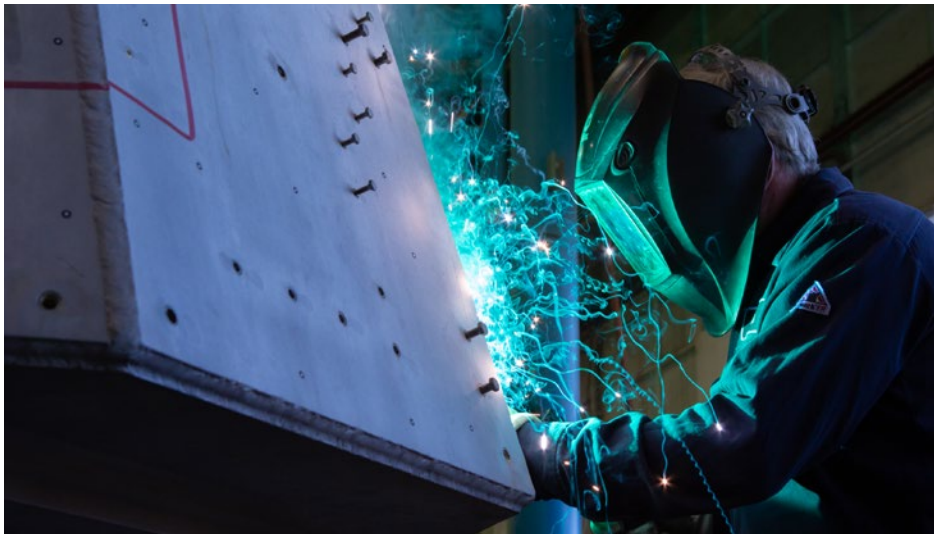
Defense Industrial Base Vitality Outlook 2022

A COMPANION TO NDIA'S ANNUAL VITAL SIGNS REPORT

SPECIAL REPORT

Vital Signs 2022, An Introduction

By Nick Jones



■ The day after Thanksgiving, I awoke to a cacophony of noise behind my backyard. Hammers, construction equipment, blaring music. I was a little bit alarmed. I took a look outside and it was just siding being installed on the new homes being built behind my backyard. The houses have been sitting quietly for the past four months awaiting the delivery of siding, of which

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Introduction *CONTINUED FROM PAGE 2*

there is a shortage.

I'm told that when the pandemic lockdowns began last March, the producers of raw materials for new home materials stopped production in anticipation of a significant drop in demand. In the case of housing, demand actually increased and the availability of windows, siding, appliances and even sod has caused significant delays — and heartache — for new home builders and buyers.

Like the housing industry — and many other sectors throughout the global economy — the defense industrial base has not been immune to the supply chain hold-ups and disruptions caused by the COVID-19 pandemic. Unfortunately, the pandemic's impact on the defense industry is not as easily observable as empty half-built homes and requires a systematic approach to first observe and understand the current situation. The National Defense Industrial Association's *Vital Signs 2022* report provides this systematic approach and will provide an unclassified look at the state of the defense industrial base, shedding light on the industry's business conditions that are not readily observable.

Like the traditional vital signs that we are all familiar with from visits to the doctor — pulse rate, temperature, respiration rate, and blood pressure — NDIA's third annual report, *Vital Signs 2022: The Health and Readiness of the Defense Industrial Base*, seeks to provide a measurement of defense industrial base well being. It's based on an evaluation of eight environmental conditions that defense contractors must cope with to deliver the goods and services required to support national security and the needs of men and women in uniform. We hope that the report will be easily understood and useful for policymakers, students and the American public at large during discussion of the health and readiness of the defense industrial base.

Moving into our third year of this project, there are a few indications that the *Vital Signs* series is a useful contribution to discussions concerning the health of the defense industrial base. In the past year, we have had policymakers and major corporations invite us to speak about findings from previous editions. I've heard of previous editions used in university courses. I have even had a group of Syracuse University students use the series as part of a consulting project in collaboration with a government client. We welcome continued engagement with the release of this year's report.

The 2022 report captures the impact of the first year of the COVID-19 pandemic on the defense industry.

The evaluation of the environmental conditions, in which we ask our defense industrial base to operate, resulted in a score of 69, for the first time dipping below a passing grade.

Surprisingly, this is only three points down from our previous edition of *Vital Signs*, when accounting for slight changes in our methodology. A closer look at the eight environmental conditions reveals several areas of concern: two more failing grades for the Supply Chain and Innovation categories, in addition to the two failing grades that remained from last year's report — Production Inputs and Productive Capacity and Surge Readiness.

Industrial Security, which includes a measure of the number of cybersecurity vulnerabilities, remained the lowest scoring condition, just like our previous edition.

These are soberingly low marks and are reflective of the disruptions created since the pandemic began almost two years ago.

In addition to the overall scores, the upcoming *Vital Signs* report will include the results of our annual member company survey, which we fielded last summer. Not surprisingly, when asked: What is "the most important thing that the government can do to help the defense industrial base?" The No. 1 answer remained "streamlining the acquisition process."

Within the data, we noticed that contract failures declined significantly in the first year of the pandemic. We saw a reverse of the trend of Americans increasingly feeling that the amount of money spent on military and defense is "about right." The cost of production inputs began to increase and several supply chain indicators declined.

Like the previous editions, *Vital Signs 2022* will not provide a series of recommendations for policymakers to consider. Instead, similar to last year, we will provide a set of recommendations in the new year which will be made available on NDIA's website.

Just like last year, this study is a joint effort between NDIA and Govini, a decision science company.

NDIA could not complete the *Vital Signs* series without the hard work of the association's marketing and strategy and policy teams, which includes graduate students from the Junior Policy Fellows program. This year, we were fortunate to have six graduate student Junior Policy Fellows during our summer and academic year cohorts. These individuals are students at renowned institutions including the University of California, San Diego GPS; Johns Hopkins SAIS; Johns Hopkins-Krieger; Harvard Kennedy School; George Mason University Schar School; and Georgetown's School of Foreign Service.

We are lucky to have such a motivated group of graduate students and we cannot wait to see their impact as their careers unfold. **ND**

Nick Jones is NDIA's director of strategy.

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VITAL SIGNS 2022

ANNUAL DEFENSE SECTOR REPORT CARD SHOWS FAILING GRADE

BY WES HALLMAN, NICK JONES, JEFF GOLDBERG AND ROBBIE VAN STEENBERG

This year's iteration of *Vital Signs: The Health and Readiness of the Defense Industrial Base* marks the third consecutive year that the National Defense Industrial Association offers an unclassified analysis of the state and performance of America's defense industrial base as an enterprise.

Accessible to both the American public and defense policy community, *Vital Signs* strives to provide a comprehensive assessment of the resiliency of the defense sector by standardizing and integrating a set of criteria that reviews its performance in the context of the overall business environment.

The report frames the health of the defense industrial base as essential to economic and national security and does not examine individual companies or the Defense Department specifically, but rather the challenging business environment in which all stakeholders operate.

When researching *Vital Signs*, NDIA examined data relating to eight "signs" that collectively shape the performance of defense contractors. In a departure from *Vital Signs 2020*, this year's report indicates a final grade of "Unsatisfactory, Failing" for the health and readiness of the defense industrial base. While technically one point short of a pass mark, specific signs provide cause for real concern.

The eight signs that collectively shaped the performance of defense contractors include: Demand, Production Inputs, Innovation, Supply Chain, Competition, Industrial Security, Political and Regulatory, and Productive Capacity and Surge Readiness. Categorized by factor, NDIA analyzed over 50 publicly available statistical indicators, converted them into an index score scaled from 0 to 100, and evaluated three years of scores for each indicator.

This year, five of the eight signs received a failing grade. This reflects the tumultuous state of the industry as it grappled with the extraordinary ramifications of the COVID-19 pandemic, which dramatically disrupted the lives of individual Americans as well as global commerce.

This past year has witnessed significant deterioration in the signs including "supply chain" as well as "production capacity and surge readiness," which almost certainly is a result of the impact of the pandemic. Conversely, the only sign that significantly improved was "demand," reflecting recent growth in the defense budget.

Vital Signs 2022 also reflects the story of recent political and regulatory action against adversaries and their influence over the defense industrial base, and the way in which that has shaped and will continue to shape the future of the warfighter.

As always, NDIA intends *Vital Signs 2022* to be a reference document that sets forth conditions for an annual discussion on defense sector issues. It is NDIA's hope that this report contributes to the critical debate surrounding the nation's defense acquisition strategy by offering a common set of fact-based data points on industrial partners that give the men and women in uniform, and their civilian counterparts, an advantage in all domains of warfare.

With the exception of the survey of NDIA members fielded in August 2021, the datasets are lagging indicators. This year for the first time, it includes datasets from COVID-19. These lagging indicators provide insight into the environment in which the industrial base had to operate during the first year of the pandemic.

As a majority of the eight signs received failing grades for the first time this year, *Vital Signs 2022* reveals a defense industrial base that, similar to other industries, suffered sustained losses during the COVID-19 pandemic. Six of the indicators earned composite scores lower than 80 and five of these earned scores below 70, a grade considered failing. These scores point to a defense industrial base struggling to meet the unprecedented and ongoing challenges created by the pandemic in the face of an increasing challenge from competitor nations.

Industrial Security has gained renewed prominence due to data breaches and brazen acts of economic espionage, perpetrated by both state and non-state actors, that have plagued defense contractors. However, despite the importance of industrial security, this category received a score of 50 in 2021, the lowest among the eight signs in 2022. To assess the "industrial security" sign, NDIA analyzed threat indicators to information security and intellectual property (IP) rights. The score incorporates the nonprofit MITRE Corp.'s annual average of the threat severity of new cyber vulnerabilities. This year, the analysis included the new National Institute of Standards and Technology's 3.1 scoring system, superseding last year's usage of the 2.7 system. Threats to IP rights scored well at 80 in 2021, as the number of FBI investigations into intellectual property violations declined to 38. This pattern marks a steady decline since investigations reached an all-time high of 235 in 2011.

Production Inputs also scored poorly in 2021, receiving a failing score of 67. These inputs encompass skilled labor,

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intermediate goods and services, and raw materials used to manufacture or develop end-products and services for defense consumption. In particular, the indicators for security clearance processing contributed to the low score for production inputs, as on-boarding backlogs persist.

Despite numerous negative scores, areas of confidence give cause for optimism within the industrial base. For instance, "Demand" for defense goods and services remained robust in 2021 and received an outstanding score of 94. This increase stems from a rise in contract obligations issued by the Defense Department. Moving forward, this will be an indicator to closely monitor, as the prospect of flatter defense budgets and rising inflation pose potential headwinds in the near term.

Competition last year was 88 – no decline or drop from this year – it is the same level but the area is still a strength. This high mark was driven by several high-scoring factors including a low level of market concentration for total contract awards, the low share of total contract awards received by foreign contractors, and a high level of capital expenditures in the defense industrial base.

Conversely other factors within the Competition sign experienced decreases, including a significant 11-point decrease for liquidity. These decreases were anticipated, however, due to the impact of the pandemic on the economy.

In 2021, the Innovation sign remained stagnant and received an unsatisfactory score of 69.

Scores also declined for the Political and Regulatory sign.

In early 2020, prior to the onset of the pandemic, 50 percent of participants believed that defense spending is "about right," which marked a 7 percent increase from 43 percent in 2019. This 2020 result of 50 percent is the highest percentage of "about right" responses for this question since Gallup began asking it more than 52 years ago.

"Acquisition Reform" and "budget stability," two of NDIA's strategic priorities, once again topped the list of concerns for industry leaders. In the *Vital Signs* survey, participants were asked about the most important thing government could do to help the defense industrial base. Respondents stated that both streamlining the acquisition process, 37.6 percent, and budget stability, 27.8 percent, were paramount, which is consistent with last year's findings.

Similarly, a vast majority, 72.3 percent, said "uncertain business conditions" when asked to cite what conditions would limit their willingness to allocate additional capacity to military production. And 62.8 percent of survey respondents cited the burden of government paperwork as a deterrent. Both findings underscore the continued importance of acquisition reform and budget stability.

The ability of the defense industrial base to expand output and fulfill increased military demand is a key test of its health and readiness. The COVID-19 pandemic, which began in early 2020, exemplifies this. In 2021, Productive Capacity and Surge Readiness earned a critical risk score of 52. This represents a 15-point decrease from 2020 and can largely be attributed to declines in output efficiency. However, it is important to note that this score is not based upon a fully mobilized economy, similar to the context of World War II. Rather, the Productive Capacity and Surge Readiness sign is baselined against the late Cold War defense buildup, a surge of 31 percent that began during the Carter administration and accelerated throughout the Reagan presidency.

The critical impact of COVID-19 also became evident in the Supply Chain sign, which experienced an 8-point drop that is largely attributed to a worsening in cash conversion cycles for the top 100 defense contractors. Also, as indicated by our survey, workforce challenges and the availability of talent are a top concern. Interestingly, the pandemic also changed the makeup of the top 100 defense contractors, with Moderna, the maker of one of the approved COVID-19 vaccines, making it onto the list.

The health and readiness of the defense industrial base poses a challenge to the national security community. As the DIB evolves to meet new and complex challenges, *Vital Signs 2022* highlights several obstacles the nation must overcome, especially in light of the continuing pandemic.

It is the hope of NDIA that *Vital Signs 2022* will help inform policy discussions that lead to improvements in the health and readiness of the industrial base and a higher overall grade in *Vital Signs 2023*, and beyond. **ND**

Wes Hallman is senior vice president of strategy and policy, Nick Jones is director of strategy, Jeff Goldberg, director of regulatory policy, and Robbie Van Steenburg is a regulatory policy associate, at NDIA.

Pentagon Struggles to Attract New Entrants Into Industrial Base

BY YASMIN TADJDEH

The Defense Department has for years been plagued by a perennial problem: attracting new entrants into the defense industrial base.

Injecting the DIB with the innovation that small businesses, nontraditional companies and startups bring is critical if the Pentagon wants to maintain overmatch against adversaries, experts say. But despite a myriad of programs and efforts to entice firms to work with the Pentagon, data shows that there has been a continued downward trajectory.

There has been a decrease in both the total number of Defense Department vendors, and new entrants into the defense industrial base, according to a draft of the National Defense Industrial Association's *Vital Signs 2022: The Health and Readiness of the Defense Industrial Base* report, which included data provided by decision science company Govini.

The DIB has dropped from about 58,000 vendors in 2019 to about 55,000 in 2020, according to Govini data. That is also a significant drop from the 69,000 vendors that were in the market in 2016.

Likewise, there has been a decrease in new vendors, the report found.

"While not as extreme as last year's drop, the DIB did drop from 6,500 new entrants in fiscal year 2019, to 6,300 in fiscal year 2020," the study said. "The fact that the drop continues is worrying."

The Government Accountability Office also recently flagged the trend in an October report titled, "Small Business Contracting: Actions Needed to Implement and Monitor DoD's Small Business Strategy."

The number of new entrants entering the defense industrial base declined from 2016 through 2020, the report found. In 2020, there were a total of 5,526 new entrants compared to 7,083 in 2016. There is no unified standard definition of the term "new entrant," which accounts for some variations in data between studies.

Additionally, the number of small businesses contracting with the Pentagon has significantly declined since 2011, GAO found. Small businesses receiving contract awards plummeted 43 percent from 42,723 in 2011 to 24,296 in 2020.

GAO cited two major issues facing small businesses: certain government-wide contracting initiatives and administrative difficulties working with the Pentagon, including burdensome cybersecurity requirements.

"Since 2005, government-wide initiatives led by the Office of Management and Budget have encouraged agencies to consolidate and coordinate their purchases of common products and services," the report said. "OMB's ongoing category management initiative, in effect since 2016, intends to help federal agencies buy like a single entity so they can leverage the government's buying power, save taxpayer dollars and eliminate duplicative contracts."

However, Defense Department officials and small business executives told GAO that the initiative has in some cases reduced opportunities for small businesses.

Meanwhile, administrative burdens have dissuaded some companies from joining the DIB, the watchdog found.

"The DoD contracting process can be difficult to manage and many businesses prefer to work instead with the private sector because it offers more administrative flexibility," the report said. "Small business executives said contracting with DoD often involves unpredictable and burdensome delays in award selection decisions, security clearances, work-start dates and payment dates."

The study cited the Pentagon's Cybersecurity Maturation Model Certification, or CMMC, as another potential barrier,

with businesses telling GAO that the process was difficult to understand, problematic to implement and expensive. However, in November the Defense Department released CMMC 2.0, a version that many experts have said sufficiently addresses many of those issues.

The problem of attracting new entrants has officials' attention at the highest echelons of the Pentagon. In December, Secretary of Defense Lloyd Austin III flagged the issue during a keynote

speech at the Reagan National Defense Forum in Simi Valley, California.

"For far too long, it's been far too hard for innovators and entrepreneurs to work with the department," he said. "The barriers for entry … to work with us in national security are often too steep — far too steep."

To entice new companies to work with the Pentagon, the department is "doubling down" on its Small Business Innovation Research program, Austin said.

"This program helps fuel American firms to pursue [research and development] tailored to the department's unique tech requirements," he said. "So far this year, we've awarded funds to more than 2,500 small businesses working on groundbreaking tech."

In a memo released in October, Austin said the Pentagon has faced a decline in its small business industrial base. He urged acquisition officials across the services and other defense agencies

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to identify opportunities for increased contracting with small businesses and to minimize barriers to entry for companies.

"DoD components shall give increased focus to reducing barriers to entry for new entrants to help expand our industrial base, cultivate new and vital capabilities and increase outreach to underserved communities," he said in the memo.

The Pentagon's Office of Small Business Programs will refresh its small business strategy to maximize "capabilities through a department-wide approach and better align the department's efforts with the president's focus on increasing the share of dollars going to small disadvantaged businesses, lowering barriers to entry and increasing competition opportunities for small businesses and traditionally underserved entrepreneurs," he said.

In an interview with *National Defense*, Farooq Mitha, director of the Defense Department's Office of Small Business Programs, said Congress tasked his office to submit the strategy by October 2022, but he hopes to complete it much sooner.

"This is really important to us and to the secretary and the deputy secretary," he said.

This past fall, Mitha's office requested comments from industry about barriers facing small businesses. Responses were due in October and the office was still sifting through the more than 150 comments at the time of the interview.

"Category management has been something that we've heard a lot about," he said. The office is working "to create more opportunities within category management for small businesses, and the ability to get more small businesses … onto our contracting vehicles."

Respondents also said the Pentagon's contracting timelines are far too long and that there are not enough acquisition personnel and contracting officers to move contracts along rapidly, Mitha said.

Industry also cited CMMC as an issue, he noted. While CMMC 2.0 addresses many concerns that small businesses had, Mitha's office is working to make cybersecurity easier for companies.

Through Project Spectrum, "we're actually providing free cyber training, the ability for small businesses to do self-assessments, to get access to cyber [subject matter experts and] to get access to tools," he said.

Bringing small businesses and nontraditional companies into the defense industrial base is important for the nation's security, Mitha said.

"We're at a really critical inflection point related to our domestic capabilities," he said. "We've got pacing challenges, we've got supply chain challenges that we've seen exacerbated by COVID, we've got competition challenges, and we've got equity and inclusion challenges."

Small businesses are at the nexus of meeting many of those issues, Mitha noted.

"I want to make sure that we're doing everything we can to leverage the capabilities that we have that will … enable our nation to maintain our competitive advantage, to make sure that we've got strong, resilient supply chains here in the United States, and that we are creating more opportunities for underserved communities and leveraging the purchasing power of the federal government to do so," he said.

While the government has faced issues attracting new companies into the DIB, Gregory Sanders, deputy director of the Center for Strategic and International Studies' Defense-Industrial Initiatives Group, said it hasn't been all doom and gloom.

Sanders highlighted the Air Force's pitch day concept spearheaded by the service's former Undersecretary for Acquisition,

Technology and Logistics Will Roper, which put companies on contracts with the service in as little as three minutes after their presentations.

"The key thing that pitch day brings is the ability to get under contract fast," Sanders said.

For small businesses or startups, working with the government isn't just about finding the right point of contact, making a connection, and then bidding on an opportunity, he noted. They also must work through a range of administrative requirements.

"If you don't do a lot of work with the government or haven't done any work with the government, there's a cost to entry there," he said. "You have to adopt government cost and accounting standards that are not … really commercial standards."

Stacie Pettyjohn, director of the Center for a New American Security's defense program, said major prime contractors have optimized themselves for the Pentagon's burdensome procurement process, but nontraditional and small businesses have not.

"They have to sort of adapt to this really onerous process that exists," she said. The process can be very slow and inflexible, and the threshold for obtaining a program of record is extremely high. Programs of record are where the real money is, she noted.

While the Pentagon has stood up innovation hubs such as the Defense Innovation Unit and AFWERX, most of their money is for early research and development efforts, she said.

"They don't actually have money to procure any of these programs at scale," Pettyjohn said. "They provide seed funding, which is in DoD dollars relatively modest. That helps to start and to get some of these companies going, and then maybe to prototype, but then it ultimately has to be picked up probably by one of the services."

That's where the so-called "Valley of Death" problem kicks in, she said. The term has been used to describe the chasm between developing a prototype and then getting it into a program of record.

Meanwhile, Logan Jones, president of SparkCognition Government Systems, an AI company that was founded in May 2020, said the pandemic has made working with the government more difficult for new businesses.

While it is impressive that contracts and work continued to be executed despite the challenges presented by the pandemic, "I suspect that a lot of that business went to the path of least resistance, which was the current incumbents," he said. "That's because trust has already been built, contract vehicles have already been enabled. … Virtual [engagement] makes that really difficult."

Mitha noted that from an outreach perspective, the COVID-19 crisis created challenges. Under normal conditions, his staff of 750 business professionals would be fanned out across the country hosting industry days and connecting with companies.

"Just in my office alone, we used to do conferences where we would do matchmaking with our mentor-protégé program," he said. "For the last 18 months, we weren't able to do that."

While it is sometimes easier to get a hold of someone virtually, there is a need for in-person connection, he said. ND

COMMENTARY

Demand Grows For Multi-Skilled, Flexible Engineers

STEPHANIE C. HILL, VICE PRESIDENT OF ROTARY AND MISSION SYSTEMS AT LOCKHEED MARTIN

Emerging digital technologies deeply impact all aspects of society, and modern warfare is no exception.

Adversaries are growing more sophisticated — disrupting the battlefield and contesting the United States in all domains. As the threat and national security landscape rapidly change, it is imperative the defense industry ensures the nation outpaces its opponents.

To maintain a high-tech competitive advantage and influence across all domains, U.S. industry must track the evolving needs of the armed forces by understanding their challenges and equipping them with the capabilities required to deter and counter any threat.

Amidst this changing character of warfare, the talented engineers of the aerospace and defense industry must place a heavier focus on digitally powered, data-focused and centralized technology. The true lethality of the Joint Force is not any one platform or capability, but the ability to connect all sensors, shooters and command nodes across all branches of the military and across all domains.

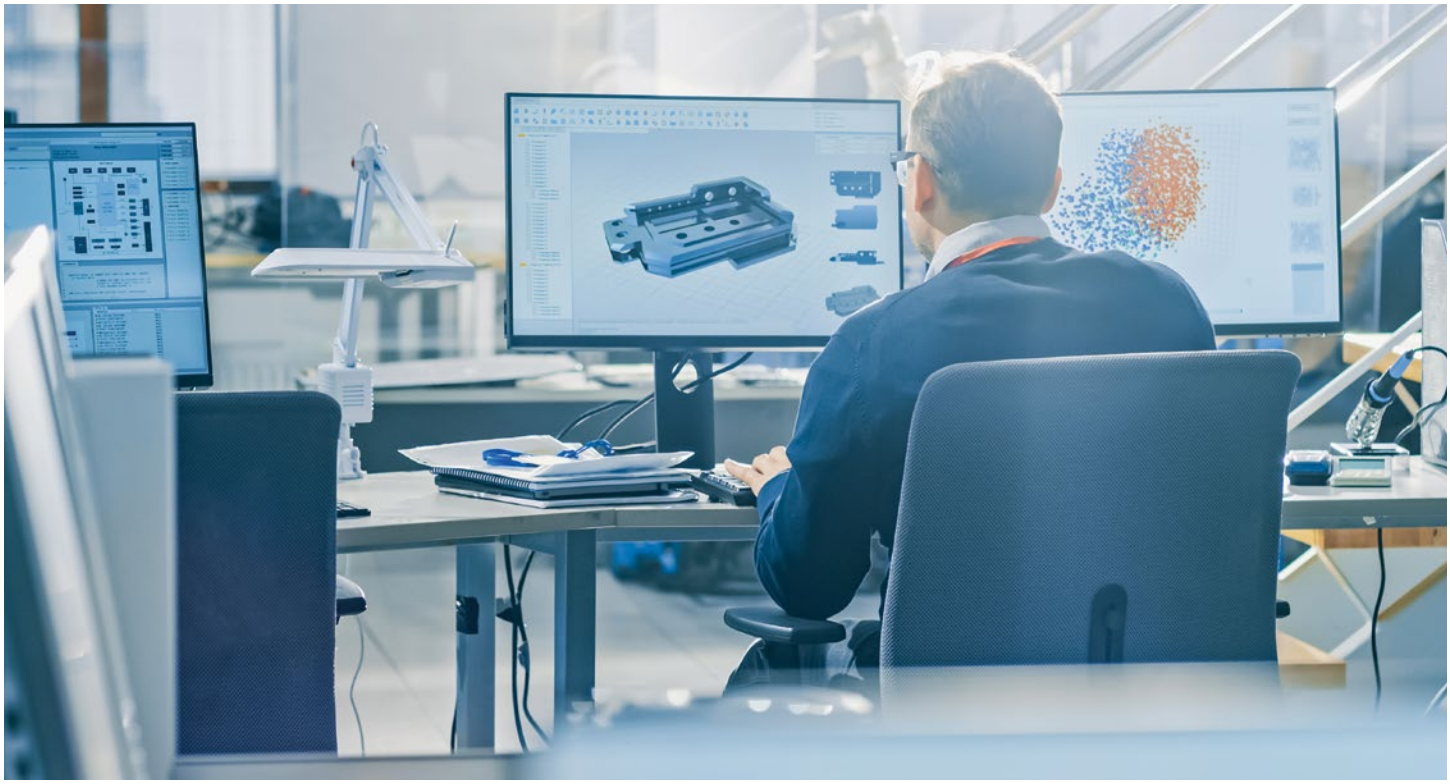
It's clear that this requires a vastly different skill set and preparation than in the past. Traditionally, industry prioritized developing "specialized" engineers who would focus on one or two core areas. Today, the defense engineering industry values "T-shaped" engineers — those with a broad knowledge base, but who can also go deep.

For example, engineers with hardware skills should also understand how to integrate software. And software engineers must be knowledgeable of the artificial intelligence NeoPulse Modeling Language network.

As engineers follow a "T-shaped" approach to developing their skill set, expertise in AI is not the only in-demand area of knowledge. They must also understand how these tools can be connected to other technologies such as machine learning and 5G. These technologies allow for greater connectivity among domains, helping armed forces navigate complex, highly contested battlefields. Engineers must possess an understanding of data analytics to make use of large quantities of both structured and unstructured data. They must understand edge computing so that data can be used to enhance decision-making in real time. By placing a new focus in these areas, current and future engineers can upgrade their skill set.

Technical skills are refined over time through continuous training and learning on the job. Today's aerospace and defense engineers must combine their expertise with new learnings in emerging areas to drive innovation forward.

Lockheed Martin experienced this firsthand as it devel-



oped an AI-based tool for predicting spare equipment demands across multiple aerospace and maritime application areas. In this instance, the company needed engineers who could configure a holistic solution that had the same look and feel for both maritime and aviation systems, streamlining multiple legacy systems previously requiring separate solutions.

As the military engages in new initiatives like joint all-domain command and control, defense engineers must further understand how to apply their expertise to a variety of different application areas. This requires a "build once, use many" mindset. This is common with data analytics, where the tools and techniques are platform agnostic, allowing engineers to configure them with their engineering know-how to a variety of different application areas.

Through experimentation, continuous improvement and rapid prototyping, new and better ways to solve challenges can be discovered. Technology companies will work with each of the military services to accelerate integration between intelligence, surveillance and reconnaissance; command and control; and fire control systems.

The key is using AI and ML in an open, standards-driven environment for cross-service integrated air-and-missile defense.

This includes developing machine-to-machine interfaces to connect the Army and Navy in a long-range precision fires mission as was demonstrated at last year's Northern Edge exercise.

Whereas larger programs tend to have months, if not years, of scheduling to certify, install and test capabilities in operational environments, exercises such as Northern Edge challenge the service and industry teams to install and test systems in days — and sometimes hours.

The most in-demand areas of expertise required for engineers today go beyond AI and data analytics. They also include 5G, autonomy, cyber, electric propulsion, electronic warfare, program management and radio frequency.

To develop in-demand skills for engineers, there must be programs that foster hands-on training with specialists acting as mentors. With proper mentorship, learners can pursue new paths and pave the way for the next generation. This has been an effective method of upskilling, particularly in the areas of cyber, DevSecOps, program management and data analytics, and works best at all career levels.

As we see great hiring demand for systems, software and project engineering, colleges and universities are not the only pipelines which we must tap into. Apprenticeships for recent high school graduates and young adults are also effective in filling needs across a number of areas.

These programs train young engineers on basic skills, and they are provided with an opportunity to grow their careers with continued mentorship, training and opportunities. The key is to ensure proper education and training to drive future interest in the profession, while developing a pipeline of talent who possess the skills required of future defense engineers.

Engineers are the creators of great innovations and scientific marvels. The best engineers are those who seek out and embrace diverse perspectives and ideas. The more talent from varying backgrounds, whether educational or professional, the more diversity of thought we bring to the industry. And just as important, we need engineers that come ready to challenge the status quo, who aren't afraid to experiment and fail fast and share their ideas openly to help their teams move forward. **ND**

Stephanie C. Hill is executive vice president of Rotary and Mission

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2021 Brought Another 'Banner Year' for OTAs

BY JON HARPER

The Defense Department continues to run hot with its use of other transaction authority agreements, with experts calling 2021 another banner year for the contracting mechanism that has rapidly grown in popularity among acquisition officials.

OTAs are designed to cut through the red tape of the Pentagon's more traditional Federal Acquisition Regulation contracting processes. They are intended to facilitate rapid prototyping and follow-on production as well as attract nontraditional industry partners who would otherwise take a hard pass on working with the Defense Department's cumbersome bureaucracy.

Although other transaction authority has existed for decades, the use of OTAs has exploded since the passage of the 2015 and 2016 National Defense Authorization Acts, which encouraged Pentagon officials to leverage them more in pursuit of new capabilities.

The total dollar value of OTAs issued in fiscal year 2015 was less than $1 billion. By 2019, that number increased to more than $8 billion, according to a draft of the National Defense Industrial Association's *Vital Signs 2022: The Health and Readiness of the Defense Industrial Base* report, which included data provided by decision science company Govini.

The largest year-over-year bump was seen in 2020, when the dollar value of OTAs awarded roughly doubled to more than $16 billion — almost the same amount as the previous four years combined.

"In 2020, the Defense Department obligated a considerable amount in defense innovation at $73.5 billion," said the *Vital Signs* report. "While a large majority of these obligations were appropriated to [traditional] research, development, test and evaluation contracts as they typically are, most notable was a shift toward the use of other transactions authority awards."

An example of this trend in R&D efforts for key technologies is the Space Enterprise Consortium agreement. The program gives the Space Force the ability to grow the space industrial base through a more rapid acquisition process and provides flexibility between government and industry while prototyping new technology, the study said.

"With the space domain growing increasingly competitive amongst peer competitors, OTAs provide a new approach for increased resiliency and reduced cost to get technology in the hands of the warfighter at a faster rate," it added.

Although final data for 2021 was not yet available at press time, preliminary findings suggested it would be another strong year for OTAs, said Gregory Sanders, deputy director of the Defense-Industrial Initiatives Group at the Center for Strategic and International Studies.

"We are seeing sustained spending," he said. "It looks like '21 will be another banner year."

Through the third quarter, there had been about $12 billion in OTA spending — more than there had been at that point in fiscal year 2020, according to Sanders.

Undersecretary of Defense for Research and Engineering Heidi Shyu told *National Defense* she sees room for additional growth in OTA funding as the Pentagon looks to work with nontraditional partners.

"It's the most flexible mechanism that we have … for small businesses," she said in December on the sidelines of the Reagan National Defense Forum. "They would much rather deal with that than the FAR."

A major trend in '20 and '21 has been the use of other transaction authority for COVID-19-related efforts such as vaccine development and bolstering telework capabilities, Sanders said.

More than $7 billion in OTA transactions in 2020 were related to the federal government's response to the global pandemic, he noted.

"We are seeing more of that in '21 as well," he said. "The growth in OTAs we've seen is both driven by the range of things we traditionally think of for defense OTAs, but also as a rapid vehicle to respond for DoD's role in supporting the larger efforts" to combat the novel coronavirus.

Maiya Clark, a defense analyst at the Heritage Foundation think tank, said the pandemic presented a "stress test" for the Pentagon's ability to leverage other transaction authority agreements to deal with a crisis.

"Suddenly there's this emergency, you need to respond. You need to rapidly field a lot of new and different things," she said. "There's just a lot of changes that need to happen, money that needs to be spent."

The leveraging of OTAs "allowed for that flexible and rapid contracting, or that avenue around the FAR at a time when things needed to happen quickly and the FAR was not the best way to do that," she added. "That stress has, I think, taught DoD a lot of things … but certainly how to use OTAs to get things done in an emergency was one lesson learned, and possibly even a benefit gained from an otherwise pretty destructive pandemic."

OTAs could be employed again in a future crisis, whether it's another pandemic or an armed conflict, she noted. "It's good that we already have a tool in place to respond in a flexible manner to some sort of emergency."

However, the COVID crisis also brought additional scrutiny to other transaction authority agreements, and could lead to tougher oversight, experts say.

OTAs are often managed by consortia that issue awards to their members on behalf of the Pentagon.

In April 2021, the Defense Department Inspector General's office released a report, "Audit of Other Transactions Awarded Through Consortiums," that found fault with how they are

being implemented.

"DoD contracting personnel did not always plan and execute OTs awarded through consortiums in accordance with OT laws and regulations," the IG said.

"DoD officials do not have access to important information associated with OTs awarded through consortiums, such as which contractor received the OT award and the specific costs associated with funded OT projects," it added. "Without this information, the DoD does not have the necessary oversight of the projects it is funding, which may hinder its ability to make important real-time decisions that enhance mission effectiveness."

In July 2021, the Government Accountability Office released its own report, "COVID-19 Contracting: Actions Needed to Enhance Transparency and Oversight of Selected Awards." The watchdog found problems with how the Defense Department and other agencies tracked and reported agreements due to limitations with the federal procurement database.

"The database is the only way for Congress and the public to track these obligations, but transparency is limited without accurate reporting," the study said.

GAO issued a number of recommendations, including that the secretary of defense should: consider prioritizing the development and implementation of a systematic approach to consistently and accurately track other transaction agreements used for "national interest events" and the associated dollars obligated; and consider prioritizing the development and implementation of a systematic approach to track the consortium members performing for each other transaction agreement awarded through a consortium or consortium management firm.

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The Defense Department concurred or partially concurred with the recommendations, according to GAO.

Key lawmakers are also voicing concerns.

The House-Senate compromise version of the 2022 National Defense Authorization Act would require the secretary of defense to review the current authorities, regulations and policies relative to the use of other transaction authorities and make recommendations to Congress on possible modifications.

"The [Senate Armed Services] Committee notes that the use of the other transaction authority has increased significantly over the last few years and that industry and independent experts have proposed a number of new proposals for possible adjustments to the authorities," said a SASC report on the NDAA. "The committee also is concerned about the differing interpretations by Department of Defense counsels on the flexibilities currently authorized, resulting in inconsistent application of the authority and significant confusion among industry and government personnel."

The compromise version of the NDAA would require the department to establish procedures for identifying individual projects awarded using OTAs and individual task orders under task order contracts. It would also require the Pentagon to make certain information about these awards publicly available.

Clark suggested cutting consortia out of the OTA process wouldn't be the right solution to the problems that have been identified. Leveraging them makes sense as the Pentagon tries to attract small businesses and other nontraditional partners, and "probably in the end is a good framework for organizing OTAs," she said.

However, "there's going to have to be, probably, increased transparency on the part of consortia and possibly more careful tracking on the part of DoD," she added.

Analysts say lawmakers and other officials should be careful not to add too many restrictions in response to concerns that have been raised.

"The benefit of the OTA is that it's more flexible and has less of those requirements. And to add the oversight also adds to the administrative burden and kind of hampers that agility," Clark said. "And yet you need a certain level of accountability of making sure that these are being used in lawful and correct situations."

Sanders said policymakers need to make sure they don't "kill the golden goose" with onerous oversight obligations that greatly restricts the Pentagon's ability to use other transaction authority agreements.

However, "there's going to be continued new steps forward and oversight, and there are definitely areas where you could have a lot more visibility without dramatically hurting your flexibility," he added.

In the near term there could be a decrease in total OTA spending once the pandemic wanes and the other transaction authority isn't being applied to deal with the crisis, analysts say. However, in the years ahead experts anticipate OTA spending on defense capabilities will remain strong, although it might not increase at the same breakneck pace as it has in the recent past.

"I would expect a slowing of the growth, probably not a plateauing, and I would be very surprised if use of OTAs really decreased unless abuse of OTAs led to changing of the rules," Clark said. "I see that as a tool that's here to stay, and probably to continue growing as we pursue technologies across the different services, for different platforms and for the many different things we expect our military to do." ND

Concern Grows for High Tech's Supply Chains

BY REBECCA WOSTENBERG, EMERGING TECHNOLOGIES INSTITUTE

As COVID-19 and the ensuing economic challenges have exposed, the United States faces substantial supply chain vulnerabilities and weaknesses. Nearly every sector has been affected and there is no end in sight. However, the pandemic is not the only thing to blame for the disruptions. Winter storms, misguided government policies, poor planning, an earthquake, a fire — the list seems unending.

The defense implications of the disruptions are particularly bleak. However, the vulnerabilities are nothing new and efforts to address them go back a few years. One such example was Executive Order 13806 which then-President Donald Trump signed in 2017 directing a whole-of-government effort to assess risk, identify impacts and propose recommendations in support of a healthy manufacturing and defense industrial base and its supply chains.

In response, the Defense Department published an unclassified report in September 2018 which not only identified the risks to the defense industrial base but also provided actionable recommendations to minimize them. The current administration has continued to focus on securing America's supply

chains. In February, President Joe Biden signed Executive Order 14017 launching two more reviews of America's supply chains — one for 100 days, and another for one year.

Actions to address vulnerabilities are not limited to the executive branch. Earlier this year, the House Armed Services Committee launched a bipartisan Defense Critical Supply Chain Task Force and subsequently published a report outlining key findings. Multiple non-profits have also contributed to the effort including the Hudson Institute's Hamilton Commission on Securing America's National Security Innovation Base and the Reagan Institute's Task Force on National Security and U.S. Manufacturing Competitiveness.

Some may look at the many task forces and reviews and see duplication of effort on a crowded playing field. Perhaps another perspective is recognizing that competition is good, and the plethora of efforts is indicative of the issue's importance. One area that has received less attention, however, are the nascent supply chains that will support emerging technologies as outlined in the 2018 National Defense Strategy.

As such, the National Defense Industrial Association's new nonpartisan think tank, the Emerging Technologies Institute, is launching an in-depth research study focused specifically on defense emerging technologies supply chains. The forward-focused study will assess the state of these supply chains and provide policy recommendations to advance their development, health and resilience.

To achieve this goal, ETI and NDIA will bring together stakeholders from industry — both traditional industrial base members and newcomers critical to these new technologies — government and academia to deliver public reports on key findings, detailed assessments of current emerging technologies supply chains, and policy recommendations to government and the private sector. The study will take on the most pressing questions while building off existing research and analyses.

The study will focus on four key emerging technologies such as hypersonics, directed energy, biotechnology — specifically, biologically-derived manufacturing — and quantum sensing. These four were selected because they represent the full spectrum, from very nascent supply chains — such as quantum sensing and certain biotechnologies — to less nascent and more established ones such as hypersonics and directed energy.

And each one is critical to defense modernization. As ETI examines each of the technologies, it will be through four different lenses, or pieces of the supply chain: critical raw materials and goods; manufacturing base and workforce; supply chain security, redundancies and vulnerabilities; and international partnerships, allied near-shoring and domestic on-shoring.

For years, the United States has been a beacon of innovation and a leader in emerging technologies. However, systems are evolving at the most rapid pace in modern history, and the nation needs to adapt to secure our future success. To maintain and grow our competitive edge, the United States must not only win the race but also maintain secure and resilient supply chains for each technology.

Those who are interested in participating in this study may reach out to ETI Emerging Technologies Supply Chain Study Chair Rebecca Wostenberg at rwostenberg@ndia.org, and NDIA Strategy Associate Jacob Winn at jwinn@ndia.org. ETI also welcomes all questions, comments and suggestions regarding the task force. **ND**

Rebecca Wostenberg is a research fellow at NDIA's Emerging Technologies Institute.

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VIEWPOINT

Four Essential Rules for Developing Revolutionary Networked Capabilities

BY TOM MADDUX, CONSULTANT FOR SYSTEMS EVOLUTION INC.

■ The Defense Department is undertaking a challenging mission to prepare for both limited conflicts and emerging near-peer threats.

This mission will require operating in hostile environments full of cheap commercially produced systems that utilize artificial intelligence, machine learning, data analytics and internet-of-things technological breakthroughs. These revolutionary advances will allow enemy forces to make lightning-fast operational decisions based on sensor cognition and allow for real-time data driven force synchronization to supplement human observation and decision making.

These capabilities will allow traditionally weaker forces to seize the initiative and execute the chain of decisions and actions required to neutralize capabilities before the U.S. military can even project force into the operational environments. Weapon systems that cost less than $1 million to procure will effectively eliminate the effectiveness of multibillion-dollar weapon systems like naval carrier groups, manned fighter aircraft and integrated missile defense systems.

The U.S defense acquisition process must improve the transfer of new technologies and end user feedback between development steps, implement proven early stage development design processes, and better incentivize commercial developer participation in defense capability development to compete in this new operating environment.

The Defense Department is recognizing that some of the legacy franchise systems that are pillars of its budgets will become liabilities in the future operating environment. For example, the Pentagon is phasing out the JSTARS air surveillance franchise and the Marine Corps made the decision to discontinue vulnerable amphibious ships.

These efforts are encouraging and will prevent the earmarking of billions of dollars that could be used to develop more effective solutions. But the department cannot just rely on cutting programs. The existing procurement process is not designed to develop the new solutions needed to compete in the future operational environment or integrate them into existing defense capabilities. The process needs to reform its new product development principles and refine its organizational structure to attract the commercial developers and talent necessary to create overmatch capabilities against these new threats.

To counter these threats, it is essential to not just focus on integrating the latest available technology into existing platforms. Simply adding new technology to existing platforms that are designed for an increasingly obsolete operational environment has been shown to fail in previous defense and commercial projects. Networked capabilities that successfully implement AI and new technologies into tactical capabilities will be a step-by-step evolution rather than a one-time cataclysmic revolution. New commercial development incentives, organizational structures, and increased testing and evaluation capabilities will be needed to effectively manage this step-by-step evolution.

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Early system field testing competitions need to be implemented to incentivize and de-risk the development of risky innovative solutions for commercial developers. The latest commercial sector development management processes will be necessary to achieve development milestones and deliver capabilities on time.

Two recently published books based on historical analysis provide excellent guidance on how to both create the organizational environment and development mindset necessary to achieve these goals and improve early-stage development success of revolutionary defense solutions. Loonshots: How to Nurture Crazy Ideas That Win Wars, Cure Diseases and Transform Industries, by Safi Bahcall, describes research and development management concepts that maximize the success rate

of effective innovative solution development. Christian Brose's The Kill Chain: Defending America in the Future of High-Tech Warfare describes both the new emerging operational threat environment and recommends methods to work within the current procurement system to incentivize the development of the risky and unproven solutions that will soon be the backbone of the U.S. national defense strategy.

Concepts explained in these two books can describe a set of organizational changes to the capability procurement process that will ensure the U.S. military maintains operational overmatch on future potential threats.

The current procurement process impedes the development of new revolutionary capabilities. It is easier to refine and improve existing systems with standalone user needs documents refined over decades of development. Bahcall in Loonshots refers to these existing systems that are lower risk for commercial developers and have been the cornerstone of defense funding as franchises. Riskier new solutions will continue to be crowded out by franchises in the procurement process if only the current procurement processes are utilized.

For the last 40 years, the Defense Department has maintained a capabilities development and procurement system that mainly funds, develops and builds franchise solutions, not revolutionary innovations.

Brose in *Kill Chain* states that much of the commercial technology sector and private capital have turned away from committing resources to early-stage defense solutions development due to slow development processes, unpredictable demands and biased evaluation criteria. This has created a consolidated commercial defense industry reliant on developing less risky franchises that are sustained and improved with each funding cycle.

But the new networked solutions the U.S. military needs are not franchise solutions. They are high risk, new capabilities solutions.

Development incentives, processes and organization capabilities need to be tailored to new capabilities solutions in early stage development.

Both private commercial companies and government organizations must feel like the risks of spending resources on nascent ideas are mitigated by the incentives and new processes put in place to foster early stage ideas.

The current procurement process has a labyrinth of phase gates and design reviews intended to eliminate ineffective and unnecessary early stage developments as soon as possible. These well-intentioned efforts often kill off new systems that have higher risk designs and require more in-depth analysis to be integrated into operational and organizational capabilities.

Bahcall provides a proven series of rules to prevent this problem of early development project risk. It is based on the organizational principles implemented by Vannevar Bush while managing the development of early-stage revolutionary solutions like radar through the high stakes World War II weapons procurement process.

Bush learned these rules from Theodore Vail and Frank Jewett who were the leaders of the most successful industrial research laboratory in history, Bell Telephone Laboratories. Using these four rules, deemed the Bush-Vail rules by Bahcall, innovations like the transistor, radar, solar cell, foundational programming languages and the basis of digital photography were developed.

The overall goal of the rules is ensuring that early developments are protected from cancellation while undergoing early iterative prototyping when the first design obstacles are encountered. The rules also account for the fact that the problem solving and thinking necessary for new development is different than what is necessary for efficient updates to steady growth franchise solutions. These rules — applied to the Defense Department's procurement process — have four main concepts.

Process managers must separate the development processes of franchise solution improvements and the early stage new solutions. These new processes will inevitably be covered in "warts" that need to be solved with fast user feedback loops and top-level protection from senior leaders.

Also, tailor the evaluation methods and organizational structures to the phase of development. Focusing on efficiency systems like Six Sigma and Total Quality Management might help improve projects focused on the upkeep of franchise weapon systems, but they will suffocate the early development projects which will be producing the next generation of innovations.

Next, organizations must focus on managing the transfer of early development capabilities to the operational environment. New organizational emphasis must be placed on the touch point between scientists and private companies exploring the new breakthroughs and soldiers in the field or prime contractors assembling existing capabilities.

Bahcall reiterates that a flawed transfer from developers to field units should not be the only focus. Information transfer in the other direction is equally important. No product works perfectly the first time. If feedback from the field units is ignored by developers, initial enthusiasm can rapidly fade and a promising program will be dropped.

Early aircraft radar, for example, was practically useless; pilots ignored it. To solve this problem Bush made sure that pilots went back to the scientists and developers and explained why they were not using it. The reason had nothing to do with the technology: pilots in the heat of battle did not have time to fiddle with the complicated switches on the early radar boxes. The user interface was lousy. Scientists and developers quickly created a custom display technology now familiar as a sweeping line and moving dots. Radar then revolutionized the way battles were fought.

Leaders must instill a system mindset and not focus on just outcomes of the procurement process. They must analyze how the process went and improve the processes utilized to achieve results. This is easier said than done but should be instilled as a mindset for all members of organizations responsible for ensuring the right solutions are being developed and correctly implemented. Bahcall points out that the principle applies very broadly to the process. It is easy for an organization to analyze why a new solution did not work. Possibly it was determined the sustainment plan was inadequate or maybe the initial training plan was ineffective. That is an outcome mindset.

The organization will gain much more from analyzing the process by which they arrived at a decision. Identify what went wrong with the process and how to ensure those mistakes will not happen again. That is the systems mindset. Failures are guaranteed and setbacks when procuring and implementing new solutions will occur, but leadership must make sure members of the organization are incentivized to analyze and own the effort to fix the process.

Development organizations must invest time and money in open innovation. Bahcall emphasizes the importance of growing the practice of open innovation. In open innovation, the Defense Department and developers jointly develop new ideas, technologies and strategies to solve existing problems. This already occurs with well-defined and fully fleshed out franchise solutions, but the major benefits of this process would be seen with the new early stage solutions.

Sharing unfinished solutions with both existing contractors and new commercial industry partners will allow for faster feedback and easier participation by new developers. Bachall points out that open innovation allows for developers to decrease their risk in engaging in early-stage development projects with the military.

These four rules should be the foundation of both how new capabilities are managed and design processes can be updated to improve the success rate of early stage development capabilities.

The military cannot wait for armed conflict to test and iterate designs like commercial developers who can use their existing markets to test their solutions and get rapid feedback from customers. That is why implementing these process changes and the concepts described in the Bush-Vail rules are so essential.

The threat to current capabilities is present and growing at a rapid pace. The time for implementing these changes is now — before any capability gaps become too large or the outside developers that will be needed to create the needed solutions leave the industry to engage less risky early stage development environments.

Leadership, persistence and smart organizational decisions will be the essential aspects for implementing and sustaining these necessary changes. **ND**

Tom Maddux is a consultant at Systems Evolution Inc. (SEI) and was an officer in the Army Engineer Corps for eight years.

U.S. Startups Seek to Claw Back China's Share of 'Technology Minerals' Market

BY STEW MAGNUSON

MOUNTAIN PASS, Calif. — Atop an arid mountain about an hour's drive from Las Vegas, an excavator scooped up giant boulders mined from a nearby open pit and dumped them into a machine designed to reduce them to pebbles about the size of a marble.

Down in the pit, some 500 feet below, miners were preparing explosive charges that would blast basalt out of the mountain later that afternoon. Inside that rock were rare earth minerals, 17 different elements valued as building blocks for some of today's most ubiquitous technologies — everything from electric cars to smartphones.

Despite all the activity and the dozens of workers moving tons of material at the site, Michael Rosenthal, chief operating officer of MP Materials, said mining is only about 10 percent of what the company did there.

"The rest is chemistry," he said.

The Mountain Pass mine has existed for some 60 years and is the only one of its kind currently in operation. It's renowned for its high concentration of rare earth elements, sometimes called the "technology minerals."

The elements that occupy 17 spots on the periodic table are categorized as "strategic minerals" by the U.S. government and therefore considered vital for national defense. Along with smartphones, they are used in fiber-optic cables, medical devices and high-performance magnets, which are needed in a host of machines, including jet fighters, wind turbines — and most importantly on the commercial side — electric vehicle engines.

"From an economic security perspective and defense perspective, magnets are very, very important to national security," Rosenthal said.

The problem is that China has a near monopoly on the complex process of separating 16 of the 17 elements currently used in these technologies from the source material and refining them to a point where they can be made into useful metals and materials.

The Biden administration's 100-day review, "Building Resilient Supply Chains, Revitalizing American Manufacturing and Fostering Broad-Based Growth," released in June, devoted an entire section on strategic and critical materials and minerals, including its thoughts on rare earths.

"The United States imports substantially greater quantities of rare earth elements in value-added products. … Implicit in this trade phenomenon is the gradual decline in value-creation, innovation, research and human capital development," it stated. That imbalance with China will only increase with the expected growth of green energy technology such as electric vehicles and wind turbines, the review added.

"Rare earths" are a misnomer and are not that rare. China does have an abundance of them, but they are also found in concentrations high enough to mine in several U.S. states and other nations throughout the world. They are further divided into two categories, light and heavy, with the heavier ones considered more difficult to refine and thus, more valuable.

MP Materials — along with three other companies interviewed — are seeking to exploit the abundance of rare earths found in the United States and to end China's monopoly on their refinement and return some of the market share back to the United States.

Separating the elements from the host rock and further refining them to the point where they are separate from each other is a complex process requiring several steps.

Rosenthal explained that the boulders being fed into the grinder may look the same, but they're not being selected by happenstance. Every day, geologists drill holes in the mine, mark them with GPS coordinates, and use X-ray fluorescence on the samples to determine the rare earth element content — specifically which and how much of the 17 elements are in that part of the mine. The result is a daily "recipe" to determine a blend.

Extracting the most valuable rare earth elements as efficiently and cheaply as possible is the road to profitability, Rosenthal said.

For example, the Mountain Pass mine's rare earth content is almost 50 percent composed of cerium (Ce), which is used in glass making and polishing. While abundant, it is not where the company sees future profits. Neodymium (Nd), dysprosium (Dy) and samarium (Sm) — three of the four elements that can make high-performance magnets — are now viewed as the

Bags of partially refined rare earth minerals await shipment to China at the Mountain Pass mine in California.

Stew Magnuson photo

biggest money makers. The company that previously ran the mine focused its business on cesium, which Rosenthal considers one of the main reasons it ceased operations after three years.

Rosenthal moved on to a building where the pebbles that emerged from the giant grinder are further crushed into sub-100-micron particles. Those are fed into towering vats of water and further separated from each other. A chemical process removes the waste while the rare earths float to the top.

Yet, at this point, the rare earths are still not refined enough for them to be used to serve as technology "building blocks." The final step involves heat — described as a slow-roasting process — that delivers the purity required. That is all done in China.

The raw material resulting from the second step is packed into giant white bags and moved to the foot of the mountain.

MP Materials has aspirations to not only refine these crucial elements at Mountain Pass, but to make high-intensity magnets as well.

Contractors near the mine were at work building the new facility where light rare earth elements will be refined to the point where they can be used in manufacturing.

In December, MP Materials earned a $10 million Defense Department grant to help it build a $200 million refinement facility for light rare earths. The company broke ground on the building in 2021 and expects it to be operational by 2022.

As is the case for many technologies, the U.S. military market for rare earths is crucial, but would not be large enough to sustain a domestic industry. Magnets are used in every electric system that moves. But the ones needed to spin a radar, for example, are not the everyday magnets found on refrigerators. Neodymium magnets, for example, are prized by the consumer market for their strength and low costs.

The military and its contractors will eventually benefit from the commercial demand for magnets and the other elements needed for other systems by no longer having to depend on China, Rosenthal said.

Meanwhile, flatbed trucks hauled the giant white bags of raw material to the western edge of the facility where they were lined up waiting for shipment. Next stop, the port of Long Beach, California, then China.

Rosenthal acknowledged the irony. But until there is some domestic refinement capability, MP Materials has no choice but to send the raw material to China, he said. The publicly traded company would not be profitable and currently employing 200 workers if it had to wait for the refinement facility to come online. The bags would be sitting ready to go nowhere.

MP Materials spokesman Matt Sloustcher said critics have pointed out that the company has a Chinese investor with an 8 percent stake in the operation. However, this investor doesn't have a seat on the board of directors and the deal has been reviewed and approved by the Committee on Foreign Investment in the United States, he said.

There will be space in the facility to process the heavy elements later and studies on how to accomplish that are ongoing, Rosenthal said.

Meanwhile, other companies are entering the rare earth mining business in the United States, with their sights set on the burgeoning high-performance magnet market.

One of them is the Round Top Mine near El Paso, Texas, operated by USA Rare Earth, which also has aspirations to mine, process and then convert the rare earths to magnets, said its CEO and director, Pini Althaus.

A preliminary economic assessment report showed that of the mine's important elements, one-third was composed of rare earths — including all four that can produce magnets — one-third lithium — needed to make lithium-ion batteries — and one-third gallium, a vital element used to make semiconductor chips used in 5G technology.

"It's a very strange geological anomaly to have rare earths and lithium sitting side by side," he said.

Deeper inside the mountain are deposits of beryllium, another strategic mineral used by Defense Department contractors to make alloys. There are no plans to mine the beryllium now, but the mine could produce 36 tons of the mineral per year, he said.

Despite all these bonus minerals, it's the magnet-making materials that interests the company the most, he said.

The company has also opened a rare earth critical minerals processing facility at Wheat Ridge, Colorado, which is a mining technology hub in the United States. It is a pilot plant that will eventually be scaled up and moved to Texas. The company hopes to be able to demonstrate refinement by the end of the year or early 2022, with full commercial production taking place in Texas by 2023, Althaus said.

Both Round Top and Mountain Pass executives said they want to be able to take feedstock from other sources and do

the refinement there so they don't have to send it to China.

"Then hopefully that material stays in the U.S. supply chain," Althaus said.

"One of the processes we're working on is optimizing the feedstock we are starting to receive from other mines around the world," he added, including one in Australia.

USA Rare Earth has also purchased a mothballed magnet manufacturing facility in North Carolina from Hitachi Metals America Ltd. and is reconditioning that plant with a goal of producing 2,400 tons of magnets per year. It should be operational by the second half of 2022, he said.

Another possible source of rare earths is the nation's coal seams. A Department of Energy National Energy Technology Laboratory study found rare earth element concentrations exceeding 300 parts per million in several U.S. coal regions, including Illinois, Northern Appalachia, Central Appalachia, the Rocky Mountain coal basins and the Pennsylvania Anthracite region.

"We found that in certain seams in Kentucky, there is a very high mineral content in the coal itself that may date back to volcanic activity so many years ago," said David McCarthy, CEO of McCarthy Merchant Capital, which is raising funds for a company, Digital Commodities LLC.

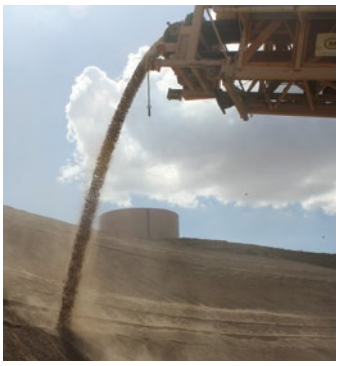
Previous concepts were to separate the rare earths and other minerals from coal ash after it was burned.

"The problem with that is you have to burn the coal to get the ashes," he said. "That's not a green alternative."

McCarthy is raising funds to establish a refinery in Harlan, Kentucky.

Researchers from the University of Kentucky have discovered a patent-pending way to pulverize the coal into a fine dust, then spin the powder and separate the elements in a process McCarthy described as a "tornado in a can."

This solves two "American problems" — reliance on China for rare earths and the decline of the coal industry, he said.



Rocks containing rare earth elements are crushed into pebbles at the Mountain Pass mine in California.

The coal seams not only contain all the rare earth elements, but other strategic minerals such as lithium — also used in electric vehicles for lithium-ion batteries — and precious metals such as gold and silver, he said.

"We're finding a new green use for coal in an area of economic hardship," he said. His fund is selling securities for a rare earth company and a separate offering for the precious metals.

The company is building a processing facility in Harlan that it hopes to have running by the end of the year. It is about 50 percent complete, but not all of the financing is in place.

"The quicker we get funding, the quicker we finish," McCarthy said.

It also has a laboratory in Charlottesville, Virginia, where it is running experiments that McCarthy said will help them to mine and separate 2,400 tons of raw material per day at the beginning of the operation.

Caldera Holdings, which owns the Pea Ridge iron ore mine in Washington County, Missouri, is seeking funding and Department of Energy grants to create America's first 100 percent green steel manufacturing plant. It would forgo using hydrocarbons and use nearby nuclear power plants' energy to manufacture the steel.

The company's president, James Kennedy, also wants to exploit the rare earths found in the mine's leavings as byproducts. The problem is that they contain a high concentration of thorium, an element used to make nuclear fuel.

To Kennedy, a watershed moment that helped usher in China's dominance in the rare earths market was a 1980 U.S. government rule that regulated the handling of thorium. Until then, rare earths were extracted as byproducts at several U.S. mines, especially copper. The regulation forced the mines to put the leavings aside and seal them up, or risk liability, thus cutting off the most economical way of extraction at the dawn of a new technological age.

Kennedy — a public and strident critic of current efforts to revive the U.S rare earths industry — said the only way to compete with the Chinese monopoly is by setting up a cooperative that exploits the inexpensive leavings already extracted, and then putting the thorium in a national stockpile.

"The U.S. could meet 85 percent of the global demand for rare earths if they would just solve the problem they created for themselves in 1980 when they defined rare earths byproducts of nuclear fuel," he said.

All four executives interviewed made claims of having the most of one element, or the richest veins, and some accused the other mines of lacking one element or another to make magnets. MP's Rosenthal, USA Rare Earth's Althaus and McCarthy all said their companies — or proposed companies — could withstand a price war brought on by China.

There are other companies seeking investors and applying for mining permits in Texas, Nebraska and Wyoming — to name a few locations — as well as plans to recycle rare earths from used electric engines or other devices.

"The truth is," Althaus said, "nobody has everything that is required." The Round Top Mine at its peak would only account for a small percentage of the rare earths needed for the magnet market. The 2,400 tons of magnets the mothballed plant could produce would be a drop in the bucket with early estimates calling for as much as 20 times that figure as the electric vehicle market ramps up, he said.

The Biden administration's 100-day review said: "Independent of permitting activities, a reasonable industry benchmark for the development of a mineral-based strategic and critical materials project is not less than 10 years."

Althaus said: "We need a number of mines in the next five to 10 years, otherwise, we will still be 80 to 90 percent dependent on China." That includes processing plants, he said.

McCarthy added: "When we put our heads together, we can solve these problems." **ND**

Stew Magnuson photo

New Micro-3D Printing Technique Could Benefit Pentagon

BY YASMIN TADJDEH

The Defense Department has been researching and investing in additive manufacturing technologies for years, but emerging techniques and procedures being developed by industry could spark new opportunities.

One promising new technology that could aid the military is micro-3D printing, which enables the miniaturization of parts and components. "There are numerous areas where this can help the DoD," said James Zunino III, senior scientific technical manager for munitions at Army Combat Capabilities Development Command's advanced materials and manufacturing division.

These include enhancing capabilities to existing systems, volume optimization to reduce the size and weight of equipment troops must carry, and allowing for new technology solutions that were previously unavailable, he said during a recent webinar hosted by FedInsider.

John Kawola, CEO of Boston Micro Fabrication, a Maynard, Massachusetts-based company, said micro-3D printing is a burgeoning market.

"Certainly, miniaturization is a growing field," he said during a webinar sponsored by *Design World*. "More and more medical device companies, electronics companies, optics and photonics companies want to make things smaller and smaller. The market demand is there [and] the pressure from customers for applications" is there.

Boston Micro Fabrication is conducting pioneering work with micro-3D printing techniques to meet the growing demand, Kawola said.

"BMF has really developed the technology to try to develop and help engineers with this and enable them to better design and reach their miniaturization goals," he said.

For many pieces of equipment, such as lenses or sensors, there is a trend to make them smaller and smaller, he said. But traditional manufacturing techniques that have historically been used to make the parts don't scale well and have other limitations.

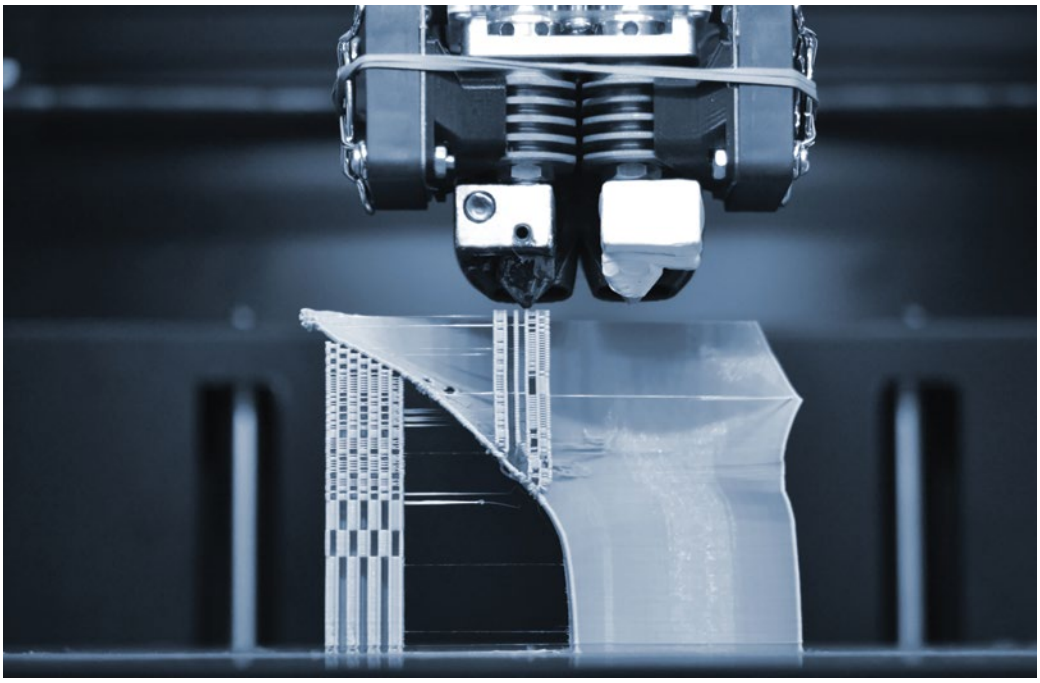
To address this, the company developed a process it calls projection micro stereolithography, he said. The technique allows for the rapid photopolymerization of a layer of resin with ultraviolet light at micro-scale resolution, allowing the company to achieve ultra-high accuracy precision and resolution that cannot be achieved with other technologies, according to Kawola's slides.

For micro-scale parts, engineers and designers often don't have a good way to prototype today, he said. BMF's new process can help with that.

"Right now, we're fulfilling a real need because we're able to make things at the scale … that designers and engineers can use," he said. The company wants to "bring additive manufacturing to the micro market and help enable engineers and designers … fulfill the design that they are after in terms of miniatures," he added.

The technology is particularly useful for manufacturing aids, jigs, fixtures, molding and casting tools and cavities, component parts, spare parts and personalized parts, he said.

There is a general rule that costs rise as components become smaller, he noted.



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"As parts get smaller, they get more difficult to manufacture conventionally, … whether that's standard geometries or more creative or challenging geometries," he said.

For example, using traditional methods to manufacture a microfluidic chip would typically require etching or injection molding, bonding, layering and several other steps.

However, it's relatively easy for a 3D printing machine, according to Kawola.

Micro-3D printing is particularly useful in manufacturing electro-mechanical parts that can be found in the optics and photonics market, he said. They are critical pieces of technology for augmented reality and virtual reality training systems, and particularly for head-worn equipment, Kawola added.

"Many, many people have seen the AR/VR glasses that are being used either for entertainment, but also for lots of really

valuable … training and simulation applications," he said. Oculus platforms have become increasingly popular in both the commercial and military worlds, for example.

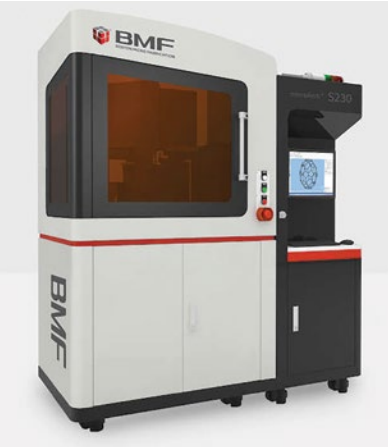
However, one of the challenges with the technology is delivering a deluge of content to users coming from cameras, sensors and lighting systems, and putting it all in a package that is small, he said.

"People are excited about the AR/VR market — they're not necessarily excited about the really large glasses that you have to wear on your head, and so we have a number of customers who are thinking about miniaturization in a range of optics and photonics markets," Kawola said.

Using the technology for microneedle arrays could also be useful in the medical realm, he noted. Microneedle arrays are a series of very small needles used to rapidly deliver drugs to patients.

While there has previously been research into additively manufacturing this type of technology, micro-3D printing could "drive this much faster, and has really come to head with what we've been living through for the last 18 months," Kawola said, referring to the COVID-19 pandemic. "The world has discovered that immunizing billions of people with the traditional needle in the vial … just doesn't scale very well. It takes months and months and months even if you had all the vaccines ready to go."

In September, the company unveiled its microArch S230 system to facilitate micro-3D printing. The system offers ultra-high resolution, accuracy and precision. It has a larger build volume, is faster than its predecessor by five times and can print industrial-grade materials including composites such as ceramics, Kawola said.



microArch S230

Brandon Ribic, technology director at America Makes, a national accelerator for additive manufacturing and 3D printing based in Youngstown, Ohio, said he is seeing an increased demand for miniaturization technologies.

"There are definitely folks who are interested in that," he said. "There's a couple of factors there where you can … derive utility, and those are largely the ability to, of course, make a geometry that you need. But then there's also the ability to produce something that's functional."

As 3D printing took off in recent years — and particularly in the defense and aerospace sectors — additive manufacturing companies have been working to drive economies of scale, he said.

"There are a lot of folks who are trying to figure out how to turn the knobs of additive to make it a more economically favorable solution for higher volume applications," he said. One way to "solve that problem is to look at smaller volume products where you can make … a considerable number of them in a given run, where you're getting more from a single machine."

Todd Spurgeon, a project engineer at America Makes, said he sees several ways the technology could be leveraged for the Defense Department. For example, it could be employed for higher-end electronics, circuits, small unmanned aerial vehicles and microneedle arrays for fast-acting medicines.

Using micro-3D printing for electronic and chip components could help ease supply chain issues that have been plaguing the nation, he said. A global chip shortage has clobbered countless industries as demand soared for electronic devices during the pandemic.

While the United States is a leader in the design of semiconductors — which are foundational to everything from laptops to fighter jets — the manufacturing and production of microelectronics has moved offshore and is now concentrated in places such as Taiwan and China.

However, industry is still likely a few years away from manufacturing chips using 3D printing, he said. "I think we would have to mature the technology" more, he noted.

Meanwhile, other trends are developing in the 3D printing world, including bioprinting.

Finland-based startup company Brinter unveiled in November a new 3D printer known as the Brinter Core that can print multi-material and highly complex tissue structures in 3D, providing the basic features needed for bioprinting, according to a news release. The system is a modular and portable system that is 50 percent smaller and lower in cost than its predecessor. Brinter is active in more than 10 countries, including the United States, Germany, India and the United Kingdom.

The machine can print both stiff and soft materials, including liquids and hydrogels with living cells, bio-paste, metal and plastic, according to the company.

"We can combine liquid materials with solid materials and everything in between — all kinds of hydrogels, including cells," said Brinter CEO Tomi Kalpio. The hope is to one day be able to print spare parts for patients including organs such as kidneys.

Kalpio believes Brinter Core could have applications for the military, but at these beginning stages it may be more utilized in healthcare research and development. The first steps would be printing patches of skin, he noted.

Pasi Kaskinen, Brinter's sales and marketing director, said it would likely be 15 years at least before full organs could be printed. However, it's difficult to predict how quickly technology will develop. "It always kind of surprises" people, he said.

For nearer term applications, Kaskinen said the Brinter Core could be used to model the effects of pathogens on humans.

"There are many ways [the] military can benefit from 3D bioprinting, and most are not directly action related," he said. "Military personnel are exposed to all sorts of environments around the globe. Our understanding of how pathogens work in humans increases exponentially when applied in 3D that mimics reality."

The company is currently working on some military projects but declined to disclose details. **ND**

BMF photo

ANALYSIS

Improving the Shipbuilding Industrial Base

Huntington Ingalls photo

BY HEBERTO LIMAS-VILLERS, NDIA JUNIOR FELLOW

In the 2022 National Defense Authorization Act, Congress authorized $4.9 billion in funding for Arleigh Burke-class destroyers and an additional $4.7 billion for shipbuilding to include two destroyers, two expeditionary transports and a fleet oiler.

The increased attention to U.S. naval capabilities comes after increasing competition with China, as well as discussions around changes to the current force structure. Currently, the Navy is required by law to have at least 355 ships, though plans are in place for expanding the fleet to between 398 and 512 vessels, which includes both manned and unmanned platforms.

This objective is largely aspirational as the number of both private and public shipyards has significantly declined with gaps in experienced personnel, rising costs and a boom-bust cycle in naval acquisitions.

The United States became a global power through its power-projection capabilities, including its naval prowess. To maintain its edge, it must build those capabilities once again.

Since 1993, the number of public shipyards the Navy used fell from eight to four — two on the West Coast and two on the East Coast — due to the "peace dividend" of the 1990s. However, these four shipyards have limited functional dry docks, old equipment, and regularly delay maintenance for the submarine and aircraft carrier fleets.

The U.S. shipbuilding industry is bolstered by 22 private shipyards. Three shipbuilders have left the industry and only one shipyard has opened since the 1960s. Both Huntington Ingalls Industries and General Dynamics, the two largest U.S. shipbuilders, reported a record new construction backlog for 2020 competing for drydock space with essential ship maintenance.

What is left is a diminished industrial base incapable of even maintaining the Navy's current presence. Worse, U.S. shipbuilding is significantly behind China, which has dozens of shipyards capable of building and maintaining a fleet that can project naval power beyond the First Island Chain. Because of the nation's investments, the Chinese navy grew to approximately 350 ships by 2020, and Beijing now has the largest navy in the world by ship numbers albeit not by tonnage.

Efforts are being made by the U.S. Navy to renovate its public shipyards through a 20-year, $21 billion Shipyard Infrastructure Optimization Plan. However, more attention needs to be given to the private shipyards that already construct and maintain most of the fleet from fleet oilers to destroyers.

Private shipyards remained largely profitable during the COVID-19 pandemic, though their margins have been negatively impacted. The main issues that limit private shipbuilders in the long term lies in personnel, rising costs of materials, and inconsistent acquisition priorities that threaten to consolidate the industry further if not properly addressed.

Having enough skilled technicians to construct and maintain these ships is a considerable problem for industry. Since the 1990s, the workforce has aged, leaving shipyards with an increasingly fragile workforce with a dearth of skilled younger workers in the pipeline. While shipbuilders like Huntington Ingalls have some form of an apprenticeship program, demand for a skilled workforce during COVID remains considerable. This lack of skilled technicians causes delays in construction and maintenance, compromising the Navy in a possible future engagement.

Fortunately, there is a growing recognition of this employment gap by the Defense Department. In June 2020, it announced a pilot program to train new welders and other specialized roles for public shipyards. While it is starting small, programs like these will help eventually bridge the gap with proper funding and training provided.

Another issue shipbuilders face is the rising costs of materials. This is a problem throughout the entire economy, though the Congressional Budget Office found that the Navy shipbuilding cost index was 1.2 percent higher than overall inflation between 1986 to 2009. This is partly due to specialized construction needs in contrast to the general economy, low competition among shipyards and low-volume orders.

In the long term, encouraging more contractors to provide shipbuilding capabilities will lower the cost index, though this will require an increased budget for the Navy.

Lastly, the main issue inhibiting private shipbuilding is the inconsistency in demand from the Navy. Currently, there is a bipartisan consensus on increasing the service's size, though this follows decades of boom-and-bust cycles in procurements reducing the industrial base as seen with the closure of Huntington Ingalls' Avondale Shipyard in 2014.

The Navy's shipbuilding plan has also been unhelpful, given a vacillating post-Cold War period with halting efforts to modernize and properly adapt to the era, as seen with the Littoral Combat Ship program and Zumwalt-class destroyers. Shipyards are harmed as each program requires significant investment to properly construct and maintain new ships, only for it to be squandered when the Navy cancels orders and moves to develop other systems.

Further, this encourages consolidation that limits the competition needed for a robust naval acquisition strategy. To ensure that the shipbuilding industrial base doesn't deteriorate further, it is important that there is a consistent procurement of ships and a clear commitment toward new systems as needed.

In the long term, more shipyard capacity must be built — both by the government and private sector — to meet the demands of a larger U.S. Navy. However, significant changes to training and acquisitions need to take place to ensure sustainability for the longer term. ND

Heberto Limas-Villers is a junior fellow at NDIA.

COMMENTARY

Major Cyber Attacks Not the 'New Normal'

BY GENTRY LANE, SENIOR FELLOW AT THE POTOMAC INSTITUTE

■ Cyberspace is the only warfighting domain in which daily degradation of critical assets is tolerated. This tolerance is not born out of willful indifference, but out of willful engagement in a losing battle due to lack of strategic response.

The scale and scope of advanced persistent threat-perpetrated aggression is beyond existing surveillance and incident response capabilities of any one nation. Despite America's technical advantage and consequential fighting force, it is and will always be outnumbered in the cyber domain. However, "always outnumbered" is not necessarily a decisive disadvantage. Military history is replete with smaller forces overcoming larger ones to achieve mission success.

The imbalance of power should be the leading factor when evaluating engagement strategies, but this is not currently the case. Instead, priority is given to triaging obvious insufficiencies in lieu of developing a viable asymmetric battle strategy. This approach yields stopgap solutions, piecemeal strategy and continued unencumbered success for adversaries.

Despite doctrine issued from both the Defense Department and the White House, the United States does not have a cohesive, sustainable strategy to efficiently deter nation-state aggression nor to adequately defend critical assets.

"Persistent engagement" and "defend forward," the two pillars of the current cyber national security strategy, are lines of effort unviable as standalone strategies. While both gambits yield intermittent efficacy in shaping adversary behavior, there are limits to their effectiveness. Given the escalating sophistication and scale of malicious cyber actors, scaling these lines of effort in a sustainable way is not possible.

Unfortunately, effort and budget continue to be allocated to the low hanging fruit and triage initiatives: establishment of norms and redlines for adversaries who flout international humanitarian law; initiatives that only incrementally increase the cybersecurity workforce; innovation programs that yield few results; and vague vows to increase resiliency. These initiatives fall short of the kind of strategic thinking and cohesive, sustainable, strategy development that the current situation requires.

These efforts are misaligned because the objective is unclear. The desired end-state has yet to be defined in the context of comprehensive strategy.

Further confounding the disorganization is a lack of consensus on the current state of affairs. There is no doubt among adversaries that they are each engaged in effective, active conflict on American soil, yet American authorities are still discussing where on the conflict continuum cyberattacks rank.

Adversaries are fighting — and winning — and we can't decide if we're in cooperation, competition, or conflict. The disconnect is stark.

The ultimate authority for strategy development is nebulous given the number of military, law enforcement, civilian, homeland security and diplomatic stakeholders who have equity in the cyber conflict at hand. Defense leaders articulate disparate goals. "Collective defense," "integrated deterrence" and "strategic stability" are neither aligned nor have they been built out beyond catchphrases into comprehensive strategies. Responsibility and negligence for the lack of a fully developed strategy lay somewhere, but it isn't clear where.

Regardless of who leads a strategic response, resilience and defense alone are inadequate. Even the most viable defense strategies necessitate prolonged engagement in a resource-intensive battle to maintain a status quo in which the best outcome is a condition of precarious security. This begs the questions of what exactly are the desired ends and what are we willing to sacrifice to achieve them? A defeat strategy has a high likelihood of escalating into traditional armed conflict and a coercion strategy is de-escalatory, but there is currently no authority engaged in the composition of this unprecedented and complicated effort.

To reset security conditions that favor the United States and its allies, conflict resolution must occur and result in a condition in which the nation is not restricted to a persistently defensive posture.

However, as in any conflict, the adversary has a vote in the direction of this current one. For the major threat actors, cyber aggression is a highly effective way to achieve their mission of degrading U.S. power and economic and institutional stability. It is reasonable to assume that they do not desire resolution and prefer to continue offensive operations.

De-escalation via coercion is a viable strategy for conflict resolution with favorable conditions. Taxonomic classification divides coercion into two main types: compellence and deterrence. Compellence requires a significant direct action or credible threat of action — which in this case could be singular or combined consequential military, economic, or diplomatic actions — that compel the adversary to abandon their U.S.-targeted offensive cyber operations. Compellence could be perceived as provocative by the major threat actors and yield an unintentional escalatory response. Given the high level of economic and trade entanglement with China — and Russia's historic volatility and perceived willingness to engage in kinetic conflict — compellence is not a viable resolution strategy for the current cyber conflict.

Deterrence also can be delineated into two types: "deterrence by punishment" and "deterrence by denial." Both forms are de-escalatory by nature because they are collaborative and afford the adversary agency. Deterrence by punishment presents a credible threat of strong punishment to deter the

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adversary from taking an unwanted action. The clumsy, uncoordinated efforts currently in place are the application of deterrence by punishment. The full gamut of punishments — such as sanctions, public naming/shaming, criminal prosecution and tacit threat of an armed response — have been applied, but they have done little or nothing to deter a state of persistent aggression.

Deterrence by denial deters unwanted aggression by rendering adversary offensive operations impossible or unlikely to succeed, thus negatively impacting the adversary's cost-benefit calculus and prompting prioritization of other opportunities with higher likelihoods of success.

But the application of deterrence by denial in the cyber domain manifests differently than it does in traditional warfighting domains. Deterrence by denial on land, air and sea often rely on a level of impenetrability that is neither practical nor achievable in the cyber domain. The attack surface in cyberspace is simply too big, too complex and too dynamic to adequately secure without impeding the free flow of information or denying the right to reasonable privacy.

Effective deterrence by denial in cyberspace may eschew impenetrable resilience and permit the breach of lines of defense, but reliably denies operations at some point in the kill chain before mission success can be achieved.

Deterrence by denial has never been applied in the cyber domain, nor has any cohesive battle strategy. The value in the de-escalatory nature and also the collaborative aspect of deterrence by denial cannot be underestimated in multinational conflict resolution. Allowing the adversary agency to determine and decline engagement by their own volition is key to sustainability. Without adversary buy-in, sustaining the achieved ends is precarious.

The unique features of this nascent warfighting domain — an ephemeral, binary battlefield that traverses all other warfighting domains as well as civilian, governmental and international environments — offer advantages and constraints that have yet to be studied, let alone tested. As the primary architect and provider of internet infrastructure, the United States has inherent advantages. Full strategic, tactical and operational exploitation of these advantages is essential in the development of strategy, but this knowledge remains siloed among operational teams in intelligence agencies and far from the offices where military strategy development occurs.

Understanding the gaps in technological capabilities required to achieve coercion is crucial. Currently, there are no commercial off-the-shelf or government-bespoke solutions that reliably deny mission success. Timely, deep situational awareness over civilian critical infrastructure is currently unavailable to any security authority. The lack of traditional visibility and latency in determining conclusive attribution is an adversary advantage that can and must be removed.

None of these deficits are technologically insurmountable, but without understanding and acknowledging that these capabilities are required for cyber conflict resolution, resources for their realization will never be prioritized. Nor will these capabilities be valued or recognized as essential when they do appear.

While the adversary's capabilities are advancing, their capacity is subject to constraints. Aggregate analysis of advanced persistent threat behavior over time shows an intentional focus on critical infrastructure assets and the software supply chain that affords access, indicating limited capacity that necessitates prioritization.

Adequate surveillance and incident response capabilities for the several hundred-thousand public and private entities that comprise critical infrastructure is possible, but the programs in current use are deficient. The technology that powers them is clumsy and verging on outdated. And the programs themselves are subject to suspicion by the assets they are meant to protect. It's essential that authorities instill confidence and engender trust in civilian sector partners to successfully execute a conflict response. The current government-provided monitoring technology, and slew of fusion centers and collaboration centers, have done little to engender trust and continue to deliver subpar results for both private and public stakeholders.

The impunity which adversaries currently enjoy is not a permanent feature of the cyber domain. Major cyber attacks on civilian assets do not have to be the new normal, nor can they be without significant compromise to the American way of life. Lack of stability in the cyber domain undermines power projection in all warfighting domains and standing in the liberal world order. Lack of domain dominance hinders the ability to strike at the time and place of America's choosing in all warfighting domains. The risk of intentional or inadvertent catastrophic failure of critical functions or significant compromise to force readiness is too high.

Until a clear end is defined, authorities are deconflicted, and the myopic focus on triage is eschewed in favor of resources allocated toward the composition of a viable coercion strategy, adversaries will continue to exploit the disorganization and draw the United States further into a quagmire of resource attrition. This current level of aggression is not sustainable and certainly on an escalatory trajectory. A cohesive, sustainable, equitable, coercion strategy that leverages all diplomatic, informational, military and economic institutions and elements of power, creates a coalition of allies, implements viable technology, and aligns incentives for private sector collaboration that are required to resolve the current state of conflict.

Perpetual cyber conflict engagement is futile, expensive and does not yield a secure end-state. And further pursuance of misaligned, Sisyphean efforts is not in the best interest of the country. ND

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